The New Organon

FRANCIS BACON
1561–1626

The New Organon

Novum Organum

Translated from the Latin with AI (Claude) and edited

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The New Organon · Francis Bacon (1561–1626)

Translated from the Latin with AI (Claude) and edited. Parallel-text edition, Forage, September 2026. forage.com/bacon/new-organon

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INTRODUCTION

Francis Bacon (1561–1626), lawyer, politician and Lord Chancellor of England, published the *Novum Organum* in Latin in 1620 as the second part of a vast unfinished project, the Great Renewal of the sciences. The title answers Aristotle's *Organon*, the collection of logical works on which university learning rested: Bacon offers a new instrument for the mind.

Book I clears the ground. The sciences, Bacon argues, have made almost no progress because the mind rushes from a few observations to sweeping principles and then argues down from them. He catalogs the "Idols" that distort human understanding—of the Tribe, the Cave, the Marketplace and the Theater—and gives his reasons for hope. Book II sets out the method: gather natural and experimental history, arrange instances in tables, exclude what does not fit, and rise step by step to true causes, worked through in a famous inquiry into the nature of heat.

The book is written as numbered aphorisms, short and pointed in Book I, longer and more technical in Book II. "Knowledge and power meet in one." "Nature is conquered only by obeying her."

Preface

Between dogmatism and despair: a new, certain road from the senses to the mind.

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Pref.	Qui de natura, tanquam de re explorata, pronuntiare ausi sunt, sive hoc ex animi fiducia fecerint sive ambitiose et more professorio, maximis illi philosophiam et scientias detrimentis affecere. Ut enim ad fidem faciendam validi, ita etiam ad inquisitionem extinguendam et abrumpendam efficaces fuerunt. Neque virtute propria tantum profuerunt, quantum in hoc nocuerunt, quod aliorum virtutem corruperint et perdiderint. Qui autem contrariam huic viam ingressi sunt atque nihil prorsus sciri posse asseruerunt, sive ex sophistarum veterum odio sive ex animi fluctuatione aut etiam ex quadam doctrinae copia in hanc opinionem delapsi sint, certe non contemnendas ejus rationes adduxerunt; veruntamen nec a veris initiis sententiam suam derivarunt, et, studio quodam atque affectatione provecti, prorsus modum excesserunt.	Those who have ventured to pronounce on nature as though it were a subject already explored have done the greatest damage to philosophy and the sciences, whether they did so from self-confidence or from ambition and professorial habit. They were strong at winning belief, and just as effective at extinguishing and cutting short inquiry. Nor have they done as much good by their own abilities as they have done harm by corrupting and ruining the abilities of others. Others took the opposite road and asserted that absolutely nothing can be known. They may have slipped into this opinion from hatred of the old sophists, from a wavering mind, or even from a kind of surfeit of learning. They certainly brought forward reasons that are not to be despised. Yet they did not derive their view from true beginnings, and, carried away by zeal and affectation, they went far beyond all measure.
	At antiquiores ex Graecis (quorum scripta perierunt) inter pronuntiandi jactantiam et *Acatalepsiae* desperationem prudentius se sustinuerunt: atque de inquisitionis difficultate et rerum obscuritate saepius querimonias et indignationes miscentes, et veluti fraenum mordentes, tamen propositum urgere atque naturae se immiscere non destiterunt; consentaneum (ut videtur) existimantes, hoc ipsum (videlicet utrum aliquid sciri possit) non disputare, sed experiri. Et tamen illi ipsi, impetu tantum intellectus usi, regulam non adhibuerunt, sed omnia in acri meditatione et mentis volutatione et agitatione perpetua posuerunt.	But the more ancient of the Greeks, whose writings have perished, held themselves more wisely between the boastfulness of pronouncing and the despair of *Acatalepsia* [the impossibility of grasping anything]. They often mixed complaints and indignation about the difficulty of inquiry and the obscurity of things, and, as it were, champed at the bit. Yet they did not cease to press their purpose and to engage with nature. They thought it fitting, it seems, not to argue about this very question, whether anything can be known, but to put it to the test. And yet even they relied only on the force of the understanding and applied no rule. They staked everything on intense meditation and on a continual turning over and agitation of the mind.[1]
	Nostra autem ratio, ut opere ardua, ita dictu facilis est. Ea enim est, ut certitudinis gradus constituamus, sensum	Our method is hard to carry out but easy to state. It is this. We establish degrees of certainty. We

1 *Akatalēpsia* was the Greek Skeptics' term, used especially by the later Platonic Academy, for the view that nothing can be known with certainty.

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per reductionem quandam tueamur, sed mentis opus quod sensum subsequitur plerunque rejiciamus; novam autem et certam viam, ab ipsis sensuum perceptionibus, menti aperiamus et muniamus. Atque hoc proculdubio viderunt et illi qui tantas dialecticae partes tribuerunt. Ex quo liquet, illos intellectui adminicula quaesivisse, mentis autem processum nativum et sponte moventem, suspectum habuisse. Sed serum plane rebus perditis hoc adhibetur remedium; postquam mens ex quotidiana vitae consuetudine, et auditionibus et doctrinis inquinatis occupata, et vanissimis *idolis* obsessa fuerit. Itaque ars illa dialecticae, sero (ut diximus) cavens, neque rem ullo modo restituens, ad errores potius figendos quam ad veritatem aperiendam valuit.

Restat unica salus ac sanitas, ut opus mentis universum de integro resumatur; ac mens, jam ab ipso principio, nullo modo sibi permittatur, sed perpetuo regatur; ac res veluti per machinas conficiatur. Sane si homines opera mechanica nudis manibus, absque instrumentorum vi et ope, aggressi essent, quemadmodum opera intellectualia nudis fere mentis viribus tractare non dubitarunt, parvae admodum fuissent res quas movere et vincere potuissent, licet operas enixas atque etiam conjunctas praestitissent. Atque si paulisper morari, atque in hoc ipsum exemplum, veluti in speculum, intueri velimus; exquiramus (si placet) si forte obeliscus aliquis magnitudine insignis ad triumphi vel hujusmodi magnificentiae decus transferendus esset, atque id homines nudis manibus aggrederentur, annon hoc magnae cujusdam esse dementiae spectator quispiam rei sobrius fateretur?

Quod si numerum augerent operariorum, atque hoc modo se valere posse confiderent, annon tanto magis? Sin autem delectum quendam adhibere vellent, atque imbecilliores separare, et robustis tantum et vigentibus uti, atque hinc saltem se voti compotes fore sperarent, annon adhuc eos impensius delirare diceret? Quin etiam si hoc ipso non contenti, artem tandem athleticam consulere statuerent, ac omnes deinceps manibus et lacertis et nervis ex arte bene unctis et medicatis adesse juberent, annon prorsus eos dare operam ut cum ratione quadam et prudentia insanirent, clamaret?

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safeguard the senses by a kind of correction, but for the most part reject the work of the mind that follows upon the senses. In its place we open and build for the mind a new and certain road, starting from the very perceptions of the senses. This, no doubt, was also seen by those who gave dialectic so large a role. It is clear from this that they were looking for supports for the understanding, and that they distrusted the mind's native and spontaneous movement. But this remedy comes far too late, when all is already lost. By then the mind has been taken over by the daily habits of life, filled with hearsay and corrupt doctrines, and besieged by the emptiest *idols*. So that art of dialectic, taking precautions too late (as we said) and in no way setting matters right, has served to fix errors rather than to open up the truth.[2]

The one remaining hope of health and salvation is to begin the whole work of the mind afresh. From the very beginning the mind must in no way be left to itself but must be guided at every step, and the business must be done as if by machines. Suppose people had undertaken mechanical works with bare hands, without the force and aid of instruments, just as they have not hesitated to tackle intellectual works with little more than the bare strength of the mind. The things they could move and overcome would have been very small indeed, however strenuous, and even united, their efforts. Let us pause a little over this very example and look into it as into a mirror. Suppose some obelisk of remarkable size had to be moved to adorn a triumph or some such magnificent occasion, and people set about it with bare hands. Would not any sober spectator admit that this was a sign of great madness?

And if they increased the number of workmen, trusting that this way they could manage it, would he not think them all the madder? What if they chose to be selective, setting aside the weaker and using only the strong and vigorous, and hoped by this at least to get their wish? Would he not say that they were raving still more wildly? And what if, not content even with this, they finally resolved to consult the art of athletics, and ordered everyone to turn up with hands, arms and sinews well

2 Idols: false images or phantoms (Greek *eidōla*). By "dialectic" Bacon means the logic of the schools, above all Aristotelian syllogistic.

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oiled and treated by the rules of that art? Would he not cry out that they were taking pains to be mad by method and with prudence?

Atque homines tamen simili malesano impetu et conspiratione inutili feruntur in intellectualibus; dum ab ingeniorum vel multitudine et consensu vel excellentia et acumine magna sperant, aut etiam dialectica (quae quaedam athletica censeri possit) mentis nervos roborant; sed interim, licet tanto studio et conatu, (si quis vere judicaverit) intellectum nudum applicare non desinunt. Manifestissimum autem est, in omni opere magno, quod manus hominis praestat, sine instrumentis et machinis, vires nec singulorum intendi nec omnium coire posse.

And yet in intellectual matters people are carried along by just such an unsound impulse and useless combination of effort. They hope for great things from the number and agreement of minds, or from their excellence and sharpness. Or they even strengthen the sinews of the mind with dialectic, which can be thought of as a kind of athletics. Meanwhile, for all their zeal and effort, they never stop applying the naked understanding, if one judges truly. Yet it is perfectly obvious that in every great work done by the hand of man without instruments and machines, the strength of individuals cannot be increased, nor the strength of all be combined.

Itaque ex his quae diximus praemissis, statuimus duas esse res de quibus homines plane monitos volumus, ne forte illae eos fugiant aut praetereant. Quarum prima hujusmodi est; fieri fato quodam (ut existimamus) bono, ad extinguendas et depellendas contradictiones et tumores animorum, ut et veteribus honor et reverentia intacta et imminuta maneant, et nos destinata perficere et tamen modestiae nostrae fructum percipere possimus. Nam nos, si profiteamur nos meliora afferre quam antiqui, eandem quam illi viam ingressi, nulla verborum arte efficere possimus, quin inducatur quaedam ingenii vel excellentiae vel facultatis comparatio sive contentio; non ea quidem illicita aut nova; -- quidni enim possimus pro jure nostro (neque eo ipso alio, quam omnium) si quid apud eos non recte inventum aut positum sit, reprehendere aut notare?

With these premises laid down, then, there are two things of which we want people to be plainly warned, so that they do not slip past unnoticed. The first is this. By a kind of good fortune (as we think), which serves to quench and dispel contradiction and swollen tempers, the ancients keep their honor and reverence untouched and undiminished. At the same time we can carry out what we intend and still reap the fruit of our modesty. Suppose we claimed to bring something better than the ancients while going the same way they did. Then no art of words could prevent a comparison or contest of talent, excellence or ability. It would not, it is true, be an illegitimate or unheard-of contest. For why should we not, by our own right, which is no other than everyone's, criticize or point out anything they did not rightly discover or lay down?

-- sed tamen utcunque justa aut permissa, nihilominus impar fortasse fuisset ea ipsa contentio, ob virium nostrarum modum. Verum quum per nos illud agatur, ut alia omnino via intellectui aperiatur illis intentata et incognita, commutata jam ratio est; cessant studium et partes; nosque indicis tantummodo personam sustinemus, quod mediocris certe est authoritatis, et fortunae cujusdam potius quam facultatis et excellentiae. Atque haec moniti species ad personas pertinet; altera ad res ipsas.

—But however just or permissible, that contest might still have been unequal, given the limits of our strength. But since what we are doing is opening for the understanding a wholly different road, which they neither tried nor knew, the situation has changed. Rivalry and partisanship cease, and we play only the part of a guide. That role surely carries modest authority, and it depends more on a kind of luck than on ability and excellence. This first kind of warning concerns persons; the second concerns the things themselves.

Nos siquidem de deturbanda ea quae nunc floret philosophia, aut si quae alia sit aut erit hac emendatior

We are not in the least concerned to overthrow the philosophy that now flourishes, or any other that

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aut auctior, minime laboramus. Neque enim officimus, quin philosophia ista recepta, et aliae id genus, disputationes alant, sermones ornent, ad professoria munera et vitae civilis compendia adhibeantur et valeant. Quin etiam aperte significamus et declaramus, eam quam nos adducimus philosophiam ad istas res admodum utilem non futuram. Non praesto est, neque in transitu capitur, neque ex praenotionibus intellectui blanditur, neque ad vulgi captum nisi per utilitatem et effecta descendet.

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is or will be more correct or more complete. We do not stand in the way of this received philosophy and others of its kind. Let them feed disputations, adorn conversation, and serve and prove effective in professorial duties and in the conveniences of civil life. Indeed, we openly declare that the philosophy we are introducing will not be much use for those purposes. It is not ready to hand, and it is not caught in passing. It does not flatter the understanding with preconceptions. And it will not come down to the grasp of ordinary people except through its usefulness and its effects.

TWO KINDS OF LEARNING

Bacon proposes one method for cultivating the sciences and another for discovering them, and asks for a patient reader.

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Sint itaque (quod foelix faustumque sit utrique parti) duae doctrinarum emanationes, ac duae dispensationes; duae similiter contemplantium sive philosophantium tribus ac veluti cognationes; atque illae neutiquam inter se inimicae aut alienae, sed foederatae et mutuis auxiliis devinctae: sit denique alia scientias colendi, alia inveniendi ratio. Atque quibus prima potior et acceptior est, ob festinationem, vel vitae civilis rationes, vel quod illam alteram ob mentis infirmitatem capere et complecti non possint (id quod longe plurimis accidere necesse est), optamus ut iis foeliciter et ex voto succedat quod agunt, atque ut quod sequuntur teneant.

Quod si cui mortalium cordi et curae sit, non tantum inventis haerere atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique, non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant; ut omissis naturae atriis, quae infiniti contriverunt, aditus aliquando ad interiora patefiat. Atque ut melius intelligamur, utque illud ipsum quod volumus ex nominibus impositis magis familiariter occurrat, altera ratio sive via Anticipatio Mentis, altera *Interpretatio Naturae,* a nobis appellari consuevit.

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Let there be, then, two streams and two dispensations of learning, and may this be happy and propitious for both sides. Likewise let there be two tribes, or kindreds as it were, of contemplatives or philosophers. They are in no way hostile or strangers to each other, but allied and bound together by mutual help. Let there be, in short, one method for cultivating the sciences and another for discovering them. Some will find the first preferable and more acceptable. This may be because of haste, or the demands of civil life, or because weakness of mind prevents them from grasping and embracing the other, as must happen to by far the greater number. For them we wish that what they do may prosper as they would wish, and that they may keep what they pursue.

But some may have it at heart not merely to cling to what has been discovered and make use of it, but to press on further. They may wish to conquer not an opponent by argument but nature by work, and not to hold fine and probable opinions but to know with certainty and demonstration. Let such people, as true sons of the sciences, join us if they see fit. Leaving behind the outer courts of nature, which countless people have trodden, we may then at last open a way into its inner rooms. We want to be better understood, and to have our meaning come more readily to mind through the names we give it. So we have been accustomed to call the one method or way the Anticipation of the Mind, and the other the *Interpretation of Nature*.[3]

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Est etiam quod petendum videtur. Nos certe cogitationem suscepimus et curam adhibuimus, ut quae a nobis proponentur non tantum vera essent, sed etiam ad animos hominum (licet miris modis occupatos et interclusos) non incommode aut aspere accederent.

Veruntamen aequum est, ut ab hominibus impetremus (in tanta praesertim doctrinarum et scientiarum restauratione) ut qui de hisce nostris aliquid, sive ex sensu proprio, sive ex authoritatum turba, sive ex demonstrationum formis (quae nunc tanquam leges quaedam judicialis invaluerunt), statuere aut existimare velit, ne id in transitu et velut aliud agendo facere se posse speret; sed ut rem pernoscat; nostram, quam describimus et munimus, viam ipse paullatim tentet; subtilitati rerum quae in experientia signata est assuescat; pravos denique atque alte haerentes mentis habitus tempestiva et quasi legitima mora corrigat; atque tum demum (si placuerit) postquam in potestate sua esse coeperit, judicio suo utatur.

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There is also a request we think we should make. We have certainly taken thought and care that what we propose should not only be true. It should also approach people's minds without awkwardness or harshness, however strangely those minds are preoccupied and blocked.

Still, it is fair to ask this of people, especially in so great a restoration of learning and the sciences. Some will wish to decide or form a view about these proposals of ours, whether from their own sense, or from the crowd of authorities, or from the forms of demonstration, which now have the force of laws of court. They should not hope to do so in passing, as if busy with something else. Let such a reader get to know the matter thoroughly, and try out for himself, little by little, the road we describe and build. Let him grow used to the subtlety of things that is marked out in experience. Let him correct the bad and deep-rooted habits of the mind by a timely and, as it were, lawful delay. Then at last, once he has begun to be his own master, let him use his own judgment if he wishes.

3 "Anticipation" is Bacon's term for premature generalization, which leaps from a few observations to sweeping conclusions.

Book I

Clearing the ground
Why the sciences have stalled; the Idols of the Tribe, Cave, Marketplace and Theater; signs and hopes of renewal.

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1.1	Homo, naturae minister et interpres, tantum facit et intelligit quantum de naturae ordine re vel mente observaverit: nec amplius scit, aut potest.	Man, the servant and interpreter of nature, does and understands only as much as he has observed of the order of nature, in fact or in thought. Beyond this he neither knows anything nor can do anything.
1.2	Nec manus nuda, nec intellectus sibi permissus, multum valet; instrumentis et auxiliis res perficitur; quibus opus est, non minus ad intellectum, quam ad manum. Atque ut instrumenta manus motum aut cient aut regunt; ita et instrumenta mentis intellectui aut suggerunt aut cavent.	Neither the bare hand nor the understanding left to itself can do much. The work is done by instruments and aids, and the understanding needs them no less than the hand. The hand's instruments either set its motion going or guide it. In the same way, the mind's instruments either prompt the understanding or guard it.
1.3	Scientia et potentia humana in idem coincidunt, quia ignoratio causae destituit effectum. Natura enim non nisi parendo vincitur: et quod in contemplatione instar causae est, id in operatione instar regulae est.	Human knowledge and human power come to the same thing, because ignorance of the cause defeats the effect. Nature is conquered only by being obeyed. What in contemplation serves as the cause, in operation serves as the rule.
1.4	Ad opera nil aliud potest homo, quam ut corpora naturalia admoveat et amoveat: reliqua natura intus transigit.	In producing works, all that man can do is bring natural bodies together and move them apart. The rest nature carries out within.
1.5	Solent se immiscere naturae (quoad opera) mechanicus, mathematicus, medicus, alchemista, et magus; sed omnes (ut nunc sunt res) conatu levi, successu tenui.	The mechanic, the mathematician, the physician, the alchemist and the magician all meddle with nature for the sake of works. But all of them, as things now stand, do so with slight effort and meager success.
1.6	Insanum quiddam esset, et in se contrarium, existimare ea, quae adhuc nunquam facta sunt, fieri posse, nisi per modos adhuc nunquam tentatos.	It would be mad, and self-contradictory, to think that things never yet done can be done except by means never yet tried.
1.7	Generationes mentis et manus numerosae admodum videntur in libris et opificiis. Sed omnis ista varietas sita est in subtilitate eximia, et derivationibus paucarum rerum, quae innotuerunt; non in numero axiomatum.	The products of mind and hand, in books and in workshops, seem very numerous. But all that variety lies in exquisite refinement and in derivations from a few things already known, not in any number of axioms.
1.8		

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	Etiam opera, quae jam inventa sunt, casui debentur et experientiae, magis quam scientiis: scientiae enim, quas nunc habemus, nihil aliud sunt quam quaedam concinnationes rerum antea inventarum; non modi inveniendi, aut designationes novorum operum.	Even the works already discovered are owed to chance and experience more than to the sciences. The sciences we now have are nothing but neat arrangements of things already discovered. They are not methods of discovery or plans for new works.
1.9	Causa vero et radix fere omnium malorum in scientiis ea una est; quod dum mentis humanae vires falso miramur et extollimus, vera ejus auxilia non quaeramus.	The cause and root of nearly all the evils in the sciences is this one thing. We falsely admire and extol the powers of the human mind, and so we fail to seek its true aids.
1.10	Subtilitas naturae subtilitatem sensus et intellectus multis partibus superat; ut pulchrae illae meditationes et speculationes humanae et causationes res malesana sint, nisi quod non adsit qui advertat.	The subtlety of nature exceeds the subtlety of the senses and the understanding many times over. So all those fine human meditations, speculations and explanations are an unsound business, only there is no one standing by to notice.
1.11	Sicut scientiae, quae nunc habentur, inutiles sunt ad inventionem operum; ita et logica, quae nunc habetur, inutilis est ad inventionem scientiarum.	The sciences we now have are useless for the discovery of works. In the same way, the logic we now have is useless for the discovery of sciences.
1.12	Logica, quae in usu est, ad errores (qui in notionibus vulgaribus fundantur) stabiliendos et figendos valet, potius quam ad inquisitionem veritatis; ut magis damnosa sit, quam utilis.	The logic now in use serves to establish and fix errors, which are founded on common notions, rather than to search for truth. So it does more harm than good.
1.13	Syllogismus ad principia scientiarum non adhibetur, ad media axiomata frustra adhibetur, cum sit subtilitati naturae longe impar. Assensum itaque constringit, non res.	The syllogism is not applied to the first principles of the sciences, and it is applied in vain to middle axioms, since it falls far short of the subtlety of nature. It therefore constrains assent, not things.
1.14	Syllogismus ex propositionibus constat, propositiones ex verbis, verba notionum tesserae sunt. Itaque si notiones ipsae (id quod basis rei est) confusae sint, et temere a rebus abstractae; nihil in iis, quae superstruuntur, est firmitudinis. Itaque spes est una in *inductione* vera.	The syllogism consists of propositions, propositions of words, and words are tokens of notions. The notions themselves are the foundation of the whole. So if they are confused and rashly abstracted from things, nothing built on them is firm. Our one hope therefore lies in true *induction*.
1.15	In notionibus nil sani est, nec in logicis, nec in physicis: non *substantia*, non *qualitas, agere, pati,* ipsum *esse,* bonae notiones sunt; multo minus *grave, leve, densum, tenue, humidum, siccum, generatio, corruptio, attrahere, fugare, elementum, materia, forma,* et id genus; sed omnes phantasticae et male terminatae.	There is nothing sound in our notions, whether in logic or in physics. *Substance*, *quality*, *acting*, *being acted upon*, and even *being* itself are not good notions. Still less are *heavy*, *light*, *dense*, *rare*, *moist*, *dry*, *generation*, *corruption*, *attraction*, *repulsion*, *element*, *matter*, *form* and the like. All of them are fanciful and ill defined.
1.16	Notiones infimarum specierum, *hominis, canis, columbae,* et prehensionum immediatarum sensus, *calidi, frigidi, albi, nigri,* non fallunt magnopere; quae tamen ipsae a fluxu materiae et commissione rerum quandoque confunduntur; reliquae omnes (quibus homines hactenus usi sunt) aberrationes sunt, nec debitis modis a rebus abstractae et excitatae.	Our notions of the lowest species, such as *man*, *dog* and *dove*, and of the immediate perceptions of the senses, such as *hot*, *cold*, *white* and *black*, do not deceive us much. Yet even these are sometimes confused by the flux of matter and the mingling of things. All the others that people have used so far

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		are aberrations, not abstracted and drawn out from things in the proper ways.
1.17	Nec minor est libido et aberratio in constituendis axiomatibus, quam in notionibus abstrahendis; idque in ipsis principiis, quae ab inductione vulgari pendent. At multo major est in axiomatibus, et propositionibus inferioribus, quae educit syllogismus.	There is no less willfulness and aberration in setting up axioms than in abstracting notions. This holds even for the first principles, which depend on ordinary induction. But there is far more in the axioms and lower propositions that the syllogism draws out.
1.18	Quae adhuc inventa sunt in scientiis, ea hujusmodi sunt, ut notionibus vulgaribus fere subjaceant: ut vero ad interiora et remotiora naturae penetretur, necesse est ut tam notiones quam axiomata magis certa et munita via a rebus abstrahantur, atque omnino melior et certior intellectus adoperatio in usum veniat.	The discoveries made in the sciences so far mostly fall within the scope of common notions. To penetrate to the inner and more remote parts of nature, both notions and axioms must be abstracted from things by a more certain and better-guarded road. A better and more certain working of the understanding must come into use altogether.

TWO WAYS TO TRUTH

One way leaps from particulars to the most general axioms; the true way rises to them step by step.

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1.19	Duae viae sunt, atque esse possunt, ad inquirendam et inveniendam veritatem. Altera a sensu et particularibus advolat ad axiomata maxime generalia, atque ex iis principiis eorumque immota veritate judicat et invenit axiomata media; atque haec via in usu est. Altera a sensu et particularibus excitat axiomata, ascendendo continenter et gradatim, ut ultimo loco perveniatur ad maxime generalia; quae via vera est, sed intentata.	There are, and can be, only two ways of searching for and discovering truth. The one flies from the senses and particulars to the most general axioms. From these principles and their supposedly unshakable truth, it proceeds to judge and discover the middle axioms. This is the way now in use. The other draws out axioms from the senses and particulars, rising steadily and by degrees, so that it arrives at the most general axioms last of all. This is the true way, but it has not been tried.
1.20	Eandem ingreditur viam (priorem scilicet) intellectus sibi permissus, quam facit ex ordine dialecticae. Gestit enim mens exsilire ad magis generalia, ut acquiescat; et post parvam moram fastidit experientiam: sed haec mala demum aucta sunt a dialectica ob pompas disputationum.	The understanding left to itself takes the same way, namely the first, that it takes when following the order of dialectic. For the mind longs to leap up to the more general so that it can rest there, and after a short while it grows tired of experience. These evils, moreover, have been increased by dialectic, for the sake of the pomp of disputations.
1.21	Intellectus sibi permissus, in ingenio sobrio et patiente et gravi (praesertim si a doctrinis receptis non impediatur), tentat nonnihil illam alteram viam, quae recta est, sed exiguo profectu; cum intellectus, nisi regatur et juvetur, res inaequalis sit, et omnino inhabilis ad superandam rerum obscuritatem.	In a sober, patient and serious mind, especially one not hindered by received doctrines, the understanding left to itself makes some attempt at that other way, which is the right one. But it makes little progress. Unless the understanding is guided and helped, it is an uneven thing and wholly unfit to overcome the obscurity of things.
1.22		

	LATIN	ENGLISH
	Utraque via orditur a sensu et particularibus, et acquiescit in maxime generalibus: sed immensum quiddam discrepant; cum altera perstringat tantum experientiam et particularia cursim; altera in iis rite et ordine versetur; altera rursus jam a principio constituat generalia quaedam abstracta et inutilia; altera gradatim exsurgat ad ea quae revera naturae sunt notiora.	Both ways start from the senses and particulars, and both come to rest in the most general. But they differ immensely. The one merely brushes past experience and particulars in haste; the other dwells on them properly and in order. The one sets up, right from the start, certain abstract and useless generalities; the other rises by degrees to what is truly better known to nature.
1.23	Non leve quiddam interest inter humanae mentis *idola,* et divinae mentis ideas; hoc est, inter placita quaedam inania, et veras signaturas atque impressiones factas in creaturis, prout inveniuntur.	There is no small difference between the *idols* of the human mind and the ideas of the divine mind. The difference is between certain empty opinions and the true signatures and marks impressed on created things, as they are actually found.
1.24	Nullo modo fieri potest, ut axiomata per argumentationem constituta ad inventionem novorum operum valeant; quia subtilitas naturae subtilitatem argumentandi multis partibus superat. Sed axiomata, a particularibus rite et ordine abstracta, nova particularia rursus facile indicant et designant; itaque scientias reddunt activas.	Axioms established by argument cannot possibly serve for the discovery of new works, since the subtlety of nature exceeds the subtlety of argument many times over. But axioms properly and methodically abstracted from particulars readily point to and mark out new particulars in turn. In this way they make the sciences active.
1.25	Axiomata, quae in usu sunt, ex tenui et manipulari experientia, et paucis particularibus, quae ut plurimum occurrunt, fluxere; et sunt fere ad mensuram eorum facta et extensa: ut nil mirum sit, si ad nova particularia non ducant. Quod si forte instantia aliqua, non prius animadversa aut cognita, se offerat, axioma distinctione aliqua frivola salvatur, ubi emendari ipsum verius foret.	The axioms now in use have flowed from a thin and scanty experience and from a few particulars of the most common sort. They are generally made and stretched to fit these, so it is no wonder that they do not lead to new particulars. And if some instance not previously noticed or known happens to turn up, the axiom is rescued by some frivolous distinction, when it would be truer to correct it.

ANTICIPATION AND INTERPRETATION

Bacon names the two ways of reasoning about nature and explains why hasty anticipations win easy agreement.

	LATIN	ENGLISH
1.26	Rationem humanam, qua utimur ad naturam, *anticipationes naturae* (quia res temeraria est et praematura), at illam rationem quae debitis modis elicitur a rebus, *interpretationem naturae,* docendi gratia, vocare consuevimus.	For the sake of teaching, we are accustomed to give two names. Human reasoning as it is usually applied to nature we call *anticipations of nature*, because it is rash and premature. The reasoning that is drawn from things in the proper ways we call the *interpretation of nature*.
1.27	*Anticipationes* satis firmae sunt ad consensum; quandoquidem, si homines etiam insanirent ad unum modum et conformiter, illi satis bene inter se congruere possent.	*Anticipations* are firm enough to produce agreement. After all, even if people all went mad in one and the same way, they could agree among themselves well enough.
1.28	Quin longe validiores sunt ad subeundum assensum *anticipationes,* quam *interpretationes;* quia ex paucis	Indeed, *anticipations* are far more powerful than *interpretations* at winning assent. They are

	LATIN	ENGLISH
	collectae, iisque maxime quae familiariter occurrunt, intellectum statim perstringunt, et phantasiam implent; ubi contra, *interpretationes,* ex rebus admodum variis et multum distantibus sparsim collectae, intellectum subito percutere non possunt; ut necesse sit eas, quoad opiniones, duras et absonas, fere instar mysteriorum fidei videri.	gathered from a few instances, mostly from those that occur familiarly, and so they immediately strike the understanding and fill the imagination. *Interpretations*, by contrast, are gathered here and there from very varied and widely separated things, and cannot strike the understanding all at once. So, measured against current opinion, they must seem harsh and discordant, almost like the mysteries of faith.
1.29	In scientiis, quae in opinionibus et placitis fundatae sunt, bonus est usus *anticipationum* et dialecticae; quando opus est assensum subjugare, non res.	In sciences founded on opinions and dogmas, *anticipations* and dialectic are of good use, since there the task is to subdue assent, not things.
1.30	Non, si omnia omnium aetatum ingenia coierint, et labores contulerint et transmiserint, progressus magnus fieri poterit in scientiis per *anticipationes:* quia errores radicales, et in prima digestione mentis, ab excellentia functionum et remediorum sequentium non curantur.	Suppose all the minds of all the ages came together, pooling their labors and handing them on. Even so, no great progress could be made in the sciences by means of *anticipations*. Radical errors, made in the mind's first digestion, are not cured by the excellence of the functions and remedies that follow.
1.31	Frustra magnum expectatur augmentum in scientiis ex superinductione et insitione novorum super vetera; sed instauratio facienda est ab imis fundamentis, nisi libeat perpetuo circumvolvi in orbem, cum exili et quasi contemnendo progressu.	It is idle to expect any great advance in the sciences from grafting and superimposing new things on old. The renewal must be made from the very foundations, unless we want to go round in circles forever, with meager and almost contemptible progress.[1]
1.32	Antiquis auctoribus suus constat honos, atque adeo omnibus; quia non ingeniorum aut facultatum inducitur comparatio, sed viae; nosque non judicis, sed indicis personam sustinemus.	The ancient authors keep their honor, and indeed so does everyone. What is being compared is not minds or abilities but ways. And we play the part not of a judge but of a guide.
1.33	Nullum (dicendum enim est aperte) recte fieri potest judicium nec de via nostra, nec de iis quae secundum eam inventa sunt, per *anticipationes* (rationem scilicet quae in usu est), quia non postulandum est ut ejus rei judicio stetur, quae ipsa in judicium vocatur.	It must be said plainly: no correct judgment can be made by means of *anticipations*, that is, by the reasoning now in use, either of our way or of what is discovered by it. One cannot demand that the verdict rest with the very thing that is itself on trial.
1.34	Neque etiam tradendi aut explicandi ea, quae adducimus, facilis est ratio; quia, quae in se nova sunt, intelligentur tamen ex analogia veterum.	Nor is it easy to convey or explain what we are bringing forward. Things that are new in themselves will still be understood by analogy with the old.
1.35	Dixit Borgia de expeditione Gallorum in Italiam, eos venisse cum creta in manibus, ut diversoria notarent, non cum armis, ut perrumperent. Itidem et nostra ratio est,	Borgia said of the French expedition into Italy that they came with chalk in their hands to mark their lodgings, not with weapons to force their way in.

1 "Renewal" (*instauratio*) is Bacon's word for his larger project, the *Instauratio Magna* (Great Renewal), of which this work is the second part.

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	ut doctrina nostra animos idoneos et capaces subintret; confutationum enim nullus est usus, ubi de principiis et ipsis notionibus, atque etiam de formis demonstrationum dissentimus.	Our plan is the same. We want our teaching to find its way quietly into minds that are fit and able to receive it. Refutations are of no use when we disagree about principles and notions themselves, and even about the forms of demonstration.[2]
1.36	Restat vero nobis modus tradendi unus et simplex, ut homines ad ipsa particularia et eorum series et ordines adducamus; et ut illi rursus imperent sibi ad tempus abnegationem notionum, et cum rebus ipsis consuescere incipiant.	One simple way of teaching remains to us. We must lead people to the particulars themselves, in their series and orders. They in turn must make themselves renounce their notions for a while and begin to grow familiar with things themselves.
1.37	Ratio eorum, qui acatalepsiam tenuerunt, et via nostra initiis suis quodammodo consentiunt; exitu immensum disjunguntur et opponuntur. Illi enim nihil sciri posse simpliciter asserunt; nos, non multum sciri posse in natura, ea, quae nunc in usu est, via: verum illi exinde authoritatem sensus et intellectus destruunt; nos auxilia iisdem excogitamus et subministramus.	The method of those who held *acatalepsia* [that nothing can be grasped] and our own way agree to some extent at the outset. At the end they are immensely far apart and opposed. They assert flatly that nothing can be known. We say that not much can be known about nature by the way now in use. And from there they go on to destroy the authority of the senses and the understanding, whereas we devise and supply aids for them.

THE FOUR IDOLS

Bacon introduces the false images that besiege the mind: the Idols of the Tribe, Cave, Marketplace and Theater.

	LATIN	ENGLISH
1.38	*Idola* et notiones falsae, quae intellectum humanum jam occuparunt atque in eo alte haerent, non solum mentes hominum ita obsident, ut veritati aditus difficilis pateat; sed etiam dato et concesso aditu, illa rursus in ipsa instauratione scientiarum occurrent et molesta erunt; nisi homines praemoniti adversus ea se, quantum fieri potest, muniant.	The *idols* and false notions have already taken hold of the human understanding and are deeply rooted in it. They so besiege people's minds that truth can hardly find a way in. And even when a way in is granted, they will meet us again in the very renewal of the sciences and cause trouble. This will happen unless people are forewarned and fortify themselves against them as far as possible.
1.39	Quatuor sunt genera *idolorum,* quae mentes humanas obsident. Iis (docendi gratia) nomina imposuimus; ut primum genus, *idola tribus;* secundum, *idola specus;* tertium, *idola fori;* quartum, *idola theatri,* vocentur.	There are four kinds of *idols* that besiege human minds. For the sake of teaching we have given them names. The first kind we call *Idols of the Tribe*; the second, *Idols of the Cave*; the third, *Idols of the Marketplace*; the fourth, *Idols of the Theater*.
1.40	Excitatio notionum et axiomatum per *inductionem* veram est certe proprium remedium ad *idola* arcenda et summovenda; sed tamen indicatio *idolorum* magni est usus. Doctrina enim de *idolis* similiter se habet ad *interpretationem naturae,* sicut doctrina de sophisticis elenchis ad dialecticam vulgarem.	Forming notions and axioms by true *induction* is certainly the proper remedy for keeping off and clearing away *idols*. But pointing out the *idols* is also of great use. For the doctrine of *idols* stands to the *interpretation of nature* as the doctrine of sophistical refutations stands to ordinary dialectic.[3]

2 Pope Alexander VI (Rodrigo Borgia), speaking of Charles VIII's unopposed invasion of Italy in 1494; the chalk marked houses for billeting troops.

	LATIN	ENGLISH
1.41	*Idola tribus* sunt fundata in ipsa natura humana, atque in ipsa tribu seu gente hominum. Falso enim asseritur, sensum humanum esse mensuram rerum; quin contra, omnes perceptiones, tam sensus quam mentis, sunt ex analogia hominis, non ex analogia universi. Estque intellectus humanus instar speculi inaequalis ad radios rerum, qui suam naturam naturae rerum immiscet, eamque distorquet et inficit.	The *Idols of the Tribe* are founded in human nature itself, and in the very tribe or race of mankind. For it is falsely asserted that the human senses are the measure of things. On the contrary, all perceptions, of the senses as well as of the mind, are on the scale of man, not on the scale of the universe. The human understanding is like an uneven mirror that receives the rays of things. It mixes its own nature with the nature of things, and so distorts and discolors it.[4]
1.42	*Idola specus* sunt idola hominis individui. Habet enim unusquisque (praeter aberrationes naturae humanae in genere) specum sive cavernam quandam individuam, quae lumen naturae frangit et corrumpit: vel propter naturam cujusque propriam et singularem; vel propter educationem et conversationem cum aliis; vel propter lectionem librorum, et authoritates eorum quos quisque colit et miratur; vel propter differentias impressionum, prout occurrunt in animo praeoccupato et praedisposito, aut in animo aequo et sedato, vel ejusmodi: ut plane spiritus humanus (prout disponitur in hominibus singulis) sit res varia, et omnino perturbata, et quasi fortuita. Unde bene Heraclitus, homines scientias quaerere in minoribus mundis, et non in majore sive communi.	The *Idols of the Cave* are the idols of the individual. Everyone, besides the aberrations of human nature in general, has a cave or den of his own, which breaks up and corrupts the light of nature. This may come from each person's own particular nature, or from upbringing and dealings with others. It may come from reading books and from the authority of those one reveres and admires. Or it may come from differences in impressions, depending on whether they fall on a mind preoccupied and predisposed or on one calm and settled, and so on. So the human spirit, as it is disposed in each individual, is plainly a variable thing, thoroughly disordered and as it were subject to chance. Hence Heraclitus rightly said that people seek knowledge in their own lesser worlds, and not in the greater or common world.[5]
1.43	Sunt etiam *idola* tanquam ex contractu et societate humani generis ad invicem, quae *idola fori,* propter hominum commercium et consortium, appellamus. Homines enim per sermones sociantur; at verba ex captu vulgi imponuntur. Itaque mala et inepta verborum impositio miris modis intellectum obsidet. Neque definitiones aut explicationes, quibus homines docti se munire et vindicare in nonnullis consueverunt, rem ullo modo restituunt. Sed verba plane vim faciunt intellectui, et omnia turbant; et homines ad inanes et innumeras controversias et commenta deducunt.	There are also *idols* that arise, as it were, from the association and fellowship of the human race with one another. We call these *Idols of the Marketplace*, because of people's commerce and dealings with one another. People associate through speech, and words are assigned according to the grasp of the common people. So a bad and unsuitable assignment of words besieges the understanding in remarkable ways. Learned people have been accustomed to fortify and protect themselves in some cases with definitions and explanations, but these do nothing to set matters right. Words plainly do violence to the understanding and throw everything into confusion. They lead people into empty and countless controversies and fictions.
1.44	Sunt denique *idola,* quae immigrarunt in animos hominum ex diversis dogmatibus philosophiarum, ac	Lastly, there are *idols* that have migrated into people's minds from the various dogmas of philo-

3 Aristotle's *Sophistical Refutations* is a treatise on fallacies in argument.
4 An allusion to Protagoras's saying that man is the measure of all things.

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etiam ex perversis legibus demonstrationum; quae *idola theatri* nominamus; quia quot philosophiae receptae aut inventae sunt, tot fabulas productas et actas censemus, quae mundos effecerunt fictitios et scenicos. Neque de his quae jam habentur, aut etiam de veteribus philosophiis et sectis tantum loquimur, cum complures aliae ejusmodi fabulae componi et concinnari possint; quandoquidem errorum prorsus diversorum causae sint nihilominus fere communes. Neque rursus de philosophiis universalibus tantum hoc intelligimus, sed etiam de principiis et axiomatibus compluribus scientiarum, quae ex traditione et fide et neglectu invaluerunt. Verum de singulis istis generibus *idolorum,* fusius et distinctius dicendum est, ut intellectui humano cautum sit.	sophies, and also from perverse rules of demonstration. We call these *Idols of the Theater*. We regard all the philosophies that have been received or invented as so many plays produced and acted, which have created fictitious, stage-set worlds. We are not speaking only of those now current, or only of the ancient philosophies and sects. Many other such plays could be composed and put together, since the causes of quite different errors are nonetheless largely the same. Nor do we mean this only of whole philosophies. We also mean many principles and axioms in the sciences that have gained strength through tradition, credulity and negligence. But each of these kinds of *idols* must be discussed more fully and distinctly, so that the human understanding may be put on its guard.

IDOLS OF THE TRIBE

Errors shared by all humans: imagining too much order, ignoring negative cases, restlessness, emotion and weak senses.

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1.45 Intellectus humanus ex proprietate sua facile supponit majorem ordinem et aequalitatem in rebus, quam invenit: et cum multa sint in natura monodica, et plena imparitatis, tamen affingit parallela, et correspondentia, et relativa, quae non sunt. Hinc commenta illa, *in coelestibus omnia moveri per circulos perfectos,* lineis spiralibus et draconibus (nisi nomine tenus) prorsus rejectis. Hinc elementum ignis cum orbe suo introductum est ad constituendum quaternionem cum reliquis tribus, quae subjiciuntur sensui. Etiam elementis (quae vocant) imponitur ad placitum decupla proportio excessus in raritate ad invicem; et hujusmodi somnia. Neque vanitas ista tantum valet in dogmatibus, verum etiam in notionibus simplicibus.	The human understanding, by its own nature, readily supposes more order and regularity in things than it finds. Many things in nature are unique and full of irregularity. Even so, it invents parallels, correspondences and relations that do not exist. Hence the fiction that *in the heavens all things move in perfect circles*, while spiral lines and dragons are wholly rejected, except in name. Hence the element of fire with its sphere was brought in to make up a set of four with the other three, which the senses perceive. The so-called elements, too, are arbitrarily assigned a tenfold increase in rarity from one to the next. There are other dreams of this kind. Nor does this folly hold sway only in dogmas; it affects simple notions too.[6]
1.46 Intellectus humanus in iis quae semel placuerunt (aut quia recepta sunt et credita, aut quia delectant), alia etiam omnia trahit ad suffragationem et consensum cum illis: et licet major sit instantiarum vis et copia, quae occurrunt in contrarium; tamen eas aut non observat, aut contemnit, aut distinguendo summovet et rejicit, non	Once the human understanding has settled on something, because it is received and believed or because it pleases, it draws everything else into supporting and agreeing with it. The instances on the other side may be more numerous and weighty. Yet it fails to notice them, or despises

5 The cave recalls Plato's allegory in *Republic* 7. Heraclitus of Ephesus (c. 500 BC) complained that people live as though each had a private understanding.
6 The "dragons" are the lunar nodes, the points where the moon's path crosses the sun's, traditionally called the dragon's head and tail.

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sine magno et pernicioso praejudicio, quo prioribus illis syllepsibus authoritas maneat inviolata.

Itaque recte respondit ille, qui, cum suspensa tabula in templo ei monstraretur eorum qui vota solverant, quod naufragii periculo elapsi sint, atque interrogando premeretur, anne tum quidem Deorum numen agnosceret, quaesivit denuo, *At ubi sunt illi depicti qui post vota nuncupata perierint?* Eadem ratio est fere omnis superstitionis, ut in astrologicis, in somniis, ominibus, nemesibus, et hujusmodi; in quibus homines delectati hujusmodi vanitatibus advertunt eventus, ubi implentur; ast ubi fallunt, licet multo frequentius, tamen negligunt et praetereunt. At longe subtilius serpit hoc malum in philosophiis et scientiis; in quibus quod semel placuit, reliqua (licet multo firmiora et potiora) inficit, et in ordinem redigit.

Quinetiam licet abfuerit ea, quam diximus, delectatio et vanitas, is tamen humano intellectui error est proprius et perpetuus, ut magis moveatur et excitetur affirmativis, quam negativis; cum rite et ordine aequum se utrique praebere debeat; quin contra, in omni axiomate vero constituendo, major est vis instantiae negativae.

1.47 Intellectus humanus illis, quae simul et subito mentem ferire et subire possunt, maxime movetur; a quibus phantasia impleri et inflari consuevit: reliqua vero modo quodam, licet imperceptibili, ita se habere fingit et supponit, quomodo se habent pauca illa quibus mens obsidetur; ad illum vero transcursum ad instantias remotas et heterogeneas, per quas axiomata tanquam igne probantur, tardus omnino intellectus est, et inhabilis, nisi hoc illi per duras leges et violentum imperium imponatur.

1.48 Gliscit intellectus humanus, neque consistere aut acquiescere potis est, sed ulterius petit; at frustra. Itaque incogitabile est ut sit aliquid extremum aut extimum mundi, sed semper quasi necessario occurrit ut sit aliquid ulterius. Neque rursus cogitari potest quomodo aeternitas defluxerit ad hunc diem; cum distinctio illa,

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them, or sets them aside and rejects them by drawing some distinction. It does so with great and harmful prejudice, so that the authority of its first conclusions may remain intact.

So it was a good answer that one man gave. He was shown a picture hanging in a temple, of those who had paid their vows after escaping the danger of shipwreck. When he was pressed to say whether he did not now acknowledge the power of the gods, he asked in turn, *"But where are the pictures of those who drowned after making their vows?"* The same holds for nearly all superstition, as in astrology, dreams, omens, divine retributions and the like. People who delight in such vanities note the outcomes when they are fulfilled. When they fail, which happens much more often, they ignore them and pass them by. But this evil creeps far more subtly into philosophy and the sciences. There, whatever has once pleased infects the rest, though the rest is much firmer and stronger, and brings it into line.[7]

Even apart from the delight and vanity we mentioned, the human understanding has its own perpetual error. It is more moved and excited by affirmatives than by negatives, though by right it ought to hold itself impartial toward both. Indeed, the opposite is true: in establishing any true axiom, the negative instance carries the greater force.

The human understanding is most moved by things that can strike and enter the mind all at once and suddenly. These usually fill and inflate the imagination. As for everything else, the understanding imagines and supposes, in some way though imperceptibly, that it behaves like those few things that have taken hold of the mind. But it is altogether slow and unfit to make the passage to remote and heterogeneous instances, by which axioms are tried as if by fire. It will do so only if strict rules and a firm command force it to.

The human understanding is restless. It cannot stop or rest, but keeps pressing further, in vain. So it is unthinkable that there should be any outermost limit or edge of the world; it always seems almost necessary that there be something beyond. Nor, again, can we conceive how eternity has

7 Cicero tells this story of Diagoras of Melos (*On the Nature of the Gods* 3.89).

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quae recipi consuevit, quod sit *infinitum a parte ante, et a parte post,* nullo modo constare possit; quia inde sequeretur, quod sit unum infinitum alio infinito majus, atque ut consumatur infinitum, et vergat ad finitum. Similis est subtilitas de lineis semper divisibilibus, ex impotentia cogitationis. At majore cum pernicie intervenit haec impotentia mentis in inventione causarum: nam cum maxime universalia in natura positiva esse debeant, quemadmodum inveniuntur, neque sunt revera causabilia; tamen intellectus humanus, nescius acquiescere, adhuc appetit notiora.

Tum vero, ad ulteriora tendens, ad proximiora recidit, videlicet ad causas finales, quae sunt plane ex natura hominis, potius quam universi: atque ex hoc fonte philosophiam miris modis corruperunt. Est autem aeque imperiti et leviter philosophantis, in maxime universalibus causam requirere, ac in subordinatis et subalternis causam non desiderare.

1.49 Intellectus humanus luminis sicci non est; sed recipit infusionem a voluntate et affectibus, id quod generat *ad quod vult scientias*: quod enim mavult homo verum esse, id potius credit. Rejicit itaque difficilia, ob inquirendi impatientiam; sobria, quia coarctant spem; altiora naturae, propter superstitionem; lumen experientiae, propter arrogantiam et fastum, ne videatur mens versari in vilibus et fluxis; paradoxa, propter opinionem vulgi; denique innumeris modis, iisque interdum imperceptibilibus, affectus intellectum imbuit et inficit.

1.50 At longe maximum impedimentum et aberratio intellectus humani provenit a stupore et incompetentia et fallaciis sensuum; ut ea, quae sensum feriunt, illis, quae sensum immediate non feriunt, licet potioribus, praeponderent. Itaque contemplatio fere desinit cum aspectu; adeo ut rerum invisibilium exigua aut nulla sit observatio. Itaque omnis operatio spirituum in corporibus tangibilibus inclusorum latet, et homines fugit. Omnis etiam subtilior meta schematismus in partibus rerum crassiorum (quem vulgo alterationem vocant, cum sit revera latio per minima) latet similiter: et

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flowed down to the present day. The usual distinction, that there is an *infinite in the direction of the past and an infinite in the direction of the future*, cannot hold at all. It would follow that one infinite is greater than another, and that the infinite is being used up and tending toward the finite. The subtlety about lines that are always divisible comes likewise from the weakness of thought. But this weakness of the mind does more harm in the discovery of causes. The most universal things in nature must simply be taken as given, as they are found, and cannot really be caused. Yet the human understanding, not knowing how to rest, still seeks something better known.

Then, reaching for what lies further, it falls back on what is nearer to hand, namely final causes. These plainly derive from the nature of man rather than from the nature of the universe, and from this source they have corrupted philosophy in remarkable ways. But it is equally the mark of an unskilled and shallow philosopher to seek a cause for the most universal things and to fail to look for one in subordinate and derivative things.

The human understanding is not a dry light. It receives an infusion from the will and the emotions, and this produces *sciences as one would have them*. For what a man would rather were true, he more readily believes. So he rejects difficult things out of impatience with inquiry, and sober things because they narrow his hopes. He rejects the deeper things of nature from superstition. He rejects the light of experience from arrogance and pride, lest his mind seem occupied with base and fleeting things. He rejects paradoxes out of deference to common opinion. In short, emotion imbues and infects the understanding in countless ways, some of them imperceptible.

But by far the greatest hindrance and aberration of the human understanding comes from the dullness, inadequacy and deceptions of the senses. Things that strike the senses outweigh things that do not strike them directly, even when these are more important. So contemplation mostly stops where sight stops, and there is little or no observation of invisible things. Thus every operation of the spirits enclosed in tangible bodies lies hidden and escapes us. Likewise every subtler change of configuration in the parts of coarser things lies

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	tamen nisi duo ista, quae diximus, explorata fuerint et in lucem producta, nihil magni fieri potest in natura quoad opera. Rursus ipsa natura aeris communis et corporum omnium, quae aerem tenuitate superant (quae plurima sunt), fere incognita est.	hidden. People commonly call this alteration, though it is really motion of the smallest parts. And yet unless these two things are explored and brought to light, nothing great can be done in nature in the way of works. Again, the very nature of common air, and of all bodies finer than air, which are very many, is almost unknown.[8]
	Sensus enim per se res infirma est, et aberrans: neque organa ad amplificandos sensus aut acuendos multum valent; sed omnis verior interpretatio naturae conficitur per instantias, et experimenta idonea et apposita; ubi sensus de experimento tantum, experimentum de natura et re ipsa judicat.	For the senses by themselves are weak and prone to error. Instruments for enlarging or sharpening the senses do not help much either. Every truer interpretation of nature is achieved through instances and through suitable and apt experiments. There the senses judge only the experiment, and the experiment judges nature and the thing itself.
1.51	Intellectus humanus fertur ad abstracta propter naturam propriam; atque ea, quae fluxa sunt, fingit esse constantia. Melius autem est naturam secare, quam abstrahere; id quod Democriti schola fecit, quae magis penetravit in naturam, quam reliquae. Materia potius considerari debet, et ejus schematismi, et meta-schematismi, atque actus purus, et lex actus sive motus; formae enim commenta animi humani sunt, nisi libeat leges illas actus formas appellare.	The human understanding is drawn to abstractions by its own nature, and it imagines that things in flux are constant. But it is better to dissect nature than to abstract it. That is what the school of Democritus did, and it penetrated further into nature than the others. We should rather consider matter, its configurations and changes of configuration, pure act, and the law of act or motion. For forms are fictions of the human mind, unless one chooses to call those laws of act forms.[9]
1.52	Hujusmodi itaque sunt *idola,* quae vocamus *idola tribus;* quae ortum habent aut ex aequalitate substantiae spiritus humani; aut ex praeoccupatione ejus; aut ab angustiis ejus; aut ab inquieto motu ejus; aut ab infusione affectuum; aut ab incompetentia sensuum; aut ab impressionis modo.	Such, then, are the *idols* we call *Idols of the Tribe*. They arise from the uniformity of the substance of the human spirit, or from its preoccupation, or from its narrowness. They also arise from its restless motion, from the infusion of the emotions, from the inadequacy of the senses, or from the way impressions are received.

IDOLS OF THE CAVE

Errors of the individual: favorite subjects, a bias toward differences or likenesses, and love of the old or new.

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1.53	*Idola specus* ortum habent ex propria cujusque natura et animi et corporis; atque etiam ex educatione, et consuetudine, et fortuitis. Quod genus, licet sit varium et multiplex, tamen ea proponemus, in quibus maxima cautio est, quaeque plurimum valent ad polluendum intellectum, ne sit purus.	The *Idols of the Cave* arise from each person's own nature, of mind and of body, and also from education, habit and chance. This kind is varied and manifold. We will set out only those that call for the most caution and do most to pollute the understanding and keep it from being pure.
1.54	Adamant homines scientias et contemplationes particulares; aut quia authores et inventores se earum	People become devoted to particular sciences and speculations. They may believe themselves their

8 Bacon's "spirits" are fine, invisible substances which he believed were enclosed in all tangible bodies and drove their changes.
9 Democritus of Abdera (5th century BC), with his teacher Leucippus, held that everything consists of atoms moving in the void.

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	credunt; aut quia plurimum in illis operae posuerunt, iisque maxime assueverunt. Hujusmodi vero homines, si ad philosophiam et contemplationes universales se contulerint, illas ex prioribus phantasiis detorquent, et corrumpunt; id quod maxime conspicuum cernitur in Aristotele, qui naturalem suam philosophiam logicae suae prorsus mancipavit, ut eam fere inutilem et contentiosam reddiderit. Chemicorum autem genus, ex paucis experimentis fornacis, philosophiam constituerunt phantasticam, et ad pauca spectantem: quinetiam Gilbertus, postquam in contemplationibus magnetis se laboriosissime exercuisset, confinxit statim philosophiam consentaneam rei apud ipsum praepollenti.	authors and discoverers, or they may have put a great deal of work into them and grown most accustomed to them. But when people of this kind turn to philosophy and general speculations, they twist and corrupt these to fit their earlier fancies. This is most conspicuous in Aristotle, who made his natural philosophy the complete slave of his logic and so rendered it almost useless and contentious. The tribe of chemists, from a few experiments at the furnace, have built a fanciful philosophy of narrow scope. Gilbert, too, after laboring most painstakingly over his studies of the magnet, promptly devised a philosophy to match the subject that dominated his mind.[10]
1.55	Maximum et velut radicale discrimen ingeniorum, quoad philosophiam et scientias, illud est; quod alia ingenia sint fortiora et aptiora ad notandas rerum differentias; alia, ad notandas rerum similitudines. Ingenia enim constantia et acuta figere contemplationes, et morari, et haerere in omni subtilitate differentiarum possunt: ingenia autem sublimia et discursiva etiam tenuissimas et catholicas rerum similitudines et agnoscunt et componunt: utrumque autem ingenium facile labitur in excessum, prensando aut gradus rerum, aut umbras.	The greatest and, as it were, most radical difference between minds, as regards philosophy and the sciences, is this. Some minds are stronger and better suited to noting the differences of things, others to noting their resemblances. Steady and sharp minds can fix their attention and linger over every fine distinction. Lofty and discursive minds recognize and bring together even the faintest and most universal resemblances of things. But both kinds easily fall into excess, one by grasping at fine gradations of things, the other at shadows.
1.56	Reperiuntur ingenia alia in admirationem antiquitatis, alia in amorem et amplexum novitatis effusa; pauca vero ejus temperamenti sunt, ut modum tenere possint, quin aut quae recte posita sunt ab antiquis convellant, aut ea contemnant quae recte afferuntur a novis. Hoc vero magno scientiarum et philosophiae detrimento fit, quum studia potius sint antiquitatis et novitatis, quam judicia: veritas autem non a felicitate temporis alicujus, quae res varia est; sed a lumine naturae et experientiae, quod aeternum est, petenda est. Itaque abneganda sunt ista studia; et videndum, ne intellectus ab illis ad consensum abripiatur.	Some minds are given over to admiration of antiquity, others to love and embrace of novelty. Few are so tempered that they can keep to the mean. Such minds neither tear down what the ancients rightly laid down nor despise what the moderns rightly bring forward. The lack of them does great harm to the sciences and philosophy, since what we get are partisanships for antiquity and novelty rather than judgments. Truth is to be sought not from the good fortune of some age, which is a changeable thing, but from the light of nature and experience, which is eternal. So these partisanships must be renounced, and we must take care that the understanding is not swept into assent by them.
1.57	Contemplationes naturae et corporum in simplicitate sua intellectum frangunt et comminuunt; contemplationes vero naturae et corporum in compositione et configuratione sua intellectum stupefaciunt et solvunt. Id optime cernitur in schola Leucippi et Democriti, collata cum reliquis philosophiis. Illa enim ita versatur in	Contemplating nature and bodies in their simplicity breaks up and crumbles the understanding. Contemplating nature and bodies in their composition and configuration stuns and dissolves it. This is best seen by comparing the school of Leucippus and Democritus with the other philosophies. That

10 William Gilbert (1544–1603), physician to Elizabeth I, author of *On the Magnet* (1600).

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	particulis rerum, ut fabricas fere negligat; reliquae autem ita fabricas intuentur attonitae, ut ad simplicitatem naturae non penetrent: itaque alternandae sunt contemplationes istae, et vicissim sumendae; ut intellectus reddatur simul penetrans et capax; et evitentur ea, quae diximus, incommoda, atque *idola* ex iis provenientia.	school is so taken up with the particles of things that it almost neglects their structures. The others gaze so awestruck at the structures that they do not penetrate to the simplicity of nature. So these kinds of contemplation should be alternated and taken up in turn. Then the understanding may become at once penetrating and comprehensive, and we may avoid the drawbacks we have mentioned and the *idols* that come from them.
1.58	Talis itaque esto prudentia contemplativa in arcendis et summovendis *idolis specus;* quae aut ex praedominantia, aut ex excessu compositionis et divisionis, aut ex studiis erga tempora, aut ex objectis largis et minutis, maxime ortum habent. Generaliter autem pro suspecto habendum unicuique rerum naturam contemplanti quicquid intellectum suum potissimum capit et detinet; tantoque major adhibenda in hujusmodi placitis est cautio, ut intellectus servetur aequus et purus.	Let this, then, be the contemplative prudence for keeping off and clearing away the *Idols of the Cave*. They arise chiefly from the dominance of a favorite subject, from an excess of combining or of dividing, from partisanship for particular ages, or from the largeness or minuteness of objects. In general, anyone who contemplates the nature of things should treat with suspicion whatever most captures and holds his understanding. The more pleasing such conclusions are, the greater the caution they call for, so that the understanding may be kept balanced and pure.

IDOLS OF THE MARKETPLACE

Words shaped by ordinary use mislead the understanding, naming things that do not exist or confusing things that do.

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1.59	At *idola fori* omnium molestissima sunt; quae ex foedere verborum et nominum se insinuarunt in intellectum. Credunt enim homines, rationem suam verbis imperare. Sed fit etiam ut verba vim suam super intellectum retorqueant et reflectant; quod philosophiam et scientias reddidit sophisticas et inactivas. Verba autem plerunque ex captu vulgi induntur, atque per lineas vulgari intellectui maxime conspicuas res secant. Quum autem intellectus acutior, aut observatio diligentior, eas lineas transferre velit, ut illae sint magis secundum naturam; verba obstrepunt. Unde fit, ut magnae et solennes disputationes hominum doctorum saepe in controversias circa verba et nomina desinant; a quibus (ex more et prudentia mathematicorum) incipere consultius foret, easque per definitiones in ordinem redigere.	But the *Idols of the Marketplace* are the most troublesome of all. They have crept into the understanding through the alliance of words and names. People believe that their reason governs words. But it also happens that words turn their power back upon the understanding, and this has made philosophy and the sciences sophistical and inactive. Words are for the most part imposed according to the grasp of the common people. They divide things along the lines most obvious to the common understanding. When a sharper understanding or more careful observation wants to shift those lines so that they follow nature more closely, words cry out against it. Hence the great and solemn disputes of learned people often end in controversies about words and names. It would be wiser, following the custom and prudence of mathematicians, to begin with these and bring them into order by definitions.
	Quae tamen definitiones, in naturalibus et materiatis, huic malo mederi non possunt; quoniam et ipsae definitiones ex verbis constant, et verba gignunt verba:	Yet in natural and material things even definitions cannot cure this evil, since definitions themselves consist of words, and words beget words. So we

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adeo ut necesse sit ad instantias particulares, earumque series et ordines recurrere; ut mox dicemus, quum ad modum et rationem constituendi notiones et axiomata deventum fuerit.

1.60 *Idola,* quae per verba intellectui imponuntur, duorum generum sunt; aut enim sunt rerum nomina, quae non sunt (quemadmodum enim sunt res, quae nomine carent per inobservationem; ita sunt et nomina, quae carent rebus, per suppositionem phantasticam), aut sunt nomina rerum, quae sunt, sed confusa et male terminata, et temere et inaequaliter a rebus abstracta. Prioris generis sunt, fortuna, primum mobile, planetarum orbes, elementum ignis, et hujusmodi commenta, quae a vanis et falsis theoriis ortum habent. Atque hoc genus *idolorum* facilius ejicitur, quia per constantem abnegationem et antiquationem theoriarum exterminari possunt.

At alterum genus perplexum est, et alte haerens; quod ex mala et imperita abstractione excitatur. Exempli gratia, accipiatur aliquod verbum (*humidum,* si placet), et videamus quomodo sibi constent quae per hoc verbum significantur: et invenietur verbum istud, *humidum,* nihil aliud quam nota confusa diversarum actionum, quae nullam constantiam aut reductionem patiuntur. Significat enim et quod circa aliud corpus facile se circumfundit; et quod in se est indeterminabile, nec consistere potest; et quod facile cedit undique; et quod facile se dividit et dispergit; et quod facile se unit et colligit; et quod facile fluit et in motu ponitur; et quod alteri corpori facile adhaeret, idque madefacit; et quod facile reducitur in liquidum, sive colliquatur, cum antea consisteret.

Itaque quum ad hujus nominis praedicationem et impositionem ventum sit; si alia accipias, flamma humida est; si alia accipias, aer humidus non est; si alia, pulvis minutus humidus est; si alia, vitrum humidum est: ut facile appareat istam notionem ex aqua tantum et communibus et vulgaribus liquoribus, absque ulla debita verificatione, temere abstractam esse.

In verbis autem gradus sunt quidam pravitatis et erroris. Minus vitiosum genus est nominum substantiae alicujus, praesertim specierum infirmarum, et bene deductarum (nam notio cretae, luti, bona; terrae, mala): vitiosius

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must go back to particular instances, in their series and orders. We will explain this shortly, when we come to the method and plan for forming notions and axioms.

The *idols* imposed on the understanding through words are of two kinds. Some are names of things that do not exist. Just as there are things without names because no one has observed them, so there are names without things, because of fanciful supposition. Others are names of things that do exist, but they are confused and ill defined, and rashly and unevenly abstracted from things. To the first kind belong fortune, the *primum mobile,* the planetary spheres, the element of fire, and similar fictions that arise from empty and false theories. This kind of *idol* is more easily thrown out, since such idols can be wiped out by steadily rejecting and discarding the theories.[11]

But the other kind is intricate and deeply rooted, arising from faulty and unskilled abstraction. Take some word, *moist* for example, and let us see whether the things it signifies agree with one another. The word *moist* will be found to be nothing but a confused mark for different actions that admit of no consistency or reduction to one. It means what easily spreads itself around another body. It means what is in itself indeterminate and cannot hold firm, and what easily yields in every direction. It means what easily divides and scatters itself, and what easily unites and gathers itself together. It means what easily flows and is set in motion, and what easily clings to another body and wets it. And it means what is easily reduced to a liquid, or melts, when it was solid before.

So when it comes to predicating and applying this name, the result depends on the sense taken. In some senses flame is moist; in others air is not moist; in others fine dust is moist; in others glass is moist. It is easy to see that this notion has been rashly abstracted only from water and common, ordinary liquids, without any proper verification.

There are, however, degrees of faultiness and error in words. The least faulty kind is names of substances, especially of the lowest species and those well derived: the notion of chalk or of mud is

11 The *primum mobile* ("first moved") was the outermost sphere of the old astronomy, thought to carry the other heavenly spheres round each day.

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	genus est actionum, ut *generare, corrumpere, alterare:* vitiosissimum qualitatum (exceptis objectis sensus immediatis), ut *gravis, levis, tenuis, densi,* etc.; et tamen in omnibus istis fieri non potest, quin sint aliae notiones aliis paulo meliores, prout in sensum humanum incidit rerum copia.	good, that of earth bad. A more faulty kind is names of actions, such as *to generate*, *to corrupt*, *to alter*. The most faulty is names of qualities, except the immediate objects of the senses, such as *heavy*, *light*, *rare*, *dense*, and so on. And yet in all these classes some notions are bound to be a little better than others, depending on how many things fall within the range of human perception.

IDOLS OF THE THEATER

Philosophical systems are like stage plays; Bacon sorts them into sophistical, empirical and superstitious kinds.

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1.61	At *idola theatri* innata non sunt, nec occulto insinuata in intellectum; sed ex fabulis theoriarum, et perversis legibus demonstrationum, plane indita et recepta. In his autem confutationes tentare et suscipere consentaneum prorsus non est illis, quae a nobis dicta sunt. Quum enim nec de principiis consentiamus, nec de demonstrationibus, tollitur omnis argumentatio. Id vero bono fit fato, ut antiquis suus constet honos. Nihil enim illis detrahitur, quum de via omnino quaestio sit. Claudus enim (ut dicitur) in via antevertit cursorem extra viam. Etiam illud manifesto liquet, currenti extra viam, quo habilior sit et velocior, eo majorem contingere aberrationem.	The *Idols of the Theater*, however, are not innate, nor are they secretly insinuated into the understanding. They are openly imposed and received from the fables of theories and from perverse rules of demonstration. To attempt refutations of them would not be at all consistent with what we have said. Since we agree neither on principles nor on demonstrations, all argument is ruled out. And fortunately this leaves the ancients their honor, for nothing is taken from them, since the question concerns only the way. As the saying goes, a lame man on the road outruns a runner off it. It is also plain that the more skilled and swift a runner off the road is, the further he goes astray.
	Nostra vero inveniendi scientias ea est ratio, ut non multum ingeniorum acumini et robori relinquatur; sed quae ingenia et intellectus fere exaequet. Quemadmodum enim ad hoc ut linea recta fiat, aut circulus perfectus describatur, multum est in constantia et exercitatione manus, si fiat ex vi manus propria, sin autem adhibeatur regula, aut circinus, parum aut nihil; omnino similis est nostra ratio. Licet autem confutationum particularium nullus sit usus; de sectis tamen et generibus hujusmodi theoriarum nonnihil dicendum est; atque etiam paulo post de signis exterioribus, quod se male habeant; et postremo de causis tantae infelicitatis et tam diuturni et generalis in errore consensus; ut ad vera minus difficilis sit aditus, et intellectus humanus volentius expurgetur et *idola* dimittat.	Our method of discovering the sciences leaves little to sharpness and strength of mind; it almost puts all minds and understandings on a level. Consider drawing a straight line or describing a perfect circle. If this is done by the hand alone, much depends on its steadiness and practice; if a ruler or compass is used, little or nothing does. Our method is exactly like that. Particular refutations are of no use. Still, something must be said about the sects and kinds of such theories. A little later we must also speak of the external signs that show things are in a bad state. Lastly, we must speak of the causes of so great a misfortune and of so long-lasting and general an agreement in error. In this way access to the truth may be less difficult, and the human understanding may more willingly be purged and let go of its *idols*.
1.62	*Idola theatri,* sive theoriarum, multa sunt, et multo plura esse possunt, et aliquando fortasse erunt. Nisi enim per multa jam saecula hominum ingenia circa religionem et theologiam occupata fuissent; atque etiam politiae civiles	The *Idols of the Theater*, or of theories, are many, and there could be, and perhaps someday will be, many more. For many centuries people's minds have been occupied with religion and theology.

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(praesertim monarchiae) ab istiusmodi novitatibus, etiam in contemplationibus, essent aversae; ut cum periculo et detrimento fortunarum suarum in illas homines incumbant, non solum praemio destituti, sed etiam contemptui et invidiae expositi; complures aliae proculdubio philosophiarum et theoriarum sectae, similes illis, quae magna varietate olim apud Graecos floruerunt introductae fuissent. Quemadmodum enim super *phaenomena* aetheris plura *themata* coeli confingi possunt; similiter, et multo magis, super *phaenomena* philosophiae fundari possunt et constitui varia dogmata.

Atque hujusmodi *theatri* fabulae habent etiam illud, quod in theatro poetarum usu venit; ut narrationes fictae ad scenam narrationibus ex historia veris concinniores sint et elegantiores, et quales quis magis vellet.

In genere autem, in materiam philosophiae sumitur aut multum ex paucis, aut parum ex multis; ut utrinque philosophia super experientiae et naturalis historiae nimis angustam basin fundata sit, atque ex paucioribus, quam par est, pronunciet. Rationale enim genus philosophantium ex experientia arripiunt varia et vulgaria, eaque neque certo comperta, nec diligenter examinata et pensitata; reliqua in meditatione atque ingenii agitatione ponunt.

Est et aliud genus philosophantium, qui in paucis experimentis sedulo et accurate elaborarunt, atque inde philosophias educere et confingere ausi sunt; reliqua miris modis ad ea detorquentes.

Est et tertium genus eorum, qui theologiam et traditiones ex fide et veneratione immiscent; inter quos vanitas nonnullorum ad petendas et derivandas scientias a spiritibus scilicet et geniis deflexit; ita ut stirps errorum et *philosophia falsa* genere triplex sit: *sophistica, empirica, et superstitiosa.*

1.63 Primi generis exemplum in Aristotele maxime conspicuum est, qui philosophiam naturalem dialectica sua corrupit: quum mundum ex categoriis effecerit; animae humanae, nobilissimae substantiae, genus ex vocibus secundae intentionis tribuerit; negotium *densi* et *rari,* per quod corpora subeunt majores et minores dimensiones sive spatia, per frigidam distinctionem actus

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Civil governments, too, especially monarchies, have been averse to such novelties, even in speculation. So those who devote themselves to them do so at the risk and cost of their fortunes, not only without reward but exposed to contempt and ill will. Were it not for this, no doubt many other sects of philosophies and theories would have been introduced, like those that once flourished in great variety among the Greeks. Many *themata* [systems] of the heavens can be devised on the basis of the *phenomena* of the sky. In the same way, and much more, various dogmas can be founded and built on the *phenomena* of philosophy.

These fables of the *theater* also share a feature with the theater of the poets. Stories invented for the stage are neater and more elegant than true stories from history, and more as one would wish them to be.

In general, philosophy takes its material either as a great deal from a few things, or as a little from many. Either way, philosophy is founded on too narrow a base of experience and natural history, and pronounces on the basis of fewer things than it should. The rationalist kind of philosophers snatch from experience a variety of common facts. They have neither reliably ascertained these facts nor carefully examined and weighed them. The rest they leave to meditation and the agitation of the mind.

There is another kind of philosophers who have labored diligently and carefully over a few experiments. From these they have dared to draw out and fabricate whole philosophies, twisting everything else in remarkable ways to fit them.

There is also a third kind: those who mix in theology and traditions out of faith and veneration. The vanity of some among them has strayed so far as to seek and derive the sciences from spirits and genii. So the stock of errors, *false philosophy*, is of three kinds: *sophistical, empirical, and superstitious*.

The most conspicuous example of the first kind is Aristotle, who corrupted natural philosophy with his dialectic. He built the world out of categories. He assigned to the human soul, the noblest of substances, a genus drawn from words of second intention. He disposed of the business of *dense* and *rare*, by which bodies take up greater and smaller

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	et potentiae transegerit; motum singulis corporibus unicum et proprium, et, si participent ex alio motu, id aliunde moveri, asseruerit: et innumera alia, pro arbitrio suo, naturae rerum imposuerit: magis ubique sollicitus quomodo quis respondendo se explicet, et aliquid reddatur in verbis positivum, quam de interna rerum veritate; quod etiam optime se ostendit in comparatione philosophiae ejus ad alias philosophias quae apud Graecos celebrabantur.	dimensions or spaces, through the cold distinction between act and potency. He asserted that each body has a single motion of its own, and that if it shares in another motion, this comes from something else. And he imposed countless other things on the nature of things at his own pleasure. Everywhere he cared more about how one might explain oneself in reply, and produce something positive in words, than about the inner truth of things. This shows best when his philosophy is compared with the other philosophies celebrated among the Greeks.[12]
	Habent enim homoiomera Anaxagorae, atomi Leucippi et Democriti, coelum et terra Parmenidis, lis et amicitia Empedoclis, resolutio corporum in adiaphoram naturam ignis et replicatio eorundem ad densum Heracliti, aliquid ex philosopho naturali; et rerum naturam, et experientiam, et corpora sapiunt; ubi Aristotelis physica nihil aliud quam dialecticae voces plerunque sonet: quam etiam in metaphysicis sub solenniore nomine, et ut magis scilicet realis, non nominalis, retractavit. Neque illud quenquam moveat, quod in libris ejus *De animalibus,* et in *Problematibus,* et in aliis suis tractatibus, versatio frequens sit in experimentis.	Consider the homoiomera [like-parted particles] of Anaxagoras, the atoms of Leucippus and Democritus, the heaven and earth of Parmenides, and the strife and friendship of Empedocles. Consider also Heraclitus's resolution of bodies into the undifferentiated nature of fire and their reconstitution into the dense. All these have something of the natural philosopher about them; they smack of the nature of things, of experience, and of bodies. Aristotle's physics, by contrast, mostly sounds like nothing but the terms of dialectic. He reworked these in his metaphysics under a more solemn name, as if they were now real rather than nominal. Nor should anyone be impressed that his books *On Animals*, his *Problems* and his other treatises deal frequently with experiments.[13]
	Ille enim prius decreverat, neque experientiam ad constituenda decreta et axiomata rite consuluit; sed postquam pro arbitrio suo decrevisset, experientiam ad sua placita tortam circumducit et captivam; ut hoc etiam nomine magis accusandus sit, quam sectatores ejus moderni (scholasticorum philosophorum genus) qui experientiam omnino deseruerunt.	For he had made up his mind beforehand. He did not properly consult experience in order to establish his decisions and axioms. Instead, having decided as he pleased, he dragged experience around like a captive, twisted to fit his opinions. So on this count too he is more to blame than his modern followers, the tribe of scholastic philosophers, who have abandoned experience altogether.
1.64	At philosophiae genus *empiricum* placita magis deformia et monstrosa educit, quam *sophisticum* aut rationale genus; quia non in luce notionum vulgarium (quae licet tenuis sit et superficialis, tamen est quodammodo universalis, et ad multa pertinens) sed in paucorum experimentorum angustiis et obscuritate fundatum est. Itaque talis philosophia illis, qui in hujusmodi	But the *empirical* kind of philosophy produces more deformed and monstrous doctrines than the *sophistical* or rationalist kind. It is founded not on the light of common notions, but on the narrowness and obscurity of a few experiments. That light is faint and superficial, but it is still in a way universal and relevant to many things. So such a

12 Words of second intention are logical terms, such as "form" or "genus," that apply to concepts rather than to things; Aristotle defined the soul as the form of a living body.
13 For Anaxagoras, things were made of particles of the same nature as the whole; Parmenides made heat and cold (heaven and earth) the principles of the physical world, and Empedocles made Love and Strife the forces that join and separate the elements.

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experimentis quotidie versantur atque ex ipsis phantasiam contaminarunt, probabilis videtur et quasi certa; caeteris, incredibilis et vana. Cujus exemplum notabile est in chemicis, eorumque dogmatibus; alibi autem vix hoc tempore invenitur, nisi forte in philosophia Gilberti.

Sed tamen circa hujusmodi philosophias cautio nullo modo praetermittenda erat; quia mente jam praevidemus et auguramur, si quando homines, nostris monitis excitati, ad experientiam se serio contulerint (valere jussis doctrinis sophisticis), tum demum, propter praematuram et praeproperam intellectus festinationem, et saltum sive volatum ad generalia et rerum principia, fore ut magnum ab hujusmodi philosophiis periculum immineat; cui malo etiam nunc obviam ire debemus.

1.65 At corruptio philosophiae ex *superstitione*, et theologia admista, latius omnino patet, et plurimum mali infert, aut in philosophias integras, aut in earum partes. Humanus enim intellectus non minus impressionibus phantasiae est obnoxius, quam impressionibus vulgarium notionum. Pugnax enim genus philosophiae et *sophisticum* illaqueat intellectum: at illud alterum phantasticum, et tumidum, et quasi poeticum, magis blanditur intellectui. Inest enim homini quaedam intellectus ambitio, non minor quam voluntatis; praesertim in ingeniis altis et elevatis.

Hujus autem generis exemplum inter Graecos illucescit, praecipue in Pythagora, sed cum *superstitione* magis crassa et onerosa conjunctum; at periculosius et subtilius in Platone atque ejus schola. Invenitur etiam hoc genus mali in partibus philosophiarum reliquarum, introducendo formas abstractas, et causas finales, et causas primas; omittendo saepissime medias, et hujusmodi. Huic autem rei summa adhibenda est cautio. Pessima enim res est errorum *apotheosis*, et pro peste intellectus habenda est, si vanis accedat veneratio. Huic autem vanitati nonnulli ex modernis summa levitate ita indulserunt, ut in primo capitulo Geneseos, et in libro Job, et aliis Scripturis sacris, philosophiam naturalem fundare conati sint; inter *viva quaerentes mortua*.

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philosophy seems probable and almost certain to those who deal with experiments of this kind every day and have tainted their imagination with them. To everyone else it seems incredible and empty. A notable example is the chemists and their dogmas. Elsewhere it is hardly to be found at present, except perhaps in the philosophy of Gilbert.

Still, we could by no means omit a warning about philosophies of this kind. We already foresee and predict what will happen if ever people, roused by our advice, seriously devote themselves to experience and bid farewell to the sophistical doctrines. Then the understanding's premature and headlong haste, its leap or flight to generalities and to the principles of things, will expose us to great danger from philosophies of this kind. We must head off this evil even now.

But the corruption of philosophy by *superstition* and an admixture of theology extends much more widely. It does the most harm, whether to entire philosophies or to their parts. The human understanding is no less exposed to the impressions of the imagination than to the impressions of common notions. The combative and *sophistical* kind of philosophy entangles the understanding. The other kind, fanciful, inflated and as it were poetic, flatters it more. For there is in man a certain ambition of the understanding, no less than of the will, especially in lofty and elevated minds.

Among the Greeks an example of this kind shines out, above all in Pythagoras, though there it is joined with a coarser and heavier *superstition*. It appears more dangerously and subtly in Plato and his school. This kind of evil is also found in parts of the other philosophies. They introduce abstract forms, final causes and first causes, while very often omitting intermediate causes, and the like. Here the greatest caution must be used. The worst thing of all is the *apotheosis* [deification] of errors, and it must be counted a plague of the understanding when veneration attaches to empty things. Some of the moderns have indulged this vanity with the utmost frivolity. They have tried to found natural philosophy on the first chapter of Genesis, the Book of Job and other sacred Scriptures, *seeking the living among the dead*.[14]

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Tantoque magis haec vanitas inhibenda venit, et coercenda, quia ex divinorum et humanorum malesana admistione non solum educitur philosophia phantastica, sed etiam religio haeretica. Itaque salutare admodum est, si mente sobria fidei tantum dentur quae fidei sunt.	This vanity must be checked and restrained all the more, because this unhealthy mixture of the divine and the human produces not only a fanciful philosophy but also a heretical religion. So it is very wholesome for a sober mind to give to faith only what belongs to faith.

FAULTY MATERIAL OF SPECULATION

Bacon attacks the doctrine of elements and the received kinds of motion, and proposes truly physical motions instead.

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1.66 Et de malis authoritatibus philosophiarum, quae aut in *vulgaribus notionibus*, aut in *paucis experimentis*, aut in *superstitione* fundatae sunt, jam dictum est. Dicendum porro est et de vitiosa materia contemplationum, praesertim in philosophia naturali. Inficitur autem intellectus humanus ex intuitu eorum quae in artibus mechanicis fiunt, in quibus corpora per compositiones aut separationes ut plurimum alterantur; ut cogitet simile quiddam etiam in natura rerum universali fieri.	We have now spoken of the unsound authority of philosophies founded on *common notions*, on *a few experiments*, or on *superstition*. Next we must speak of the faulty subject matter of speculation, especially in natural philosophy. The human understanding is infected by the sight of what goes on in the mechanical arts, where bodies are mostly altered by being combined or separated. So it supposes that something similar happens in the universal nature of things.
Unde fluxit commentum illud elementorum, atque illorum concursu, ad constituenda corpora naturalia. Rursus, quum homo naturae libertatem contemplatur, incidit in species rerum, animalium, plantarum, mineralium; unde facile in eam labitur cogitationem, ut existimet esse in natura quasdam formas rerum primarias, quas natura educere molitur: atque reliquam varietatem ex impedimentis et aberrationibus naturae in opere suo conficiendo, aut ex diversarum specierum conflictu, et transplantatione alterius in alteram, provenire. Atque prima cogitatio qualitates primas elementares, secunda proprietates occultas et virtutes specificas nobis peperit; quarum utraque pertinet ad inania contemplationum compendia, in quibus acquiescit animus et a solidioribus avertitur.	From this came the fiction of the elements, and of their coming together to make up natural bodies. Again, when man contemplates nature at liberty, he comes upon the species of things: animals, plants, minerals. From there he easily slips into thinking that nature contains certain primary forms of things which she strives to bring forth. On this view, the rest of the variety comes from nature being hindered and going astray in completing her work, or from the conflict of different species and the transplanting of one into another. The first thought has given us the primary elementary qualities; the second, occult properties and specific virtues. Both belong to those empty shortcuts of speculation in which the mind comes to rest and is turned away from more solid things.
At medici in secundis rerum qualitatibus et operationibus, attrahendi, repellendi, attenuandi, inspissandi, dilatandi, astringendi, discutiendi, maturandi, et hujusmodi, operam praestant meliorem; atque, nixi ex illis duobus (quae dixi) compendiis (qualitatibus scilicet elementaribus, et virtutibus specificis) illa altera (quae recte notata sunt) corrumperent, reducendo illa ad primas qualitates earumque mixturas subtiles et incommensurabiles, aut ea non producendo cum majore et diligentiore	The physicians do better work on the secondary qualities and operations of things: attracting, repelling, thinning, thickening, dilating, contracting, dispersing, ripening, and the like. They have noted these correctly. But they have leaned on the two shortcuts I mentioned, elementary qualities and specific virtues, and so have corrupted what they noted. They reduce these operations to the primary qualities and their subtle, immeasurable

14 The closing phrase echoes the angels' words at the empty tomb (Luke 24:5).

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observatione ad qualitates tertias et quartas, sed contemplationem intempestive abrumpendo, illi multo melius profecissent. Neque hujusmodi virtutes (non dico eaedem, sed similes) in humani corporis medicinis tantum exquirendae sunt; sed etiam in caeterorum corporum naturalium mutationibus.

Sed multo adhuc majore cum malo fit, quod quiescentia rerum principia, *ex quibus;* et non moventia, *per quae* res fiunt, contemplentur et inquirant. Illa enim ad sermones, ista ad opera spectant. Neque enim vulgares illae differentiae motus, quae in naturali philosophia recepta notantur, *generationis, corruptionis, augmentationis, diminutionis, alterationis*, et *lationis,* ullius sunt pretii. Quippe hoc sibi volunt; si corpus, alias non mutatum, loco tamen moveatur, hoc *lationem* esse; si, manente et loco et specie, qualitate mutetur, hoc *alterationem* esse; si vero ex illa mutatione moles ipsa et quantitas corporis non eadem maneat, hoc *augmentationis* et *diminutionis* motum esse; si eatenus mutentur, ut speciem ipsam et substantiam mutent, et in alia migrent, hoc *generationem* et *corruptionem* esse.

At ista mere popularia sunt, et nullo modo in naturam penetrant; suntque mensurae et periodi tantum, non species motus. Innuunt enim illud, *hucusque*, et non *quomodo*, vel *ex quo fonte*. Neque enim de corporum appetitu, aut de partium eorum processu, aliquid significant; sed tantum quum motus ille rem aliter ac prius, crasso modo, sensui exhibeat, inde divisionem suam auspicantur. Etiam quum de causis motuum aliquid significare volunt, atque divisionem ex illis instituere, differentiam motus naturalis et violenti, maxima cum socordia, introducunt; quae et ipsa omnino ex notione vulgari est; cum omnis motus violentus etiam naturalis revera sit, scilicet cum externum efficiens naturam alio modo in opere ponet quam quo prius.

At hisce omissis; si quis (exempli gratia) observaverit, inesse corporibus appetitum contactus ad invicem, ut non patiantur unitatem naturae prorsus dirimi aut abscindi, ut vacuum detur: aut si quis dicat, inesse

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mixtures. Or they fail to carry them forward, with greater and more careful observation, to third and fourth qualities, and break off their inquiry too soon. Had they not done so, they would have made far better progress. Nor should such virtues (I do not say the same ones, but similar) be sought only in medicines for the human body. They should also be sought in the changes of other natural bodies.

A much greater evil is that people contemplate and investigate the principles of things at rest, those *out of which* things are made, and not the moving principles, those *through which* things come about. The former serve for talk; the latter, for works. Nor are the common distinctions of motion noted in the received natural philosophy of any value: *generation, corruption, increase, diminution, alteration,* and *locomotion*. What they mean is this. If a body, otherwise unchanged, is moved in place, that is *locomotion*. If it keeps its place and species but changes in quality, that is *alteration*. If in that change the mass and quantity of the body do not remain the same, that is the motion of *increase* and *diminution*. If bodies change so far that they change their very species and substance and pass into other things, that is *generation* and *corruption*.

But these distinctions are merely popular and in no way penetrate into nature. They are only measures and periods of motion, not kinds of it. They indicate *how far*, not *how* or *from what source*. They say nothing about the appetite of bodies or the progress of their parts. They base their division only on the point at which the motion presents the thing to the senses, in a gross way, as different from before. Even when they want to say something about the causes of motion and to divide motions by those causes, they introduce, with the utmost laziness, the distinction between natural and violent motion. This too comes wholly from a common notion. For every violent motion is really natural as well: it is simply that an external efficient cause sets nature working in a different way from before.

Set these aside. Suppose someone observed (for example) that bodies have an appetite for mutual contact, so that they do not allow the unity of nature to be wholly broken or cut apart and a va-

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corporibus appetitum se recipiendi in naturalem suam dimensionem vel tensuram, ut, si ultra eam aut citra eam comprimantur aut distrahantur, statim in veterem sphaeram et exporrectionem suam se recuperare et remittere moliantur: aut si quis dicat, inesse corporibus appetitum congregationis ad massas connaturalium suorum, densorum videlicet versus orbem terrae, tenuiorum et rariorum versus ambitum coeli: haec et hujusmodi vere physica sunt genera motuum. At illa altera plane logica sunt et scholastica, ut ex hac collatione eorum manifesto liquet.

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cuum to occur. Or suppose someone said that bodies have an appetite to return to their natural dimension or tension, so that if they are compressed or stretched beyond it or short of it, they at once strive to recover and restore their former sphere and extent. Or suppose someone said that bodies have an appetite to gather into masses of their own kind: dense bodies toward the globe of the earth, thin and rare ones toward the circumference of the heavens. These and the like are truly physical kinds of motion. The others are plainly logical and scholastic, as this comparison clearly shows.

Neque minus etiam malum est, quod in philosophiis et contemplationibus suis, in principiis rerum atque ultimatibus naturae investigandis et tractandis, opera insumatur; cum omnis utilitas et facultas operandi in mediis consistat. Hinc fit, ut abstrahere naturam homines non desinant, donec ad materiam potentialem et informem ventum fuerit; nec rursus secare naturam desinant, donec perventum fuerit ad atomum; quae, etiamsi vera essent, tamen ad juvandas hominum fortunas parum possunt.

It is no less an evil that philosophers and speculators spend their effort on investigating and discussing the first principles of things and the extremes of nature, when all usefulness and power of operation lie in the intermediate things. So people do not stop abstracting nature until they arrive at potential and formless matter. Nor do they stop dissecting nature until they reach the atom. Even if these things were true, they could do little to improve human fortunes.

1.67 Danda est etiam cautio intellectui de intemperantiis philosophiarum, quoad assensum praebendum aut cohibendum; quia hujusmodi intemperantiae videntur *idola* figere, et quodammodo perpetuare, ne detur aditus ad ea summovenda.

The understanding must also be warned against the intemperance of philosophies in giving or withholding assent. Intemperance of this kind seems to fix the *idols* in place and in a way to perpetuate them, leaving no way in to remove them.

Duplex autem est excessus: alter eorum, qui facile *pronunciant*, et scientias reddunt positivas et magistrales; alter eorum, qui *acatalepsiam* introduxerunt, et inquisitionem vagam sine termino; quorum primus intellectum deprimit, alter enervat. Nam Aristotelis philosophia, postquam caeteras philosophias (more Ottomanorum erga fratres suos) pugnacibus confutationibus contrucidasset, de singulis pronunciavit; et ipse rursus quaestiones ex arbitrio suo subornat, deinde conficit; ut omnia certa sint et decreta: quod etiam apud successiones suas valet et in usu est.

There are two kinds of excess. One belongs to those who readily *pronounce*, and make the sciences dogmatic and magisterial. The other belongs to those who have introduced *acatalepsia* [the impossibility of knowing anything for certain] and an aimless inquiry without end. The first depresses the understanding; the second saps its strength. Aristotle's philosophy slaughtered the other philosophies with combative refutations, as the Ottoman sultans deal with their brothers, and then pronounced on every question. Aristotle himself sets up questions as he pleases and then disposes of them, so that everything is certain and settled. This habit still holds and prevails among his successors.[15]

At Platonis schola *acatalepsiam* introduxit, primo tanquam per jocum et ironiam, in odium veterum

The school of Plato, on the other hand, introduced *acatalepsia*. At first it did so as a kind of joke and

15 On accession, Ottoman sultans commonly had their brothers put to death to secure the throne.

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sophistarum, Protagorae, Hippiae, et reliquorum, qui nihil tam verebantur, quam ne dubitare de re aliqua viderentur. At nova academia *acatalepsiam* dogmatizavit, et ex professo tenuit: quae licet honestior ratio sit, quam *pronunciandi* licentia, quum ipsi pro se dicant se minime confundere inquisitionem, ut Pyrrho fecit et Ephectici, sed habere quod sequantur ut probabile, licet non habeant quod teneant ut verum; tamen postquam animus humanus de veritate invenienda semel desperaverit, omnino omnia fiunt languidiora: ex quo fit, ut deflectant homines potius ad amoenas disputationes et discursus, et rerum quasdam peragrationes, quam in severitate inquisitionis se sustineant.	irony, out of dislike for the older sophists, Protagoras, Hippias and the rest, who feared nothing so much as seeming to doubt anything. But the New Academy made *acatalepsia* a dogma and held it openly. This is a more honorable position than the license of *pronouncing*. Its members say in their own defense that they do not throw inquiry into confusion, as Pyrrho and the Ephectics did. They have something to follow as probable, even though they have nothing to hold as true. Yet once the human mind has despaired of finding truth, everything becomes feebler. So people turn aside to pleasant disputations and discourses and a kind of rambling through subjects, rather than holding themselves to the rigor of inquiry.[16]
Verum, quod a principio diximus et perpetuo agimus, sensui et intellectui humano eorumque infirmitati authoritas non est deroganda, sed auxilia praebenda.	But, as we said at the beginning and maintain throughout, the human senses and understanding, weak as they are, are not to be stripped of their authority. They are to be given help.
1.68 Atque de *idolorum* singulis generibus, eorumque apparatu jam diximus; quae omnia constanti et solenni decreto sunt abneganda et renuncianda, et intellectus ab iis omnino liberandus est et expurgandus; ut non alius fere sit aditus ad regnum hominis, quod fundatur in scientiis, quam ad regnum coelorum, *in quod, nisi sub persona infantis, intrare non datur.*	We have now spoken of each kind of *idol* and its trappings. All of them must be renounced and abjured with firm and solemn resolve, and the understanding must be wholly freed and cleansed of them. Entry into the kingdom of man, which is founded on the sciences, is then much like entry into the kingdom of heaven, *into which none may enter except as a little child.*[17]

BAD DEMONSTRATIONS

Each step from the senses to conclusions is flawed, and the experimenting now in use is blind.

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1.69 At pravae demonstrationes, *idolorum* veluti munitiones quaedam sunt et praesidia; eaeque, quas in dialecticis habemus, id fere agunt, ut mundum plane cogitationibus humanis, cogitationes autem verbis addicant et mancipent. Demonstrationes vero potentia quadam philosophiae ipsae sunt et scientiae. Quales enim eae sunt, ac prout rite aut male institutae, tales sequuntur philosophiae et contemplationes. Fallunt autem et incompetentes sunt eae quibus utimur in universo illo processu, qui a sensu et rebus ducit ad axiomata et conclusiones. Qui quidem processus quadruplex est, et vitia ejus totidem. Primo, impressiones sensus ipsius vitiosae sunt; sensus enim et destituit et fallit. At	Bad demonstrations are like the fortifications and defenses of the *idols*. Those we have in dialectic do little more than make the world wholly the slave of human thoughts, and thoughts the slave of words. Yet demonstrations are, potentially, philosophies and sciences themselves. As they are, and as they are rightly or wrongly set up, so the philosophies and speculations that follow will be. The demonstrations we use in the whole process that leads from the senses and things to axioms and conclusions are deceptive and inadequate. This process has four stages, and as many faults. First, the impressions of the senses themselves are

16 The New Academy (3rd–2nd century BC) taught that certainty is unattainable but probability is not. Pyrrho and his followers, the Ephectics ("those who suspend judgment"), withheld assent altogether.
17 An allusion to Matthew 18:3.

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destitutionibus substitutiones, fallaciis rectificationes debentur. Secundo, notiones ab impressionibus sensuum male abstrahuntur, et interminatae et confusae sunt, quas terminatas et bene finitas esse oportuit.

Tertio, inductio mala est, quae per enumerationem simplicem principia concludit scientiarum, non adhibitis exclusionibus et solutionibus, sive separationibus naturae debitis. Postremo, modus ille inveniendi et probandi, ut primo principia maxime generalia constituantur, deinde media axiomata ad ea applicentur et probentur, errorum mater est, et scientiarum omnium calamitas. Verum de istis, quae jam obiter perstringimus, fusius dicemus, quum veram interpretandae naturae viam, absolutis istis expiationibus et expurgationibus mentis, proponemus.

1.70 Sed demonstratio longe optima est experientia; modo haereat in ipso experimento. Nam si traducatur ad alia quae similia existimantur, nisi rite et ordine fiat illa traductio, res fallax est. At modus experiendi, quo homines nunc utuntur, caecus est et stupidus. Itaque cum errant et vagantur nulla via certa, sed ex occursu rerum tantum consilium capiunt, circumferuntur ad multa, sed parum promovent; et quandoque gestiunt, quandoque distrahuntur; et semper inveniunt quod ulterius quaerant. Fere autem ita fit, ut homines leviter et tanquam per ludum experiantur, variando paululum experimenta jam cognita; et, si res non succedat, fastidiendo et conatum deserendo. Quod si magis serio et constanter ac laboriose ad experimenta se accingant, tamen in uno aliquo experimento eruendo operam collocant; quemadmodum Gilbertus in magnete, Chymici in auro.

Hoc autem faciunt homines instituto non minus imperito quam tenui. Nemo enim alicujus rei naturam in ipsa re feliciter perscrutatur; sed amplianda est inquisitio ad magis communia.

Quod si etiam scientiam quandam et dogmata ex experimentis moliantur; tamen semper fere studio praepropero et intempestivo deflectunt ad praxin: non tantum propter usum et fructum ejusmodi praxeos, sed ut in opere aliquo novo veluti pignus sibi arripiant, se non inutiliter in reliquis versaturos: atque etiam aliis se

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faulty, for the senses both fail us and deceive us. But where they fail, substitutes are needed; where they deceive, corrections. Second, notions are badly abstracted from the impressions of the senses. They are vague and confused, when they ought to be defined and well bounded.

Third, induction is bad when it infers the principles of the sciences by simple enumeration, without the exclusions and resolutions, or separations, of nature that are required. Lastly, there is the method of discovery and proof in which the most general principles are established first, and the middle axioms are then applied to them and proved by them. That method is the mother of errors and the bane of all the sciences. But we touch on these things only in passing now. We shall speak of them more fully when we have completed these expiations and purgings of the mind and set out the true way of interpreting nature.

By far the best demonstration is experience, provided it stays with the actual experiment. If it is carried over to other cases thought to be similar, the transfer is deceptive unless it is done properly and in order. But the way of experimenting that people use now is blind and stupid. They wander and stray with no fixed path, taking their counsel only from whatever they happen upon. So they are carried around to many things but make little progress. Sometimes they are eager, sometimes distracted, and they always find something further to look for. Usually people experiment lightly, as if in play, varying slightly the experiments already known. If the thing does not succeed, they grow bored and give up the attempt. Even when they set about experiments more seriously, steadily and laboriously, they spend their effort on working out some single experiment, as Gilbert did with the magnet and the alchemists with gold.

People do this with a plan as unskilled as it is narrow. No one successfully investigates the nature of a thing in the thing itself. The inquiry must be widened to things more general.

Even when they try to build some science and doctrines out of experiments, they nearly always turn aside to practice with over-hasty and untimely zeal. They do it not only for the use and profit of such practice. They want to snatch from some new work a kind of pledge that they will not be wasting

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venditent, ad existimationem meliorem comparandam de iis in quibus occupati sunt. Ita fit ut, more Atalantae, de via decedant ad tollendum aureum pomum; interim vero cursum interrumpant, et victoriam emittant e manibus. Verum in experientiae vero curriculo eoque ad nova opera producendo, Divina Sapientia omnino et ordo pro exemplari sumenda sunt. Deus autem primo die creationis lucem tantum creavit, eique operi diem integrum attribuit; nec aliquid materiati operis eo die creavit.	their time on the rest, and also to advertise themselves to others and win a better opinion of what they are engaged in. So, like Atalanta, they leave the course to pick up the golden apple, and meanwhile they interrupt their race and let the victory slip from their hands. But in the true course of experience, and in bringing it to bear on new works, we must take divine wisdom and order as our model in everything. On the first day of creation God created light alone, and gave that work a whole day. On that day he created nothing material.[18]
Similiter et ex omnimoda experientia, primum inventio causarum et axiomatum verorum elicienda est: et lucifera experimenta, non fructifera quaerenda. Axiomata autem recte inventa et constituta praxin non strictim sed confertim instruunt; et operum agmina ac turmas post se trahunt. Verum de experiendi viis, quae non minus quam viae judicandi obsessae sunt et interclusae, postea dicemus; impraesentiarum de experientia vulgari, tanquam de mala demonstratione, tantum loquuti. Jam vero postulat ordo rerum, ut de iis quorum paulo ante mentionem fecimus, signis, quod philosophiae et contemplationes in usu male se habeant, et de causis rei primo intuitu tam mirabilis et incredibilis, quaedam subjungamus. Signorum enim notio praeparat assensum: causarum vero explicatio tollit miraculum. Quae duo ad extirpationem *idolorum* ex intellectu faciliorem et clementiorem multum juvant.	In the same way, from experience of every kind we must first draw out the discovery of causes and true axioms. We must seek experiments of light, not experiments of fruit. Axioms rightly discovered and established do not equip practice in scattered fashion but in full force, and draw whole troops and squadrons of works behind them. The ways of experimenting, which are no less beset and blocked than the ways of judging, we shall discuss later. For the present we have spoken only of common experience, as a bad kind of demonstration. The order of things now requires us to add something about the signs mentioned a little earlier, which show that the philosophies and speculations in use are in poor health. We must also say something about the causes of a state of affairs that at first sight seems so astonishing and incredible. Knowing the signs prepares assent; explaining the causes removes the wonder. Both help greatly to make the rooting out of the *idols* from the understanding easier and gentler.[19]

SIGNS THAT PHILOSOPHY IS SICK

Its Greek origins, narrow age, lack of fruits, stagnation, confessions of despair and mere agreement all count against it.

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1.71 Scientiae, quas habemus, fere a Graecis fluxerunt. Quae enim scriptores Romani, aut Arabes, aut recentiores addiderunt, non multa aut magni momenti sunt: et qualiacunque sint, fundata sunt super basin eorum quae inventa sunt a Graecis. Erat autem sapientia Graecorum professoria, et in disputationes effusa: quod genus inquisitioni veritatis adversissimum est. Itaque nomen illud sophistarum, quod per contemptum ab iis, qui se	The sciences we have came for the most part from the Greeks. What Roman, Arab, or more recent writers have added is not much and of little importance. Whatever it is, it is built on the foundation of what the Greeks discovered. But the wisdom of the Greeks was professorial and poured itself out in disputations, a kind of wisdom most hostile to the search for truth. So the name of

18 In Greek myth Atalanta lost a footrace to Hippomenes because she stopped to pick up the golden apples he threw in her path.
19 Experiments of light (*lucifera*) reveal causes and axioms; experiments of fruit (*fructifera*) aim at immediate practical use.

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philosophos haberi voluerunt, in antiquos rhetores rejectum et traductum est, Gorgiam, Protagoram, Hippiam, Polum, etiam universo generi competit, Platoni, Aristoteli, Zenoni, Epicuro, Theophrasto, et eorum successoribus, Chrysippo, Carneadi, reliquis.

Hoc tantum intererat: quod prius genus vagum fuerit et mercenarium, civitates circumcursando, et sapientiam suam ostentando, et mercedem exigendo; alterum vero solennius et generosius, quippe eorum qui sedes fixas habuerunt, et scholas aperuerunt, et gratis philosophati sunt. Sed tamen utrumque genus (licet caetera dispar) professorium erat, et ad disputationes rem deducebat, et sectas quasdam atque haereses philosophiae instituebat et propugnabat: ut essent fere doctrinae eorum (quod non male cavillatus est Dionysius in Platonem) *Verba otiosorum senum ad imperitos juvenes.* At antiquiores illi ex Graecis, Empedocles, Anaxagoras, Leucippus, Democritus, Parmenides, Heraclitus, Xenophanes, Philolaus, reliqui (nam Pythagoram, ut superstitiosum, omittimus), scholas (quod novimus) non aperuerunt: sed majore silentio, et severius, et simplicius, id est, minore cum affectatione et ostentatione, ad inquisitionem veritatis se contulerunt.

Itaque et melius, ut arbitramur, se gesserunt; nisi quod opera eorum a levioribus istis, qui vulgari captui et affectui magis respondent ac placent, tractu temporis extincta sint: tempore (ut fluvio) leviora et magis inflata ad nos devehente, graviora et solida mergente. Neque tamen isti a nationis vitio prorsus immunes erant: sed in ambitionem et vanitatem sectae condendae et aurae popularis captandae nimium propendebant. Pro desperata autem habenda est veritatis inquisitio, cum ad hujusmodi inania deflectat. Etiam non omittendum videtur judicium illud, sive vaticinium potius, sacerdotis Aegyptii de Graecis: *Quod semper pueri essent; neque haberent antiquitatem scientiae, aut scientiam antiquitatis.* Et certe habent id quod puerorum est; ut ad garriendum prompti sint, generare autem non possint: nam verbosa videtur sapientia eorum, et operum sterilis.

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sophists fits the whole class. Those who wanted to be thought philosophers threw that name back in contempt at the old rhetoricians, Gorgias, Protagoras, Hippias and Polus. But it applies just as well to Plato, Aristotle, Zeno, Epicurus, Theophrastus, and their successors Chrysippus, Carneades and the rest.[20]

The only difference was this. The first kind was wandering and mercenary: they went around the cities, showing off their wisdom and demanding fees. The second was more dignified and generous: they had fixed homes, opened schools, and taught philosophy for nothing. Yet both kinds, however different in other respects, were professorial. Both reduced everything to disputation, and set up and defended sects and factions in philosophy. So their doctrines were for the most part, as Dionysius not unfairly jibed at Plato, *the words of idle old men to ignorant youths.* But the older Greeks did not, so far as we know, open schools: Empedocles, Anaxagoras, Leucippus, Democritus, Parmenides, Heraclitus, Xenophanes, Philolaus and the rest (we leave out Pythagoras as superstitious). They devoted themselves to the search for truth more quietly, more severely and more simply, that is, with less affectation and display.[21]

So, in our judgment, they did better. But their works were extinguished in the course of time by lighter ones that better suit and please popular understanding and taste. Time, like a river, carries down to us what is lighter and more puffed up, and sinks what is heavy and solid. Yet even these men were not wholly free of their nation's fault. They leaned too much toward the ambition and vanity of founding a sect and catching popular favor. And the search for truth must be counted lost when it turns aside to such trifles. Nor should we pass over the judgment, or rather prophecy, of the Egyptian priest about the Greeks: *that they were always children, and had neither antiquity of knowledge nor knowledge of antiquity.* They certainly have the mark of children: they are quick to chatter but cannot beget. Their wisdom seems full of words and barren of works.[22]

20 Gorgias, Protagoras, Hippias and Polus were fifth-century BC teachers of rhetoric, the Sophists attacked in Plato's dialogues. The Zeno meant here is Zeno of Citium, founder of Stoicism.
21 Dionysius, tyrant of Syracuse, at whose court Plato stayed.
22 The saying comes from Plato's *Timaeus* (22b), where an Egyptian priest addresses Solon.

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Itaque ex ortu et gente philosophiae quae in usu est, quae capiuntur signa bona non sunt.

So the signs drawn from the origin and lineage of the philosophy now in use are not good.

1.72 Neque multo meliora sunt signa quae ex natura temporis et aetatis capi possunt, quam quae ex natura loci et nationis. Angusta enim erat et tenuis notitia per illam aetatem vel temporis vel orbis: quod longe pessimum est, praesertim iis qui omnia in experientia ponunt. Neque enim mille annorum historiam, quae digna erat nomine historiae, habebant; sed fabulas et rumores antiquitatis.

The signs that can be drawn from the character of the time and age are not much better than those drawn from the character of the place and nation. In that age knowledge was narrow and meager, whether of time or of the world. That is by far the worst thing, especially for those who place everything in experience. They did not have a history of a thousand years that deserved the name of history, only the fables and rumors of antiquity.

Regionum vero tractuumque mundi exiguam partem noverant: cum omnes hyperboreos, Scythas, omnes occidentales, Celtas indistincte appellarent; nil in Africa ultra citimam Aethiopiae partem, nil in Asia ultra Gangem, multo minus novi orbis provincias, ne per auditum sane aut famam aliquam certam et constantem, nossent; imo et plurima climata et zonae, in quibus populi infiniti spirant et degunt, tanquam inhabitabiles ab illis pronuntiata sint; quinetiam peregrinationes Democriti, Platonis, Pythagorae, non longinquae profecto, sed potius suburbanae, ut magnum aliquid celebrarentur. Nostris autem temporibus, et novi orbis partes complures et veteris orbis extrema undique innotescunt; et in infinitum experimentorum cumulus excrevit. Quare si ex nativitatis aut geniturae tempore (astrologorum more) signa capienda sint, nil magni de istis philosophiis significari videtur.

They knew only a small part of the regions and tracts of the world. They called all the peoples of the far north Scythians, and all western peoples Celts, without distinction. In Africa they knew nothing beyond the nearest part of Ethiopia, in Asia nothing beyond the Ganges. Still less did they know the provinces of the New World, not even by hearsay or by any sure and consistent report. Indeed, they declared many climates and zones uninhabitable in which countless peoples breathe and live. What is more, the travels of Democritus, Plato and Pythagoras were celebrated as something great, though they were hardly long journeys, more like excursions to the suburbs. In our times, by contrast, many parts of the New World and the farthest limits of the Old World on every side are becoming known, and the stock of experiments has grown beyond measure. So if signs are to be taken, as astrologers take them, from the time of birth or nativity, nothing great seems to be foretold for those philosophies.

1.73 Inter signa, nullum magis certum aut nobile est, quam quod ex fructibus. Fructus enim et opera inventa pro veritate philosophiarum velut sponsores et fidejussores sunt. Atque ex philosophiis istis Graecorum, et derivationibus earum per particulares scientias, jam per tot annorum spatia, vix unum experimentum adduci potest, quod ad hominum statum levandum et juvandum spectet, et philosophiae speculationibus ac dogmatibus vere acceptum referri possit. Idque Celsus ingenue ac prudenter fatetur; nimirum, experimenta medicinae primo inventa fuisse, ac postea homines circa ea philosophatos esse et causas indagasse et assignasse; non ordine inverso evenisse, ut ex philosophia et causarum cognitione ipsa experimenta inventa aut deprompta essent.

Of all signs, none is more certain or more noble than the one taken from fruits. Fruits and works are, as it were, sponsors and guarantors of the truth of philosophies. Yet from all those Greek philosophies, and their offshoots in the particular sciences, over so many years, hardly a single experiment can be produced that tends to relieve and benefit the human condition and can truly be credited to the speculations and doctrines of philosophy. Celsus candidly and wisely admits as much. The experiments of medicine, he says, were discovered first, and only afterwards did people philosophize about them and hunt out and assign their causes. It did not happen the other way round, with the experiments themselves dis-

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		covered or drawn out of philosophy and knowledge of causes.[23]
	Itaque mirum non erat, apud Aegyptios (qui rerum inventoribus divinitatem et consecrationem attribuerunt) plures fuisse brutorum animalium imagines quam hominum: quia bruta animalia, per instinctus naturales, multa inventa pepererunt; ubi homines, ex sermonibus et conclusionibus rationalibus, pauca aut nulla exhibuerint.	So it was not surprising that among the Egyptians, who deified and consecrated the inventors of things, there were more images of animals than of men. For animals, by natural instinct, have produced many discoveries, whereas men, with their talk and rational conclusions, have come up with few or none.
	At Chymicorum industria nonnulla peperit; sed tanquam fortuito et obiter, aut per experimentorum quandam variationem (ut mechanici solent), non ex arte aut theoria aliqua; nam ea, quam confinxerunt, experimenta magis perturbat, quam juvat. Eorum etiam, qui in magia (quam vocant) naturali versati sunt, pauca reperiuntur inventa; eaque levia, et imposturae propiora. Quocirca, quemadmodum in religione cavetur, ut fides ex operibus monstretur; idem etiam ad philosophiam optime traducitur, ut ex fructibus judicetur et vana habeatur quae sterilis sit: atque eo magis si, loco fructuum uvae et olivae, producat disputationum et contentionum carduos et spinas.	The industry of the alchemists has produced something. But it did so by accident and in passing, or through a kind of variation of experiments (as mechanics do), not from any art or theory. The theory they have made up disturbs experiments more than it helps them. Those who have dealt in so-called natural magic also have few discoveries to show, and those trivial and closer to imposture. Religion warns that faith must be shown by works. The same principle transfers excellently to philosophy: it should be judged by its fruits, and counted worthless if it is barren. All the more so if, instead of the fruits of the grape and the olive, it produces the thistles and thorns of disputes and quarrels.[24]
1.74	Capienda etiam sunt signa ex incrementis et progressibus philosophiarum et scientiarum. Quae enim in natura fundata sunt, crescunt et augentur: quae autem in opinione, variantur, non augentur. Itaque si istae doctrinae plane instar plantae a stirpibus suis revulsae non essent, sed utero naturae adhaererent atque ab eadem alerentur, id minime eventurum fuisset, quod per annos bis mille jam fieri videmus: nempe, ut scientiae suis haereant vestigiis, et in eodem fere statu maneant, neque augmentum aliquod memorabile sumpserint; quin potius in primo authore maxime floruerint, et deinceps declinaverint. In artibus autem mechanicis, quae in natura et experientiae luce fundatae sunt, contra evenire videmus: quae (quamdiu placent) veluti spiritu quodam repletae continuo vegetant et crescunt; primo rudes, deinde commodae, postea excultae, et perpetuo auctae.	Signs must also be taken from the growth and progress of philosophies and sciences. What is founded in nature grows and increases; what is founded in opinion varies but does not increase. Suppose these doctrines had not been torn up by the roots like a plant, but had stayed attached to the womb of nature and been nourished by her. Then what we have seen happen for two thousand years would never have happened. The sciences stand still in their own footprints and remain in much the same state, without any noteworthy growth. Indeed, they flourished most in their first author and have declined ever since. In the mechanical arts, which are founded in nature and the light of experience, we see the opposite. As long as they find favor, they continually thrive and grow, as if filled with a kind of breath of life: rough at first, then serviceable, then refined, and always improving.
1.75	Etiam aliud signum capiendum est (si modo signi appellatio huic competat; cum potius testimonium sit,	Another sign must be taken as well, if indeed it deserves the name of sign. It is rather testimony, and

23 Aulus Cornelius Celsus (1st century AD), Roman author of *On Medicine*; the point is made in its preface.
24 Allusions to James 2:18 (faith shown by works) and Matthew 7:16–20 (known by their fruits; grapes and thorns).

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atque adeo testimoniorum omnium validissimum); hoc est, propria confessio authorum, quos homines nunc sequuntur. Nam et illi qui tanta fiducia de rebus pronuntiant, tamen per intervalla cum ad se redeunt, ad querimonias de naturae subtilitate, rerum obscuritate, humani ingenii infirmitate, se convertunt. Hoc vero si simpliciter fieret, alios fortasse, qui sunt timidiores, ab ulteriori inquisitione deterrere, alios vero, qui sunt ingenio alacriori et magis fidenti, ad ulteriorem progressum acuere et incitare possit.

Verum non satis illis est de se confiteri, sed quicquid sibi ipsis aut magistris suis incognitum aut intactum fuerit id extra terminos possibilis ponunt, et tanquam ex arte cognitu aut factu impossibile pronuntiant: summa superbia et invidia suorum inventorum infirmitatem in naturae ipsius calumniam et aliorum omnium desperationem vertentes. Hinc schola Academiae novae, quae *acatalepsiam* ex professo tenuit, et homines ad sempiternas tenebras damnavit. Hinc opinio, quod formae sive verae rerum differentiae (quae revera sunt leges actus puri) inventu impossibiles sint, et ultra hominem. Hinc opiniones illae in activa et operativa parte: calorem solis et ignis toto genere differre; ne scilicet homines putent se per opera ignis aliquid simile iis quae in natura fiunt educere et formare posse.

Hinc illud: compositionem tantum opus hominis, mistionem vero opus solius naturae esse; ne scilicet homines sperent aliquam ex arte corporum naturalium generationem aut transformationem. Itaque ex hoc signo homines sibi persuaderi facile patientur, ne cum dogmatibus non solum desperatis, sed etiam desperationi devotis, fortunas suas et labores misceant.

1.76 Neque illud signum praetermittendum est, quod tanta fuerit inter philosophos olim dissensio et scholarum ipsarum varietas: quod satis ostendit, viam a sensu ad intellectum non bene munitam fuisse, cum eadem materia philosophiae (natura scilicet rerum) in tam vagos et multiplices errores abrepta fuerit et distracta. Atque licet hisce temporibus dissensiones et dogmatum diversitates circa principia ipsa, et philosophias integras, ut plurimum extinctae sint; tamen circa partes philosophiae innumerae manent quaestiones et controversiae; ut plane appareat, neque in philosophiis

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the strongest testimony of all: the admission of the very authors whom people now follow. Even those who pronounce so confidently on things, when from time to time they come to themselves, turn to complaints about the subtlety of nature, the obscurity of things, and the weakness of the human mind. If they simply did this, it might perhaps deter the more timid from further inquiry. At the same time it might spur and incite those of livelier and more confident temper to go further.

But it is not enough for them to make confessions about themselves. Whatever has been unknown or untouched by them or their masters they place outside the bounds of the possible. They pronounce it impossible to know or to do, as though by the rules of their art. With the utmost pride and jealousy, they turn the weakness of their own discoveries into a slander on nature herself and a cause of despair for everyone else. Hence the school of the New Academy, which openly held *acatalepsia* and condemned mankind to everlasting darkness. Hence the opinion that forms, or the true differences of things (which are in fact laws of pure act), cannot be discovered and lie beyond human reach. Hence, too, those opinions in the active and operative part of philosophy: that the heat of the sun and the heat of fire differ in kind. The aim, clearly, is that people should not suppose they can produce and form, by the works of fire, anything like what happens in nature.

Hence also the claim that composition alone is the work of man, while mixture is the work of nature alone. The aim, clearly, is that people should not hope for any generation or transformation of natural bodies by art. From this sign, then, people will easily be persuaded not to stake their fortunes and labors on doctrines that are not only despairing but dedicated to despair.

Nor should we pass over this sign: that there was once so much disagreement among philosophers and such variety among their schools. This shows clearly that the road from the senses to the understanding was not well built, since the same material of philosophy, namely the nature of things, has been seized and torn apart into so many wandering and manifold errors. In our time, disagreements and differences of doctrine about first principles and whole philosophies have mostly died

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ipsis, neque in modis demonstrationum aliquid certi aut sani esse.

out. But countless questions and controversies remain about the parts of philosophy. So it is plain that there is nothing certain or sound either in the philosophies themselves or in their modes of demonstration.

1.77 Quod vero putant homines, in philosophia Aristotelis magnum utique consensum esse; cum post illam editam antiquorum philosophiae cessaverint et exoleverint; ast apud tempora, quae sequuta sunt, nil melius inventum fuerit; adeo ut illa tam bene posita et fundata videatur, ut utrumque tempus ad se traxerit: primo, quod de cessatione antiquarum philosophiarum post Aristotelis opera edita homines cogitant, id falsum est; diu enim postea, usque ad tempora Ciceronis et secula sequentia, manserunt opera veterum philosophorum. Sed temporibus insequentibus, ex inundatione Barbarorum in imperium Romanum, postquam doctrina humana velut naufragium perpessa esset; tum demum philosophiae Aristotelis et Platonis, tanquam tabulae ex materia leviore et minus solida, per fluctus temporum servatae sunt. Illud etiam de consensu fallit homines, si acutius rem introspiciant.

Some think that there is at any rate great agreement in Aristotle's philosophy. After it was published, they say, the philosophies of the ancients ceased and fell out of use, and in the ages that followed nothing better was found. So it seems so well laid down and founded that it has won over both the age before it and the age after. First, what people think about the ancient philosophies ceasing after Aristotle's works were published is false. The works of the old philosophers survived long afterwards, down to the time of Cicero and the centuries that followed. But later, invading peoples flooded into the Roman Empire and human learning suffered something like a shipwreck. Only then were the philosophies of Aristotle and Plato saved on the waves of time, like planks of lighter and less solid material. As to agreement, too, people are deceived, if they look into the matter more sharply.

Verus enim consensus is est, qui ex libertate judicii (re prius explorata) in idem conveniete consistit. At numerus longe maximus eorum, qui in Aristotelis philosophiam consenserunt, ex praejudicio et authoritate aliorum se illi mancipavit: ut sequacitas sit potius et coitio, quam consensus. Quod si fuisset ille verus consensus et late patens, tantum abest ut consensus pro vera et solida authoritate haberi debeat, ut etiam violentam praesumptionem inducat in contrarium. Pessimum enim omnium est augurium, quod ex consensu capitur in rebus intellectualibus: exceptis divinis et politicis, in quibus suffragiorum jus est. Nihil enim multis placet, nisi imaginationem feriat, aut intellectum vulgarium notionum nodis astringat, ut supra dictum est.

True agreement consists in free judgments, the matter having first been examined, coming together on the same point. But by far the greatest number of those who have agreed with Aristotle's philosophy enslaved themselves to it out of prejudice and on the authority of others. So it is following and banding together rather than agreement. And even if it had been true and widespread agreement, agreement is far from deserving to be taken as true and solid authority. In fact it raises a strong presumption to the contrary. In intellectual matters the worst omen of all is the one taken from agreement, except in divine and political matters, where there is a right to vote. For nothing pleases the many unless it strikes the imagination or binds the understanding with the knots of common notions, as was said above.

Itaque optime traducitur illud Phocionis a moribus ad intellectualia: *Ut statim se examinare debeant homines, quid erraverint aut peccaverint, si multitudo consentiat et complaudat.* Hoc signum igitur ex aversissimis est. Itaque quod signa veritatis et sanitatis philosophiarum et scientiarum, quae in usu sunt, male se habeant; sive capiantur ex originibus ipsarum, sive ex fructibus, sive ex

So Phocion's saying transfers very well from morals to the intellect: *that people should at once examine themselves for what error or wrong they have committed, if the multitude agrees and applauds.* This sign, then, is among the most unfavorable. We have now shown that the signs of truth and soundness in the philosophies and sciences in use are

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progressibus, sive ex confessionibus authorum, sive ex consensu; jam dictum est.	poor, whether they are taken from their origins, their fruits, their progress, the admissions of their authors, or agreement.[25]

CAUSES OF ERROR

Few ages favored learning, natural philosophy was neglected, and the true goal of the sciences was never set.

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1.78	Jam vero veniendum ad causas errorum, et tam diuturnae in illis per tot secula morae; quae plurimae sunt et potentissimae: ut tollatur omnis admiratio, haec quae adducimus homines hucusque latuisse et fugisse; et maneat tantum admiratio, illa nunc tandem alicui mortalium in mentem venire potuisse, aut cogitationem cujuspiam subiisse: quod etiam (ut nos existimamus) foelicitatis magis est cujusdam, quam excellentis alicujus facultatis; ut potius pro temporis partu haberi debeat, quam pro partu ingenii.	Now we must come to the causes of these errors, and of their long persistence through so many centuries. The causes are very many and very powerful. Once they are known, all wonder should cease that the things we are putting forward have lain hidden and escaped people until now. The only wonder left will be that they have at last occurred to some mortal or entered anyone's thoughts. And this too, in our view, is due more to a certain good fortune than to any excellence of faculty. It should be taken as a birth of time rather than a birth of wit.
	Primo autem tot seculorum numerus, vere rem reputanti, ad magnas angustias recidit. Nam ex viginti quinque annorum centuriis, in quibus memoria et doctrina hominum fere versatur, vix sex centuriae seponi et excerpi possunt, quae scientiarum feraces earumve proventui utiles fuerunt. Sunt enim non minus temporum quam regionum eremi et vastitates. Tres enim tantum doctrinarum revolutiones et periodi recte numerari possunt: una, apud Graecos; altera, apud Romanos; ultima, apud nos, occidentales scilicet Europae nationes: quibus singulis vix duae centuriae annorum merito attribui possunt. Media mundi tempora, quoad scientiarum segetem uberem aut laetam, infelicia fuerunt. Neque enim causa est ut vel Arabum vel scholasticorum mentio fiat: qui per intermedia tempora scientias potius contriverunt numerosis tractatibus, quam pondus earum auxerunt.	First, those many centuries, if you weigh the matter truly, shrink to a very small span. Human memory and learning cover roughly twenty-five centuries. Of these, scarcely six can be set apart as fertile in the sciences or favorable to their growth. For there are wastes and deserts of time no less than of regions. Only three revolutions and periods of learning can rightly be counted: one among the Greeks, the second among the Romans, the last among us, the nations of western Europe. And to each of them scarcely two centuries can fairly be assigned. The intervening ages of the world were unfortunate as far as any rich or thriving harvest of sciences is concerned. Nor is there any reason to mention either the Arabs or the scholastics. In the intervening times they wore the sciences down with their many treatises rather than adding to their weight.
	Itaque prima causa tam pusilli in scientiis profectus ad angustias temporis erga illas propitii rite et ordine refertur.	So the first cause of such meager progress in the sciences is rightly and properly traced to the narrowness of the time that has been favorable to them.
1.79	At secundo loco se offert causa illa magni certe per omnia momenti: ea videlicet, quod per illas ipsas aetates, quibus hominum ingenia et literae maxime vel etiam	The second cause is of great importance in every way. In the very ages in which human wit and letters flourished most, or even moderately, natural

25 Phocion, Athenian general and statesman (4th century BC). Plutarch reports that when the crowd applauded him he asked whether he had said something bad.

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mediocriter floruerint, naturalis philosophia minimam partem humanae operae sortita sit. Atque haec ipsa nihilominus pro magna scientiarum matre haberi debet. Omnes enim artes et scientiae, ab hac stirpe revulsae, poliuntur fortasse et in usum effinguntur; sed nil admodum crescunt.

At manifestum est, postquam Christiana fides recepta fuisset et adolevisset, longe maximam ingeniorum praestantissimorum partem ad theologiam se contulisse; atque huic rei et amplissima praemia proposita, et omnis generis adjumenta copiosissime subministrata fuisse: atque hoc theologiae studium praecipue occupasse tertiam illam partem sive periodum temporis apud nos Europaeos occidentales; eo magis, quod sub idem fere tempus et literae florere, et controversiae circa religionem pullulare coeperint. At aevo superiori, durante periodo illa secunda apud Romanos, potissimae philosophorum meditationes et industriae in morali philosophia (quae ethnicis vice theologiae erat) occupatae et consumptae fuerunt: etiam summa ingenia illis temporibus ut plurimum ad res civiles se applicuerunt, propter magnitudinem imperii Romani, quod plurimorum hominum opera indigebat.

At illa aetas, qua naturalis philosophia apud Graecos maxime florere visa est, particula fuit temporis minime diuturna; cum et antiquioribus temporibus septem illi, qui sapientes nominabantur, omnes (praeter Thaletem) ad moralem philosophiam et civilia se applicuerint; et posterioribus temporibus postquam Socrates philosophiam de coelo in terras deduxisset, adhuc magis invaluerit moralis philosophia, et ingenia hominum a naturali averterit.

At ipsissima illa periodus temporis, in qua inquisitiones de natura viguerunt, contradictionibus et novorum placitorum ambitione corrupta est, et inutilis reddita. Itaque quandoquidem per tres istas periodos naturalis philosophia majorem in modum neglecta aut impedita fuerit, nil mirum si homines parum in ea re profecerint, cum omnino aliud egerint.

1.80 Accedit et illud, quod naturalis philosophia in iis ipsis viris, qui ei incubuerint, vacantem et integrum hominem, praesertim his recentioribus temporibus, vix nacta sit; nisi forte quis monachi alicujus in cellula, aut nobilis in villula lucubrantis, exemplum adduxerit: sed facta est demum naturalis philosophia instar transitus cujusdam et pontisternii ad alia.

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philosophy received the smallest share of human effort. And yet natural philosophy should be regarded as the great mother of the sciences. All arts and sciences torn from this root may perhaps be polished and shaped for use, but they hardly grow at all.

It is plain that after the Christian faith had been accepted and had grown strong, by far the greatest part of the finest minds devoted themselves to theology. The richest rewards were offered for it, and help of every kind was supplied in abundance. This study of theology chiefly occupied that third portion or period of time, among us western Europeans. All the more so because at about the same time letters began to flourish and religious controversies to multiply. In the earlier age, the second period, among the Romans, the chief meditations and labors of philosophers were taken up and spent on moral philosophy, which for the pagans took the place of theology. In those times, too, the greatest minds mostly applied themselves to public affairs, because the vast Roman Empire needed the work of a great many people.

And the age in which natural philosophy seemed to flourish most among the Greeks was a very brief portion of time. In earlier times the so-called Seven Sages all applied themselves, except Thales, to moral philosophy and politics. In later times, after Socrates had brought philosophy down from heaven to earth, moral philosophy grew stronger still and turned people's minds away from natural philosophy.[26]

And the very period in which inquiries into nature thrived was corrupted, and made useless, by contradictions and the ambition to put forward new opinions. So through these three periods natural philosophy was largely neglected or hindered. It is no wonder people made little progress in it, since they were busy with something else entirely.

Add to this that natural philosophy, even among those who have applied themselves to it, has scarcely found anyone who gave it his whole time and attention, especially in these recent times. Someone might perhaps point to a monk working late in his cell, or a gentleman in his country house. But on the whole natural philosophy has

26 The image of Socrates bringing philosophy down from heaven is Cicero's (*Tusculan Disputations* 5.10).

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become merely a passage or bridge to other things.

Atque magna ista scientiarum mater mira indignitate ad officia ancillae detrusa est; quae medicinae aut mathematices operibus ministret, et rursus quae adolescentium immatura ingenia lavet et imbuat velut tinctura quadam prima, ut aliam postea foelicius et commodius excipiant. Interim nemo expectet magnum progressum in scientiis (praesertim in parte earum operativa), nisi philosophia naturalis ad scientias particulares producta fuerit, et scientiae particulares rursus ad naturalem philosophiam reductae.

So this great mother of the sciences has, with strange indignity, been thrust down to the duties of a handmaid. She waits on the works of medicine or mathematics. She also washes and steeps the unformed minds of the young, like a first dye, so that they may afterwards take another more readily and conveniently. Meanwhile let no one expect great progress in the sciences, especially in their operative part, unless natural philosophy is carried through to the particular sciences, and the particular sciences are brought back again to natural philosophy.

Hinc enim fit, ut astronomia, optica, musica, plurimae artes mechanicae, atque ipsa medicina, atque (quod quis magis miretur) philosophia moralis et civilis, et scientiae logicae, nil fere habeant altitudinis in profundo: sed per superficiem et varietatem rerum tantum labantur: quia, postquam particulares istae scientiae dispertitae et constitutae fuerint, a philosophia naturali non amplius aluntur; quae ex fontibus et veris contemplationibus motuum, radiorum, sonorum, texturae, et schematismi corporum, affectuum, et prehensionum intellectualium, novas vires et augmenta illis impertiri potuerit. Itaque minime mirum est si scientiae non crescant, cum a radicibus suis sint separatae.

This is why astronomy, optics, music, most of the mechanical arts, medicine itself, and (more surprisingly) moral and political philosophy and the logical sciences have almost no depth. They only glide over the surface and variety of things. Once these particular sciences have been divided off and established, they are no longer nourished by natural philosophy. Yet natural philosophy could have given them new strength and growth from its sources and from the true contemplation of motions, rays, sounds, the texture and configuration of bodies, the affections, and intellectual apprehensions. So it is no wonder the sciences do not grow, when they have been cut off from their roots.

1.81 Rursus se ostendit alia causa potens et magna, cur scientiae parum promoverint. Ea vero haec est; quod fieri non possit, ut recte procedatur in curriculo, ubi ipsa meta non recte posita sit et defixa. Meta autem scientiarum vera et legitima non alia est quam ut dotetur vita humana novis inventis et copiis. At turba longe maxima nihil ex hoc sapit, sed meritoria plane est et professoria; nisi forte quandoque eveniat, ut artifex aliquis acrioris ingenii, et gloriae cupidus, novo alicui invento det operam; quod fere fit cum facultatum dispendio.

Another great and powerful cause of the sciences' small progress now appears. It is this: no one can run the course properly when the goal itself has not been properly set and fixed. The true and legitimate goal of the sciences is simply this: that human life be endowed with new discoveries and resources. But by far the greatest crowd has no sense of this at all. They are wholly mercenary and professorial. Now and then, perhaps, some craftsman of sharper wit and eager for glory devotes himself to a new discovery, and usually at the cost of his means.

At apud plerosque tantum abest ut homines id sibi proponant, ut scientiarum et artium massa augmentum obtineat, ut ex ea, quae praesto est, massa nil amplius sumant aut quaerant, quam quantum ad usum professorium aut lucrum aut existimationem aut hujusmodi compendia convertere possint. Quod si quis ex tanta multitudine scientiam affectu ingenuo et propter se

Most people are far from setting themselves to increase the stock of sciences and arts. From the stock on hand they take or seek nothing more than what they can turn to professional use, profit, reputation, or similar gains. If one of so great a multitude pursues knowledge with honest affection and for its own sake, even he will be found

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expetat; invenietur tamen ille ipse potius contemplationum et doctrinarum varietatem, quam veritatis severam et rigidam inquisitionem sequi. Rursus, si alius quispiam fortasse veritatis inquisitor sit severior; tamen et ille ipse talem sibi proponet veritatis conditionem, quae menti et intellectui satisfaciat in redditione causarum rerum quae jampridem sunt cognitae; non eam, quae nova operum pignora, et novam axiomatum lucem assequatur.

Itaque, si finis scientiarum a nemine adhuc bene positus sit, non mirum est si in iis, quae sunt subordinata ad finem, sequatur aberratio.

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pursuing a variety of speculations and doctrines rather than the strict and rigorous search for truth. Again, someone else may perhaps be a stricter seeker of truth. But he too will aim at the kind of truth that satisfies the mind and understanding by giving the causes of things long known, not the kind that wins new pledges of works and new light of axioms.

So, if no one has yet set the end of the sciences properly, it is no wonder that people go astray in everything subordinate to that end.

A ROAD NEVER BUILT

Inquiry has been left to tradition, argument and random experience, and particulars were thought beneath the mind.

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1.82 Quemadmodum autem finis et meta scientiarum male posita sunt apud homines; ita rursus etiamsi illa recte posita fuissent, viam tamen sibi delegerunt omnino erroneam et imperviam. Quod stupore quodam animum rite rem reputanti perculserit; non ulli mortalium curae aut cordi fuisse, ut intellectui humano ab ipso sensu et experientia ordinata et bene condita via aperiretur et muniretur; sed omnia vel traditionum caligini, vel argumentorum vertigini et turbini, vel casus et experientiae vagae et inconditae undis et ambagibus permissa esse. Atque cogitet quis sobrie et diligenter, qualis sit ea via, quam in inquisitione et inventione alicujus rei homines adhibere consueverunt. Et primo notabit proculdubio inveniendi modum simplicem et inartificiosum, qui hominibus maxime est familiaris.

Hic autem non alius est, quam ut is, qui se ad inveniendum aliquid comparat et accingit, primo quae ab aliis circa illa dicta sint inquirat et evolvat; deinde propriam meditationem addat, atque per mentis multam agitationem spiritum suum proprium sollicitet, et quasi invocet, ut sibi oracula pandat: quae res omnino sine fundamento est, et in opinionibus tantum volvitur.

At alius quispiam dialecticam ad inveniendum advocet, quae nomine tenus tantum ad id quod agitur pertinet. Inventio enim dialecticae non est principiorum et axiomatum praecipuorum, ex quibus artes constant, sed eorum tantum quae illis consentanea videntur. Dialectica enim magis curiosos et importunos, et sibi negotium facessentes, eamque interpellantes de probationibus et

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The end and goal of the sciences have been badly set. But even if they had been rightly set, people chose a way that is wholly mistaken and impassable. Anyone who weighs the matter properly will be struck with astonishment. No mortal has cared or troubled to open and build for the human understanding an orderly, well-made road starting from the senses and experience themselves. Everything has been left either to the darkness of tradition, or to the whirl and eddy of argument, or to the waves and windings of chance and of vague, unregulated experience. Let anyone consider soberly and carefully what way people usually follow in inquiring into and discovering anything. First, he will no doubt notice the simple and artless method of discovery that is most familiar to them.

It is simply this. Someone who prepares and girds himself to discover something first seeks out and reads what others have said about it. Then he adds his own meditation, and by much agitation of the mind stirs up, and as it were invokes, his own spirit to reveal oracles to him. This procedure has no foundation whatever and turns only on opinions.

Another may call on dialectic to help him discover, but dialectic bears on the matter in name only. What dialectic discovers is not the principles and chief axioms of which the arts consist, but only things that seem consistent with them. Some are more curious and insistent, and make trouble for themselves by pestering dialectic about the proof

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inventionibus principiorum, sive axiomatum primorum, ad fidem, et veluti sacramentum cuilibet arti praestandum, notissimo responso rejicit.

Restat experientia mera: quae, si occurrat, casus; si quaesita sit, experimentum nominatur. Hoc autem experientiae genus nihil aliud est, quam (quod aiunt) scopae dissolutae, et mera palpatio, quali homines noctu utuntur, omnia pertentando, si forte in rectam viam incidere detur; quibus multo satius et consultius foret diem praestolari, aut lumen accendere, et deinceps viam inire. At contra, verus experientiae ordo primo lumen accendit, deinde per lumen iter demonstrat, incipiendo ab experientia ordinata et digesta, et minime praepostera aut erratica, atque ex ea educendo axiomata, atque ex axiomatibus constitutis rursus experimenta nova; quum nec verbum divinum in rerum massam absque ordine operatum sit.

Itaque desinant homines mirari si spatium scientiarum non confectum sit, cum a via omnino aberraverint; relicta prorsus et deserta experientia, aut in ipsa (tanquam in labyrintho) se intricando, et circumcursando; cum rite institutus ordo per experientiae sylvas ad aperta axiomatum tramite constanti ducat.

1.83 Excrevit autem mirum in modum istud malum ex opinione quadam, sive aestimatione inveterata, verum tumida et damnosa; minui nempe mentis humanae majestatem, si experimentis, et rebus particularibus sensui subjectis et in materia determinatis, diu ac multum versetur: praesertim quum hujusmodi res ad inquirendum laboriosae, ad meditandum ignobiles, ad dicendum asperae, ad practicam illiberales, numero infinitae, et subtilitate tenues esse soleant. Itaque jam tandem huc res rediit, ut via vera non tantum deserta, sed etiam interclusa et obstructa sit; fastidita experientia, nedum relicta, aut male administrata.

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and discovery of principles or first axioms. Dialectic rebuffs them with its well-known answer: they must take it on faith, the oath of allegiance owed to each art.

What is left is mere experience. If it comes of itself, it is called chance; if it is sought, experiment. But this kind of experience is nothing but a broom without its band, as the saying goes, and mere groping. It is like people at night who feel their way over everything in the hope of chancing on the right road. It would be far better and wiser for them to wait for day, or light a lamp, and then set out. The true order of experience, by contrast, first lights the lamp, and then by the lamp shows the way. It begins with experience that is ordered and arranged, not back-to-front or wandering. From that experience it draws out axioms, and from established axioms, in turn, new experiments. For not even the divine word acted on the mass of things without order.

So let people stop wondering that the course of the sciences has not been completed, when they have wandered entirely from the way. Either they have abandoned and deserted experience altogether, or they have entangled themselves in it, as in a labyrinth, and run around in circles. A properly established order, by contrast, leads by a steady path through the forests of experience to the open ground of axioms.

This evil has grown remarkably from a certain opinion, a long-standing assumption, conceited and harmful. It holds that the majesty of the human mind is lessened if it spends long and much time on experiments and on particular things that are subject to the senses and bounded in matter. Such things are usually laborious to inquire into, mean to think about, harsh to speak of, and illiberal to practice. They are also infinite in number and minute in their subtlety. So things have come to this at last: the true way is not only deserted but blocked and barred. Experience is not merely abandoned or badly handled but despised.

ANTIQUITY, AUTHORITY AND ADMIRATION

Our own age is the true antiquity; reverence for authors and awe at existing works have held people back.

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1.84	Rursus vero homines a progressu in scientiis detinuit et fere incantavit reverentia antiquitatis, et virorum, qui in philosophia magni habiti sunt, authoritas, atque deinde consensus. Atque de consensu superius dictum est.	Again, people have been held back from progress in the sciences, and almost bewitched, by reverence for antiquity, by the authority of men considered great in philosophy, and then by general agreement. Of agreement we have spoken above.
	De antiquitate autem opinio, quam homines de ipsa fovent, negligens omnino est, et vix verbo ipsi congrua. Mundi enim senium et grandaevitas pro antiquitate vere habenda sunt; quae temporibus nostris tribui debent, non juniori aetati mundi, qualis apud antiquos fuit. Illa enim aetas, respectu nostri, antiqua et major; respectu mundi ipsius, nova et minor fuit. Atque revera quemadmodum majorem rerum humanarum notitiam et maturius judicium ab homine sene expectamus quam a juvene, propter experientiam et rerum, quas vidit, et audivit, et cogitavit, varietatem et copiam; eodem modo et a nostra aetate (si vires suas nosset, et experiri et intendere vellet) majora multo quam a priscis temporibus expectari par est; utpote aetate mundi grandiore, et infinitis experimentis et observationibus aucta et cumulata.	As for antiquity, the opinion people hold of it is quite careless and scarcely fits the word itself. The old age and great age of the world should truly be counted as antiquity. That belongs to our own times, not to the younger age of the world in which the ancients lived. Their age, relative to us, was ancient and elder; relative to the world itself, it was new and younger. We expect greater knowledge of human affairs and more mature judgment from an old man than from a young one, because of his experience and the variety and abundance of things he has seen, heard and thought about. In the same way it is fair to expect much greater things from our age than from ancient times, if our age knew its own strength and were willing to test and exert it. For it is the world's older age, enlarged and enriched with countless experiments and observations.
	Neque pro nihilo aestimandum, quod per longinquas navigationes et peregrinationes (quae seculis nostris increbuerunt) plurima in natura patuerint, et reperta sint, quae novam philosophiae lucem immittere possint. Quin et turpe hominibus foret, si globi materialis tractus, terrarum videlicet, marium, astrorum, nostris temporibus immensum aperti et illustrati sint; globi autem intellectualis finis inter veterum inventa et angustias cohibeantur.	Nor should it count for nothing that long voyages and travels, which have become frequent in our centuries, have revealed and discovered many things in nature that could shed new light on philosophy. Indeed, it would be a disgrace to mankind if the regions of the material globe, its lands, seas and stars, have been opened up and lit up so immensely in our times, while the boundaries of the intellectual globe stay confined within the narrow discoveries of the ancients.
	Authores vero quod attinet, summae pusillanimitatis est authoribus infinita tribuere, authori autem authorum, atque adeo omnis authoritatis, Tempori, jus suum denegare. Recte enim Veritas Temporis filia dicitur, non Authoritatis. Itaque mirum non est, si fascina ista antiquitatis et authorum et consensus, hominum virtutem ita ligaverint, ut cum rebus ipsis consuescere (tanquam maleficiati) non potuerint.	As for authors, it is the height of faintheartedness to grant authors unlimited credit while denying its rights to time, the author of authors and indeed of all authority. For truth is rightly called the daughter of time, not of authority. So it is no wonder that these spells of antiquity, of authors, and of agreement have so bound people's powers that, like the bewitched, they have been unable to become familiar with things themselves.
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Neque solum admiratio antiquitatis, authoritatis, et consensus, hominum industriam in iis, quae jam inventa sunt, acquiescere compulit; verum etiam operum ipsorum admiratio, quorum copia jampridem facta est humano generi. Etenim quum quis rerum varietatem, et pulcherrimum apparatum qui per artes mechanicas ad cultum humanum congestus et introductus est, oculis subjecerit, eo certe inclinabit, ut potius ad opulentiae humanae admirationem, quam ad inopiae sensum accedat; minime advertens primitivas hominis observationes atque naturae operationes (quae ad omnem illam varietatem instar animae sunt, et primi motus) nec multas, nec alte petitas esse; caetera ad patientiam hominum tantum, et subtilem et ordinatum manus vel instrumentorum motum, pertinere.

Res enim (exempli gratia) subtilis est certe et accurata confectio horologiorum, talis scilicet, quae coelestia in rotis, pulsum animalium in motu successivo et ordinato, videatur imitari; quae tamen res ex uno aut altero naturae axiomate pendet.

Quod si quis rursus subtilitatem illam intueatur quae ad artes liberales pertinet; aut etiam eam quae ad corporum naturalium praeparationem per artes mechanicas spectat, et hujusmodi res suspiciat; veluti inventionem motuum coelestium in astronomia, concentuum in musica, literarum alphabeti (quae etiam adhuc in regno Sinarum in usu non sunt) in grammatica; aut rursus in mechanicis, factorum Bacchi et Cereris, hoc est, praeparationum vini et cervisiae, panificiorum, aut etiam mensae delitiarum, et distillationum, et similium: ille quoque, si secum cogitet, et animum advertat, per quantos temporum circuitus (cum haec omnia, praeter distillationes, antiqua fuerint) haec ad eam, quam nunc habemus, culturam perducta sint, et (ut jam de horologiis dictum est) quam parum habeant ex observationibus et axiomatibus naturae, atque quam facile, et tanquam per occasiones obvias et contemplationes incurrentes, ista inveniri potuerint: ille (inquam) ab omni admiratione se facile liberabit, et potius humanae conditionis miserebitur, quod per tot secula tanta fuerit rerum et inventorum penuria et sterilitas.

Atque haec ipsa tamen, quorum nunc mentionem fecimus, inventa, philosophia et artibus intellectus

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Admiration for antiquity, authority and agreement is not the only thing that has made human effort rest content with what has already been discovered. There is also admiration for the works themselves, of which mankind has long had an abundance. Look at the variety of things and the magnificent equipment that the mechanical arts have gathered and introduced for the refinement of human life. Anyone who does so will certainly be inclined to admire human wealth rather than to feel human poverty. He does not notice that man's original observations and the operations of nature, which are the soul and first mover of all that variety, are neither many nor deeply sought. The rest is a matter only of human patience and of the fine and orderly movement of hand or instruments.

The making of clocks, for example, is certainly a fine and exact business. Their wheels seem to imitate the heavenly bodies, and their successive, regular motion the pulse of living things. Yet the whole thing depends on one or two axioms of nature.

Or again, consider the subtlety that belongs to the liberal arts, or the subtlety involved in preparing natural bodies by the mechanical arts. Someone may look up to such things as the discovery of the heavenly motions in astronomy, of harmonies in music, of the letters of the alphabet in grammar (they are still not used in the kingdom of China). Or, in the mechanical arts, he may admire the works of Bacchus and Ceres, that is, the making of wine and beer and bread, or even the delicacies of the table, distillation, and the like. But let him think it over and notice how many ages it took to bring these things to the refinement we now have, since all of them except distillation are ancient. Let him notice too how little they owe to observations and axioms of nature, as was said of clocks, and how easily they could have been discovered, through obvious opportunities and chance observations. He, I say, will easily free himself from all admiration. He will rather pity the human condition, that through so many centuries there has been such a dearth and barrenness of things and discoveries.

And yet the very discoveries we have just mentioned are older than philosophy and the intellec-

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antiquiora fuerunt: adeo ut (si verum dicendum sit) cum hujusmodi scientiae rationales et dogmaticae inceperint, inventio operum utilium desierit.

Quod si quis ab officinis ad bibliothecas se converterit, et immensam, quam videmus, librorum varietatem in admiratione habuerit, is, examinatis et diligentius introspectis ipsorum librorum materiis et contentis, obstupescet certe in contrarium; et postquam nullum dari finem repetitionibus observaverit, quamque homines eadem agant et loquantur, ab admiratione varietatis transibit ad miraculum indigentiae et paucitatis earum rerum quae hominum mentes adhuc tenuerunt et occuparunt.

Quod si quis ad intuendum ea, quae magis curiosa habentur quam sana, animum submiserit, et alchymistarum aut magorum opera penitius introspexerit, is dubitabit forsitan utrum risu an lachrymis potius illa digna sint. Alchymista enim spem alit aeternam, atque ubi res non succedit errores proprios reos substituit; secum accusatorie reputando, se aut artis aut authorum vocabula non satis intellexisse, unde ad traditiones et auriculares susurros animum applicat; aut in practicae suae scrupulis et momentis aliquid titubatum esse, unde experimenta in infinitum repetit: ac interim quum inter experimentorum sortes in quaedam incidit aut ipsa facie nova aut utilitate non contemnenda; hujusmodi pignoribus animum pascit, eaque in majus ostentat et celebrat: reliqua spe sustentat. Neque tamen negandum est, alchymistas non pauca invenisse, et inventis utilibus homines donasse.

Verum fabula illa non male in illos quadrat de sene, qui filiis aurum in vinea defossum (sed locum se nescire simulans) legaverit; unde illi vineae fodiendae diligenter incubuerunt, et aurum quidem nullum repertum, sed vindemia ex ea cultura facta est uberior.

At naturalis magiae cultores, qui per rerum sympathias et antipathias omnia expediunt, ex conjecturis otiosis et supinissimis, rebus virtutes et operationes admirabiles affinxerunt; atque si quando opera exhibuerint, ea illius

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tual arts. Indeed, to tell the truth, when rational and dogmatic sciences of this kind began, the discovery of useful works ceased.

Suppose someone turns from the workshops to the libraries and admires the immense variety of books we see there. Once he has examined and looked closely at their subject matter and contents, he will certainly be astonished in the opposite direction. He will observe that there is no end to repetition, and that people keep doing and saying the same things. Then he will pass from admiring the variety to wondering at the poverty and scarcity of the matters that have so far held and occupied human minds.

Suppose someone brings himself to look at things regarded as more curious than sound, and looks deeper into the works of the alchemists or magicians. He may well wonder whether they deserve laughter or tears. The alchemist nourishes an everlasting hope. When the thing does not succeed, he blames his own errors and accuses himself in one of two ways. Perhaps he has not understood the terms of his art or of its authors well enough, and so he turns to traditions and whispers in the ear. Or perhaps there was some slip in the fine weights and timings of his procedure, and so he repeats his experiments endlessly. Meanwhile, among the chances of his experiments, he hits upon some results that are either new in appearance or of real use. He feeds his mind on such pledges, displays and celebrates them beyond their worth, and sustains the rest with hope. Still, it must not be denied that the alchemists have found out a good deal and presented mankind with useful discoveries.

The fable fits them rather well of the old man who left his sons gold buried in the vineyard, but pretended not to know where. So they set to work diligently digging the vineyard. No gold was found, but that cultivation made the vintage all the richer.[27]

The practitioners of natural magic explain everything by the sympathies and antipathies of things. From idle and utterly lazy conjectures they have attributed wonderful virtues and operations

27 Aesop's fable of the farmer and his sons.

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sunt generis, ut ad admirationem et novitatem, non ad fructum et utilitatem, accommodata sint.

In superstitiosa autem magia (si et de hac dicendum sit) illud inprimis animadvertendum est, esse tantummodo certi cujusdam et definiti generis subjecta, in quibus artes curiosae et superstitiosae, per omnes nationes atque aetates atque etiam religiones, aliquid potuerint aut luserint. Itaque ista missa faciamus. Interim nil mirum est, si opinio copiae causam inopiae dederit.

1.86 Atque hominum admirationi, quoad doctrinas et artes, per se satis simplici et prope puerili, incrementum accessit ab eorum astu et artificio qui scientias tractaverunt et tradiderunt. Illi enim ea ambitione et affectatione eas proponunt, atque in eum modum efformatas ac veluti personatas in hominum conspectum producunt, ac si illae omni ex parte perfectae essent et ad exitum perductae. Si enim methodum aspicias et partitiones, illae prorsus omnia complecti et concludere videntur, quae in illud subjectum cadere possunt. Atque licet membra illa male impleta et veluti capsulae inanes sint; tamen apud intellectum vulgarem scientiae formam et rationem integrae prae se ferunt.

At primi et antiquissimi veritatis inquisitores, meliore fide et fato, cognitionem illam, quam ex rerum contemplatione decerpere, et in usum recondere statuebant, in *aphorismos*, sive breves easdemque sparsas nec methodo revinctas sententias, conjicere solebant; neque se artem universam complecti simulabant aut profitebantur. At eo quo nunc res agitur modo, minime mirum est, si homines in iis ulteriora non quaerant, quae pro perfectis et numeris suis jampridem absolutis traduntur.

1.87 Etiam antiqua magnum existimationis et fidei incrementum acceperunt ex eorum vanitate et levitate, qui nova proposuerunt; praesertim in philosophiae naturalis parte activa et operativa. Neque enim defuerunt homines vaniloqui et phantastici, qui partim ex credulitate, partim ex impostura, genus humanum promissis onerarunt: vitae prolongationem, senectutis retardationem, dolorum levationem, naturalium defectuum reparationem, sensuum deceptiones, affectuum ligationes et incitationes, intellectualium facultatum illuminationes et exaltationes, substantiarum transmutationes, et motuum ad libitum roborationes et

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to things. If they have ever produced works, those works are designed for wonder and novelty, not for fruit and use.

In superstitious magic, if we must speak of that too, one thing above all should be noticed. There are only certain definite kinds of subject in which the curious and superstitious arts have had any power, or played any tricks, among all nations and ages and even religions. So let us dismiss them. Meanwhile it is no wonder if the belief in plenty has been the cause of want.

People's admiration for learning and the arts is simple enough and almost childish in itself. But it has been increased by the craft and artifice of those who have handled and handed down the sciences. They set the sciences out with such ambition and affectation, and bring them before the public so shaped and, as it were, masked, that they seem perfect in every part and brought to completion. If you look at their method and divisions, they seem to embrace and include absolutely everything that can fall under the subject. The divisions are badly filled and are like empty boxes. Still, to the ordinary understanding they present the form and plan of a complete science.

The first and most ancient seekers of truth acted in better faith and with better fortune. They used to cast the knowledge they meant to gather from the contemplation of things and store up for use into *aphorisms*: short, scattered sentences not bound together by method. They did not pretend or profess to embrace a whole art. But as things are now done, it is no wonder if people seek nothing further in matters that are handed down as perfect and long since complete in every part.

Moreover, old doctrines have gained greatly in esteem and credit from the vanity and frivolity of those who have proposed new ones, especially in the active and operative part of natural philosophy. There has been no lack of boastful and fanciful people who, partly from credulity and partly from imposture, have loaded the human race with promises. They have promised and paraded the prolonging of life, the delay of old age, the relief of pain, the repair of natural defects, deceptions of the senses, the binding and stirring of the passions, the illumination and exaltation of

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multiplicationes, aeris impressiones et alterationes, coelestium influentiarum deductiones et procurationes, rerum futurarum divinationes, remotarum repraesentationes, occultarum revelationes, et alia complura pollicitando et ostentando.

Verum de istis largitoribus non multum aberraverit, qui istiusmodi judicium fecerit, tantum nimirum in doctrinis philosophiae inter horum vanitates et veras artes interesse, quantum inter res gestas Julii Caesaris, aut Alexandri Magni, et res gestas Amadicii ex Gallia, aut Arthuri ex Britannia, in historiae narrationibus intersit. Inveniuntur enim clarissimi illi imperatores revera majora gessisse, quam umbratiles isti heroes etiam fecisse fingantur; sed modis et viis scilicet actionum minime fabulosis et prodigiosis. Neque propterea aequum est verae memoriae fidem derogari, quod a fabulis illa quandoque laesa sit et violata. Sed interim minime mirum est, si propositionibus novis (praesertim cum mentione operum) magnum sit factum praejudicium per istos impostores, qui similia tentaverunt; cum vanitatis excessus et fastidium etiam nunc omnem in ejusmodi conatibus magnanimitatem destruxerit.

1.88 At longe majora a pusillanimitate, et pensorum, quae humana industria sibi proposuit, parvitate et tenuitate, detrimenta in scientias invecta sunt. Et tamen (quod pessimum est) pusillanimitas ista non sine arrogantia et fastidio se offert.

Primum enim, omnium artium illa reperitur cautela jam facta familiaris, ut in qualibet arte authores artis suae infirmitatem in naturae calumniam vertant; et quod ars ipsorum non assequitur, id ex eadem arte impossibile in natura pronunciant. Neque certe damnari potest ars, si ipsa judicet. Etiam philosophia, quae nunc in manibus est, in sinu suo posita quaedam fovet, aut placita, quibus (si diligentius inquiratur) hoc hominibus omnino persuaderi volunt; nil ab arte, vel hominis opere, arduum, aut in naturam imperiosum et validum, expectari debere; ut de heterogenia caloris astri et ignis, et mistione, superius dictum est.

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the intellectual faculties, the transmutation of substances, the strengthening and multiplying of motions at will, impressions and alterations of the air, the drawing down and procuring of celestial influences, the divination of future things, the representation of distant things, the revelation of hidden things, and a great many more.

About these generous promisers, one would not be far wrong to judge as follows. In philosophy, their vanities differ from the true arts as much as, in historical narrative, the deeds of Julius Caesar or Alexander the Great differ from the deeds of Amadis of Gaul or Arthur of Britain. For those famous commanders are found to have actually done greater things than these shadowy heroes are even imagined to have done, but by ways and means of action that are anything but fabulous and prodigious. Nor is it fair to deny credit to true history because it is sometimes damaged and violated by fables. Meanwhile, though, it is no wonder that impostors who attempted similar things have created great prejudice against new proposals, especially when works are mentioned. The excess of their vanity, and the disgust it produced, have even now destroyed all greatness of spirit in undertakings of this kind.[28]

Far greater harm has been done to the sciences by faintheartedness, and by the smallness and slightness of the tasks that human industry has set itself. And yet, worst of all, this faintheartedness comes with arrogance and disdain.

First, a certain precaution has become familiar in all the arts. In every art, its authors turn the weakness of their art into a slander on nature. What their art cannot achieve, they pronounce, on the authority of that same art, to be impossible in nature. And certainly an art cannot be condemned if it is its own judge. Even the philosophy now current cherishes in its bosom certain positions or tenets. If one looks into it more carefully, their aim is to convince people utterly that nothing difficult, nothing commanding and powerful over nature, should be expected from art or human work. We have mentioned this above, regarding the difference in kind between the heat of the sun and of fire, and regarding mixture.

28 Amadis of Gaul, hero of the early sixteenth-century Spanish chivalric romance *Amadís de Gaula*.

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Quae si notentur accuratius, omnino pertinent ad humanae potestatis circumscriptionem malitiosam, et ad quaesitam et artificiosam desperationem, quae non solum spei auguria turbet, sed etiam omnes industriae stimulos et nervos incidat, atque ipsius experientiae aleas abjiciat; dum de hoc tantum solliciti sint, ut ars eorum perfecta censeatur; gloriae vanissimae et perditissimae dantes operam, scilicet ut quicquid adhuc inventum et comprehensum non sit, id omnino nec inveniri, nec comprehendi posse in futurum credatur.

At si quis rebus addere se et novum aliquid reperire conetur, ille tamen omnino sibi proponet et destinabit unum aliquod inventum (nec ultra) perscrutari et eruere; ut magnetis naturam, maris fluxum et refluxum, thema coeli, et hujusmodi, quae secreti aliquid habere videntur, et hactenus parum feliciter tractata sint: quum summae sit imperitiae, rei alicujus naturam in se ipsa perscrutari; quandoquidem eadem natura, quae in aliis videtur latens et occulta, in aliis manifesta sit et quasi palpabilis, atque in illis admirationem, in his ne attentionem quidem moveat; ut fit in natura consistentiae, quae in ligno vel lapide non notatur, sed solidi appellatione transmittitur, neque amplius de fuga separationis aut solutionis continuitatis inquiritur; at in aquarum bullis eadem res videtur subtilis et ingeniosa; quae bullae se conjiciunt in pelliculas quasdam, in hemisphaerii formam curiose effictas, ut ad momentum temporis evitetur solutio continuitatis.

Atque prorsus illa ipsa, quae habentur pro secretis, in aliis habent naturam manifestam et communem; quae nunquam se dabit conspiciendam, si hominum experimenta aut contemplationes in illis ipsis tantum versentur. Generaliter autem et vulgo, in operibus mechanicis habentur pro novis inventis, si quis jampridem inventa subtilius poliat, vel ornet elegantius, vel simul uniat et componat, vel cum usu commodius copulet, aut opus majore, aut etiam minore, quam fieri consuevit, mole vel volumine exhibeat, et similia.

Itaque minime mirum est, si nobilia et genere humano digna inventa in lucem extracta non sint, quum homines hujusmodi exiguis pensis et puerilibus contenti et

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Looked at more closely, these tenets all amount to a malicious limiting of human power and a deliberate, contrived despair. Such despair not only confounds the omens of hope, but also cuts all the spurs and sinews of industry and throws away the dice of experience itself. Their only concern is that their art be thought perfect. They devote themselves to the emptiest and most ruinous kind of glory: that whatever has not yet been discovered and understood should be believed impossible ever to be discovered or understood in future.

And if someone does try to add to things and find something new, he will still set himself to investigate and dig out some single discovery, and no more. He may choose the nature of the magnet, the ebb and flow of the sea, the scheme of the heavens, and things of that kind, which seem to hold some secret and have so far been handled with little success. Yet it is the height of unskillfulness to investigate the nature of a thing in the thing itself. The same nature that seems latent and hidden in some things is manifest and almost palpable in others. In the first it arouses wonder; in the second, not even attention. This happens with the nature of consistency. It is not noticed in wood or stone but passed over under the name of solidity, and no one inquires further into how these bodies avoid separation or the breaking of their continuity. Yet in bubbles of water the same thing seems subtle and ingenious. The bubbles form themselves into thin films, curiously shaped into a hemisphere, so that for a moment the breaking of continuity is avoided.

In fact, the very things that are held to be secrets have, in other things, a nature that is plain and common. That nature will never let itself be seen if people confine their experiments or reflections to those things alone. Generally and commonly, however, in mechanical works people count it a new invention if someone polishes more finely what was invented long ago, or decorates it more elegantly, or joins and combines things, or links them more conveniently with use, or produces the work on a larger, or even a smaller, mass or volume than usual, and the like.

So it is not at all surprising that noble inventions, worthy of the human race, have not been brought to light. People have been content with, and de-

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	delectati fuerint; quinetiam in iisdem se magnum aliquod sequutos, aut assequutos putaverint.	lighted by, such small and childish tasks, and have even thought that in them they were pursuing, or achieving, something great.

SUPERSTITION AND THE SCHOOLS

Religious zeal, university routine and the lack of rewards have hindered the progress of the sciences.

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1.89	Neque illud praetermittendum est, quod nacta sit philosophia naturalis per omnes aetates adversarium molestum et difficilem; superstitionem nimirum, et zelum religionis caecum et immoderatum. Etenim videre est apud Graecos, eos, qui primum causas naturales fulminis et tempestatum insuetis adhuc hominum auribus proposuerunt, impietatis in deos eo nomine damnatos: nec multo melius a nonnullis antiquorum patrum religionis Christianae exceptos fuisse eos, qui ex certissimis demonstrationibus (quibus nemo hodie sanus contradixerit) terram rotundam esse posuerunt, atque ex consequenti antipodas esse asseruerunt.	Nor should we pass over the fact that natural philosophy has, in every age, had a troublesome and difficult adversary: superstition, and blind and immoderate religious zeal. Among the Greeks, we can see that those who first put forward natural causes for lightning and storms, to ears not yet used to them, were condemned on that account for impiety toward the gods. Nor were those much better received by some of the ancient fathers of the Christian religion who, on the strength of the most certain demonstrations (which no sane person would contradict today), maintained that the earth is round and consequently asserted that there are antipodes.[29]
	Quinetiam, ut nunc sunt res, conditio sermonum de natura facta est durior et magis cum periculo, propter theologorum scholasticorum summas et methodos; qui cum theologiam (satis pro potestate) in ordinem redegerint, et in artis formam effinxerint, hoc insuper effecerunt, ut pugnax et spinosa Aristotelis philosophia corpori religionis, plus quam par erat, immisceretur.	Moreover, as things now stand, the conditions for discussing nature have become harsher and more dangerous because of the *summae* and methods of the scholastic theologians. They reduced theology to order (as far as they could) and shaped it into the form of an art. On top of this, they brought it about that the contentious and thorny philosophy of Aristotle was mixed into the body of religion more than was fitting.
	Eodem etiam spectant (licet diverso modo) eorum commentationes, qui veritatem Christianae religionis ex principiis et authoritatibus philosophorum deducere et confirmare haud veriti sunt; fidei et sensus conjugium tanquam legitimum multa pompa et solennitate celebrantes, et grata rerum varietate animos hominum permulcentes; sed interim divina humanis, impari conditione, permiscentes. At in hujusmodi misturis theologiae cum philosophia, ea tantum, quae nunc in philosophia recepta sunt, comprehenduntur; sed nova, licet in melius mutata, tantum non summoventur et exterminantur.	The same end is served too, though in a different way, by the writings of those who have not hesitated to derive and confirm the truth of the Christian religion from the principles and authorities of philosophers. With great pomp and ceremony they celebrate the marriage of faith and the senses as though it were lawful, and they soothe people's minds with a pleasing variety of material. But meanwhile they mix the divine with the human on unequal terms. In such mixtures of theology with philosophy, moreover, only what is currently accepted in philosophy is taken in. New things, even changes for the better, are all but banished and driven out.

29 Bacon probably has in mind Anaxagoras, prosecuted at Athens for impiety, and the Church Fathers Lactantius and Augustine, who rejected the antipodes (people living on the opposite side of the globe).

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Denique invenias, ex quorundam theologorum imperitia, aditum alicui philosophiae, quamvis emendatae, pene interclusum esse. Alii siquidem simplicius subverentur, ne forte altior in naturam inquisitio ultra concessum sobrietatis terminum penetret; traducentes et perperam torquentes ea, quae de divinis mysteriis in Scripturis sacris adversus rimantes secreta divina dicuntur, ad occulta naturae, quae nullo interdicto prohibentur. Alii callidius conjiciunt et animo versant, si media ignorentur, singula ad manum et virgulam divinam (quod religionis, ut putant, maxime intersit) facilius posse referri: quod nihil aliud est, quam *Deo per mendacium gratificari* velle. Alii ab exemplo metuunt, ne motus et mutationes circa philosophiam in religionem incurrant ac desinant. Alii denique solliciti videntur, ne in naturae inquisitione aliquid inveniri possit, quod religionem (praesertim apud indoctos) subvertat, aut saltem labefactet.

At isti duo posteriores metus nobis videntur omnino sapientiam animalem sapere; ac si homines, in mentis suae recessibus et secretis cogitationibus de firmitudine religionis, et fidei in sensum imperio diffiderent ac dubitarent; et propterea ab inquisitione veritatis in naturalibus periculum illis impendere metuerent. At vere rem reputanti, philosophia naturalis, post verbum Dei, certissima superstitionis medicina est; eademque probatissimum fidei alimentum. Itaque merito religioni donatur tanquam fidissima ancilla: cum altera voluntatem Dei, altera potestatem manifestet. Neque enim erravit Ille, qui dixit; *erratis, nescientes Scripturas et potestatem Dei*: informationem de voluntate et meditationem de potestate nexu individuo commiscens et copulans.

Interim minus mirum est, si naturalis philosophiae incrementa cohibita sint; cum religio, quae plurimum apud animos hominum pollet, per quorundam imperitiam et zelum incautum in partem contrariam transierit et abrepta fuerit.

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Lastly, you will find that, through the ignorance of certain theologians, access to any philosophy, however improved, has been almost shut off. Some, in their simplicity, fear that too deep an inquiry into nature might go beyond the permitted limit of sobriety. They twist and misapply what the sacred Scriptures say about divine mysteries, against those who pry into the secrets of God, to the hidden things of nature, which no prohibition forbids. Others more cunningly reason and reflect that if intermediate causes are unknown, each single thing can more easily be referred to the hand and rod of God, which, they think, is of the greatest importance to religion. This is nothing other than wanting *to please God by a lie*. Others fear from precedent that movements and changes in philosophy will spill over into religion and end up there. Others, finally, seem anxious that something might be discovered in the inquiry into nature that would overturn religion, or at least unsettle it, especially among the unlearned.[30]

But these last two fears seem to us to smack entirely of a merely animal wisdom. It is as if people, in the recesses of their minds and in their secret thoughts, distrusted and doubted the firmness of religion and the rule of faith over the senses, and therefore feared that the search for truth in natural things threatened them with danger. But to anyone who considers the matter truly, natural philosophy is, after the word of God, the surest remedy for superstition, and also the most approved nourishment of faith. So it is rightly given to religion as her most faithful handmaid, since the one manifests the will of God, the other his power. For He did not err who said, *You err, not knowing the Scriptures and the power of God*, thereby joining and binding together, in an unbreakable bond, instruction about God's will and meditation on his power.[31]

Meanwhile it is less surprising that the growth of natural philosophy has been held back, since religion, which has the greatest power over people's minds, has through the ignorance and incautious zeal of some been carried over and swept away to the opposing side.

30 "To please God by a lie" alludes to Job 13:7.
31 "Animal wisdom" echoes the Vulgate of James 3:15, meaning unspiritual, worldly wisdom; the quotation is Christ's saying in Matthew 22:29.

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1.90 Rursus in moribus et institutis scholarum, academiarum, collegiorum, et similium conventuum, quae doctorum hominum sedibus et eruditionis culturae destinata sunt, omnia progressui scientiarum adversa inveniuntur. Lectiones enim et exercitia ita sunt disposita, ut aliud a consuetis haud facile cuiquam in mentem veniat cogitare aut contemplari. Si vero unus aut alter fortasse judicii libertate uti sustinuerit, is sibi soli hanc operam imponere possit; ab aliorum autem consortio nihil capiet utilitatis. Sin et hoc toleraverit, tamen in capessenda fortuna industriam hanc et magnanimitatem sibi non levi impedimento fore experietur. Studia enim hominum in ejusmodi locis in quorundam authorum scripta, veluti in carceres, conclusa sunt; a quibus si quis dissentiat, continuo ut homo turbidus et rerum novarum cupidus corripitur.

Again, in the customs and institutions of schools, academies, colleges and similar bodies intended as homes for learned men and for the cultivation of learning, everything is found to work against the progress of the sciences. The lectures and exercises are so arranged that it would not easily occur to anyone to think or reflect on anything outside the usual. If one or two perhaps venture to use freedom of judgment, they must take the labor on themselves alone; they will get no benefit from the company of others. And if they put up with this too, they will find that their industry and largeness of mind are no slight obstacle to making their fortune. For in such places people's studies are shut up in the writings of certain authors, as if in prisons; and anyone who disagrees with them is at once attacked as a troublemaker and a seeker after novelty.

At magnum certe discrimen inter res civiles et artes: non enim idem periculum a novo motu et a nova luce. Verum in rebus civilibus mutatio etiam in melius suspecta est ob perturbationem; cum civilia authoritate, consensu, fama, et opinione, non demonstratione, nitantur. In artibus autem et scientiis, tanquam in metalli fodinis, omnia novis operibus et ulterioribus progressibus circumstrepere debent. Atque secundum rectam rationem res ita se habet, sed interim non ita vivitur: sed ista, quam diximus, doctrinarum administratio et politia scientiarum augmenta durius premere consuevit.

Yet there is surely a great difference between civil affairs and the arts, for the danger from a new movement is not the same as the danger from a new light. In civil affairs, even change for the better is suspect because of the disturbance it causes, since civil affairs rest on authority, consent, reputation and opinion, not on demonstration. But in the arts and sciences, as in mines, everything should resound with new works and further advances. That is how things stand according to right reason; but meanwhile it is not how people live. Instead, the administration and government of learning we have described usually weighs heavily on the growth of the sciences.

1.91 Atque insuper licet ista invidia cessaverit; tamen satis est ad cohibendum augmentum scientiarum, quod hujusmodi conatus et industriae praemiis careant. Non enim penes eosdem est cultura scientiarum et praemium. Scientiarum enim augmenta a magnis utique ingeniis proveniunt; at pretia et praemia scientiarum sunt penes vulgus aut principes viros, qui (nisi raro admodum) vix mediocriter docti sunt. Quinetiam hujusmodi progressus non solum praemiis et beneficentia hominum, verum etiam ipsa populari laude destituti sunt. Sunt enim illi supra captum maximae partis hominum, et ab opinionum vulgarium ventis facile obruuntur et extinguuntur. Itaque nil mirum, si res illa non foeliciter successerit, quae in honore non fuit.

Moreover, even if this ill will were to cease, it is enough to check the growth of the sciences that such efforts and labors go unrewarded. For the cultivation of the sciences and their reward are not in the same hands. The growth of the sciences comes, certainly, from great minds; but the prizes and rewards of the sciences lie with the common people or with great men, who (except very rarely) are scarcely even moderately learned. Indeed, such advances lack not only the rewards and generosity of men but even popular praise itself. For they are above the grasp of most people, and are easily overwhelmed and extinguished by the winds of common opinion. So it is no wonder if a thing that was not held in honor has not prospered.

GROUNDS FOR HOPE

Bacon turns from despair to hope, beginning with providence and the lesson that past failure came from wrong methods.

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1.92	Sed longe maximum progressibus scientiarum, et novis pensis ac provinciis in iisdem suscipiendis, obstaculum deprehenditur in desperatione hominum, et suppositione impossibilis. Solent enim viri prudentes et severi in hujusmodi rebus plane diffidere: naturae obscuritatem, vitae brevitatem, sensuum fallacias, judicii infirmitatem, experimentorum difficultates, et similia secum reputantes. Itaque existimant, esse quosdam scientiarum, per temporum et aetatum mundi revolutiones, fluxus et refluxus; cum aliis temporibus crescant et floreant, aliis declinent et jaceant: ita tamen, ut cum ad certum quendam gradum et statum pervenerint, nil ulterius possint.	But by far the greatest obstacle to the progress of the sciences, and to undertaking new tasks and provinces within them, is found in people's despair and in the assumption that the thing is impossible. Prudent and serious men tend to be thoroughly distrustful in such matters, reflecting on the obscurity of nature, the shortness of life, the deceptions of the senses, the weakness of judgment, the difficulties of experiment, and the like. So they think that, through the revolutions of time and the ages of the world, the sciences have their ebbs and flows: at some times they grow and flourish, at others they decline and lie low; yet in such a way that once they have reached a certain degree and state, they can go no further.
	Itaque si quis majora credat aut spondeat, id putant esse cujusdam impotentis et immaturi animi; atque hujusmodi conatus initia scilicet laeta, media ardua, extrema confusa habere. Atque cum hujusmodi cogitationes eae sint, quae in viros graves et judicio praestantes facile cadant, curandum revera est, ne rei optimae et pulcherrimae amore capti severitatem judicii relaxemus, aut minuamus; et sedulo videndum, quid spei affulgeat, et ex qua parte se ostendat; atque auris levioribus spei rejectis, eae, quae plus firmitudinis habere videntur, omnino discutiendae sunt et pensitandae. Quinetiam prudentia civilis ad consilium vocanda est et adhibenda, quae ex praescripto diffidit, et de rebus humanis in deterius conjicit.	So if anyone believes or promises greater things, they take it as the mark of an uncontrolled and immature mind, and hold that such attempts have happy beginnings, difficult middles and confused ends. Since these are thoughts that easily occur to serious men of outstanding judgment, we must truly take care not to be so captivated by love of a most excellent and beautiful thing that we relax or weaken the strictness of our judgment. We must look carefully at what hope is shining out, and from what quarter it shows itself. Rejecting the lighter breezes of hope, we must thoroughly discuss and weigh those that seem to have more substance. Indeed, we must call in political prudence as well and take its advice, for it distrusts as a rule and assumes the worse in human affairs.
	Itaque jam et de spe dicendum est; praesertim cum nos promissores non simus, nec vim aut insidias hominum judiciis faciamus aut struamus, sed homines manu et sponte ducamus. Atque licet longe potentissimum futurum sit remedium ad spem imprimendam, quando homines ad particularia, praesertim in tabulis nostris inveniendi digesta et disposita (quae partim ad secundam, sed multo magis ad quartam *Instaurationis* nostrae partem pertinent), adducemus; cum hoc ipsum sit non spes tantum, sed tanquam res ipsa: tamen ut omnia clementius fiant, pergendum est in instituto nostro de praeparandis hominum mentibus; cujus praeparationis ista ostensio spei pars est non exigua.	So now we must also speak of hope, especially since we are not makers of promises, nor do we use force or lay traps for people's judgments, but lead them by the hand, of their own free will. By far the most powerful remedy for instilling hope will be to bring people to particulars, especially as digested and arranged in our tables of discovery (which belong partly to the second, but much more to the fourth part of our *Renewal*), since this is not just hope but, as it were, the thing itself. Yet so that everything may be done more gently, we must go on with our plan of preparing people's

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minds; and this display of grounds for hope is no small part of that preparation.

Nam absque ea, reliqua faciunt magis ad contristationem hominum (scilicet, ut deteriorem et viliorem habeant de iis, quae jam in usu sunt, opinionem, quam nunc habent, et suae conditionis infortunium plus sentiant et pernoscant), quam ad alacritatem aliquam inducendam, aut industriam experiendi acuendam. Itaque conjecturae nostrae, quae spem in hac re faciunt probabilem, aperiendae sunt et proponendae: sicut Columbus fecit, ante navigationem illam suam mirabilem maris Atlantici: cum rationes adduxerit, cur ipse novas terras et continentes praeter eas, quae ante cognitae fuerunt, inveniri posse confideret: quae rationes, licet primo rejectae, postea tamen experimento probatae sunt, et rerum maximarum causae et initia fuerunt.

For without it, the rest tends more to sadden people than to inspire any eagerness or sharpen their energy for experiment. It would make them think worse and less of what is now in use than they do now, and feel and recognize more fully the misfortune of their condition. So our conjectures, which make hope in this matter reasonable, must be laid open and set out. Columbus did the same before his wonderful voyage across the Atlantic, when he gave reasons why he was confident that new lands and continents could be found beyond those already known. Those reasons, though rejected at first, were later proved by experiment, and became the causes and beginnings of very great things.

1.93 Principium autem sumendum a Deo: hoc nimirum quod agitur, propter excellentem in ipso boni naturam, manifeste a Deo esse, qui author boni, et pater luminum est. In operationibus autem divinis, initia quaeque tenuissima exitum certo trahunt. Atque quod de spiritualibus dictum est, *Regnum Dei non venit cum observatione*, id etiam in omni majore opere Providentiae evenire reperitur; ut omnia sine strepitu et sonitu placide labantur, atque res plane agatur priusquam homines eam agi putent aut advertant. Neque omittenda est prophetia Danielis de ultimis mundi temporibus; *Multi pertransibunt, et multiplex erit scientia*: manifeste innuens et significans, esse in fatis, id est, in Providentia, ut pertransitus mundi (qui per tot longinquas navigationes impletus plane aut jam in opere esse videtur) et augmenta scientiarum in eandem aetatem incidant.

We must begin from God. This work of ours, because of the excellent nature of the good in it, is plainly from God, who is the author of good and the Father of lights. In divine operations, even the smallest beginnings unfailingly lead to their end. And what was said of spiritual things, *The kingdom of God comes not with observation*, is also found to happen in every greater work of Providence: everything glides along quietly, without noise or clamor, and the thing is fully done before people think or notice that it is being done. Nor should we omit Daniel's prophecy about the last times of the world, *Many shall pass through, and knowledge shall be manifold*. This plainly hints and signifies that it is fated, that is, ordained by Providence, that the passage through the world (which seems already accomplished, or at least under way, through so many distant voyages) and the growth of the sciences should fall in the same age.[32]

1.94 Sequitur ratio omnium maxima ad faciendam spem; nempe ex erroribus temporis praeteriti et viarum adhuc tentatarum. Optima enim est ea reprehensio, quam de statu civili haud prudenter administrato quispiam his verbis complexus est: *Quod ad praeterita pessimum est, id ad futura optimum videri debet. Si enim vos omnia, quae ad officium vestrum spectant, praestitissetis, neque tamen res vestrae in meliore loco essent; ne spes quidem ulla reliqua foret, eas in melius provehi posse.*

There follows the strongest ground of all for hope: namely, the errors of past time and of the ways tried so far. Excellent is the reproof that someone once put into these words about a state that was not wisely governed: *What is worst as regards the past should seem best as regards the future. For if you had done everything your duty required and your affairs were still in no better position, there would not be any hope left that they could be improved.*[33]

32 The allusions are to James 1:17, Luke 17:20 and Daniel 12:4 (Vulgate); Bacon used the Daniel verse as the motto of the *Instauratio Magna*.

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	Sed cum rerum vestrarum status, non a vi ipsa rerum, sed ab erroribus vestris male se habeat; sperandum est, illis erroribus missis aut correctis, magnam rerum in melius mutationem fieri posse. Simili modo, si homines per tanta annorum spatia viam veram inveniendi et colendi scientias tenuissent, nec tamen ulterius progredi potuissent; audax proculdubio et temeraria foret opinio, posse rem in ulterius provehi. Quod si in via ipsa erratum sit, atque hominum opera in iis consumpta, in quibus minime oportebat; sequitur ex eo, non in rebus ipsis difficultatem oriri, quae potestatis nostrae non sunt, sed in intellectu humano ejusque usu et applicatione; quae res remedium et medicinam suscipit.	*But since the state of your affairs is bad, not through the force of circumstances but through your own errors, there is hope that, once those errors are abandoned or corrected, a great change for the better can be made.* In the same way, if people had held to the true way of discovering and cultivating the sciences for so many years and still had been unable to advance further, it would doubtless be a bold and rash opinion that the matter could be carried further. But if the error lies in the way itself, and people's labor has been spent where it was least needed, it follows that the difficulty arises not in things themselves, which are not in our power, but in the human understanding and in how it is used and applied. And that admits of remedy and cure.
	Itaque optimum fuerit illos ipsos errores proponere: quot enim fuerint errorum impedimenta in praeterito, tot sunt spei argumenta in futurum. Ea vero licet in his, quae superius dicta sunt, non intacta omnino fuerint; tamen ea etiam nunc breviter, verbis nudis ac simplicibus, repraesentare visum est.	So it will be best to set out those very errors: for as many as were the obstacles of error in the past, so many are the arguments for hope in the future. Although they have not been left wholly untouched in what was said above, we have decided to present them again now, briefly, in bare and simple words.
1.95	Qui tractaverunt scientias aut empirici aut dogmatici fuerunt. Empirici, formicae more, congerunt tantum, et utuntur: rationales, aranearum more, telas ex se conficiunt: apis vero ratio media est, quae materiam ex floribus horti et agri elicit; sed tamen eam propria facultate vertit et digerit. Neque absimile philosophiae verum opificium est; quod nec mentis viribus tantum aut praecipue nititur, neque ex historia naturali et mechanicis experimentis praebitam materiam, in memoria integram, sed in intellectu mutatam et subactam, reponit. Itaque ex harum facultatum (experimentalis scilicet et rationalis) arctiore et sanctiore foedere (quod adhuc factum non est) bene sperandum est.	Those who have dealt with the sciences have been either empirics or dogmatists. The empirics, like ants, merely collect and use; the rationalists, like spiders, spin webs out of themselves. The bee takes a middle course: it draws its material from the flowers of the garden and the field, but then transforms and digests it by a power of its own. The true work of philosophy is not unlike this. It does not rely solely or chiefly on the powers of the mind, nor does it take the material supplied by natural history and mechanical experiments and store it unaltered in the memory; it lays it up in the understanding, changed and worked over. So much is to be hoped from a closer and holier alliance of these faculties, the experimental and the rational, such as has not yet been made.
1.96	Naturalis philosophia adhuc sincera non invenitur, sed infecta et corrupta: in Aristotelis schola, per logicam, in Platonis schola, per theologiam naturalem; in secunda schola Platonis, Procli, et aliorum, per mathematicam; quae philosophiam naturalem terminare, non generare aut procreare debet. At ex philosophia naturali pura et impermista meliora speranda sunt.	Natural philosophy has not yet been found pure, but infected and corrupted: in the school of Aristotle by logic; in the school of Plato by natural theology; in the second school of Plato, that of Proclus and others, by mathematics, which ought to set bounds to natural philosophy, not generate or beget it. But better things are to be hoped from a natural philosophy that is pure and unmixed.[34]

33 The speaker is Demosthenes, *First Philippic* 2.

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1.97	Nemo adhuc tanta mentis constantia et rigore inventus est, ut decreverit et sibi imposuerit theorias et notiones communes penitus abolere, et intellectum abrasum et aequum ad particularia de integro applicare. Itaque ratio illa humana, quam habemus, ex multa fide, et multo etiam casu, nec non ex puerilibus, quas primo hausimus, notionibus, farrago quaedam est et congeries.	No one has yet been found with such constancy and rigor of mind as to resolve and require of himself to abolish theories and common notions entirely, and to apply the understanding, scraped clean and level, to particulars afresh. So the human reason we have is a kind of hodgepodge and jumble, made up of much credulity and much chance, as well as of the childish notions we first absorbed.
	Quod si quis aetate matura, et sensibus integris, et mente repurgata, se ad experientiam et ad particularia de integro applicet, de eo melius sperandum est. Atque hac in parte nobis spondemus fortunam Alexandri Magni: neque quis nos vanitatis arguat, antequam exitum rei audiat, quae ad exuendam omnem vanitatem spectat.	But if someone of mature age, with sound senses and a purged mind, applies himself afresh to experience and to particulars, better things may be hoped of him. In this respect we promise ourselves the fortune of Alexander the Great. And let no one accuse us of vanity before hearing the outcome of a matter whose whole aim is to strip away all vanity.
	Etenim de Alexandro et ejus rebus gestis Aeschines ita loquutus est: *Nos certe vitam mortalem non vivimus; sed in hoc nati sumus, ut posteritas de nobis portenta narret et praedicet:* perinde ac si Alexandri res gestas pro miraculo habuisset.	For Aeschines spoke of Alexander and his deeds like this: *Surely we do not live a mortal life; we were born so that posterity might tell and proclaim marvels about us*—as if he had taken Alexander's deeds for a miracle.[35]
	At aevis sequentibus Titus Livius melius rem advertit et introspexit, atque de Alexandro hujusmodi quippiam dixit: *Eum non aliud quam bene ausum vana contemnere.* Atque simile etiam de nobis judicium futuris temporibus factum iri existimamus: *Nos nil magni fecisse; sed tantum ea, quae pro magnis habentur, minoris fecisse.* Sed interim (quod jam diximus) non est spes nisi in *regeneratione* scientiarum; ut eae scilicet ab experientia certo ordine excitentur et rursus condantur: quod adhuc factum esse aut cogitatum nemo (ut arbitramur) affirmaverit.	But in later ages Livy noticed and saw into the matter better, and said something like this of Alexander: *that he had simply had the courage to despise empty things*. We think a similar judgment will be made of us in times to come: *that we did nothing great, but only made little of what passes for great*. Meanwhile, as we have already said, there is no hope except in a *regeneration* of the sciences: that is, that they be raised up from experience in a fixed order and founded anew. No one, we believe, will claim that this has yet been done or even thought of.[36]

A BETTER FOUNDATION

Hope lies in fuller natural history, written records of experiment, a true ladder of axioms and new induction.

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1.98	Atque experientiae fundamenta (quando ad hanc omnino deveniendum est) aut nulla, aut admodum infirma adhuc fuerunt; nec particularium sylva et materies, vel numero, vel genere, vel certitudine, informando intellectui	The foundations of experience (since that is where we must in the end turn) have so far been either nonexistent or very weak. No stock and material of particulars fit or in any way sufficient, in num-

34 Proclus (AD 412–485), Neoplatonist philosopher and head of the Platonic school at Athens.
35 Aeschines (c. 390–c. 315 BC), Athenian orator; the words are from his speech *Against Ctesiphon* (132).
36 Livy (59 BC–AD 17), Roman historian; the passage is *History of Rome* 9.17.16.

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competens, aut ullo modo sufficiens, adhuc quaesita est et congesta. Sed contra homines docti (supini sane et faciles) rumores quosdam experientiae, et quasi famas et auras ejus, ad philosophiam suam vel constituendam vel confirmandam exceperunt, atque illis nihilominus pondus legitimi testimonii attribuerunt. Ac veluti si regnum aliquod aut status non ex literis et relationibus a legatis et nuntiis fide dignis missis, sed ex urbanorum sermunculis et ex triviis consilia sua et negotia gubernaret; omnino talis in philosophiam administratio, quatenus ad experientiam, introducta est.

Nil debitis modis exquisitum, nil verificatum, nil numeratum, nil appensum, nil dimensum in naturali historia reperitur. At quod in observatione indefinitum et vagum, id in informatione fallax et infidum est. Quod si cui haec mira dictu videantur, et querelae minus justae propiora, cum Aristoteles tantus ipse vir, et tanti regis opibus subnixus, tam accuratam *de animalibus* historiam confecerit, atque alii nonnulli majore diligentia (licet strepitu minore) multa adjecerint, et rursus alii de plantis, de metallis, et fossilibus, historias et narrationes copiosas conscripserint; is sane non satis attendere et perspicere videtur, quid agatur in praesentia. Alia enim est ratio naturalis historiae, quae propter se confecta est; alia ejus, quae collecta est ad informandum intellectum in ordine ad condendam philosophiam.

Atque hae duae historiae tum aliis rebus, tum praecipue in hoc differunt; quod prima ex illis specierum naturalium varietatem, non artium mechanicarum experimenta contineat. Quemadmodum enim in civilibus ingenium cujusque, et occultus animi affectuumque sensus, melius elicitur, cum quis in perturbatione ponitur, quam alias: simili modo, et occulta naturae magis se produnt per vexationes artium, quam cum cursu suo meant. Itaque tum demum bene sperandum est de naturali philosophia, postquam historia naturalis (quae ejus basis est et fundamentum) melius instructa fuerit; antea vero minime.

1.99 Atque rursus in ipsa experimentorum mechanicorum copia, summa eorum, quae ad intellectus informationem

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ber, kind or certainty, to inform the understanding has yet been sought out and collected. Instead, learned men—lazy, certainly, and easily satisfied—have taken up mere rumors of experience, its hearsay and whispers, to build or confirm their philosophy, and have nonetheless given them the weight of legitimate testimony. It is as if some kingdom or state were to direct its counsels and business not by letters and reports from trustworthy ambassadors and messengers, but by the gossip of townsfolk and the talk of the streets. That is exactly the kind of administration that has been brought into philosophy, as far as experience is concerned.

Nothing is found in natural history that has been duly investigated, verified, counted, weighed or measured. But what is indefinite and vague in observation is deceptive and unreliable in information. Someone may find this strange to hear, and closer to an unjust complaint, since Aristotle, so great a man himself and backed by the wealth of so great a king, produced so exact a history *of animals*; since some others have added much to it with greater diligence (if with less noise); and since others again have written copious histories and accounts of plants, metals and minerals. But such a person does not seem to attend closely enough, or to see what is at issue here. For a natural history made for its own sake is one thing; a natural history collected to inform the understanding, with a view to building philosophy, is another.[37]

These two kinds of history differ in other ways too, but chiefly in this: the first contains the variety of natural species, not the experiments of the mechanical arts. In civil life, a person's character and the hidden feelings of his mind and passions are better drawn out when he is put under stress than at other times. In the same way, the secrets of nature reveal themselves more under the harassment of the arts than when they go their own way. So good hope for natural philosophy may be entertained only when natural history, which is its basis and foundation, has been better equipped; before then, not at all.

Again, in the very abundance of mechanical experiments there is found a great scarcity of those

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maxime faciunt et juvant, detegitur inopia. Mechanicus enim, de veritatis inquisitione nullo modo sollicitus, non ad alia quam quae operi suo subserviunt aut animum erigit aut manum porrigit. Tum vero de scientiarum ulteriore progressu spes bene fundabitur, quum in Historiam Naturalem recipientur et aggregabuntur complura experimenta, quae in se nullius sunt usus, sed ad inventionem causarum et axiomatum tantum faciunt; quae nos *lucifera* experimenta, ad differentiam *fructiferorum*, appellare consuevimus. Illa autem miram habent in se virtutem et conditionem; hanc videlicet, quod nunquam fallant aut frustrentur. Cum enim ad hoc adhibeantur, non ut opus aliquod efficiant sed ut causam naturalem in aliquo revelent, quaquaversum cadunt, intentioni aeque satisfaciunt; cum quaestionem terminent.

1.100 At non solum copia major experimentorum quaerenda est et procuranda, atque etiam alterius generis, quam adhuc factum est; sed etiam methodus plane alia et ordo et processus continuandae et provehendae Experientiae introducenda. Vaga enim Experientia et se tantum sequens (ut superius dictum est) mera palpatio est, et homines potius stupefacit quam informat. At cum Experientia lege certa procedet, seriatim et continenter, de scientiis aliquid melius sperari poterit.

1.101 Postquam vero copia et materies Historiae Naturalis et Experientiae, talis qualis ad opus intellectus sive ad opus philosophicum requiritur, praesto jam sit et parata; tamen nullo modo sufficit intellectus, ut in illam materiem agat sponte et memoriter; non magis, quam si quis computationem alicujus ephemeridis memoriter se tenere et superare posse speret. Atque hactenus tamen potiores meditationis partes quam scriptionis in inveniendo fuerunt; neque adhuc Experientia literata facta est: atqui nulla nisi de scripto inventio probanda est. Illa vero in usum veniente, ab Experientia facta demum literata melius sperandum.

1.102 Atque insuper cum tantus sit particularium numerus et quasi exercitus, isque ita sparsus et diffusus, ut

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that do most to help and inform the understanding. The mechanic, not in the least concerned with inquiring into truth, neither lifts his mind nor stretches out his hand to anything except what serves his own work. But hope for the further progress of the sciences will be well founded when natural history takes in and gathers a great many experiments that are of no use in themselves but serve only for discovering causes and axioms. These we usually call experiments *of light*, to distinguish them from experiments *of fruit*. They have a wonderful property and character: they never deceive or disappoint. For since they are used not to produce some work but to reveal a natural cause in something, whichever way they turn out they serve the purpose equally well, since they settle the question.

But we must seek out and procure not only a greater supply of experiments, and of a different kind from those made so far; we must also introduce an entirely different method, order and process for continuing and advancing experience. For experience that wanders and follows only itself (as was said above) is mere groping, and stupefies people rather than informs them. But when experience proceeds by a fixed law, in series and without interruption, something better may be hoped for the sciences.

But even when a supply and material of natural history and experience such as the work of the understanding, or philosophical work, requires is at hand and ready, the understanding is still by no means adequate to act on that material spontaneously and from memory. It is no more able to do so than someone who hoped to hold in memory and work through the calculations of an astronomical almanac. Yet until now, meditation has played a larger part than writing in discovery, and experience has not yet become literate. But no discovery should be approved unless it is in writing. When that practice comes into use, better things may be hoped from experience made literate at last.[38]

Moreover, the number of particulars is so great—an army of them, as it were—and so scattered and dispersed that it divides and confuses the under-

37 Aristotle's *History of Animals*; ancient tradition held that Alexander the Great funded his research.

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	intellectum disgreget et confundat, de velitationibus et levibus motibus et transcursibus intellectus non bene sperandum est; nisi fiat instructio et coordinatio, per tabulas inveniendi idoneas et bene dispositas et tanquam vivas, eorum quae pertinent ad subjectum in quo versatur inquisitio, atque ad harum tabularum auxilia praeparata et digesta mens applicetur.	standing. So little good can be hoped from the skirmishes, light maneuvers and sallies of the understanding, unless the particulars bearing on the subject of inquiry are drawn up and coordinated by means of suitable, well-arranged and, as it were, living tables of discovery, and unless the mind is applied to the prepared and digested aid of these tables.
1.103	Verum post copiam particularium rite et ordine veluti sub oculos positorum, non statim transeundum est ad inquisitionem et inventionem novorum particularium aut operum; aut saltem, si hoc fiat, in eo non acquiescendum. Neque enim negamus, postquam omnia omnium artium experimenta collecta et digesta fuerint atque ad unius hominis notitiam et judicium pervenerint, quin ex ipsa traductione experimentorum unius artis in alias multa nova inveniri possint ad humanam vitam et statum utilia, per istam Experientiam quam vocamus Literatam: sed tamen minora de ea speranda sunt; majora vero a nova luce Axiomatum ex particularibus illis certa via et regula eductorum, quae rursus nova particularia indicent et designent. Neque enim in plano via sita est, sed ascendendo et descendendo; ascendendo primo ad Axiomata, descendendo ad Opera.	But once a supply of particulars has been duly set in order before our eyes, as it were, we must not pass straight on to investigating and discovering new particulars or works; or at least, if this is done, we must not rest there. We do not deny that, once all the experiments of all the arts have been collected and digested and have come within one man's knowledge and judgment, many new things useful to human life and condition can be discovered simply by transferring the experiments of one art to others, through what we call literate experience. But less is to be hoped from this. More is to be hoped from the new light of axioms drawn from those particulars by a sure way and rule, axioms which in turn point out and indicate new particulars. For the road does not lie on the level, but goes up and down: first up to axioms, then down to works.
1.104	Neque tamen permittendum est, ut intellectus a particularibus ad axiomata remota et quasi generalissima (qualia sunt principia, quae vocant, artium et rerum) saliat et volet; et ad eorum immotam veritatem axiomata media probet et expediat: quod adhuc factum est, prono ad hoc impetu naturali intellectus, atque etiam ad hoc ipsum, per demonstrationes quae fiunt per syllogismum, jampridem edocto et assuefacto. Sed de scientiis tum demum bene sperandum est, quando per scalam veram, et per gradus continuos et non intermissos aut hiulcos, a particularibus ascendetur ad axiomata minora, et deinde ad media, alia aliis superiora, et postremo demum ad generalissima. Etenim axiomata infirma non multum ab experientia nuda discrepant. Suprema vero illa et generalissima (quae habentur) notionalia sunt et abstracta, et nil habent solidi.	Yet the understanding must not be allowed to leap and fly from particulars to remote and almost the most general axioms (such as the so-called principles of arts and things), and then to prove and settle the middle axioms by the supposedly unshakable truth of these. That is what has been done so far, because the understanding is drawn to it by a natural impulse, and has long been trained and accustomed to it through demonstrations made by syllogism. But good hope for the sciences will come only when we climb by a true ladder, by continuous steps without breaks or gaps, from particulars to lesser axioms, then to middle ones, each higher than the last, and finally to the most general. For the lowest axioms differ little from bare experience. And the highest and most general ones (as they are now held) are notional and abstract, and have nothing solid in them.

38 Literate experience (*experientia literata*): experience recorded in writing and systematically arranged, so that it can be worked on.

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At media sunt axiomata illa vera et solida et viva, in quibus humanae res et fortunae sitae sunt; et supra haec quoque, tandem ipsa illa generalissima; talia scilicet quae non abstracta sint, sed per haec media vere limitantur.

Itaque hominum intellectui non plumae addendae, sed plumbum potius et pondera; ut cohibeant omnem saltum et volatum. Atque hoc adhuc factum non est; quum vero factum fuerit, melius de scientiis sperare licebit.

1.105 In constituendo autem axiomate, forma *inductionis* alia quam adhuc in usu fuit excogitanda est; eaque non ad principia tantum (quae vocant) probanda et invenienda, sed etiam ad axiomata minora et media, denique omnia. Inductio enim quae procedit per enumerationem simplicem res puerilis est, et precario concludit, et periculo exponitur ab instantia contradictoria, et plerumque secundum pauciora quam par est, et ex his tantummodo quae praesto sunt, pronunciat. At *inductio*, quae ad inventionem et demonstrationem scientiarum et artium erit utilis, naturam separare debet, per rejectiones et exclusiones debitas; ac deinde, post negativas tot quot sufficiunt, super affirmativas concludere; quod adhuc factum non est, nec tentatum certe, nisi tantummodo a *Platone*, qui ad excutiendas definitiones et ideas hac certe forma inductionis aliquatenus utitur.

Verum ad hujus inductionis, sive demonstrationis, instructionem bonam et legitimam quamplurima adhibenda sunt, quae adhuc nullius mortalium cogitationem subiere; adeo ut in ea major sit consumenda opera, quam adhuc consumpta est in syllogismo. Atque hujus inductionis auxilio, non solum ad axiomata invenienda, verum etiam ad notiones terminandas, utendum est. Atque in hac certe *inductione* spes maxima sita est.

1.106 At in axiomatibus constituendis per hanc inductionem, examinatio et probatio etiam facienda est, utrum quod constituitur axioma aptatum sit tantum et ad mensuram factum eorum particularium ex quibus extrahitur; an vero sit amplius et latius. Quod si sit amplius aut latius, videndum an eam suam amplitudinem et latitudinem per novorum particularium designationem, quasi fidejussione quadam, firmet; ne vel in jam notis tantum haereamus, vel laxiore fortasse complexu umbras et formas abstractas, non solida et determinata in materia,

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But the middle axioms are the true, solid and living ones, on which human affairs and fortunes depend; and above them, finally, come the most general axioms themselves—such, that is, as are not abstract, but are truly bounded by these middle ones.

So the human understanding must be given not feathers but rather lead and weights, to hold back all leaping and flying. This has not yet been done; but when it has, better things may be hoped for the sciences.

In establishing axioms, a form of *induction* must be devised other than the one used so far. It must serve to prove and discover not only the so-called principles but also the lesser and middle axioms—indeed, all of them. For induction that proceeds by simple enumeration is a childish thing. Its conclusions are precarious, it is exposed to danger from a contradictory instance, and it generally pronounces on fewer facts than it should, and only on those that happen to be at hand. But the *induction* that will be useful for the discovery and demonstration of sciences and arts must separate out nature by due rejections and exclusions, and then, after a sufficient number of negatives, conclude on the affirmatives. This has not yet been done, nor even attempted, except by *Plato*, who certainly uses this form of induction to some extent to sift definitions and ideas.

But to equip this induction, or demonstration, well and legitimately, a great many things must be brought to bear that have so far entered no mortal's thoughts, so that more work must be spent on it than has so far been spent on the syllogism. And this induction must be used not only to discover axioms but also to define notions. It is in this *induction*, certainly, that our greatest hope lies.

In establishing axioms by this induction, we must also examine and test whether the axiom established is fitted only to, and made to the measure of, the particulars from which it is drawn, or whether it is broader and wider. If it is broader or wider, we must see whether it confirms that breadth and width by pointing to new particulars, as a kind of surety. Otherwise we may either stick only to what is already known, or, with a looser

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	prensemus. Haec vero cum in usum venerint, solida tum demum spes merito affulserit.	embrace, grasp at shadows and abstract forms rather than at things solid and determinate in matter. When these practices come into use, then at last solid hope will rightly dawn.
1.107	Atque hic etiam resumendum est, quod superius dictum est de Naturali Philosophia producta et scientiis particularibus ad eam reductis, ut non fiat scissio et truncatio scientiarum; nam etiam absque hoc minus de progressu sperandum est.	Here too we must take up again what was said above about extending natural philosophy and bringing the particular sciences back to it, so that there is no splitting and truncating of the sciences. For without this, too, there is less to hope for in the way of progress.

DISCOVERIES BY CHANCE

Gunpowder, silk, the compass and printing show how much remains hidden; Bacon offers his own example.

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1.108	Atque de desperatione tollenda et spe facienda, ex praeteriti temporis erroribus valere jussis aut rectificatis, jam dictum est. Videndum autem et si quae alia sint quae spem faciant. Illud vero occurrit; si hominibus non quaerentibus, et aliud agentibus, multa utilia, tanquam casu quodam aut per occasionem, inventa sint; nemini dubium esse posse, quin iisdem quaerentibus et hoc agentibus, idque via et ordine, non impetu et desultorie, longe plura detegi necesse sit. Licet enim semel aut iterum accidere possit, ut quispiam in id forte fortuna incidat, quod magno conatu et de industria scrutantem antea fugit; tamen in summa rerum proculdubio contrarium invenitur.	So much for removing despair and creating hope by dismissing or correcting the errors of past time. We must now see whether there is anything else that gives hope. This occurs to us. If many useful things have been discovered by people who were not looking for them and were busy with something else—by chance, as it were, or by accident—no one can doubt that far more must be uncovered by people who are looking for them and intent on the task, and who proceed by method and in order, not by impulse and in fits and starts. For although it may happen once or twice that someone stumbles by sheer luck on what had escaped another who searched for it with great effort and on purpose, on the whole the opposite is certainly the case.
	Itaque longe plura et meliora, atque per minora intervalla, a ratione et industria et directione et intentione hominum speranda sunt, quam a casu et instinctu animalium et hujusmodi, quae hactenus principium inventis dederunt.	So far more and better things, and at shorter intervals, are to be hoped from human reason, industry, direction and purpose than from chance and animal instinct and the like, which have so far been the origin of inventions.
1.109	Etiam illud ad spem trahi possit, quod nonnulla ex his quae jam inventa sunt ejus sint generis ut antequam invenirentur haud facile cuiquam in mentem venisset de iis aliquid suspicari; sed plane quis illa ut impossibilia contempsisset. Solent enim homines de rebus novis ad exemplum veterum, et secundum phantasiam ex iis praeceptam et inquinatam, hariolari; quod genus opinandi fallacissimum est, quandoquidem multa ex his quae ex fontibus rerum petuntur per rivulos consuetos non fluant.	This too may be counted a ground for hope: some of the things already discovered are of such a kind that, before they were discovered, it would hardly have occurred to anyone to suspect anything of the sort; people would simply have dismissed them as impossible. For people usually guess at new things on the model of old ones, and by a fancy that has been prejudiced and colored by them. This way of forming opinions is most deceptive, since much of what is drawn from the sources of things does not flow through the familiar channels.

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Veluti si quis, ante tormentorum igneorum inventionem, rem per effectus descripsisset, atque in hunc modum dixisset: inventum quoddam detectum esse, per quod muri et munitiones quaeque maximae ex longo intervallo concuti et dejici possint; homines sane de viribus tormentorum et machinarum per pondera et rotas et hujusmodi arietationes et impulsus multiplicandis, multa et varia secum cogitaturi fuissent; de vento autem igneo, tam subito et violenter se expandente et exsufflante, vix unquam aliquid alicujus imaginationi aut phantasiae occursurum fuisset; utpote cujus exemplum in proximo non vidisset, nisi forte in terrae motu aut fulmine, quae, ut magnalia naturae et non imitabilia ab homine, homines statim rejecturi fuissent.

Eodem modo si, ante fili bombycini inventionem, quispiam hujusmodi sermonem injecisset: esse quoddam fili genus inventum ad vestium et supellectilis usum, quod filum linteum aut laneum tenuitate, et nihilominus tenacitate, ac etiam splendore et mollitie, longe superaret; homines statim aut de serico aliquo vegetabili, aut de animalis alicujus pilis delicatioribus, aut de avium plumis et lanugine, aliquid opinaturi fuissent; verum de vermis pusilli textura, eaque tam copiosa et se renovante et anniversaria, nil fuissent certe commenturi. Quod si quis etiam de vermi verbum aliquod injecisset, ludibrio certe futurus fuisset, ut qui novas aranearum operas somniaret.

Similiter, si ante inventionem acus nauticae quispiam hujusmodi sermonem intulisset: inventum esse quoddam instrumentum, per quod cardines et puncta coeli exacte capi et dignosci possint; homines statim de magis exquisita fabricatione instrumentorum astronomicorum ad multa et varia, per agitationem phantasiae, discursuri fuissent; quod vero aliquid inveniri possit, cujus motus cum coelestibus tam bene conveniret, atque ipsum tamen ex coelestibus non esset, sed tantum substantia lapidea aut metallica, omnino incredibile visum fuisset. Atque haec tamen et similia per tot mundi aetates homines latuerunt, nec per philosophiam aut artes rationales inventa sunt, sed casu et per occasionem; suntque illius (ut diximus) generis, ut ab iis quae antea cognita fuerunt plane heterogenea et remotissima sint, ut praenotio aliqua nihil prorsus ad illa conducere potuisset.

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Suppose, for example, that before the invention of artillery someone had described it by its effects and said something like this: that an invention had been found by which walls and even the greatest fortifications could be shaken and thrown down from a long way off. People would certainly have come up with many and various ideas about multiplying the force of siege engines and machines by weights and wheels and similar kinds of battering and impact. But a fiery wind, expanding and blasting out so suddenly and violently, would hardly ever have entered anyone's imagination or fancy. For they would have seen no example of it close at hand, except perhaps in an earthquake or lightning, which they would at once have dismissed as great works of nature that humans cannot imitate.

In the same way, suppose that before the discovery of silk thread someone had let fall a remark like this: that a kind of thread had been discovered, for use in clothing and furnishings, which far surpassed linen or woolen thread in fineness, yet also in strength, and in sheen and softness as well. People would at once have imagined some kind of plant silk, or the finer hair of some animal, or the feathers and down of birds. But they would certainly never have thought of the weaving of a tiny worm, so abundant, renewing itself every year. And if anyone had so much as said a word about a worm, he would surely have been laughed at, as one dreaming of a new kind of spider's work.

Likewise, suppose that before the invention of the mariner's compass someone had said something like this: that an instrument had been invented by which the cardinal points and quarters of the heavens could be exactly taken and distinguished. People's fancy would at once have been set racing through many and various ideas about constructing astronomical instruments more precisely. But that something could be found whose motion agreed so well with the heavens, and which was yet not itself heavenly but merely a stony or metallic substance, would have seemed utterly incredible. Yet these and similar things lay hidden from people through so many ages of the world, and were discovered not by philosophy or the rational arts but by chance and accident. And they

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are, as we said, of such a kind as to be utterly different from, and very remote from, anything known before, so that no foreknowledge could have led to them at all.

Itaque sperandum omnino est, esse adhuc in naturae sinu multa excellentis usus recondita, quae nullam cum jam inventis cognationem habent aut parallelismum, sed omnino sita sunt extra vias phantasiae; quae tamen adhuc inventa non sunt; quae proculdubio per multos saeculorum circuitus et ambages et ipsa quandoque prodibunt, sicut illa superiora prodierunt; sed per viam, quam nunc tractamus, propere et subito et simul repraesentari et anticipari possunt.

So there is every reason to hope that many things of excellent use still lie stored away in the lap of nature which have no kinship or parallel with what has already been discovered, but lie entirely outside the paths of fancy—things not yet discovered. No doubt they too will come to light in time, through the long circuits and windings of the centuries, just as those earlier ones did. But by the way we are now discussing, they can be presented and anticipated quickly, suddenly and all at once.

1.110 Attamen conspiciuntur et alia inventa ejus generis, quae fidem faciant, posse genus humanum nobilia inventa, etiam ante pedes posita, praeterire et transilire. Utcunque enim pulveris tormentarii vel fili bombycini vel acus nauticae vel sacchari vel papyri vel similium inventa quibusdam rerum et naturae proprietatibus niti videantur, at certe imprimendi artificium nil habet quod non sit apertum et fere obvium.

Yet there are also other inventions to be seen of a kind that convince us that the human race can pass over and step past noble inventions even when they lie at its feet. However much the inventions of gunpowder, silk thread, the mariner's compass, sugar, paper and the like may seem to depend on certain properties of things and of nature, the art of printing certainly has nothing in it that is not open and almost obvious.

Et nihilominus homines, non advertentes literarum modulos difficilius scilicet collocari quam literae per motum manus scribantur, sed hoc interesse, quod literarum moduli semel collocati infinitis impressionibus, literae autem per manum exaratae unicae tantum scriptioni, sufficiant; aut fortasse iterum non advertentes atramentum ita inspissari posse, ut tingat, non fluat; praesertim literis resupinatis et impressione facta desuper; hoc pulcherrimo invento (quod ad doctrinarum propagationem tantum facit) per tot saecula caruerunt.

And yet people went without this most beautiful invention, which does so much for the spread of learning, for so many centuries. They did not notice that, although it is harder to set type than to write letters by hand, there is this difference: type once set serves for countless impressions, whereas letters written by hand serve for only a single copy. Or perhaps, again, they did not notice that ink could be thickened so as to color and not run, especially with the letters laid face up and the impression made from above.

Solet autem mens humana, in hoc inventionis curriculo, tam laeva saepenumero et male composita esse, ut primo diffidat, et paulo post se contemnat; atque primo incredibile ei videatur aliquid tale inveniri posse, postquam autem inventum sit, incredibile rursus videatur id homines tamdiu fugere potuisse. Atque hoc ipsum ad spem rite trahitur; superesse nimirum adhuc magnum inventorum cumulum, qui non solum ex operationibus incognitis eruendis, sed et ex jam cognitis transferendis et componendis et applicandis, per eam quam diximus Experientiam Literatam, deduci possit.

In this course of invention the human mind is often so awkward and ill-disposed that first it distrusts, and shortly afterward despises itself. At first it seems incredible to it that any such thing can be discovered; after it has been discovered, it seems incredible again that people could have missed it for so long. And this very fact is rightly taken as ground for hope: there still remains a great heap of inventions that can be brought forth not only by digging out unknown operations but also by transferring, combining and applying

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those already known, through what we have called literate experience.

1.111 Neque illud omittendum ad faciendam spem: reputent (si placet) homines infinitas ingenii, temporis, facultatum expensas, quas homines in rebus et studiis longe minoris usus et pretii collocant; quorum pars quota si ad sana et solida verteretur, nulla non difficultas superari possit. Quod idcirco adjungere visum est, quia plane fatemur Historiae Naturalis et Experimentalis collectionem, qualem animo metimur et qualis esse debet, opus esse magnum, et quasi regium, et multae operae atque impensae.

Nor should this be left out as a ground for hope. Let people consider, if they please, the boundless expenditure of intelligence, time and means that they devote to matters and pursuits of far less use and value. If even a fraction of this were turned to sound and solid ends, there is no difficulty that could not be overcome. We have thought fit to add this because we freely admit that collecting a natural and experimental history such as we have in mind, and as it ought to be, is a great work—a royal one, as it were—and one requiring much labor and expense.

1.112 Interim particularium multitudinem nemo reformidet, quin potius hoc ipsum ad spem revocet. Sunt enim artium et naturae particularia Phaenomena manipuli instar ad ingenii commenta, postquam ab evidentia rerum disjuncta et abstracta fuerint. Atque hujus viae exitus in aperto est, et fere in propinquo; alterius exitus nullus, sed implicatio infinita. Homines enim adhuc parvam in Experientia moram fecerunt, et eam leviter perstrinxerunt, sed in meditationibus et commentationibus ingenii infinitum tempus contriverunt. Apud nos vero si esset praesto quispiam qui de facto naturae ad interrogata responderet, paucorum annorum esset inventio causarum et scientiarum omnium.

Meanwhile, let no one dread the multitude of particulars; rather, let this very thing be taken as a reason for hope. For the particular phenomena of the arts and of nature are a mere handful compared with the fictions of human ingenuity, once these have been cut off and abstracted from the evidence of things. The end of this road is in the open and almost near at hand; the other road has no end, only endless entanglement. People have so far lingered little on experience and only brushed it lightly, but have wasted endless time on meditations and the fictions of ingenuity. If we had someone at hand who could answer our questions about the facts of nature, the discovery of all causes and sciences would be the work of a few years.

1.113 Etiam nonnihil hominibus spei fieri posse putamus ab exemplo nostro proprio; neque jactantiae causa hoc dicimus sed quod utile dictu sit. Si qui diffidant, me videant, hominem inter homines aetatis meae civilibus negotiis occupatissimum, nec firma admodum valetudine (quod magnum habet temporis dispendium), atque in hac re plane protopirum, et vestigia nullius sequutum, neque haec ipsa cum ullo mortalium communicantem, et tamen veram viam constanter ingressum et ingenium rebus submittentem, haec ipsa aliquatenus (ut existimamus) provexisse: et deinceps videant, quid ab hominibus otio abundantibus, atque a laboribus consociatis, atque a temporum successione, post haec indicia nostra expectandum sit; praesertim in via quae non singulis solummodo pervia est (ut fit in via illa rationali), sed ubi hominum labores et operae (praesertim quantum ad experientiae collectam) optime distribui et deinde componi possint.

We also think that our own example may give people some hope; and we say this not to boast but because it is useful to say. Let those who lack confidence look at me. Of all the men of my time I was the most occupied with public business; my health was none too firm, which costs a great deal of time; in this matter I was an absolute pioneer, following in no one's footsteps and sharing these very things with no one. And yet, by steadily entering on the true way and submitting my mind to things, I have, I think, advanced these matters to some extent. Then let them see what may be expected, after these indications of ours, from people with abundant leisure, from joint labors, and from the succession of ages—especially on a road that is not passable by individuals alone (as is the case with the way of reason), but where people's labors and efforts, especially in collecting

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		experience, can best be divided up and then combined.
	Tum enim homines vires suas nosse incipient, cum non eadem infiniti, sed alia alii praestabunt.	For people will begin to know their strength only when, instead of countless people all doing the same things, different people carry out different tasks.
1.114	Postremo, etiamsi multo infirmior et obscurior aura spei ab *ista Nova Continente* spiraverit, tamen omnino experiendum esse (nisi velimus animi esse plane abjecti) statuimus. Non enim res pari periculo non tentatur, et non succedit; cum in illo ingentis boni, in hoc exiguae humanae operae, jactura vertatur. Verum ex dictis, atque etiam ex non dictis, visum est nobis spei abunde subesse, non tantum homini strenuo ad experiendum, sed etiam prudenti et sobrio ad credendum.	Lastly, even if a much weaker and fainter breath of hope were to blow from *that New Continent*, we still judge that the attempt must be made, unless we want to be utterly abject in spirit. For the risk in not trying and in not succeeding is not equal: in the first case the loss is of an immense good, in the second of a little human effort. But from what has been said, and also from what has been left unsaid, it seems to us that there is ample ground for hope—not only for an energetic man to make the attempt, but also for a prudent and sober one to believe.

OBJECTIONS ANSWERED

Bacon ends the destructive part and answers objections about his history, his method and his aims.

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1.115	Atque de desperatione tollenda, quae inter causas potentissimas ad progressum scientiarum remorandum et inhibendum fuit, jam dictum est. Atque simul sermo de signis et causis errorum, et inertiae et ignorantiae quae invaluit, absolutus est; praesertim cum subtiliores causae, et quae in judicium populare aut observationem non incurrunt, ad ea quae de Idolis animi humani dicta sunt referri debeant.	So much for removing despair, which has been among the most powerful causes delaying and hindering the progress of the sciences. With this, our discussion of the signs and causes of errors, and of the inertia and ignorance that have prevailed, is also complete—especially since the subtler causes, which do not fall under popular judgment or observation, must be referred to what has been said about the idols of the human mind.
	Atque hic simul pars destruens Instaurationis nostrae claudi debet, quae perficitur tribus redargutionibus: redargutione nimirum *Humanae Rationis Nativae* et sibi permissae; redargutione *Demonstrationum*; et redargutione *Theoriarum*, sive philosophiarum et doctrinarum quae receptae sunt. Redargutio vero earum talis fuit qualis esse potuit; videlicet per signa, et evidentiam causarum; cum confutatio alia nulla a nobis (qui et de principiis et de demonstrationibus ab aliis dissentimus) adhiberi potuerit.	Here too the destructive part of our Renewal must be brought to a close. It is carried out through three refutations: the refutation of *native human reason* left to itself; the refutation of *demonstrations*; and the refutation of *theories*, that is, of the philosophies and doctrines that have been received. Their refutation has been of the only kind possible: namely, by signs and by the evidence of causes. No other kind of confutation was open to us, since we disagree with others about both principles and demonstrations.
	Quocirca tempus est, ut ad ipsam artem et normam *Interpretandi Naturam* veniamus; et tamen nonnihil restat quod praevertendum est. Quum enim in hoc primo Aphorismorum libro illud nobis propositum sit, ut tam ad	So it is time for us to come to the very art and rule of *interpreting nature*; and yet something remains that must be dealt with first. Our aim in this first book of aphorisms is to prepare people's minds

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intelligendum quam ad recipiendum ea quae sequuntur mentes hominum praeparentur; expurgata jam et abrasa et aequata mentis area, sequitur ut mens sistatur in positione bona, et tanquam aspectu benevolo, ad ea quae proponemus. Valet enim in re nova ad praejudicium, non solum praeoccupatio fortis opinionis veteris, sed et praeceptio sive praefiguratio falsa rei quae affertur. Itaque conabimur efficere ut habeantur bonae et verae de iis quae adducimus opiniones, licet ad tempus tantummodo, et tanquam usurariae, donec res ipsa pernoscatur.

1.116 Primo itaque postulandum videtur, ne existiment homines nos, more antiquorum Graecorum, aut quorundam novorum hominum, Telesii, Patricii, Severini, sectam aliquam in philosophia condere velle. Neque enim hoc agimus; neque etiam multum interesse putamus ad hominum fortunas quales quis opiniones abstractas de natura et rerum principiis habeat; neque dubium est, quin multa hujusmodi et vetera revocari et nova introduci possint; quemadmodum et complura themata coeli supponi possunt, quae cum phaenomenis sat bene conveniunt, inter se tamen dissentiunt.

At nos de hujusmodi rebus opinabilibus, et simul inutilibus, non laboramus. At contra nobis constitutum est experiri, an revera potentiae et amplitudinis humanae firmiora fundamenta jacere ac fines in latius proferre possimus. Atque licet sparsim, et in aliquibus subjectis specialibus, longe veriora habeamus et certiora (ut arbitramur) atque etiam magis fructuosa quam quibus homines adhuc utuntur (quae in quintam Instaurationis nostrae partem congessimus), tamen theoriam nullam universalem aut integram proponimus. Neque enim huic rei tempus adhuc adesse videtur. Quin nec spem habemus vitae producendae ad sextam Instaurationis partem (quae philosophiae per legitimam Naturae Interpretationem inventae destinata est) absolvendam; sed satis habemus si in mediis sobrie et utiliter nos geramus, atque interim semina veritatis sincerioris in posteros spargamus, atque initiis rerum magnarum non desimus.

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both to understand and to accept what follows. Now that the floor of the mind has been swept, scraped and leveled, the next step is to set the mind in a good position and, as it were, in a favorable attitude toward what we shall propose. For in a new matter, prejudice arises not only from the strong hold of an old opinion but also from a false preconception or prefiguring of the thing being offered. So we shall try to ensure that good and true opinions are held of what we bring forward, even if only for the time being and, as it were, on loan, until the thing itself is thoroughly understood.

First, then, it seems we must ask people not to think that we want to found some sect in philosophy, in the manner of the ancient Greeks or of certain moderns such as Telesio, Patrizi or Severinus. That is not what we are doing. Nor do we think it matters much to human fortunes what abstract opinions anyone holds about nature and the principles of things. And there is no doubt that many such opinions could be put forward, old ones revived and new ones introduced, just as several systems of the heavens can be supposed which agree well enough with the phenomena, yet disagree with one another.[39]

But we are not concerned with matters of that kind, which are matters of opinion and useless as well. On the contrary, we have resolved to test whether we can in fact lay firmer foundations for human power and greatness, and extend its boundaries more widely. Here and there, and on some special subjects, we have things far truer and more certain (as we believe), and also more fruitful, than those people have used so far; and we have gathered these into the fifth part of our Renewal. Yet we propose no universal or complete theory, for the time for that does not yet seem to have come. Nor do we hope to live long enough to complete the sixth part of the Renewal, which is reserved for the philosophy discovered by the legitimate interpretation of nature. We are content if we conduct ourselves soberly and usefully in the intermediate stages, and meanwhile sow the seeds

39 Bernardino Telesio (1509–1588) and Francesco Patrizi (1529–1597), Italian anti-Aristotelian philosophers of nature; Petrus Severinus (d. 1602), Danish physician and follower of Paracelsus.

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of a purer truth for posterity, and do not fail the beginnings of great things.

1.117 Atque quemadmodum sectae conditores non sumus, ita nec operum particularium largitores aut promissores. Attamen possit aliquis hoc modo occurrere; quod nos, qui tam saepe operum mentionem faciamus et omnia eo trahamus, etiam operum aliquorum pignora exhibeamus. Verum via nostra et ratio (ut saepe perspicue diximus et adhuc dicere juvat) ea est; ut non opera ex operibus sive experimenta ex experimentis (ut empirici), sed ex operibus et experimentis causas et axiomata, atque ex causis et axiomatibus rursus nova opera et experimenta (ut legitimi Naturae Interpretes), extrahamus.

Just as we are not founders of a sect, so neither are we lavish givers or promisers of particular works. Yet someone may object that we, who mention works so often and refer everything to them, should also show some pledges of works. But our way and method, as we have often said plainly and are glad to say again, is this: not to extract works from works or experiments from experiments, as the empirics do, but, as legitimate interpreters of nature, to extract causes and axioms from works and experiments, and from causes and axioms, in turn, new works and experiments.

Atque licet in tabulis nostris inveniendi (ex quibus quarta pars Instaurationis consistit), atque etiam exemplis particularium (quae in secunda parte adduximus), atque insuper in observationibus nostris super historiam (quae in tertia parte operis descripta est), quivis vel mediocris perspicaciae et solertiae complurium operum nobilium indicationes et designationes ubique notabit; ingenue tamen fatemur, historiam naturalem quam adhuc habemus, aut ex libris aut ex inquisitione propria, non tam copiosam esse et verificatam, ut legitimae Interpretationi satisfacere aut ministrare possit.

In our tables of discovery (which make up the fourth part of the Renewal), in the examples of particulars (which we have brought forward in the second part), and moreover in our observations on the history (which is set out in the third part of the work), anyone of even moderate insight and skill will notice everywhere indications and outlines of many noble works. Nevertheless, we frankly admit that the natural history we have so far, whether from books or from our own inquiry, is not so abundant or so well verified as to satisfy or serve a legitimate interpretation.

Itaque si quis ad mechanica sit magis aptus et paratus, atque sagax ad venanda opera ex conversatione sola cum experimentis, ei permittimus et relinquimus illam industriam, ut ex historia nostra et tabulis multa tanquam in via decerpat et applicet ad opera, ac veluti foenus recipiat ad tempus, donec sors haberi possit. Nos vero, cum ad majora contendamus, moram omnem praeproperam et praematuram in istiusmodi rebus tanquam Atalantae pilas (ut saepius solemus dicere) damnamus. Neque enim aurea poma pueriliter affectamus, sed omnia in victoria cursus artis super naturam ponimus; neque muscum aut segetem herbidam demetere festinamus, sed messem tempestivam expectamus.

So if anyone is more suited and ready for mechanical work, and shrewd at hunting out works simply through familiarity with experiments, we allow and leave to him the task of plucking many things from our history and tables, as it were along the way, and applying them to works—taking the interest, so to speak, for the time being, until the principal can be had. But we, since we are striving for greater things, condemn all hasty and premature lingering over such matters, as we often say, as so many apples of Atalanta. For we do not childishly grasp at golden apples, but stake everything on the victory of art over nature in the race; nor do we hurry to reap moss or unripe grain, but wait for the harvest in its season.

1.118 Occurret etiam alicui proculdubio, postquam ipsam historiam nostram et inventionis tabulas perlegerit, aliquid in ipsis experimentis minus certum, vel omnino falsum; atque propterea secum fortasse reputabit, fundamentis et principiis falsis et dubiis inventa nostra niti. Verum hoc nihil est; necesse enim est talia sub initiis

No doubt it will also occur to someone, after reading through our history itself and our tables of discovery, that something in the experiments themselves is less than certain, or even wholly false; and he may therefore reflect that our discoveries rest on false and doubtful foundations and prin-

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evenire. Simile enim est ac si in scriptione aut impressione una forte litera aut altera perperam posita aut collocata sit; id enim legentem non multum impedire solet, quandoquidem errata ab ipso sensu facile corriguntur. Ita etiam cogitent homines, multa in historia naturali experimenta falso credi et recipi posse, quae paulo post a causis et axiomatibus inventis facile expunguntur et rejiciuntur.

Sed tamen verum est, si in historia naturali et experimentis magna et crebra et continua fuerint errata, illa nulla ingenii aut artis foelicitate corrigi aut emendari posse. Itaque si in historia nostra naturali, quae tanta diligentia et severitate et fere religione probata et collecta est, aliquid in particularibus quandoque subsit falsitatis aut erroris, quid tandem de naturali historia vulgari, quae prae nostra tam negligens est et facilis, dicendum erit? aut de philosophia et scientiis super hujusmodi arenas (vel syrtes potius) aedificatis? Itaque hoc quod diximus neminem moveat.

1.119 Occurrent etiam in historia nostra et experimentis plurimae res, primo leves et vulgatae, deinde viles et illiberales, postremo nimis subtiles ac mere speculativae, et quasi nullius usus: quod genus rerum hominum studia avertere et alienare possit.

Atque de istis rebus, quae videntur vulgatae, illud homines cogitent; solere sane eos adhuc nihil aliud agere, quam ut eorum quae rara sunt causas ad ea quae frequenter fiunt referant et accommodent, at ipsorum quae frequenter eveniunt nullas causas inquirant, sed ea ipsa recipiant tanquam concessa et admissa.

Itaque non ponderis, non rotationis coelestium, non caloris, non frigoris, non luminis, non duri, non mollis, non tenuis, non densi, non liquidi, non consistentis, non animati, non inanimati, non similaris, non dissimilaris, nec demum organici, causas quaerunt; sed illis, tanquam pro evidentibus et manifestis, receptis, de ceteris rebus, quae non tam frequenter et familiariter occurrunt, disputant et judicant.

Nos vero, qui satis scimus nullum de rebus raris aut notabilibus judicium fieri posse, multo minus res novas in lucem protrahi, absque vulgarium rerum causis et causarum causis rite examinatis et repertis, necessario ad

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ciples. But this is nothing; such things are bound to happen at the start. It is as if, in writing or printing, a letter or two happened to be wrongly put or placed. That does not usually hinder the reader much, since the sense itself easily corrects the errors. So too let people reflect that many experiments in natural history may be wrongly believed and accepted, which shortly afterward are easily struck out and rejected by the causes and axioms that have been discovered.

Yet it is true that if natural history and experiments contain great, frequent and continual errors, no felicity of intelligence or art can correct or amend them. So if in our natural history, which has been tested and collected with such diligence, strictness and almost religious scruple, there is sometimes some falsehood or error in the particulars, what must be said, then, of ordinary natural history, which is so careless and easygoing compared with ours? Or of philosophy and sciences built on such sands—or rather quicksands? So let no one be troubled by what we have said.

Our history and experiments will also contain a great many things that are, first, trivial and commonplace; second, mean and unrefined; and finally, too subtle and merely speculative, and of almost no use. Things of this kind could turn people's interest away and put them off.

As for the things that seem commonplace, let people consider this: so far they have usually done nothing but refer and adapt the causes of rare things to things that happen often, while never inquiring into the causes of the things that happen often, but accepting them as granted and admitted.

So they do not seek the causes of weight, of the rotation of the heavenly bodies, of heat, of cold, of light, of hard, of soft, of rare, of dense, of liquid, of solid, of animate, of inanimate, of homogeneous, of heterogeneous, nor finally of the organic. Instead, accepting these as evident and obvious, they dispute and pass judgment about other things that do not occur so often and familiarly.

But we know well that no judgment can be made about rare or remarkable things, much less can new things be brought to light, unless the causes of common things, and the causes of those causes,

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res vulgarissimas in historiam nostram recipiendas compellimur. Quinetiam nil magis philosophiae offecisse deprehendimus quam quod res, quae familiares sunt et frequenter occurrunt, contemplationem hominum non morentur et detineant, sed recipiantur obiter, neque earum causae quaeri soleant: ut non saepius requiratur informatio de rebus ignotis, quam attentio in notis.	are duly examined and discovered. So we are necessarily compelled to admit the most common things into our history. Indeed, we find that nothing has harmed philosophy more than this: that familiar and frequent things do not make people stop and hold their attention, but are taken in passing, and their causes are not usually sought. Information about unknown things is needed no more often than attention to known ones.
1.120 Quod vero ad rerum vilitatem attinet, vel etiam turpitudinem, quibus (ut ait Plinius) honos praefandus est; eae res, non minus quam lautissimae et pretiosissimae, in historiam naturalem recipiendae sunt. Neque propterea polluitur naturalis historia: sol enim aeque palatia et cloacas ingreditur, neque tamen polluitur. Nos autem non Capitolium aliquod aut Pyramidem hominum superbiae dedicamus aut condimus, sed templum sanctum ad exemplar mundi in intellectu humano fundamus. Itaque exemplar sequimur. Nam quicquid essentia dignum est, id etiam scientia dignum, quae est essentiae imago. At vilia aeque subsistunt ac lauta. Quinetiam, ut e quibusdam putridis materiis, veluti musco et zibetho, aliquando optimi odores generantur; ita et ab instantiis vilibus et sordidis quandoque eximia lux et informatio emanat.	As for the meanness, or even the foulness, of certain things—for which, as Pliny says, one must first beg pardon—these, no less than the most splendid and precious, must be admitted into natural history. Nor is natural history polluted by them; for the sun enters palaces and sewers alike, and yet is not polluted. We are not dedicating or building some Capitol or Pyramid to human pride, but founding in the human understanding a holy temple on the model of the world. So we follow the model. For whatever is worthy of being is also worthy of knowledge, which is the image of being. And mean things exist just as much as splendid ones. Indeed, just as the finest scents are sometimes produced from certain putrid matter, such as musk and civet, so too exceptional light and information sometimes come from mean and sordid instances.[40]
Verum de hoc nimis multa; cum hoc genus fastidii sit plane puerile et effoeminatum.	But enough and more than enough of this, since this kind of fastidiousness is plainly childish and squeamish.
1.121 At de illo omnino magis accurate dispiciendum; quod plurima in historia nostra captui vulgari, aut etiam cuivis intellectui (rebus praesentibus assuefacto), videbuntur curiosae cujusdam et inutilis subtilitatis. Itaque de hoc ante omnia et dictum et dicendum est: hoc scilicet; nos jam sub initiis et ad tempus, tantum *lucifera* experimenta, non *fructifera* quaerere; ad exemplum creationis divinae, quod saepius diximus, quae primo die lucem tantum produxit, eique soli unum integrum diem attribuit, neque illo die quicquam materiati operis immiscuit.	But we must look more carefully at this point: that many things in our history will seem, to ordinary comprehension or indeed to any understanding accustomed to things as they now are, to be of a curious and useless subtlety. So on this point above all it has been said, and must be said again, that at the beginning and for the time being we seek only experiments *of light*, not *of fruit*. In this we follow the example of the divine creation, as we have often said, which on the first day produced light alone, gave it a whole day to itself, and mixed no material work into that day.
Itaque si quis istiusmodi res nullius esse usus putet, idem cogitat ac si nullum etiam lucis esse usum censeat, quia res scilicet solida aut materiata non sit. Atque revera dicendum est, simplicum naturarum cognitionem bene	So if anyone thinks such things are of no use, he thinks as if he held light, too, to be of no use because it is not a solid or material thing. And in-

40 Pliny the Elder, *Natural History*, Preface 13.

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examinatam et definitam instar lucis esse; quae ad universa operum penetralia aditum praebet, atque tota agmina operum et turmas, et axiomatum nobilissimorum fontes, potestate quadam complectitur et post se trahit; in se tamen non ita magni usus est. Quin et literarum elementa per se et separatim nihil significant nec alicujus usus sunt, sed tamen ad omnis sermonis compositionem et apparatum instar materiae primae sunt. Etiam semina rerum potestate valida, usu (nisi in processu suo) nihili sunt. Atque lucis ipsius radii dispersi, nisi coeant, beneficium suum non impertiuntur.

Quod si quis subtilitatibus speculativis offendatur, quid de scholasticis viris dicendum erit, qui subtilitatibus immensum indulserunt? quae tamen subtilitates in verbis, aut saltem vulgaribus notionibus (quod tantundem valet), non in rebus aut natura consumptae fuerunt, atque utilitatis expertes erant, non tantum in origine, sed etiam in consequentiis; tales autem non fuerunt, ut haberent in praesens utilitatem nullam, sed per consequens infinitam; quales sunt eae de quibus loquimur. Hoc vero sciant homines pro certo, omnem subtilitatem disputationum et discursuum mentis, si adhibeatur tantum post axiomata inventa, seram esse et praeposteram; et subtilitatis tempus verum ac proprium, aut saltem praecipuum, versari in pensitanda experientia et inde constituendis axiomatibus: nam illa altera subtilitas naturam prensat et captat, sed nunquam apprehendit aut capit.

Et verissimum certe est quod de occasione sive fortuna dici solet, si transferatur ad naturam: videlicet, *eam a fronte comatam, ab occipitio calvam esse.*

Denique de contemptu in naturali historia rerum aut vulgarium, aut vilium, aut nimis subtilium et in originibus suis inutilium, illa vox mulierculae ad tumidum principem, qui petitionem ejus ut rem indignam et majestate sua inferiorem abjecisset, pro oraculo sit; *Desine ergo rex esse:* quia certissimum est, imperium in naturam, si quis hujusmodi rebus ut nimis exilibus et minutis vacare nolit, nec obtineri nec geri posse.

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deed it must be said that a well-examined and well-defined knowledge of simple natures is like light. It gives access to all the inner recesses of works, and potentially embraces and draws after it whole troops and squadrons of works, and the sources of the noblest axioms; yet in itself it is of no great use. So too the letters of the alphabet, by themselves and taken separately, mean nothing and are of no use, yet they are like the prime matter for composing and furnishing all speech. The seeds of things, too, are strong in potency but of no use except as they develop. And the scattered rays of light itself confer no benefit unless they are brought together.

But if anyone is offended by speculative subtleties, what are we to say of the schoolmen, who indulged in subtleties beyond all measure? Yet those subtleties were spent on words, or at least on common notions (which comes to the same thing), not on things or nature. And they were useless not only at their origin but in their consequences too. They were not the kind that have no use at present but infinite use in consequence, as are those we speak of. But let people know this for certain: all subtlety of disputation and mental reasoning, if it is applied only after the axioms have been discovered, comes late and in the wrong order. The true and proper time for subtlety, or at least the chief one, lies in weighing experience and establishing axioms from it. For that other subtlety clutches and snatches at nature, but never lays hold of it or catches it.

And what is commonly said of opportunity or fortune is certainly most true if transferred to nature: namely, that *she has hair in front but is bald behind.*[41]

Finally, there is the contempt shown in natural history for things that are common, or lowly, or too subtle and useless in their origins. Here let the retort of a humble woman to a haughty prince be taken as an oracle. He had brushed aside her petition as unworthy of him and beneath his majesty, and she said: *Then stop being king.* For it is quite certain that no one can win or wield command over nature if he will not make time for such things because they seem too slight and petty.[42]

41 A proverb from the classical image of Opportunity (Occasio), shown with a forelock and a bald back of the head: she must be seized as she approaches.

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1.122 Occurrit etiam et illud; mirabile quiddam esse et durum, quod nos omnes scientias atque omnes authores simul ac veluti uno ictu et impetu summoveamus: idque non assumpto aliquo ex antiquis in auxilium et praesidium nostrum, sed quasi viribus propriis.	Another objection will come up too. It is a strange and harsh thing, people will say, for us to set aside all the sciences and all authors at once, as if in a single stroke and assault. And we do this without enlisting any of the ancients to help and protect us, relying, as it were, on our own strength.
Nos autem scimus, si minus sincera fide agere voluissemus, non difficile fuisse nobis, ista quae afferuntur vel ad antiqua saecula ante Graecorum tempora (cum scientiae de natura magis fortasse sed tamen majore cum silentio floruerint, neque in Graecorum tubas et fistulas adhuc incidissent), vel etiam (per partes certe) ad aliquos ex Graecis ipsis referre, atque astipulationem et honorem inde petere: more novorum hominum, qui nobilitatem sibi ex antiqua aliqua prosapia, per genealogiarum favores, astruunt et affingunt.	We know, however, that had we been willing to act in less good faith, it would not have been hard for us to trace what we are putting forward to some earlier source. We could have traced it to ancient ages before the time of the Greeks, when the sciences of nature may perhaps have flourished more, though in greater silence, since they had not yet fallen into the trumpets and pipes of the Greeks. Or we could have traced it, at least in part, to some of the Greeks themselves, and sought support and honor from that quarter. That is what self-made men do: they build up and fabricate a noble lineage for themselves from some ancient family, with the help of obliging genealogies.
Nos vero rerum evidentia freti, omnem commenti et imposturae conditionem rejicimus; neque ad id quod agitur plus interesse putamus, utrum quae jam invenientur antiquis olim cognita, et per rerum vicissitudines et saecula occidentia et orientia sint, quam hominibus curae esse debere, utrum Novus Orbis fuerit insula illa Atlantis et veteri mundo cognita, an nunc primum reperta. Rerum enim inventio a naturae luce petenda, non ab antiquitatis tenebris repetenda est.	But we rely on the evidence of things, and we reject every kind of fiction and imposture. We do not think it matters to the business at hand whether what will now be discovered was once known to the ancients, and has set and risen again with the changes of things and the passing of ages. It matters no more than people ought to care whether the New World was the island of Atlantis known to the ancient world, or has only now been found for the first time. For discoveries are to be sought from the light of nature, not fetched back from the darkness of antiquity.[43]
Quod vero ad universalem istam reprehensionem attinet, certissimum est vere rem reputanti, eam et magis probabilem esse et magis modestam, quam si facta fuisset ex parte. Si enim in primis notionibus errores radicati non fuissent, fieri non potuisset quin nonnulla recte inventa alia perperam inventa correxissent. Sed cum errores fundamentales fuerint, atque ejusmodi, ut homines potius res neglexerint ac praeterierint, quam de illis pravum aut falsum judicium fecerint; minime mirum est, si homines id non obtinuerint quod non egerint, nec ad metam pervenerint quam non posuerint aut collocarint, neque viam emensi sint quam non ingressi sint aut tenuerint.	As for this wholesale criticism, anyone who truly thinks the matter over will see that it is both more plausible and more modest than a piecemeal one would have been. If errors had not been rooted in the first notions, some correct discoveries would inevitably have corrected others that were wrong. But the errors were fundamental. They were of such a kind that people neglected and passed things over, rather than forming a wrong or false judgment about them. So it is no wonder at all if people did not obtain what they were not pursuing, or reach a goal they had never set or fixed, or

42 Plutarch tells this story of Philip II of Macedon; Cassius Dio tells it of the emperor Hadrian.
43 Atlantis is the legendary island described by Plato in the *Timaeus* and *Critias*.

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cover the length of a road they had never entered or kept to.

Atque insolentiam rei quod attinet; certe si quis manus constantia atque oculi vigore lineam magis rectam aut circulum magis perfectum se describere posse quam alium quempiam sibi assumat, inducitur scilicet facultatis comparatio: quod si quis asserat se adhibita regula aut circumducto circino lineam magis rectam aut circulum magis perfectum posse describere, quam aliquem alium vi sola oculi et manus, is certe non admodum jactator fuerit. Quin hoc, quod dicimus, non solum in hoc nostro conatu primo et incoeptivo locum habet; sed etiam pertinet ad eos qui huic rei posthac incumbent. Nostra enim via inveniendi scientias exaequat fere ingenia, et non multum excellentiae eorum relinquit: cum omnia per certissimas regulas et demonstrationes transigat.

As for the presumption of it: suppose someone claimed he could draw a straighter line or a more perfect circle than anyone else by a steady hand and a keen eye. He would clearly be inviting a comparison of abilities. But suppose someone asserts that with a ruler, or by turning a compass, he can draw a straighter line or a more perfect circle than another person can with eye and hand alone. He is hardly boasting. And what we say holds not only for this first, initial effort of ours. It applies also to those who take up the work hereafter. For our way of discovering the sciences almost levels intellects and leaves little room for their excellence, since it carries everything through by the most certain rules and demonstrations.

Itaque haec nostra (ut saepe diximus) foelicitatis cujusdam sunt potius quam facultatis, et potius temporis partus quam ingenii. Est enim certe casus aliquis non minus in cogitationibus humanis, quam in operibus et factis.

So these achievements of ours (as we have often said) come from a kind of good fortune rather than from ability. They are the offspring of time rather than of wit. For there is certainly an element of chance in human thinking, no less than in works and deeds.

1.123 Itaque dicendum de nobis ipsis quod ille per jocum dixit, praesertim cum tam bene rem secet: *fieri non potest ut idem sentiant, qui aquam et qui vinum bibant*. At caeteri homines, tam veteres quam novi, liquorem biberunt crudum in scientiis, tanquam aquam vel sponte ex intellectu manantem, vel per dialecticam, tanquam per rotas ex puteo, haustam. At nos liquorem bibimus et propinamus ex infinitis confectam uvis, iisque maturis et tempestivis, et per racemos quosdam collectis ac decerptis, et subinde in torculari pressis, ac postremo in vase repurgatis et clarificatis. Itaque nil mirum si nobis cum aliis non conveniat.

So we may say of ourselves what someone once said in jest, especially since it cuts so neatly to the heart of the matter: *it is impossible for water drinkers and wine drinkers to think alike*. Other people, ancient and modern alike, have drunk a crude liquor in the sciences, like water. Either it flowed of its own accord from the understanding, or it was drawn up by dialectic, as if by wheels from a well. We, however, drink and pledge a liquor pressed from countless grapes. The grapes were ripe and in season. They were gathered and picked cluster by cluster, then pressed in the winepress, and finally purified and clarified in the vat. So it is no wonder if we do not agree with others.

1.124 Occurret proculdubio et illud: nec metam aut scopum scientiarum a nobis ipsis (id quod in aliis reprehendimus) verum et optimum praefixum esse. Esse enim contemplationem veritatis omni operum utilitate et magnitudine digniorem et celsiorem: longam vero istam et sollicitam moram in experientia et materia et rerum particularium fluctibus mentem veluti humo affigere, vel potius in Tartarum quoddam confusionis et perturbationis dejicere; atque ab abstractae sapientiae serenitate et tranquillitate (tanquam a statu multo diviniore) arcere et summovere. Nos vero huic rationi

No doubt this too will be raised: that we ourselves have not fixed on the true and best goal or aim for the sciences, which is the very thing we fault in others. The contemplation of truth, the argument goes, is worthier and loftier than all the usefulness and greatness of works. This long and anxious lingering among experience and matter and the shifting tide of particular things pins the mind to the ground, so to speak. Or rather, it casts the mind down into a kind of Tartarus of confusion

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libenter assentimur; et hoc ipsum, quod innuunt ac praeoptant, praecipue atque ante omnia agimus. Etenim verum exemplar mundi in intellectu humano fundamus; quale invenitur, non quale cuipiam sua propria ratio dictaverit. Hoc autem perfici non potest, nisi facta mundi dissectione atque anatomia diligentissima.

Modulos vero ineptos mundorum et tanquam simiolas, quas in philosophiis phantasiae hominum extruxerunt, omnino dissipandas edicimus. Sciant itaque homines (id quod superius diximus) quantum intersit inter humanae mentis *idola* et divinae mentis ideas. Illa enim nihil aliud sunt quam abstractiones ad placitum: hae autem sunt vera signacula Creatoris super creaturas, prout in materia per lineas veras et exquisitas imprimuntur et terminantur. Itaque ipsissimae res sunt (in hoc genere) veritas et utilitas: atque opera ipsa pluris facienda sunt, quatenus sunt veritatis pignora, quam propter vitae commoda.

1.125 Occurret fortasse et illud: nos tanquam actum agere, atque antiquos ipsos eandem quam nos viam tenuisse. Itaque verisimile putabit quispiam etiam nos, post tantum motum et molitionem, deventuros tandem ad aliquam ex illis philosophiis quae apud antiquos valuerunt. Nam et illos in meditationum suarum principiis vim et copiam magnam exemplorum et particularium paravisse, atque in commentarios per locos et titulos digessisse, atque inde philosophias suas et artes confecisse, et postea, re comperta, pronuntiasse, et exempla ad fidem et docendi lumen sparsim addidisse; sed particularium notas et codicillos ac commentarios suos in lucem edere supervacuum et molestum putasse: ideoque fecisse quod in aedificando fieri solet, nempe post aedificii structuram machinas et scalas a conspectu amovisse. Neque aliter factum esse credere certe oportet.

Verum nisi quis omnino oblitus fuerit eorum quae superius dicta sunt, huic objectioni (aut scrupulo potius) facile respondebit. Formam enim inquirendi et

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and turmoil. It keeps the mind away from the serenity and calm of abstract wisdom, and shuts it out, as if from a far more divine state. We gladly agree with this reasoning. The very thing they hint at and prefer is what we are doing, above all and before everything else. For we are laying down in the human understanding a true model of the world, as it is found to be, not as anyone's own reason has dictated. And this cannot be done without a dissection and a most careful anatomy of the world.

As for the foolish models of worlds that human fancies have built in philosophies, apish imitations as it were, we declare that they must be scattered altogether. Let people know, then (as we said above), how great a difference there is between the *idols* of the human mind and the ideas of the divine mind. The former are nothing but arbitrary abstractions. The latter are the Creator's true seals on his creatures, as they are stamped and marked out in matter by true and exact lines. So in this domain truth and usefulness are the very same thing. And works themselves are to be valued more as pledges of truth than for the comforts they bring to life.

Perhaps this too will be raised: that we are doing what has already been done, and that the ancients themselves kept to the same path as we do. So someone will think it likely that we too, after all this stir and effort, will end up at last at one of the philosophies that prevailed among the ancients. For they too, it will be said, gathered a great mass and wealth of examples and particulars at the start of their inquiries. They arranged these in notebooks under topics and headings, and from them built their philosophies and arts. Then, once the matter was established, they pronounced on it, adding examples here and there to win belief and to light up their teaching. But they thought it superfluous and troublesome to publish their notes, memoranda and notebooks of particulars. So they did what builders usually do: once the building is up, they remove the machinery and ladders from sight. And surely, the objection runs, one must believe it happened no other way.

But anyone who has not completely forgotten what was said above will easily answer this objection, or rather this scruple. For we ourselves state

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inveniendi apud antiquos et ipsi profitemur, et scripta eorum prae se ferunt. Ea autem non alia fuit, quam ut ab exemplis quibusdam et particularibus (additis notionibus communibus, et fortasse portione nonnulla ex opinionibus receptis, quae maxime placuerunt) ad conclusiones maxime generales sive principia scientiarum advolarent, ad quorum veritatem immotam et fixam conclusiones inferiores per media educerent ac probarent; ex quibus artem constituebant.

Tum demum si nova particularia et exempla mota essent et adducta quae placitis suis refragarentur, illa aut per distinctiones aut per regularum suarum explanationes in ordinem subtiliter redigebant, aut demum per exceptiones grosso modo summovebant: at rerum particularium non refragantium causas ad illa principia sua laboriose et pertinaciter accommodabant. Verum nec historia naturalis et experientia illa erat, quam fuisse oportebat (longe certe abest), et ista advolatio ad generalissima omnia perdidit.

1.126 Occurret et illud: nos, propter inhibitionem quandam pronuntiandi et principia certa ponendi donec per medios gradus ad generalissima rite perventum sit, suspensionem quandam judicii tueri, atque ad Acatalepsiam rem deducere. Nos vero non *Acatalepsiam*, sed *Eucatalepsiam* meditamur et proponimus: sensui enim non derogamus, sed ministramus; et intellectum non contemnimus, sed regimus. Atque melius est scire quantum opus sit, et tamen nos non penitus scire putare, quam penitus scire nos putare, et tamen nil eorum quae opus est scire.

1.127 Etiam dubitabit quispiam potius quam objiciet, utrum nos de Naturali tantum Philosophia, an etiam de scientiis reliquis, Logicis, Ethicis, Politicis, secundum viam nostram perficiendis loquamur. At nos certe de universis haec quae dicta sunt intelligimus: atque quemadmodum vulgaris logica, quae regit res per syllogismum, non tantum ad naturales, sed ad omnes scientias pertinet; ita et nostra, quae procedit per *inductionem*, omnia complectitur. Tam enim historiam et tabulas inveniendi conficimus de ira, metu, et verecundia, et similibus; ac etiam de exemplis rerum civilium: nec minus de motibus

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what the ancients' form of inquiry and discovery was, and their writings display it openly. It was nothing other than this. From certain examples and particulars, with common notions added, and perhaps some portion of the received opinions that were most popular, they flew to the most general conclusions, or principles of the sciences. Then, treating these as unshaken and fixed truths, they drew out and proved lower conclusions through middle terms. Out of these they built their art.

Then, if new particulars and examples were raised and brought forward that contradicted their doctrines, they had two remedies. Either they brought these subtly back into line by distinctions or by explanations of their rules, or else they simply cleared them away crudely by exceptions. Meanwhile they laboriously and stubbornly fitted the causes of particulars that did not contradict them to those principles of theirs. But their natural history and experience was not what it should have been, far from it. And that flight to the most general ruined everything.

This too will be raised. We hold back from pronouncing and laying down fixed principles until the most general are properly reached through intermediate steps. So, it will be said, we are defending a kind of suspension of judgment and bringing things to Acatalepsy [the view that nothing can be known]. But what we have in mind and propose is not *Acatalepsy* but *Eucatalepsy* [sound comprehension]. For we do not disparage the senses but serve them, and we do not despise the understanding but direct it. And it is better to know as much as we need, and yet think we do not know it fully, than to think we know it fully and yet know nothing of what we need.

Someone may also wonder, rather than object, about the scope of our way. Are we speaking only of perfecting natural philosophy by it, or also the other sciences, such as logic, ethics and politics? We certainly mean what has been said to apply to all of them. Ordinary logic, which governs things by syllogism, extends not only to the natural sciences but to all sciences. In the same way ours, which proceeds by *induction*, embraces everything. For we compile histories and tables of discovery on anger, fear, shame and the like, and

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mentalibus memoriae, compositionis et divisionis, judicii, et reliquorum, quam de calido et frigido, aut luce, aut vegetatione, aut similibus.	also on examples from civil affairs. We compile them no less on the mental motions of memory, of composition and division, of judgment and the rest, than on hot and cold, or light, or vegetative growth, and the like.
Sed tamen cum nostra ratio *interpretandi*, post historiam praeparatam et ordinatam, non mentis tantum motus et discursus (ut logica vulgaris), sed et rerum naturam intueatur; ita mentem regimus, ut ad rerum naturam se, aptis per omnia modis, applicare possit. Atque propterea multa et diversa in doctrina *interpretationis* praecipimus, quae ad subjecti, de quo inquirimus, qualitatem et conditionem, modum inveniendi nonnulla ex parte applicent.	But once a history has been prepared and set in order, our method of *interpretation* looks not only to the motions and workings of the mind, as ordinary logic does, but also to the nature of things. So we direct the mind in such a way that it can apply itself to the nature of things by means suited to it in every respect. That is why, in the doctrine of *interpretation*, we lay down many different precepts. In part, these adapt the method of discovery to the quality and condition of the subject under inquiry.
1.128 At illud de nobis ne dubitare quidem fas sit; utrum nos philosophiam et artes et scientias quibus utimur destruere et demoliri cupiamus: contra enim, earum et usum et cultum et honores libenter amplectimur. Neque enim ullo modo officimus, quin istae, quae invaluerunt, et disputationes alant, et sermones ornent, et ad professoria munera ac vitae civilis compendia adhibeantur et valeant; denique, tanquam numismata quaedam, consensu inter homines recipiantur. Quinetiam significamus aperte, ea quae nos adducimus ad istas res non multum idonea futura; cum ad vulgi captum deduci omnino non possint, nisi per effecta et opera tantum. At hoc ipsum, quod de affectu nostro et bona voluntate erga scientias receptas dicimus, quam vere profiteamur, scripta nostra in publicum edita (praesertim libri *De Progressu Scientiarum*) fidem faciant.	But on one point let there be no doubt at all about us: we do not wish to destroy and demolish the philosophy, arts and sciences now in use. On the contrary, we gladly embrace their use, their cultivation and the honors paid them. We in no way stand in the way of the prevailing ones. Let them feed disputations and adorn discourse. Let them be used, and serve well, for professorial duties and the conveniences of civil life. In short, let them be accepted among people by common consent, like a kind of currency. Indeed, we say openly that what we bring forward will not be very suitable for these purposes, since it cannot be brought down to the grasp of the crowd at all, except through its effects and works. As for how sincerely we profess this affection and goodwill toward the received sciences, let our published writings bear witness, especially the books *On the Advancement of Learning*.[44]
Itaque id verbis amplius vincere non conabimur. Illud interim constanter et diserte monemus; his modis, qui in usu sunt, nec magnos in scientiarum doctrinis et contemplatione progressus fieri, nec illas ad amplitudinem operum deduci posse.	So we will not try to win the point further with words. Meanwhile we give this warning, firmly and plainly. By the methods now in use, no great progress can be made in the teaching and contemplation of the sciences, nor can they be brought to yield works in any abundance.

THE EXCELLENCE OF THE END

Discoveries benefit all humankind, and man's rightful dominion over nature rests on the arts and sciences.

LATIN	ENGLISH
1.129 Superest ut de Finis excellentia pauca dicamus. Ea si prius dicta fuissent, votis similia videri potuissent: sed	It remains for us to say a few words about the excellence of the end. Had this been said earlier, it

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spe jam facta, et iniquis praejudiciis sublatis, plus fortasse ponderis habebunt. Quod si nos omnia perfecissemus et plane absolvissemus, nec alios in partem et consortium laborum subinde vocaremus, etiam ab hujusmodi verbis abstinuissemus, ne acciperentur in praedicationem meriti nostri. Cum vero aliorum industria acuenda sit et animi excitandi atque accendendi, consentaneum est ut quaedam hominibus in mentem redigamus.

Primo itaque, videtur inventorum nobilium introductio inter actiones humanas longe primas partes tenere: id quod antiqua saecula judicaverunt. Ea enim rerum inventoribus divinos honores tribuerunt; iis autem qui in rebus civilibus merebantur (quales erant urbium et imperiorum conditores, legislatores, patriarum a diuturnis malis liberatores, tyrannidum debellatores, et his similes), heroum tantum honores decreverunt. Atque certe si quis ea recte conferat, justum hoc prisci saeculi judicium reperiet. Etenim inventorum beneficia ad universum genus humanum pertinere possunt, civilia ad certas tantummodo hominum sedes: haec etiam non ultra paucas aetates durant, illa quasi perpetuis temporibus. Atque status emendatio in civilibus non sine vi et perturbatione plerumque procedit: at inventa beant, et beneficium deferunt absque alicujus injuria aut tristitia.

Etiam inventa quasi novae creationes sunt, et divinorum operum imitamenta; ut bene cecinit ille:

Primum frugiferos foetus mortalibus aegris
Dididerant quondam praestanti nomine Athenae;
Et RECREAVERUNT vitam, legesque rogarunt.

Atque videtur notatu dignum in Solomone; quod cum imperio, auro, magnificentia operum, satellitio, famulitio, classe insuper, et nominis claritate, ac summa hominum admiratione floreret, tamen nihil horum delegerit sibi ad gloriam sed ita pronuntiaverit: *Gloriam Dei esse, celare rem; gloriam regis, investigare rem.*

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might have seemed like mere wishing. But now that hope has been raised and unfair prejudices removed, it will perhaps carry more weight. If we had completed and fully finished everything ourselves, and were not calling on others to share and join in the labor, we would have refrained from words of this kind, so that they would not be taken as a proclamation of our own merit. But the industry of others must be sharpened, and their spirits roused and kindled. So it is fitting that we remind people of certain things.

First, then, the introduction of noble discoveries seems to hold by far the first place among human actions, and this was the judgment of ancient times. They paid divine honors to the discoverers of things. To those who did good service in civil affairs, however, they decreed only the honors of heroes. These were the founders of cities and empires, lawgivers, those who delivered their countries from long misfortunes, those who overthrew tyrannies, and the like. Anyone who compares the two properly will find this judgment of the early age just. For the benefits of discoveries can extend to the whole human race, while civil benefits reach only particular places where people live. The latter last no more than a few generations, the former, as it were, for all time. Moreover, reform of the state in civil matters seldom proceeds without violence and disorder, whereas discoveries bring blessing and confer their benefits without injury or grief to anyone.

Discoveries are also like new creations, and imitations of divine works, as the poet sang so well:[45]

It was Athens of famous name that first, long ago,
Gave grain-bearing crops to suffering mortals;
And she RE-CREATED life, and enacted laws.

It seems worth noting about Solomon that he flourished in power, gold, magnificent works, bodyguards, servants, a fleet besides, renown, and the highest admiration of mankind. Yet he chose none of these for his glory, but declared: *It is the glory of God to conceal a thing; the glory of the king to search a thing out.*[46]

44 Bacon's *The Advancement of Learning* (1605), later expanded in Latin as *De Augmentis Scientiarum* (1623).
45 Lucretius, *On the Nature of Things* 6.1–3.
46 Proverbs 25:2.

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Rursus (si placet) reputet quispiam, quantum intersit inter hominum vitam in excultissima quapiam Europae provincia, et in regione aliqua Novae Indiae maxime fera et barbara: ea tantum differre existimabit, ut merito *hominem homini Deum esse,* non solum propter auxilium et beneficium, sed etiam per status comparationem, recte dici possit. Atque hoc non solum, non coelum, non corpora, sed artes praestant.

Rursus, vim et virtutem et consequentias rerum inventarum notare juvat; quae non in aliis manifestius occurrunt, quam in illis tribus quae antiquis incognitae, et quarum primordia, licet recentia, obscura et ingloria sunt: Artis nimirum Imprimendi, Pulveris Tormentarii, et Acus Nauticae. Haec enim tria rerum faciem et statum in orbe terrarum mutaverunt: primum, in re literaria; secundum, in re bellica; tertium, in navigationibus: unde innumerae rerum mutationes sequutae sunt; ut non imperium aliquod, non secta, non stella, majorem efficaciam et quasi influxum super res humanas exercuisse videatur, quam ista mechanica exercuerunt.

Praeterea non abs re fuerit, tria hominum ambitionis genera et quasi gradus distinguere. Primum eorum, qui propriam potentiam in patria sua amplificare cupiunt; quod genus vulgare est et degener. Secundum eorum, qui patriae potentiam et imperium inter humanum genus amplificare nituntur; illud plus certe habet dignitatis, cupiditatis haud minus. Quod si quis humani generis ipsius potentiam et imperium in rerum universitatem instaurare et amplificare conetur, ea proculdubio ambitio (si modo ita vocanda sit) reliquis et sanior est et augustior. Hominis autem imperium in res, in solis artibus et scientiis ponitur. Naturae enim non imperatur, nisi parendo.

Praeterea, si unius alicujus particularis inventi utilitas ita homines affecerit, ut eum qui genus humanum universum beneficio aliquo devincire potuerit homine majorem putaverint; quanto celsius videbitur tale aliquid invenire, per quod alia omnia expedite inveniri possint? Et tamen (ut verum omnino dicamus) quemadmodum luci magnam habemus gratiam, quod per eam vias inire,

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Again, let anyone consider, if he will, how great a difference there is between human life in some highly civilized province of Europe and in some utterly wild and uncivilized region of the West Indies. He will think the difference so great that it may rightly be said that *man is a god to man*. This is true not only because of the help and benefit one gives another, but also when their conditions are compared. And this difference comes not from the soil, not from the climate, not from bodies, but from the arts.

Again, it is worth noting the force, power and consequences of discoveries. These appear nowhere more plainly than in three that were unknown to the ancients, and whose origins, though recent, are obscure and without glory: printing, gunpowder and the compass. For these three have changed the whole face and state of things throughout the world: the first in learning, the second in warfare, the third in navigation. Countless changes have followed from them. No empire, no sect, no star seems to have exerted greater power and, so to speak, influence over human affairs than these mechanical discoveries.

Further, it will not be out of place to distinguish three kinds, or as it were grades, of human ambition. The first belongs to those who want to enlarge their own power within their own country; this kind is common and base. The second belongs to those who strive to enlarge the power and dominion of their country among the human race; this certainly has more dignity, but no less greed. But if someone tries to renew and enlarge the power and dominion of the human race itself over the universe of things, that ambition (if it should even be called ambition) is without doubt both sounder and nobler than the others. Now man's dominion over things rests solely on the arts and sciences. For nature is commanded only by being obeyed.

Further, the usefulness of a single particular discovery has so impressed people that they have thought anyone who could bind the whole human race to him by some benefit to be more than human. How much loftier, then, will it seem to discover something through which all other things can readily be discovered? And yet, to tell the

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artes exercere, legere, nos invicem dignoscere possimus; et nihilominus ipsa visio lucis res praestantior est et pulchrior, quam multiplex ejus usus: ita certe ipsa contemplatio rerum prout sunt, sine superstitione aut impostura, errore aut confusione, in seipsa magis digna est, quam universus inventorum fructus.

Postremo, siquis depravationem scientiarum et artium ad malitiam et luxuriam et similia objecerit; id neminem moveat. Illud enim de omnibus mundanis bonis dici potest, ingenio, fortitudine, viribus, forma, divitiis, luce ipsa, et reliquis. Recuperet modo genus humanum jus suum in naturam quod ei ex dotatione divina competit, et detur ei copia: usum vero recta ratio et sana religio gubernabit.

1.130 Jam vero tempus est ut artem ipsam Interpretandi Naturam proponamus: in qua licet nos utilissima et verissima praecepisse arbitremur, tamen necessitatem ei absolutam (ac si absque ea nil agi possit) aut etiam perfectionem non attribuimus. Etenim in ea opinione sumus: si justam Naturae et Experientiae Historiam praesto haberent homines, atque in ea sedulo versarentur, sibique duas res imperare possent; unam, ut receptas opiniones et notiones deponerent; alteram, ut mentem a generalissimis et proximis ab illis ad tempus cohiberent; fore ut etiam vi propria et genuina mentis, absque alia arte, in formam nostram Interpretandi incidere possent. Est enim *Interpretatio* verum et naturale opus mentis, demptis iis quae obstant: sed tamen omnia certe per nostra praecepta erunt magis in procinctu, et multo firmiora.

Neque tamen illis nihil addi posse affirmamus: sed contra, nos, qui mentem respicimus non tantum in facultate propria, sed quatenus copulatur cum rebus, Artem inveniendi cum Inventis adolescere posse, statuere debemus.

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whole truth, consider light. We are very grateful to light, because by it we can find our way, practice the arts, read and recognize one another. And yet the sight of light itself is a finer and more beautiful thing than its many uses. In the same way, the very contemplation of things as they are, without superstition or imposture, error or confusion, is surely worthier in itself than all the fruits of discovery.

Finally, someone may object that the sciences and arts are perverted to serve malice, luxury and the like. Let that move no one. For the same can be said of all worldly goods: intelligence, courage, strength, beauty, wealth, light itself, and the rest. Only let the human race recover its right over nature, which belongs to it by divine bequest, and let it be given the means. Right reason and sound religion will govern the use.

Now it is time to set out the art of interpreting nature itself. We believe that the precepts we have given in it are most useful and most true. Yet we do not claim that it is absolutely necessary, as if nothing could be done without it, nor that it is perfect. For our view is this. Suppose people had a proper history of nature and experience at hand, and worked hard at it. Suppose too they could impose two rules on themselves: first, to lay aside received opinions and notions; second, to restrain the mind for a time from the most general principles and those nearest them. Then they could arrive at our form of interpretation by the native force of the mind alone, without any other art. For *interpretation* is the true and natural work of the mind once what stands in its way is removed. But certainly everything will be more ready to hand, and far more secure, through our precepts.

Nor do we claim that nothing can be added to them. On the contrary, we regard the mind not only in its own capacity but as it is joined with things. So we must hold that the art of discovery can grow along with discoveries.

Book II

The method
Forms, tables of presence and absence, the inquiry into heat, and the prerogative instances.

	LATIN	ENGLISH
2.1	Super datum corpus novam naturam sive novas naturas generare et superinducere, opus et intentio est humanae potentiae. Datae autem naturae Formam, sive differentiam veram, sive naturam naturantem, sive fontem emanationis (ista enim vocabula habemus, quae ad indicationem rei proxime accedunt) invenire, opus et intentio est humanae scientiae. Atque his operibus primariis subordinantur alia opera duo secundaria et inferioris notae; priori, transformatio corporum concretorum de alio in aliud, intra terminos *Possibilis*; posteriori, inventio in omni generatione et motu *latentis processus*, continuati ab efficiente manifesto et materia manifesta usque ad Formam inditam; et inventio similiter *latentis schematismi* corporum quiescentium et non in motu.	To generate and superinduce a new nature, or new natures, on a given body is the work and aim of human power. To discover the form of a given nature is the work and aim of human knowledge. By form we also mean its true difference, or *natura naturans*, or source of emanation, for these are the terms we have that come closest to indicating the thing. Subordinate to these primary works are two others, secondary and of lower rank. Under the former comes the transformation of concrete bodies from one into another, within the bounds of the *possible*. Under the latter comes the discovery, in every generation and motion, of the *latent process*, running continuously from the manifest efficient cause and the manifest material up to the form that is imparted. It also includes the discovery of the *latent configuration* of bodies that are at rest and not in motion.[1]
2.2	Quam infeliciter se habeat scientia humana, quae in usu est, etiam ex illis liquet quae vulgo asseruntur. Recte ponitur; *Vere scire, esse per causas scire*. Etiam non male constituuntur causae quatuor; Materia, Forma, Efficiens, et Finis. At ex his causa finalis tantum abest ut prosit, ut etiam scientias corrumpat, nisi in hominis actionibus. Formae inventio habetur pro desperata. Efficiens vero, et materia (quales quaeruntur et recipiuntur, remotae scilicet, absque *latenti processu* ad formam) res perfunctoriae sunt, et superficiales, et nihili fere ad scientiam veram et activam. Neque tamen obliti sumus nos superius notasse et correxisse errorem mentis humanae, in deferendo formis primas essentiae.	Even what is commonly asserted shows how badly human knowledge as now practiced is faring. It is rightly laid down that *to know truly is to know through causes*. It is also not wrongly established that there are four causes: matter, form, efficient cause and end. But of these, the final cause is so far from helping that it actually corrupts the sciences, except where human actions are concerned. The discovery of form is regarded as hopeless. And the efficient and material causes, as they are now sought and accepted, are perfunctory and superficial things, of almost no value for true and active knowledge. For they are sought as remote causes, without the *latent process* that leads to the form. Nor have we forgotten that we noted and corrected above the error of the human mind in giving forms the first place in essence.
	Licet enim in natura nihil vere existat praeter corpora individua, edentia actus puros individuos ex lege; in	For in nature nothing really exists except individual bodies, performing pure individual acts according to law. Yet in the sciences it is that very

	LATIN	ENGLISH
	doctrinis tamen, illa ipsa lex, ejusque inquisitio et inventio atque explicatio, pro fundamento est tam ad sciendum, quam ad operandum. Eam autem *legem*, ejusque *paragraphos*, formarum nomine intelligimus; praesertim cum hoc vocabulum invaluerit, et familiariter occurrat.	law, and the investigation, discovery and explanation of it, that is the foundation for knowing and acting alike. It is this *law*, with its *clauses*, that we mean by the name of forms. We use that word especially because it has become established and is in common use.
2.3	Qui causam alicujus naturae (veluti albedinis aut caloris) in certis tantum subjectis novit; ejus scientia imperfecta est: et qui effectum super certas tantum materias (inter eas, quae sunt susceptibiles) inducere potest; ejus potentia pariter imperfecta est. At qui efficientem et materialem causam tantummodo novit (quae causae fluxae sunt, et nihil aliud quam vehicula et causae formam deferentes in aliquibus), is ad nova inventa, in materia aliquatenus simili et praeparata, pervenire potest; sed rerum terminos altius fixos non movet. At qui formas novit, is naturae unitatem in materiis dissimillimis complectitur; itaque quae adhuc facta non sunt, qualia nec naturae vicissitudines, neque experimentales industriae, neque casus ipse, in actum unquam perduxissent, neque cogitationem humanam subitura fuissent, detegere et producere potest.	Someone who knows the cause of some nature, such as whiteness or heat, only in certain subjects has imperfect knowledge. And someone who can produce an effect only on certain materials, among those susceptible to it, has equally imperfect power. Someone who knows only the efficient and material cause can arrive at new discoveries in material that is somewhat similar and prepared. But these causes are unstable, nothing more than vehicles, causes that carry the form in some cases. So he does not move the more deeply fixed boundaries of things. But whoever knows forms grasps the unity of nature in the most dissimilar materials. He can therefore uncover and produce things that have never yet been done. These are things that neither the vicissitudes of nature, nor the diligence of experiment, nor chance itself would ever have brought into being. Nor would they ever have entered human thought.
	Quare ex formarum inventione sequitur contemplatio vera, et operatio libera.	Therefore from the discovery of forms follow true contemplation and free operation.

A RULE FOR PRACTICE

A true precept for producing a nature must be certain, free and practical, which amounts to finding its form.

	LATIN	ENGLISH
2.4	Licet viae ad potentiam atque ad scientiam humanam conjunctissimae sint et fere eaedem, tamen propter perniciosam et inveteratam consuetudinem versandi in abstractis, tutius omnino est ordiri et excitare scientias ab iis fundamentis quae in ordine sunt ad partem activam, atque ut illa ipsa partem contemplativam signet et determinet. Videndum itaque est, ad aliquam naturam super corpus datum generandam et superinducendam, quale quis praeceptum aut qualem quis directionem aut deductionem maxime optaret; idque sermone simplici et minime abstruso.	The paths to human power and to human knowledge lie very close together and are almost the same. Nevertheless, people have a pernicious and long-standing habit of dwelling in abstractions. Because of it, it is altogether safer to begin and build the sciences from foundations that relate to the active part, and to let that active part mark out and determine the contemplative. So we must consider what kind of precept, or what kind of direction or guidance, a person would most wish for in order to generate and superinduce some nature on a given body. And we must put it in simple and not at all obscure language.

1 Form, in Bacon's technical sense, is the law of a nature's action, not a scholastic essence. *Natura naturans* ("nature naturing") is a scholastic term for nature as active cause, and the latent configuration is the hidden structure of a body's parts.

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Exempli gratia; si quis argento cupiat superinducere flavum colorem auri aut augmentum ponderis (servatis legibus materiae), aut lapidi alicui non diaphano diaphaneitatem, aut vitro tenacitatem, aut corpori alicui non vegetabili vegetationem; videndum (inquam) est, quale quis praeceptum aut deductionem potissimum sibi dari exoptet. Atque primo, exoptabit aliquis proculdubio sibi monstrari aliquid hujusmodi, quod opere non frustret neque experimento fallat. Secundo, exoptabit quis aliquid sibi praescribi, quod ipsum non astringat et coerceat ad media quaedam et modos quosdam operandi particulares. Fortasse enim destituetur, nec habebit facultatem et commoditatem talia media comparandi et procurandi.

Quod si sint et alia media et alii modi (praeter illud praeceptum) progignendae talis naturae, ea fortasse ex iis erunt quae sunt in operantis potestate; a quibus nihilominus per angustias praecepti excludetur, nec fructum capiet. Tertio, optabit aliquid sibi monstrari, quod non sit aeque difficile ac illa ipsa operatio de qua inquiritur, sed propius accedat ad praxin.

Itaque de praecepto vero et perfecto operandi, pronuntiatum erit tale; *ut sit certum, liberum, et disponens sive in ordine ad actionem.* Atque hoc ipsum idem est cum inventione formae verae. Etenim forma naturae alicujus talis est ut, ea posita, natura data infallibiliter sequatur. Itaque adest perpetuo, quando natura illa adest, atque eam universaliter affirmat, atque inest omni. Eadem forma talis est ut, ea amota, natura data infallibiliter fugiat. Itaque abest perpetuo, quando natura illa abest, eamque perpetuo abnegat, atque inest soli. Postremo, forma vera talis est, ut naturam datam ex fonte aliquo essentiae deducat quae inest pluribus, et notior est naturae (ut loquuntur) quam ipsa forma.

Itaque de axiomate vero et perfecto sciendi pronuntiatum et praeceptum tale est; *ut inveniatur natura alia, quae sit cum natura data convertibilis, et tamen sit limitatio naturae notioris, instar generis veri*. Ista autem duo pronuntiata, activum et contemplativum, res eadem sunt; et quod in operando utilissimum, id in sciendo verissimum.

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For example, someone may want to superinduce on silver the yellow color of gold, or an increase in weight (observing the laws of matter). Or he may want to give transparency to some stone that is not transparent, or toughness to glass, or vegetative life to some body that is not vegetative. We must consider, I say, what kind of precept or guidance he would most wish to be given. First, he will certainly wish to be shown something that will not disappoint him in practice or fail him in the trial. Second, he will wish to be prescribed something that does not tie him down and confine him to certain particular means and ways of operating. For he may lack them, and not have the ability or opportunity to obtain and procure such means.

There may also be other means and other ways, apart from that precept, of producing such a nature. These may well be among those within the operator's power. Yet the narrowness of the precept will shut him out from them, and he will gain no fruit. Third, he will wish to be shown something that is not as difficult as the very operation under inquiry, but comes closer to practice.

So for a true and perfect precept of operation, the pronouncement will be this: *that it be certain, free, and disposing, or leading toward action.* And this is the same thing as the discovery of the true form. For the form of a nature is such that, given the form, the nature infallibly follows. So the form is always present when that nature is present, it universally implies the nature, and it is found in every case of it. The same form is such that, if it is taken away, the nature infallibly vanishes. So it is always absent when that nature is absent, it always implies the nature's absence, and it is found in that nature alone. Finally, the true form is such that it derives the given nature from some source of being that is present in several natures. This source is better known to nature (as they say) than the form itself.

And so for a true and perfect axiom of knowledge, the pronouncement and precept is this: *that another nature be found which is convertible with the given nature, and yet is a limitation of a better-known nature, as of a true genus*. These two pronouncements, the active and the contemplative, are the same thing. What is most useful in operating is truest in knowing.

LATENT PROCESS AND CONFIGURATION

Bacon describes two kinds of axioms for transforming bodies, and the hidden processes and structures they depend on.

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2.5	At praeceptum sive axioma de transformatione corporum duplicis est generis. Primum intuetur corpus, ut turmam sive conjugationem naturarum simplicium: ut in auro haec conveniunt; quod sit flavum; quod sit ponderosum, ad pondus tale; quod sit malleabile aut ductile, ad extensionem talem; quod non fiat volatile, nec deperdat de quanto suo per ignem; quod fluat fluore tali; quod separetur et solvatur modis talibus; et similiter de caeteris naturis, quae in auro concurrunt. Itaque hujusmodi axioma rem deducit ex formis naturarum simplicium. Nam qui formas et modos novit superinducendi flavi, ponderis, ductilis, fixi, fluoris, solutionum, et sic de reliquis, et eorum graduationes et modos, videbit et curabit ut ista conjungi possint in aliquo corpore, unde sequatur transformatio in aurum. Atque hoc genus operandi pertinet ad actionem primariam.	The precept or axiom for the transformation of bodies is of two kinds. The first regards a body as a troop or combination of simple natures. In gold, for example, these natures come together. It is yellow. It is heavy, to a certain weight. It is malleable or ductile, to a certain extent. It does not become volatile or lose any of its quantity in fire. It flows with a certain fluidity. It is separated and dissolved in certain ways. And so on for the other natures that meet in gold. An axiom of this kind, then, derives the thing from the forms of simple natures. Someone may know the forms, and the ways of superinducing yellowness, weight, ductility, fixity, fluidity, solubility and the rest, together with their degrees and modes. He will see to it that they can be joined in some body, and the transformation into gold will follow. And this kind of operation belongs to primary action.
	Eadem enim est ratio generandi naturam unam aliquam simplicem, et plures; nisi quod arctetur magis restringatur homo in operando, si plures requirantur, propter difficultatem tot naturas coadunandi; quae non facile conveniunt, nisi per vias naturae tritas et ordinarias. Utcunque tamen dicendum est, quod iste modus operandi (qui naturas intuetur simplices, licet in corpore concreto) procedat ex iis, quae in natura sunt constantia et aeterna et catholica, et latas praebeat potentiae humanae vias, quales (ut nunc sunt res) cogitatio humana vix capere aut repraesentare possit.	For the method of generating a single simple nature is the same as that for generating several. The only difference is that a person is more constrained and restricted in operating if several are required. That is because it is difficult to unite so many natures, which do not easily come together except by nature's well-worn and ordinary paths. At any rate, it must be said that this mode of operating looks to simple natures, though in a concrete body. It proceeds from what is constant, eternal and universal in nature, and it opens broad roads to human power, such as human thought, as things now stand, can scarcely grasp or picture.
	At secundum genus axiomatis (quod a *latentis processus* inventione pendet) non per naturas simplices procedit, sed per concreta corpora, quemadmodum in natura inveniuntur, cursu ordinario. Exempli gratia; in casu ubi fit inquisitio, ex quibus initiis, et quo modo, et quo processu, aurum aut aliud quodvis metallum aut lapis generetur, a primis menstruis aut rudimentis suis usque ad mineram perfectam; aut similiter, quo processu herbae generentur, a primis concretionibus succorum in terra, aut a seminibus, usque ad plantam formatam, cum universa illa successione motus, et diversis et continuatis naturae nixibus; similiter, de generatione ordinatim explicata animalium, ab initu ad partum; et similiter de corporibus aliis.	The second kind of axiom depends on the discovery of *latent process*. It proceeds not by simple natures but by concrete bodies, as they are found in nature in its ordinary course. Take, for example, the inquiry into how gold, or any other metal or stone, is generated. We ask from what beginnings, in what manner and by what process it forms, from its first formative fluids or rudiments up to the finished ore. Or we ask likewise by what process plants are generated, from the first concretions of juices in the earth, or from seeds, up to the formed plant. This includes that whole succession of motion and nature's varied and continuous ef-

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forts. Likewise we may trace, step by step, the generation of animals from conception to birth; and likewise with other bodies.

Enimvero neque ad generationes corporum tantum spectat haec inquisitio, sed etiam ad alios motus et opificia naturae. Exempli gratia; in casu ubi fit inquisitio de universa serie et continuatis actionibus alimentandi, a prima receptione alimenti ad assimilationem perfectam; aut similiter de motu voluntario in animalibus, a prima impressione imaginationis et continuatis nixibus spiritus usque ad flexiones et motus artuum; aut de explicato motu linguae et labiorum et instrumentorum reliquorum usque ad editionem vocum articulatarum. Nam haec quoque spectant ad naturas concretas, sive collegiatas et in fabrica; et intuentur veluti consuetudines naturae particulares et speciales, non leges fundamentales et communes, quae constituunt formas. Veruntamen omnino fatendum est, rationem istam videri expeditiorem et magis sitam in propinquo, et spem injicere magis, quam illam primariam.

Nor does this inquiry concern only the generation of bodies. It extends also to other motions and workings of nature. We may inquire, for example, into the whole series and continuous actions of nutrition, from the first intake of food to its complete assimilation. Or likewise into voluntary motion in animals, from the first impression on the imagination, through the continuous efforts of the spirit, up to the bending and movements of the limbs. Or into the unfolding motion of the tongue, lips and other organs, up to the utterance of articulate sounds. For these too concern concrete natures, or natures joined together and built into a structure. They regard nature's particular and special habits, as it were, not the fundamental and common laws that constitute forms. Yet it must certainly be admitted that this method seems readier and closer at hand, and gives more hope, than the primary one.

At pars Operativa similiter, quae huic parti Contemplativae respondet, operationem extendit et promovet ab iis quae ordinario in natura inveniuntur ad quaedam proxima, aut a proximis non admodum remota; sed altiores et radicales operationes super naturam pendent utique ab axiomatibus primariis. Quinetiam ubi non datur homini facultas operandi, sed tantum sciendi, ut in coelestibus (neque enim ceditur homini operari in coelestia, aut ea immutare aut transformare), tamen inquisitio facti ipsius sive veritatis rei, non minus quam cognitio causarum et consensuum, ad primaria illa et catholica axiomata de naturis simplicibus (veluti de natura rotationis spontaneae, attractionis sive virtutis magneticae, et aliorum complurium quae magis communia sunt quam ipsa coelestia) refertur.

Similarly, the operative part that corresponds to this contemplative part extends and advances operation from what is ordinarily found in nature to certain things close by, or not very far from what is close by. But the deeper and more radical operations on nature depend entirely on the primary axioms. Moreover, a person may be given no ability to operate, but only to know, as with the heavens; for it is not granted to man to operate on the heavens, or to change or transform them. Even there, the investigation of the fact itself, or the truth of the matter, is referred to those primary and universal axioms about simple natures, no less than the knowledge of causes and correspondences is. These simple natures include spontaneous rotation, attraction or magnetic force, and many others that are more common than the heavenly bodies themselves.

Neque enim speret aliquis terminare quaestionem, utrum in motu diurno revera terra aut coelum rotet, nisi naturam rotationis spontaneae prius comprehenderit.

For no one should hope to settle whether, in the daily motion, it is really the earth or the heavens that rotate, unless he has first grasped the nature of spontaneous rotation.

2.6 *Latens* autem *Processus*, de quo loquimur, longe alia res est quam animis hominum (qualiter nunc obsidentur) facile possit occurrere. Neque enim intelligimus mensuras

The *latent process* we speak of is something very different from what can easily occur to people's minds, beset as they now are. We do not mean cer-

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quasdam, aut signa, aut scalas processus in corporibus spectabiles; sed plane processum continuatum, qui maxima ex parte sensum fugit.

Exempli gratia; in omni generatione et transformatione corporum, inquirendum quid deperdatur et evolet, quid maneat, quid accedat; quid dilatetur, quid contrahatur; quid uniatur, quid separetur; quid continuetur, quid abscindatur; quid impellat, quid impediat; quid dominetur, quid succumbat; et alia complura.

Neque hic rursus, haec tantum in generatione aut transformatione corporum quaerenda sunt; sed et in omnibus aliis alterationibus et motibus similiter inquirendum quid antecedat, quid succedat; quid sit incitatius, quid remissius; quid motum praebeat, quid regat; et hujusmodi. Ista vero omnia scientiis (quae nunc pinguissima Minerva et prorsus inhabili contexuntur) incognita sunt et intacta. Cum enim omnis actio naturalis per minima transigatur, aut saltem per illa quae sunt minora quam ut sensum feriant, nemo se naturam regere aut vertere posse speret, nisi illa debito modo comprehenderit et notaverit.

2.7 Similiter, inquisitio et inventio *latentis schematismi* in corporibus res nova est, non minus quam inventio *latentis processus* et formae. Versamur enim plane adhuc in atriis naturae, neque ad interiora paramus aditum. At nemo corpus datum nova natura dotare vel in novum corpus foeliciter et apposite transmutare potest, nisi corporis alterandi aut transformandi bonam habuerit notitiam. In modos enim vanos incurret, aut saltem difficiles et perversos, nec pro corporis natura in quod operatur. Itaque ad hoc etiam via plane est aperienda et munienda.

Atque in anatomia corporum organicorum (qualia sunt hominis et animalium) opera sane recte et utiliter insumitur, et videtur res subtilis et scrutinium naturae bonum. At hoc genus anatomiae spectabile est, et sensui subjectum, et in corporibus tantum organicis locum habet. Verum hoc ipsum obvium quiddam est, et in promptu situm, prae anatomia vera *schematismi latentis* in corporibus quae habentur pro similaribus: praesertim in rebus specificatis et earum partibus, ut ferri, lapidis; et

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tain measures, or signs, or visible stages of a process in bodies. We mean simply a continuous process, which for the most part escapes the senses.

For example, in every generation and transformation of bodies we must ask what is lost and flies off, what remains, what is added; what expands, what contracts; what is united, what separated; what is continued, what cut off; what drives, what hinders; what dominates, what gives way; and much else.

Nor, again, are these things to be sought only in the generation or transformation of bodies. In all other alterations and motions too we must likewise ask what goes before and what comes after; what is quicker and what slower; what supplies motion and what governs it; and the like. All these things are unknown and untouched by the sciences, which are now woven by a most thick-witted Minerva, with no skill at all. For every natural action is carried out through the smallest particles, or at least through things too small to strike the senses. So no one should hope to govern or change nature unless he has grasped and noted them in the proper way.

Similarly, the investigation and discovery of the *latent configuration* in bodies is something new, no less than the discovery of *latent process* and of form. For we are plainly still lingering in nature's forecourts, and are not preparing any way into her inner rooms. Yet no one can endow a given body with a new nature, or transform it successfully and fittingly into a new body, unless he has a good knowledge of the body to be altered or transformed. Otherwise he will stumble into methods that are futile, or at least difficult and wrong-headed, and unsuited to the nature of the body he is working on. So here too a road must be opened and built.

In the anatomy of organic bodies, such as those of humans and animals, effort is indeed spent rightly and usefully, and it seems a subtle matter and a good scrutiny of nature. But this kind of anatomy is visible and subject to the senses, and it applies only to organic bodies. It is something obvious and ready to hand compared with the true anatomy of the *latent configuration* in bodies considered uniform. This holds especially for specific

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partibus similaribus plantae, animalis, veluti radicis, folii, floris, carnis, sanguinis, ossis, etc. At etiam in hoc genere non prorsus cessavit industria humana; hoc ipsum enim innuit separatio corporum similarium per distillationes et alios solutionum modos, ut dissimilaritas compositi per congregationem partium homogenearum appareat.

Quod etiam ex usu est, et facit ad id quod quaerimus; licet saepius res fallax sit; quia complures naturae separationi imputantur et attribuuntur, ac si prius substitissent in composito, quas revera ignis et calor et alii modi apertionum de novo indunt et superinducunt. Sed et haec quoque parva pars est operis, ad inveniendum *schematismum* verum in composito; qui *schematismus* res est longe subtilior et accuratior, et ab operibus ignis potius confunditur quam eruitur et elucescit.

Itaque facienda est corporum separatio et solutio; non per ignem certe, sed per rationem et *inductionem* veram, cum experimentis auxiliaribus; et per comparationem ad alia corpora, et reductionem ad naturas simplices et earum formas, quae in composito conveniunt et complicantur; et transeundum plane a *Vulcano* ad *Minervam*, si in animo sit veras corporum texturas et *schematismos* (unde omnis occulta atque, ut vocant, specifica proprietas et virtus in rebus pendet; unde etiam omnis potentis alterationis et transformationis norma educitur) in lucem protrahere.

Exempli gratia; inquirendum, quid sit in omni corpore spiritus, quid essentiae tangibilis; atque ille ipse spiritus, utrum sit copiosus et turgeat, an jejunus et paucus; tenuis, aut crassior; magis aereus, aut igneus; acris, aut deses; exilis, aut robustus; in progressu, aut in regressu; abscissus, aut continuatus; consentiens cum externis et ambientibus, aut dissentiens; etc. Et similiter, essentia tangibilis (quae non pauciores recipit differentias, quam spiritus) atque ejus villi, et fibrae, et omnimoda textura; rursus autem collocatio spiritus per corpoream molem, ejusque pori, meatus, venae, et cellulae, et rudimenta, sive tentamenta corporis organici, sub eandem inquisitionem cadunt. Sed et in his quoque, atque adeo in omni *latentis schematismi* inventione, lux vera et clara ab axiomatibus primariis immittitur, quae certe caliginem omnem et subtilitatem discutit.

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kinds of things and their parts, such as iron or stone. It holds also for the uniform parts of a plant or animal, such as root, leaf, flower, flesh, blood, bone, etc. Yet even here human industry has not been wholly idle. This is just what the separation of uniform bodies by distillations and other kinds of dissolution aims at. It seeks to reveal the varied makeup of the compound by bringing together its homogeneous parts.

This too is useful, and serves our purpose, though it is often deceptive. For many natures are attributed to separation, as if they had existed beforehand in the compound, when in fact fire, heat and other ways of opening bodies introduce and superinduce them anew. But this too is only a small part of the work of finding the true *configuration* in the compound. For that *configuration* is a far subtler and more exact thing, and the work of fire confuses it rather than bringing it out into the light.

So bodies must be separated and dissolved, not by fire, certainly, but by reason and true *induction*, with auxiliary experiments. We must also compare them with other bodies, and reduce them to the simple natures and their forms that meet and are interwoven in the compound. We must pass over entirely from *Vulcan* to *Minerva* if we intend to bring into the light the true textures and *configurations* of bodies. Every hidden, or as they call it, specific property and virtue in things depends on these. From them too is drawn the rule of every powerful alteration and transformation.[2]

For example, we must ask how much in every body is spirit and how much tangible essence. And we must ask whether that spirit is abundant and swelling, or meager and scant; thin or rather coarse; more airy or more fiery; lively or sluggish; weak or strong; advancing or retreating; broken or continuous; in harmony with things outside and around it, or at odds with them; and so on. The tangible essence admits no fewer differences than the spirit, and it falls under the same inquiry, with its hairs, fibers and every kind of texture. So too does the distribution of the spirit through the bodily mass, with its pores, passages, veins and cells, and the rudiments or first attempts of an organic body. But in these too, and indeed in every discov-

2 Vulcan, god of fire and the forge, stands for the furnace; Minerva, goddess of wisdom, for reason.

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ery of *latent configuration*, a true and clear light is let in by the primary axioms. It certainly dispels all darkness and subtlety.

2.8 Neque propterea res deducetur ad atomum, quae praesupponit vacuum et materiam non fluxam (quorum utrumque falsum est) sed ad particulas veras, quales inveniuntur. Neque rursus est, quod exhorreat quispiam istam subtilitatem, ut inexplicabilem; sed contra, quo magis vergit inquisitio ad naturas simplices, eo magis omnia erunt sita in plano et perspicuo; translato negotio a multiplici in simplex, et ab incommensurabili ad commensurabile, et a surdo ad computabile, et ab infinito et vago ad definitum et certum; ut fit in elementis literarum, et tonis concentuum. Optime autem cedit inquisitio naturalis, quando physicum terminatur in mathematico. At rursus multitudinem aut fractiones nemo reformidet. In rebus enim, quae per numeros transiguntur, tam facile quis posuerit aut cogitaverit millenarium, quam unum; aut millesimam partem unius, quam unum integrum.

Nor will the matter be reduced to the atom, which presupposes a vacuum and unchanging matter, both of which are false. It will be reduced to real particles, as they are found. Nor, again, need anyone shrink from this subtlety as impossible to unravel. On the contrary, the more the inquiry turns toward simple natures, the more everything will lie plain and clear. The task moves from the manifold to the simple, from the incommensurable to the commensurable, from the irrational to the calculable, and from the infinite and vague to the defined and certain. This is what happens with the letters of the alphabet and the notes of music. Natural inquiry turns out best when the physical ends in the mathematical. Again, let no one fear large numbers or fractions. For where things are handled by numbers, one can as easily posit or think of a thousand as of one, or of a thousandth part of one as of a whole.

METAPHYSICS AND PHYSICS

Bacon divides philosophy by the two kinds of axioms and sets out the aids to sense, memory and reason.

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2.9 Ex duobus generibus axiomatum, quae superius posita sunt, oritur vera divisio philosophiae et scientiarum; translatis vocabulis receptis (quae ad indicationem rei proxime accedunt) ad sensum nostrum. Videlicet, ut inquisitio *formarum*, quae sunt (ratione certe, et sua lege) aeternae et immobiles, constituat *metaphysicam*; inquisitio vero *efficientis*, et *materiae*, et *latentis processus*, et *latentis schematismi* (quae omnia cursum naturae communem et ordinarium, non leges fundamentales et aeternas respiciunt) constituat *physicam*: atque his subordinentur similiter practicae duae; *physicae mechanica; metaphysicae* (perpurgato nomine) *magia*, propter latas ejus vias et majus imperium in naturam.

From the two kinds of axioms set out above arises a true division of philosophy and the sciences. Here the received terms, those closest to indicating the thing, are transferred to our meaning. The inquiry into *forms*, which are eternal and unchangeable (certainly in reason, and by their own law), will constitute *metaphysics*. The inquiry into the *efficient cause*, the *material*, the *latent process* and the *latent configuration* will constitute *physics*. All of these regard the common and ordinary course of nature, not its fundamental and eternal laws. And two practical disciplines will be subordinate to these in the same way. To *physics* belongs *mechanics*. To *metaphysics* belongs *magic*, in a purified sense of the word, because of its broad paths and greater command over nature.

2.10 Posito itaque doctrinae scopo, pergendum ad praecepta; idque ordine minime perverso aut perturbato. Atque indicia de *interpretatione naturae* complectuntur partes in genere duas; primam, de educendis aut excitandis axiomatibus ab experientia; secundam, de deducendis aut

With the goal of our teaching thus set, we must proceed to the precepts, in an order that is neither perverse nor confused. The directions for the *interpretation of nature* comprise two general parts. The first concerns drawing out or raising axioms

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derivandis experimentis novis ab axiomatibus. Prior autem trifariam dividitur: in tres nempe ministrationes; ministrationem ad sensum, ministrationem ad memoriam, et ministrationem ad mentem sive rationem.	from experience. The second concerns deducing or deriving new experiments from axioms. The first is divided three ways, into three kinds of assistance: assistance to the senses, assistance to the memory, and assistance to the mind or reason.
Primo enim paranda est *historia naturalis* et *experimentalis*, sufficiens et bona; quod fundamentum rei est: neque enim fingendum, aut excogitandum, sed inveniendum, quid natura faciat aut ferat.	First, we must prepare a *natural and experimental history* that is sufficient and good; this is the foundation of the whole matter. For we are not to imagine or invent what nature does or undergoes, but to discover it.
Historia vero *naturalis* et *experimentalis* tam varia est et sparsa, ut intellectum confundat et disgreget, nisi sistatur et compareat ordine idoneo. Itaque formandae sunt *tabulae* et *coordinationes instantiarum*, tali modo et instructione ut in eas agere possit intellectus.	But *natural and experimental history* is so varied and scattered that it confuses and distracts the understanding unless it is arranged and presented in a suitable order. So *tables* and *arrangements of instances* must be formed, set out and organized in such a way that the understanding can work on them.
Id quoque licet fiat, tamen intellectus sibi permissus, et sponte movens, incompetens est et inhabilis ad opificium axiomatum, nisi regatur et muniatur. Itaque tertio, adhibenda est *inductio* legitima et vera, quae ipsa *clavis est interpretationis*. Incipiendum autem est a fine, et retro pergendum ad reliqua.	Even when this is done, the understanding left to itself and moving of its own accord is incompetent and unfit to build axioms, unless it is directed and protected. So, third, we must apply a legitimate and true *induction*, which is the very *key of interpretation*. But we must begin from the end and work back to the rest.

TABLE OF ESSENCE AND PRESENCE

Bacon lists the instances in which heat is found, as a first example of his method.

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2.11	Inquisitio formarum sic procedit; super naturam datam primo facienda est *comparentia ad intellectum* omnium *instantiarum* notarum, quae in eadem natura conveniunt, per materias licet dissimillimas. Atque hujusmodi collectio facienda est historice, absque contemplatione praefestina, aut subtilitate aliqua majore. Exempli gratia; in inquisitione de forma calidi.	The inquiry into forms proceeds as follows. First, for a given nature, we must make a *presentation to the understanding* of all known *instances* that agree in this same nature, even in the most dissimilar materials. And this collection must be made as a history, without premature speculation or any excessive subtlety. Take, for example, the inquiry into the form of heat.
	Instantiae convenientes in natura calidi.	*Instances agreeing in the nature of heat.*
	1. Radii solis, praesertim aestate et meridie.	1. The rays of the sun, especially in summer and at noon.
	2. Radii solis, reflexi et constipati, ut inter montes, aut per parietes, et maxime omnium in speculis comburentibus.	2. The rays of the sun reflected and concentrated, as between mountains or off walls, and most of all in burning glasses.
	3. Meteora ignita.	3. Fiery meteors.

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4. Fulmina comburentia.	4. Lightning that burns.
5. Eructationes flammarum ex cavis montium, etc.	5. Eruptions of flame from mountain hollows, etc.
6. Flamma omnis.	6. All flame.
7. Ignita solida.	7. Solids that are on fire.
8. Balnea calida naturalia.	8. Natural hot springs.
9. Liquida ferventia, aut calefacta.	9. Liquids that are boiling or heated.
10. Vapores et fumi ferventes, atque aer ipse, qui fortissimum et furentem suscipit calorem, si concludatur; ut in reverberatoriis.	10. Hot vapors and fumes, and air itself, which takes on the strongest and fiercest heat when it is shut in, as in reverberatory furnaces.
11. Tempestates aliquae sudae per ipsam constitutionem aeris, non habita ratione temporis anni.	11. Certain spells of clear weather, owing to the very constitution of the air, regardless of the season.
12. Aer conclusus et subterraneus in cavernis nonnullis, praesertim hyeme.	12. Air shut up underground in some caves, especially in winter.
13. Omnia villosa, ut lana, pelles animalium, et plumagines, habent nonnihil teporis.	13. All shaggy things, such as wool, animal skins and plumage, have some warmth.
14. Corpora omnia, tam solida, quam liquida, et tam densa, quam tenuia (qualis est ipse aer), igni ad tempus approximata.	14. All bodies, whether solid or liquid, dense or rare (as air itself is), when brought near fire for a time.
15. Scintillae ex silice et chalybe per fortem percussionem.	15. Sparks struck from flint and steel by a strong blow.
16. Omne corpus fortiter attritum, ut lapis, lignum, pannus, etc.; adeo ut temones et axes rotarum aliquando flammam concipiant: et mos excitandi ignis apud Indos occidentales fuerit per attritionem.	16. Any body rubbed hard, such as stone, wood, cloth, etc.; so much so that carriage poles and wheel axles sometimes catch fire. The people of the West Indies used to make fire by rubbing.
17. Herbae virides et humidae simul conclusae et contrusae, ut rosae, pisae in corbibus; adeo ut foenum, si repositum fuerit madidum, saepe concipiat flammam.	17. Green, damp plants packed and pressed together, such as roses or peas in baskets; so much so that hay, if stored wet, often catches fire.
18. Calx viva, aqua aspersa.	18. Quicklime sprinkled with water.
19. Ferrum, cum primo dissolvitur per aquas fortes in vitro, idque absque ulla admotione ad ignem: et stannum similiter, etc. sed non adeo intense.	19. Iron, when it is first dissolved by nitric acid (aqua fortis) in a glass vessel, and that without being brought near any fire; and tin likewise, etc., though not so intensely.
20. Animalia, praesertim et perpetuo per interiora; licet in insectis calor ob parvitatem corporis non deprehendatur ad tactum.	20. Animals, especially and always in their inner parts; though in insects the heat cannot be detected by touch because of the small size of their bodies.

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	21. Fimus equinus, et hujusmodi excrementa animalium recentia.	21. Horse dung, and fresh animal excrement of that kind.
	22. Oleum forte sulphuris et vitrioli exequitur opera caloris, in linteo adurendo.	22. Strong oil of sulfur and oil of vitriol do the work of heat in scorching linen.[3]
	23. Oleum origani, et hujusmodi, exequitur opera caloris in adurendis ossibus dentium.	23. Oil of origanum and the like does the work of heat in burning the bone of the teeth.
	24. Spiritus vini fortis et bene rectificatus exequitur opera caloris; adeo ut si albumen ovi in eum injiciatur, concrescat et albescat, fere in modum albuminis cocti; panis injectus torrefiat et incrustetur, ad modum panis tosti.	24. Strong, well-rectified spirit of wine does the work of heat. If egg white is dropped into it, it thickens and turns white, almost like cooked egg white. And bread dropped into it is toasted and crusted, like toast.
	25. Aromata, et herbae calidae, ut dracunculus, nasturtium vetus, etc. licet ad manum non sint calida (nec integra, nec pulveres eorum), tamen ad linguam et palatum parum masticata percipiuntur calida, et quasi adurentia.	25. Spices and hot herbs, such as tarragon, old cress, etc., are not warm to the hand, either whole or powdered. Yet when chewed a little, they are felt as hot, almost burning, on the tongue and palate.
	26. Acetum forte, et omnia acida, in membro ubi non sit epidermis, ut in oculo, lingua, aut aliqua alia parte vulnerata, et cute detecta, dolorem cient, non multum discrepantem ab eo, qui inducitur a calido.	26. Strong vinegar and all acids cause a pain not very different from that caused by heat. They do so on any part without epidermis, such as the eye, the tongue, or any other wounded part where the skin is laid bare.
	27. Etiam frigora acria et intensa inducunt sensum quendam ustionis; Nam Boreae penetrabile frigus adurit.	27. Even sharp and intense cold produces a sensation of burning: "the North Wind's piercing cold scorches."[4]
	28. Alia.	28. Others.
	Hanc *tabulam essentiae et praesentiae* appellare consuevimus.	We are accustomed to call this the *table of essence and presence*.

TABLE OF ABSENCE IN PROXIMITY

For each instance of heat, Bacon looks for a closely related instance in which heat is lacking.

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2.12	Secundo, facienda est *comparentia* ad intellectum *instantiarum*, quae natura data privantur: quia forma (ut dictum est) non minus abesse debet, ubi natura data abest, quam adesse, ubi adest. Hoc vero infinitum esset in omnibus.	Second, we must make a *presentation* to the understanding of *instances* that lack the given nature. For the form (as has been said) should be no less absent where the given nature is absent than present where it is present. But to do this for everything would be endless.
	Itaque subjungenda sunt *negativa affirmativis*, et privationes inspiciendae tantum in illis subjectis quae	So *negatives* must be attached to the *affirmatives*, and absences examined only in those subjects

3 Both are old names for sulfuric acid.
4 Virgil, *Georgics* 1.93.

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sunt maxime cognata illis alteris, in quibus natura data inest et comparet. Hanc *tabulam declinationis*, sive *absentiae in proximo*, appellare consuevimus.

Instantiae in proximo, quae privantur natura Calidi.

Ad Instantiam primam *affirmativam*, Instantia prima *negativa* vel subjunctiva. Lunae et stellarum et cometarum radii non inveniuntur calidi ad tactum: quinetiam observari solent acerrima frigora in pleniluniis. At stellae fixae majores, quando sol eas subit aut iis approximatur, existimantur fervores solis augere et intendere; ut fit cum sol sistitur in Leone, et diebus canicularibus.

Ad 2am 2a. Radii solis in media (quam vocant) regione aeris non calefaciunt; cujus ratio vulgo non male redditur; quia regio illa nec satis appropinquat ad corpus solis, unde radii emanant, nec etiam ad terram, unde reflectuntur. Atque hoc liquet ex fastigiis montium (nisi sint praealti), ubi nives perpetuo durant. Sed contra notatum est a nonnullis, quod in cacumine Picus de Tenariph, atque etiam in Andis Peruviae, ipsa fastigia montium nive destituta sint; nivibus jacentibus tantum inferius in ascensu. Atque insuper aer illis ipsis verticibus montium deprehenditur minime frigidus, sed tenuis tantum et acer; adeo ut in Andis pungat et vulneret oculos per nimiam acrimoniam, atque etiam pungat os ventriculi, et inducat vomitum.

Atque ab antiquis notatum est, in vertice Olympi tantam fuisse aeris tenuitatem, ut necesse fuerit illis qui eo ascenderant secum deferre spongias aceto et aqua madefactas, easque ad os et nares subinde apponere, quia aer ob tenuitatem non sufficiebat respirationi: in quo vertice etiam relatum est, tantam fuisse serenitatem et tranquillitatem a pluviis et nivibus et ventis, ut sacrificantibus literae descriptae digito in cineribus sacrificiorum super aram Jovis, manerent in annum proximum absque ulla perturbatione. Atque etiam hodie ascendentes ad verticem Picus de Tenariph eo vadunt noctu et non interdiu; et paulo post ortum solis monentur et excitantur a ducibus suis ut festinent descendere, propter periculum (ut videtur) a tenuitate aeris, ne solvat spiritus et suffocet.

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most closely related to the others, in which the given nature is present and appears. We are accustomed to call this the *table of deviation, or of absence in proximity*.

Instances in proximity that lack the nature of heat.

To the first *affirmative* instance, the first *negative* or subjoined instance. The rays of the moon, the stars and comets are not found to be warm to the touch. Indeed, the sharpest cold is usually observed at full moon. The larger fixed stars, however, are thought to increase and intensify the sun's heat when the sun passes beneath them or comes near them, as happens when the sun is in Leo and during the dog days.

To 2: 2. The sun's rays do not heat in what is called the middle region of the air. The common explanation of this is not a bad one: that region is not near enough either to the body of the sun, from which the rays emanate, or to the earth, from which they are reflected. This is clear from mountaintops, unless they are very high, where the snow lasts all year. But on the other hand, some have observed that on the summit of the Peak of Tenerife, and also in the Andes of Peru, the mountaintops themselves are bare of snow, and snow lies only lower down on the ascent. Moreover, the air at those very summits is found to be not at all cold, but only thin and sharp. In the Andes it is so sharp that it stings and hurts the eyes, and also irritates the pit of the stomach and causes vomiting.

And the ancients noted that on the summit of Olympus the air was so thin that those who climbed it had to carry sponges soaked in vinegar and water, and hold them to their mouths and noses from time to time, because the air was too thin to breathe. On that summit, it is also reported, the weather was so calm, and so free from rain, snow and wind, that letters traced with a finger in the ashes of sacrifices on the altar of Jupiter remained undisturbed until the following year. And even today those who climb to the top of the Peak of Tenerife go by night and not by day. Shortly after sunrise their guides warn and urge them to hurry down, because of the danger, it seems, that the thinness of the air may dissolve their spirits and suffocate them.

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Ad 2am 3a. Reflexio radiorum solis, in regionibus prope circulos polares, admodum debilis et inefficax invenitur in calore: adeo ut Belgae, qui hybernarunt in Nova Zembla, cum expectarent navis suae liberationem et deobstructionem a glaciali mole (quae eam obsederat) per initia mensis Julii spe sua frustrati sint, et coacti scaphae se committere. Itaque radii solis directi videntur parum posse, etiam super terram planam; nec reflexi etiam, nisi multiplicentur et uniantur, quod fit cum sol magis vergit ad perpendiculum, quia tum incidentia radiorum facit angulos acutiores, ut lineae radiorum sint magis in propinquo: ubi contra in magnis obliquitatibus solis anguli sint valde obtusi, et proinde lineae radiorum magis distantes.

Sed interim notandum est, multas esse posse operationes radiorum solis, atque etiam ex natura calidi, quae non sunt proportionatae ad tactum nostrum: adeo ut respectu nostri non operentur usque ad calefactionem, sed respectu aliorum nonnullorum corporum exequantur opera calidi.

Ad 2am 4a. Fiat hujusmodi experimentum. Accipiatur speculum fabricatum contra ac fit in speculis comburentibus, et interponatur inter manum et radios solis; et fiat observatio, utrum minuat calorem solis, quemadmodum speculum comburens eundem auget et intendit. Manifestum est enim, quoad radios opticos, prout fabricatur speculum in densitate inaequali respectu medii et laterum, ita apparere simulachra magis diffusa aut magis contracta. Itaque idem videndum in calore.

Ad 2am 5a. Fiat experimentum diligenter, utrum per specula comburentia fortissima et optime fabricata radii lunae possint excipi et colligi in aliquem vel minimum gradum teporis. Is vero gradus teporis si fortasse nimis subtilis et debilis fuerit, ut ad tactum percipi et deprehendi non possit, confugiendum erit ad vitra illa quae indicant constitutionem aeris calidam aut frigidam; ita ut radii lunae per speculum comburens incidant et jaciantur in summitatem vitri hujusmodi; atque tum notetur, si fiat depressio aquae per teporem.

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To 2: 3. In regions near the polar circles, the reflection of the sun's rays is found to be very weak and ineffective in producing heat. The Dutch who wintered in Novaya Zemlya expected their ship to be freed and released by the beginning of July from the mass of ice that had trapped it. They were disappointed in their hope and forced to take to a small boat. So the direct rays of the sun seem to have little power, even over level ground. Nor do reflected rays, unless they are multiplied and combined, which happens when the sun is closer to the perpendicular. For then the incidence of the rays makes sharper angles, so that the lines of the rays are closer together. When the sun is very oblique, by contrast, the angles are very obtuse, and so the lines of the rays are farther apart.[5]

But it should be noted meanwhile that the sun's rays, and heat itself by its nature, may have many effects that are not proportioned to our touch. So with respect to us they do not go as far as heating, but with respect to some other bodies they do perform the work of heat.

To 2: 4. Let an experiment of this kind be made. Take a glass made the opposite way to burning glasses, place it between the hand and the sun's rays, and observe whether it lessens the sun's heat, as a burning glass increases and intensifies it. For it is clear that with rays of sight, images appear more spread out or more contracted according to how the glass is made, with unequal thickness at the middle and at the sides. So the same must be checked for heat.

To 2: 5. Let a careful experiment be made to see whether the strongest and best-made burning glasses can catch and gather the moon's rays into even the slightest degree of warmth. That degree of warmth may perhaps be too faint and weak to be perceived and detected by touch. If so, we must resort to those glasses that show whether the state of the air is warm or cold. Let the moon's rays fall through the burning glass onto the top of such a glass, and then note whether the water sinks because of the warmth.[6]

5 Willem Barents's expedition of 1596–97, which was trapped by ice off Novaya Zemlya.
6 Bacon means the calendar glass (weatherglass), an early air thermometer in which a column of water falls as the air above it warms; he describes it at 2.13.

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Ad 2am 6a. Practicetur etiam vitrum comburens super calidum, quod non sit radiosum aut luminosum; ut ferri et lapidis calefacti sed non igniti, aut aquae ferventis, aut similium; et notetur utrum fiat augmentum et intentio calidi, ut in radiis solis.

Ad 2am 7a. Practicetur etiam speculum comburens in flamma communi.

Ad 3am 8a. Cometarum (si et illos numerare inter meteora libuerit) non deprehenditur constans aut manifestus effectus in augendis ardoribus anni, licet siccitates saepius inde sequi notatae sint. Quinetiam trabes et columnae lucidae et chasmata et similia apparent saepius temporibus hybernis quam aestivis; et maxime per intensissima frigora, sed conjuncta cum siccitatibus. Fulmina tamen et coruscationes et tonitrua raro eveniunt hyeme, sed sub tempus magnorum fervorum. At stellae (quas vocant) cadentes existimantur vulgo magis constare ex viscosa aliqua materia splendida et accensa, quam esse naturae igneae fortioris. Sed de hoc inquiratur ulterius.

Ad 4am 9a. Sunt quaedam coruscationes quae praebent lumen sed non urunt; eae vero semper fiunt sine tonitru.

Ad 5am 10a. Eructationes et eruptiones flammarum inveniuntur non minus in regionibus frigidis quam calidis; ut in Islandia et Groenlandia: quemadmodum et arbores per regiones frigidas magis sunt quandoque inflammabiles et magis piceae ac resinosae quam per regiones calidas; ut fit in abiete, pinu, et reliquis: verum in quali situ et natura soli hujusmodi eruptiones fieri soleant, ut possimus *affirmativae* subjungere *negativam*, non satis quaesitum est.

Ad 6am 11a. Omnis flamma perpetuo est calida magis aut minus, neque omnino subjungitur *negativa*: et tamen referunt ignem fatuum (quem vocant), qui etiam aliquando impingitur in parietem, non multum habere caloris; fortasse instar flammae spiritus vini, quae clemens et lenis est. Sed adhuc lenior videtur ea flamma quae in nonnullis historiis fidis et gravibus invenitur apparuisse circa capita et comas puerorum et virginum; quae nullo modo comas adurebat, sed molliter circum eas trepidabat. Atque certissimum est, circa equum in itinere sudantem noctu et suda tempestate apparuisse

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To 2: 6. Let the burning glass also be tried on heat that is not radiant or luminous, such as iron or stone that is heated but not glowing, or boiling water, and the like. And note whether the heat is increased and intensified, as it is with the sun's rays.

To 2: 7. Let the burning glass also be tried on ordinary flame.

To 3: 8. Comets (if we choose to count them among meteors too) are not found to have any constant or evident effect in increasing the heat of the year, though droughts have often been observed to follow them. Moreover, beams and columns of light, chasms in the sky and the like appear more often in winter than in summer. They appear most of all in the most intense cold, but when it comes with dry weather. Lightning, flashes and thunder, however, rarely occur in winter, but come around the time of great heat. As for so-called shooting stars, they are commonly thought to consist of some sticky, shining, kindled matter rather than to be of a strongly fiery nature. But this should be investigated further.

To 4: 9. There are some flashes that give light but do not burn; and these always occur without thunder.

To 5: 10. Outbursts and eruptions of flame are found no less in cold regions than in hot ones, as in Iceland and Greenland. Likewise, trees in cold regions are sometimes more flammable, and more pitchy and resinous, than in hot regions, as with fir, pine and the rest. But it has not been sufficiently investigated in what kind of site and soil such eruptions usually occur, so that we could attach a *negative* to the *affirmative*.

To 6: 11. Every flame is always hot, to a greater or lesser degree, and no *negative* can be added at all. Yet people report that the will-o'-the-wisp (*ignis fatuus*, as they call it), which sometimes even strikes against a wall, has little heat. Perhaps it is like the flame of spirit of wine, which is mild and gentle. Gentler still, it seems, is the flame that several reliable and serious histories say appeared around the heads and hair of boys and young girls. It did not scorch their hair at all, but flickered softly around it. And it is quite certain that a kind of flashing light has sometimes appeared, without

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quandoque coruscationem quandam absque manifesto calore.

Atque paucis abhinc annis, notissimum est et pro miraculo quasi habitum gremiale cujusdam puellae paulo motum aut fricatum coruscasse; quod fortasse factum est ob alumen aut sales quibus gremiale tinctum erat paulo crassius haerentia et incrustata, et ex fricatione fracta. Atque certissimum est saccharum omne, sive conditum (ut vocant) sive simplex, modo sit durius, in tenebris fractum aut cultello scalptum coruscare. Similiter aqua marina et salsa noctu interdum invenitur, remis fortiter percussa, coruscare. Atque etiam in tempestatibus spuma maris fortiter agitata noctu coruscat; quam coruscationem Hispani *pulmonem marinum* vocant. De illa flamma autem quam antiqui nautae vocabant *Castorem et Pollucem*, et moderni *Focum Sancti Ermi*, qualem calorem habeat non satis quaesitum est.

Ad 7am 12a. Omne ignitum ita ut vertatur in ruborem igneum etiam sine flamma perpetuo calidum est, neque huic *affirmativae* subjungitur *negativa*; sed quod in proximo est videtur esse lignum putre, quod splendet noctu neque tamen deprehenditur calidum; et squamae piscium putrescentes, quae etiam splendent noctu, nec inveniuntur ad tactum calidae; neque etiam corpus cicindelae aut muscae (quam vocant luciolam) calidum ad tactum deprehenditur.

Ad 8am 13a. De balneis calidis, in quo situ et natura soli emanare soleant, non satis quaesitum est; itaque non subjungitur *negativa*.

Ad 9am 14a. Liquidis ferventibus subjungitur *negativa* ipsius liquidi in natura sua. Nullum enim invenitur liquidum tangibile quod sit in natura sua et maneat constanter calidum, sed superinducitur ad tempus tantum calor, ut natura ascititia: adeo ut quae potestate et operatione sunt maxime calida, ut spiritus vini, olea aromatum chymica, etiam olea vitrioli et sulphuris, et similia, quae paulo post adurunt, ad primum tactum sint frigida. Aqua autem balneorum naturalium excepta in vas aliquod et separata a fontibus suis defervescit perinde ac aqua igne calefacta. At verum est corpora oleosa ad tactum paulo minus esse frigida quam aquea; ut oleum

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noticeable heat, around a horse sweating on a journey at night in clear weather.

A few years ago, too, it was very widely known, and treated almost as a miracle, that a girl's apron gave off flashes of light when it was moved or rubbed a little. This perhaps happened because of alum or salts with which the apron had been dyed. These clung to it in a rather thick crust, and the rubbing broke them. And it is quite certain that all sugar, whether candied (as they call it) or plain, provided it is fairly hard, flashes when broken or scraped with a knife in the dark. Likewise, sea water and salt water are sometimes found to flash at night when struck hard with oars. In storms, too, sea foam violently tossed flashes at night; the Spanish call this flashing *sea lung*. But what heat there is in the flame that ancient sailors called *Castor and Pollux*, and modern sailors *Saint Elmo's Fire*, has not been sufficiently investigated.[7]

To 7: 12. Everything that is ignited so as to turn fiery red, even without flame, is always hot, and no *negative* can be added to this *affirmative*. The nearest case seems to be rotten wood, which shines at night and yet is not found to be hot. There are also the scales of rotting fish, which likewise shine at night and are not found hot to the touch. Nor is the body of the glow-worm, or of the fly they call the firefly (*luciola*), found hot to the touch.

To 8: 13. In what kind of location and soil hot springs usually rise has not been sufficiently investigated; so no *negative* is added.

To 9: 14. To boiling liquids is added the *negative* of the liquid itself in its own nature. For no tangible liquid is found that is hot in its own nature and stays constantly hot. Heat is only laid on it for a time, as an acquired nature. So much so that the liquids that are hottest in power and operation are cold at first touch: spirit of wine, chemical oils of spices, even oil of vitriol and oil of sulfur, and the like, which burn after a short while. The water of natural hot springs, if drawn off into a vessel and separated from its source, cools down just like water heated on a fire. It is true, though, that oily bodies are slightly less cold to the touch than wa-

7 Castor and Pollux, the twin sons of Zeus, were protectors of sailors; the glow that appears on masts in stormy weather was named after them, and later after Saint Elmo (Erasmus), patron of sailors.

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minus quam aqua, sericum minus quam linteum. Verum hoc pertinet ad *Tabulam Graduum* de Frigido.

Ad 10am 15a. Similiter vapori fervido subjungitur negativa naturae ipsius vaporis, qualis apud nos invenitur. Etenim exhalationes ex oleosis, licet facile inflammabiles, tamen non inveniuntur calidae, nisi a corpore calido recenter exhalaverint.

Ad 10am 16a. Similiter aeri ipsi ferventi subjungitur *negativa* naturae aeris ipsius. Neque enim invenitur apud nos aer calidus; nisi fuerit aut conclusus, aut attritus, aut manifeste calefactus a sole, igne, aut aliquo alio corpore calido.

Ad 11am 17a. Subjungitur *negativa* tempestatum frigidarum magis quam pro ratione temporis anni, quae eveniunt apud nos flante Euro et Borea; quemadmodum et contrariae tempestates eveniunt flante Austro et Zephyro. Etiam inclinatio ad pluviam (praesertim temporibus hyemalibus) comitatur tempestatem tepidam; at gelu contra frigidam.

Ad 12am 18a. Subjungitur *negativa* aeris conclusi in cavernis tempore aestivo. At de aere concluso omnino diligentius inquirendum. Primo enim non absque causa in dubitationem venit, qualis sit natura aeris quatenus ad calidum et frigidum in natura sua propria. Recipit enim aer calidum manifesto ex impressione coelestium; frigidum autem fortasse ab expiratione terrae; et rursus in media (quam vocant) regione aeris a vaporibus frigidis et nivibus: ut nullum judicium fieri possit de aeris natura per aerem qui foras est et sub dio, sed verius foret judicium per aerem conclusum. Atqui opus est etiam ut aer concludatur in tali vasi et materia quae nec ipsa imbuat aerem calido vel frigido ex vi propria, nec facile admittat vim aeris extranei.

Fiat itaque experimentum per ollam figularem multiplici corio obductam ad muniendam ipsam ab aere extraneo, facta mora per tres aut quatuor dies in vase bene occluso; deprehensio autem fit post apertionem vasis vel per manum vel per vitrum graduum ordine applicatum.

Ad 13am 19a. Subest similiter dubitatio, utrum tepor in lana et pellibus et plumis et hujusmodi fiat ex quodam exili calore inhaerente, quatenus excernuntur ab

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tery ones: oil less than water, silk less than linen. But this belongs to the *table of degrees* for cold.

To 10: 15. Likewise, to hot vapor is added the negative of the nature of vapor itself, as it is found among us. For exhalations from oily substances, though easily set alight, are not found to be hot unless they have just been given off by a hot body.

To 10: 16. Likewise, to hot air itself is added the *negative* of the nature of air itself. For no hot air is found among us unless it has been enclosed, or rubbed, or plainly heated by the sun, by fire, or by some other hot body.

To 11: 17. The *negative* added here is weather colder than usual for the time of year, which among us comes with east and north winds, just as the opposite weather comes with south and west winds. Also, a tendency to rain (especially in winter) goes with mild weather, while frost goes with cold.

To 12: 18. The *negative* added is air enclosed in caves in summer. But the whole matter of enclosed air must be investigated more carefully. First, it is not without reason that doubt arises about the proper nature of air with respect to hot and cold. Air obviously receives heat from the influence of the heavenly bodies. It receives cold perhaps from the earth's exhalations, and again, in the so-called middle region of the air, from cold vapors and snows. So no judgment about the nature of air can be made from air that is outside and in the open. A truer judgment would come from enclosed air. But the air must also be enclosed in a vessel, and a material, of such a kind that neither imbues the air with hot or cold by its own force nor readily admits the force of the outside air.

So let the experiment be made with an earthenware pot wrapped in many layers of leather to protect it from the outside air, the air being kept in the well-sealed vessel for three or four days. The test is made after opening the vessel, either by hand or with a graduated glass applied in the proper way.

To 13: 19. There is likewise a doubt about the warmth in wool, skins, feathers and the like. Does it come from some faint heat inherent in them, in-

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animalibus; aut etiam ob pinguedinem quandam et oleositatem, quae sit naturae congruae cum tepore; vel plane ob conclusionem et fractionem aeris, ut in articulo praecedente dictum est. Videtur enim omnis aer abscissus a continuitate aeris forinseci habere nonnihil teporis. Itaque fiat experimentum in fibrosis quae fiunt ex lino; non ex lana aut plumis aut serico, quae excernuntur ab animatis. Notandum est etiam, omnes pulveres (ubi manifesto includitur aer) minus esse frigidos quam corpora integra ipsorum; quemadmodum etiam existimamus omnem spumam (utpote quae aerem contineat) minus esse frigidam quam liquorem ipsum.

Ad 14am 20a. Huic non subjungitur *negativa*. Nihil enim reperitur apud nos sive tangibile sive spiritale, quod admotum igni non excipiat calorem. In eo tamen differunt, quod alia excipiant calorem citius, ut aer, oleum, et aqua; alia tardius, ut lapis et metalla. Verum hoc pertinet ad *Tabulam Graduum*.

Ad 15am 21a. Huic Instantiae non subjungitur *negativa* alia, quam ut bene notetur non excitari scintillas ex silice et chalybe aut alia aliqua substantia dura nisi ubi excutiuntur minutiae aliquae ex ipsa substantia lapidis vel metalli, neque aerem attritum unquam per se generare scintillas, ut vulgo putant; quin et ipsae illae scintillae ex pondere corporis igniti magis vergunt deorsum quam sursum, et in extinctione redeunt in quandam fuliginem corpoream.

Ad 16am 22a. Existimamus huic instantiae non subjungi *negativam*. Nullum enim invenitur apud nos corpus tangibile, quod non ex attritione manifesto calescat; adeo ut veteres somniarent non inesse coelestibus aliam viam aut virtutem calefaciendi nisi ex attritione aeris per rotationem rapidam et incitatam. Verum in hoc genere ulterius inquirendum est, utrum corpora quae emittuntur ex machinis (qualia sunt pilae ex tormentis) non ex ipsa percussione contrahant aliquem gradum caloris; adeo ut postquam deciderint inveniantur nonnihil calida. At aer motus magis infrigidat quam calefacit; ut in ventis et follibus et flatu oris contracti. Verum hujusmodi motus non est tam rapidus ut excitet calorem, et fit secundum totum, non per particulas; ut mirum non sit, si non generet calorem.

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sofar as they are produced by animals? Or from a certain fat and oiliness, which is akin in nature to warmth? Or simply from the enclosing and breaking up of the air, as was said in the preceding item? For all air cut off from continuity with the outside air seems to have some warmth. So let the experiment be made with fibrous materials made from flax, not from wool, feathers or silk, which are produced by living creatures. It should also be noted that all powders (in which air is obviously enclosed) are less cold than the same bodies whole; just as we think all foam (since it contains air) is less cold than the liquid itself.

To 14: 20. No *negative* is added to this. For nothing is found among us, whether tangible or pneumatic, that does not take on heat when placed near a fire. They differ, however, in that some take on heat more quickly, like air, oil and water, and others more slowly, like stone and metals. But this belongs to the *table of degrees*.

To 15: 21. No *negative* is added to this instance, except that it should be carefully noted that sparks are not struck from flint and steel, or any other hard substance, unless tiny particles are knocked off the substance of the stone or metal itself. Rubbed air never generates sparks by itself, as is commonly thought. Indeed, the sparks themselves, because of the weight of the ignited body, tend downward rather than upward, and when they go out they turn into a kind of material soot.

To 16: 22. We think no *negative* is added to this instance. For no tangible body is found among us that does not plainly grow hot from friction. So much so that the ancients dreamed that the heavenly bodies had no other way or power of heating than friction with the air in their swift and rapid rotation. But in this area we must inquire further whether bodies discharged from machines (such as balls from cannon) acquire some degree of heat from the impact itself, so that after they have fallen they are found somewhat hot. Air in motion, however, cools rather than heats, as in winds, in bellows, and in blowing through pursed lips. But motion of this kind is not rapid enough to excite heat, and it is a motion of the whole, not of the particles; so it is no wonder if it does not generate heat.

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Ad 17am 23a. Circa hanc instantiam facienda est inquisitio diligentior. Videntur enim herbae et vegetabilia viridia et humida aliquid habere in se occulti caloris. Ille vero calor tam tenuis est ut in singulis non percipiatur ad tactum; verum postquam illa adunata sint et conclusa, ut spiritus ipsorum non expiret in aerem sed se invicem foveat, tum vero oritur calor manifestus, et nonnunquam flamma in materia congrua.

Ad 18am 24a. Etiam circa hanc instantiam diligentior facienda est inquisitio. Videtur enim calx viva aqua aspersa concipere calorem vel propter unionem caloris qui antea distrahebatur (ut ante dictum est de herbis conclusis), vel ob irritationem et exasperationem spiritus ignei ab aqua, ut fiat quidam conflictus et antiperistasis. Utra vero res sit in causa facilius apparebit, si loco aquae immittatur oleum; oleum enim aeque ac aqua valebit ad unionem spiritus inclusi, sed non ad irritationem. Etiam faciendum est experimentum latius tam in cineribus et calcibus diversorum corporum, quam per immissionem diversorum liquorum.

Ad 19am 25a. Huic instantiae subjungitur *negativa* aliorum metallorum, quae sunt magis mollia et fluxa. Etenim bracteolae auri, solutae in liquorem per aquam regis, nullum dant calorem ad tactum in dissolutione; neque similiter plumbum in aqua forti; neque etiam argentum vivum (ut memini); sed argentum ipsum parum excitat caloris, atque etiam cuprum (ut memini), sed magis manifesto stannum, atque omnium maxime ferrum et chalybs, quae non solum fortem excitant calorem in dissolutione, sed etiam violentam ebullitionem. Itaque videtur calor fieri per conflictum, cum aquae fortes penetrant et fodiunt et divellunt partes corporis, et corpora ipsa resistunt. Ubi vero corpora facilius cedunt, vix excitatur calor.

Ad 20am 26a. Calori animalium nulla subjungitur *negativa*, nisi insectorum (ut dictum est) ob parvitatem corporis. Etenim in piscibus collatis ad animalia terrestria magis notatur gradus caloris quam privatio. In vegetabilibus autem et plantis nullus percipitur gradus caloris ad tactum, neque in lachrymis ipsorum, neque in medullis recenter apertis. At in animalibus magna reperitur diversitas caloris, tum in partibus ipsorum

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To 17: 23. A more careful inquiry must be made about this instance. For herbs and green, moist plants seem to have some hidden heat in them. This heat is so slight that it is not perceived by touch in single pieces. But once they have been gathered together and shut in, so that their spirit does not escape into the air but they warm one another, a noticeable heat arises, and sometimes flame, in suitable material.

To 18: 24. A more careful inquiry must also be made about this instance. For quicklime sprinkled with water seems to take on heat for one of two reasons. It may be the union of heat that was previously dispersed (as was said above of herbs shut in together). Or it may be the irritation and exasperation of the fiery spirit by the water, producing a kind of conflict and antiperistasis. Which of the two is the cause will more easily appear if oil is poured in instead of water. For oil will serve as well as water to unite the enclosed spirit, but not to irritate it. The experiment should also be extended, both to the ashes and calxes of different bodies and to pouring in different liquids.[8]

To 19: 25. To this instance is added the *negative* of other metals, which are softer and more fluid. For gold leaf dissolved into liquid by aqua regia gives no heat to the touch as it dissolves; nor does lead in aqua fortis; nor does quicksilver (as I recall). Silver itself excites a little heat, and so does copper (as I recall), but tin more noticeably. Most of all, iron and steel not only excite strong heat as they dissolve, but also a violent boiling. So heat seems to arise from conflict, when the strong waters penetrate, dig into and tear apart the parts of a body, and the bodies themselves resist. Where bodies yield more easily, hardly any heat is excited.

To 20: 26. No *negative* is added to the heat of animals, except that of insects (as was said), because of the smallness of their bodies. For in fish, compared with land animals, what is noticed is a lower degree of heat rather than its absence. In vegetables and plants, however, no degree of heat is perceived by touch, either in their gums or in their pith freshly cut open. But in animals there is

8 Antiperistasis: an Aristotelian notion that a quality is intensified when surrounded by its contrary, as heat is concentrated by surrounding cold.

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(alius est enim calor circa cor, alius in cerebro, alius circa externa), tum in accidentibus eorum, ut in exercitatione vehementi et febribus.

Ad 21am 27a. Huic instantiae vix subjungitur *negativa*. Quinetiam excrementa animalium non recentia manifeste habent calorem potentialem, ut cernitur in impinguatione soli.

Ad 22am et 23am 28a. Liquores (sive aquae vocentur sive olea) qui habent magnam et intensam acrimoniam exequuntur opera caloris in divulsione corporum, atque adustione post aliquam moram; sed tamen ad ipsum tactum manus non sunt calidi ab initio. Operantur autem secundum analogiam et poros corporis cui adjunguntur. Aqua enim regis aurum solvit, argentum minime; at contra aqua fortis argentum solvit, aurum minime; neutrum autem solvit vitrum. Et sic de caeteris.

Ad 24am 29a. Fiat experimentum spiritus vini in lignis, ac etiam in butyro aut cera aut pice; si forte per calorem suum ea aliquatenus liquefaciat. Etenim instantia 24a ostendit potestatem ejus imitativam caloris in incrustationibus. Itaque fiat similiter experimentum in liquefactionibus. Fiat etiam experimentum per vitrum graduum sive calendare quod concavum sit in summitate sua per exterius; et immittatur in illud concavum exterius spiritus vini bene rectificatus, cum operculo, ut melius contineat calorem suum; et notetur utrum per calorem suum faciat aquam descendere.

Ad 25am 30a. Aromata, et herbae acres ad palatum, multo magis sumptae interius, percipiuntur calida. Videndum itaque in quibus aliis materiis exequantur opera caloris. Atque referunt nautae, cum cumuli et massae aromatum diu conclusae subito aperiuntur, periculum instare illis, qui eas primo agitant et extrahunt, a febribus et inflammationibus spiritus. Similiter fieri poterit experimentum, utrum pulveres hujusmodi aromatum aut herbarum non arefaciant laridum et carnem suspensam super ipsos, veluti fumus ignis.

Ad 26am 31a. Acrimonia sive penetratio inest tam frigidis, qualia sunt acetum et oleum vitrioli, quam calidis, qualia sunt oleum origani et similia. Itaque similiter et in animatis cient dolorem et in non animatis divellunt partes et consumunt. Neque huic instantiae

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great diversity of heat, both in their parts (the heat around the heart is one thing, in the brain another, around the outer parts another) and in what befalls them, as in violent exercise and fevers.

To 21: 27. Hardly any *negative* can be added to this instance. In fact, animal dung that is not fresh plainly has potential heat, as is seen in the enriching of soil.

To 22 and 23: 28. Liquids (whether called waters or oils) that have great and intense sharpness perform the works of heat, tearing bodies apart and burning them after a while; yet at first they are not hot to the touch of the hand. They act according to the analogy and the pores of the body they are applied to. For aqua regia dissolves gold but not silver; aqua fortis, on the contrary, dissolves silver but not gold; and neither dissolves glass. And so with the rest.

To 24: 29. Let an experiment be made with spirit of wine on wood, and also on butter, wax or pitch, to see whether its heat melts them to some extent. For instance 24 shows its power of imitating heat in forming crusts; so let an experiment likewise be made with melting. Let an experiment also be made with a graduated glass, or calendar glass, that has a hollow on the outside at its top. Pour well-rectified spirit of wine into this outer hollow, with a lid so that it keeps its heat better, and note whether its heat makes the water go down.

To 25: 30. Spices and herbs that are sharp to the palate are felt as hot, much more so when taken internally. We must therefore see on what other materials they perform the works of heat. Sailors report that when heaps and masses of spices that have long been shut up are suddenly opened, those who first stir them and take them out are in danger of fevers and inflammations of the spirit. Similarly, an experiment could be made whether powders of such spices or herbs dry out bacon and meat hung over them, as the smoke of a fire does.

To 26: 31. Sharpness, or penetration, is found as much in cold things, such as vinegar and oil of vitriol, as in hot ones, such as oil of origanum and the like. So both kinds cause pain in living things, and in non-living things they tear parts apart and consume them. No *negative* is added to this in-

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subjungitur *negativa*. Atque in animatis nullus reperitur dolor, nisi cum quodam sensu caloris.

Ad 27am 32a. Communes sunt complures actiones et calidi et frigidi, licet diversa admodum ratione. Nam et nives puerorum manus videntur paulo post urere; et frigora tuentur carnes a putrefactione, non minus quam ignis; et calores contrahunt corpora in minus, quod faciunt et frigida. Verum haec et similia opportunius est referre ad Inquisitionem de Frigido.

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stance. And in living things no pain is found without some sense of heat.

To 27: 32. Many actions are common to both hot and cold, though they come about in very different ways. Snow seems after a little while to burn boys' hands; cold preserves meat from putrefaction no less than fire does; and heat contracts bodies into a smaller size, which cold also does. But it is more appropriate to refer these and similar things to the Inquiry into Cold.

TABLE OF DEGREES

Bacon compares instances in which heat increases or decreases, in one body or across different bodies.

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2.13 Tertio facienda est *comparentia ad intellectum* instantiarum in quibus natura, de qua fit inquisitio, inest secundum magis et minus; sive facta comparatione incrementi et decrementi in eodem subjecto, sive facta comparatione ad invicem in subjectis diversis. Cum enim forma rei sit ipsissima res; neque differat res a forma, aliter quam differunt apparens et existens, aut exterius et interius, aut in ordine ad hominem et in ordine ad universum; omnino sequitur ut non recipiatur aliqua natura pro vera forma, nisi perpetuo decrescat quando natura ipsa decrescit, et similiter perpetuo augeatur quando natura ipsa augetur. Hanc itaque tabulam *Tabulam Graduum* sive *Tabulam Comparativae* appellare consuevimus.

Tabula Graduum sive *Comparativae* in Calido.

Primo itaque dicemus de iis quae nullum prorsus gradum caloris habent ad tactum, sed videntur habere potentialem tantum quendam calorem, sive dispositionem et praeparationem ad calidum. Postea demum descendemus ad ea quae sunt actu sive ad tactum calida, eorumque fortitudines et gradus.

1. In corporibus solidis et tangibilibus non invenitur aliquid quod in natura sua calidum sit originaliter. Non enim lapis aliquis, non metallum, non sulphur, non fossile aliquod, non lignum, non aqua, non cadaver animalis, inveniuntur calida. Aquae autem calidae in balneis videntur calefieri per accidens, sive per flammam aut ignem subterraneum, qualis ex Aetna et montibus aliis compluribus evomitur, sive ex conflictu corporum, quemadmodum calor fit in ferri et stanni dissolutionibus.

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Third, we must make a *presentation to the understanding* of instances in which the nature under inquiry is present in greater or lesser degree. This may be done by comparing its increase and decrease in the same subject, or by comparing it across different subjects. For the form of a thing is the very thing itself. The thing differs from the form only as the apparent differs from the real, or the outer from the inner, or what exists in relation to man from what exists in relation to the universe. It follows absolutely that no nature is to be accepted as the true form unless it always decreases when the nature itself decreases, and likewise always increases when the nature itself increases. This table, then, we are accustomed to call the *table of degrees*, or *table of comparison*.

Table of degrees, or of comparison, for heat.

First, then, we shall speak of things that have no degree of heat whatever to the touch, but seem to have only a kind of potential heat, or a disposition and readiness for heat. Afterward we shall come down to things that are actually hot, or hot to the touch, and to their strengths and degrees.

1. Among solid and tangible bodies nothing is found that is originally hot in its own nature. No stone, no metal, no sulfur, no mineral, no wood, no water, no animal carcass is found to be hot. The hot waters of baths seem to be heated accidentally. The cause may be flame or underground fire, such as Etna and many other mountains spew out, or the conflict of bodies, as heat arises when iron and tin are dissolved. So, as far as human touch goes,

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Itaque gradus caloris in inanimatis, quatenus ad tactum humanum, nullus est; veruntamen illa gradu frigoris differunt; non enim aeque frigidum est lignum ac metallum. Sed hoc pertinet ad *Tabulam Graduum in Frigido*.

2. Attamen quoad potentiales calores et praeparationes ad flammam, complura inveniuntur inanimata admodum disposita, ut sulphur, naphtha, petrelaeum.

3. Quae antea incaluerunt, ut fimus equinus ex animali, aut calx, aut fortasse cinis aut fuligo ex igne, reliquias latentes quasdam caloris prioris retinent. Itaque fiunt quaedam distillationes et separationes corporum per sepulturam in fimo equino; atque excitatur calor in calce per aspersionem aquae; ut jam dictum est.

4. Inter vegetabilia non invenitur aliqua planta sive pars plantae (veluti lachryma aut medulla) quae sit ad tactum humanum calida. Sed tamen (ut superius dictum est) herbae virides conclusae calescunt; atque ad interiorem tactum, veluti ad palatum aut ad stomachum aut etiam ad exteriores partes, post aliquam moram (ut in emplastris et unguentis) alia vegetabilia inveniuntur calida, alia frigida.

5. Non invenitur in partibus animalium, postquam fuerint mortuae aut separatae, aliquid calidum ad tactum humanum. Nam neque fimus equinus ipse, nisi fuerit conclusus et sepultus, calorem retinet. Sed tamen omnis fimus habere videtur calorem potentialem, ut in agrorum impinguatione. Et similiter, cadavera animalium hujusmodi habent latentem et potentialem calorem; adeo ut in coemeteriis, ubi quotidie fiunt sepulturae, terra calorem quendam occultum colligat, qui cadaver aliquod recenter impositum consumit longe citius quam terra pura. Atque apud orientales traditur inveniri textile quoddam tenue et molle, factum ex avium plumagine, quod vi innata butyrum solvat et liquefaciat in ipso leviter involutum.

6. Quae impinguant agros, ut fimi omnis generis, creta, arena maris, sal, et similia, dispositionem nonnullam habent ad calidum.

7. Omnis putrefactio in se rudimenta quaedam exilis caloris habet, licet non hucusque ut ad tactum percipiatur. Nam nec ea ipsa quae putrefacta solvuntur in animalcula, ut caro, caseus, ad tactum percipiuntur calida; neque lignum putre, quod noctu splendet,

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there is no degree of heat in inanimate things. But they do differ in degree of cold, for wood is not as cold as metal. But this belongs to the *table of degrees* for cold.

2. Yet as regards potential heat and readiness for flame, many inanimate things are found to be highly disposed, such as sulfur, naphtha and petroleum.

3. Things that have been hot before, like horse dung from the animal, or lime, or perhaps ash or soot from the fire, keep certain hidden remains of their former heat. So some distillations and separations of bodies are carried out by burying them in horse dung; and heat is excited in lime by sprinkling it with water, as has already been said.

4. Among vegetables, no plant or part of a plant (such as its gum or pith) is found that is hot to human touch. But (as was said above) green herbs shut up together grow hot. And to the inner touch, such as the palate or the stomach, or even to the outer parts after some time (as with plasters and ointments), some vegetables are found hot and others cold.

5. Nothing hot to human touch is found in the parts of animals once they are dead or separated. Not even horse dung itself keeps its heat unless it has been enclosed and buried. Yet all dung seems to have potential heat, as in the enriching of fields. Likewise, animal corpses have a hidden and potential heat of this kind. So in cemeteries where burials take place daily, the earth collects a certain hidden heat, which consumes a newly buried corpse far more quickly than pure earth does. And it is reported that the peoples of the East have a fine, soft fabric made from birds' plumage that by its innate power dissolves and melts butter lightly wrapped in it.

6. Things that enrich fields, such as dung of every kind, chalk, sea sand, salt and the like, have some disposition to heat.

7. All putrefaction has in it certain rudiments of faint heat, though not to the point where it can be perceived by touch. For even things that putrefy and break down into tiny creatures, like meat or cheese, are not felt as hot; nor is rotten wood, which shines at night, found hot to the touch. Heat

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deprehenditur ad tactum calidum. Calor autem in putridis quandoque se prodit per odores tetros et fortes.

8. Primus itaque caloris gradus, ex iis quae ad tactum humanum percipiuntur calida, videtur esse calor animalium, qui bene magnam habet graduum latitudinem. Nam infimus gradus (ut in insectis) vix ad tactum deprenditur; summus autem gradus vix attingit ad gradum caloris radiorum solis in regionibus et temporibus maxime ferventibus, neque ita acris est quin tolerari possit a manu. Et tamen referunt de Constantio, aliisque nonnullis qui constitutionis et habitus corporis admodum sicci fuerunt, quod acutissimis febribus correpti ita incaluerint ut manum admotam aliquantulum urere visi sint.

9. Animalia, ex motu et exercitatione, ex vino et epulis, ex venere, ex febribus ardentibus, et ex dolore, augentur calore.

10. Animalia, in accessibus febrium intermittentium, a principio frigore et horrore corripiuntur, sed paulo post majorem in modum incalescunt; quod etiam faciunt a principio in causonibus et febribus pestilentialibus.

11. Inquiratur ulterius de calore comparato in diversis animalibus, veluti piscibus, quadrupedibus, serpentibus, avibus; atque etiam secundum species ipsorum, ut in leone, milvio, homine; nam ex vulgari opinione, pisces per interiora minus calidi sunt, aves autem maxime calidae; praesertim columbae, accipitres, struthiones.

12. Inquiratur ulterius de calore comparato in eodem animali, secundum partes et membra ejus diversa. Nam lac, sanguis, sperma, ova, inveniuntur gradu modico tepida, et minus calida quam ipsa caro exterior in animali quando movetur aut agitatur. Qualis vero gradus sit caloris in cerebro, stomacho, corde, et reliquis, similiter adhuc non est quaesitum.

13. Animalia omnia, per hyemem et tempestates frigidas, secundum exterius frigent; sed per interiora etiam magis esse calida existimantur.

14. Calor coelestium, etiam in regione calidissima atque temporibus anni et diei calidissimis, non eum gradum caloris obtinet, qui vel lignum aridissimum vel stramen vel etiam linteum ustum incendat aut adurat, nisi per specula comburentia roboretur; sed tamen e rebus humidis vaporem excitare potest.

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in putrid things sometimes reveals itself through foul and strong smells.

8. So the first degree of heat, among things felt as hot to human touch, seems to be the heat of animals, which covers a very wide range of degrees. The lowest degree (as in insects) is barely detectable by touch. The highest degree barely reaches the heat of the sun's rays in the hottest regions and seasons, and it is never so sharp that the hand cannot bear it. And yet it is reported of Constantius, and of some others who had a very dry constitution and habit of body, that when seized by very acute fevers they grew so hot that they seemed to burn a hand placed on them a little.

9. Animals increase in heat from motion and exercise, from wine and feasting, from sexual activity, from burning fevers, and from pain.

10. In the onset of intermittent fevers, animals are at first seized with cold and shivering, but soon afterward grow extremely hot. In burning fevers (causus) and pestilential fevers, they grow hot from the very beginning.

11. Let further inquiry be made into comparative heat in different animals, such as fish, quadrupeds, snakes and birds, and also by species, as in the lion, the kite and man. For in common opinion fish are less hot inside, and birds hottest of all, especially doves, hawks and ostriches.

12. Let further inquiry be made into comparative heat in the same animal, according to its different parts and members. For milk, blood, semen and eggs are found to be moderately warm, and less hot than the animal's outer flesh when it is moving or agitated. What degree of heat there is in the brain, the stomach, the heart and the rest has likewise not yet been investigated.

13. All animals are cold on the outside in winter and cold weather, but are thought to be even hotter inside.

14. The heat of the heavenly bodies, even in the hottest region and at the hottest times of year and day, does not reach a degree of heat that would set alight or scorch the driest wood, or straw, or even linen tinder, unless it is strengthened by burning glasses. But it can raise vapor from moist things.

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15. Ex traditione astronomorum ponuntur stellae aliae magis, aliae minus calidae. Inter planetas enim post solem ponitur Mars calidissimus, deinde Jupiter, deinde Venus; ponuntur autem tanquam frigidi Luna et deinde omnium maxime Saturnus. Inter fixas autem ponitur calidissimus Sirius, deinde Cor Leonis, sive Regulus, deinde Canicula, etc.

16. Sol magis calefacit, quo magis vergit ad perpendiculum sive Zenith, quod etiam credendum est de aliis planetis, pro modulo suo caloris; exempli gratia, Jovem magis apud nos calefacere, cum positus sit sub Cancro aut Leone quam sub Capricorno aut Aquario.

17. Credendum est solem ipsum et planetas reliquos magis calefacere in perigaeis suis, propter propinquitatem ad terram, quam in apogaeis. Quod si eveniat ut in aliqua regione sol sit simul in perigaeo et propius ad perpendiculum, necesse est ut magis calefaciat quam in regione ubi sol sit similiter in perigaeo sed magis ad obliquum. Adeo ut comparatio exaltationis planetarum notari debeat, prout ex perpendiculo aut obliquitate participet, secundum regionum varietatem.

18. Sol etiam, et similiter reliqui planetae calefacere magis existimantur cum sint in proximo ad stellas fixas majores; veluti cum sol ponitur in Leone, magis vicinus fit Cordi Leonis, Caudae Leonis, et Spicae Virginis, et Sirio, et Caniculae, quam cum ponitur in Cancro, ubi tamen magis sistitur ad perpendiculum. Atque credendum est partes coeli majorem infundere calorem (licet ad tactum minime perceptibilem) quo magis ornatae sint stellis, praesertim majoribus.

19. Omnino calor coelestium augetur tribus modis; videlicet ex perpendiculo, ex propinquitate sive perigaeo, et ex conjunctione sive consortio stellarum.

20. Magnum omnino invenitur intervallum inter calorem animalium ac etiam radiorum coelestium (prout ad nos deferuntur), atque flammam, licet lenissimam, atque etiam ignita omnia, atque insuper liquores, aut aerem ipsum majorem in modum ab igne calefactum. Etenim

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15. According to the tradition of astronomers, some stars are held to be hotter and others less hot. Among the planets, after the sun, Mars is held to be the hottest, then Jupiter, then Venus. The moon is held to be cold, and Saturn coldest of all. Among the fixed stars, Sirius is held to be the hottest, then the Heart of the Lion, or Regulus, then the Little Dog, and so on.[9]

16. The sun heats more the nearer it comes to the perpendicular, or zenith. The same must be believed of the other planets, in proportion to their heat. For example, Jupiter heats us more when it is under Cancer or Leo than under Capricorn or Aquarius.

17. It must be believed that the sun itself and the other planets heat more at their perigees, because they are nearer the earth, than at their apogees. And if in some region the sun happens to be both at perigee and nearer the perpendicular, it must heat more than in a region where the sun is likewise at perigee but more oblique. So the elevation of the planets should be compared according to how far it approaches the perpendicular or the oblique in different regions.

18. The sun, too, and likewise the other planets, are thought to heat more when they are near the larger fixed stars. For example, when the sun is in Leo it is closer to the Heart of the Lion, the Tail of the Lion, Spica (the Ear of Wheat) in Virgo, Sirius and the Little Dog than when it is in Cancer, where it nevertheless stands nearer the perpendicular. And it must be believed that parts of the sky pour out more heat (though hardly perceptible to touch) the more richly they are adorned with stars, especially large ones.

19. In short, the heat of the heavenly bodies is increased in three ways: by the perpendicular, by nearness or perigee, and by the conjunction or company of stars.

20. There is a great gap between, on one side, the heat of animals and also of the heavenly rays (as they reach us), and, on the other, flame, however gentle, all ignited things, and liquids or air itself strongly heated by fire. For the flame of spirit of

9 The "Little Dog" (Canicula) here is probably Procyon, since Sirius is named separately.

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flamma spiritus vini, praesertim rara nec constipata, tamen potis est stramen aut linteum aut papyrum incendere; quod nunquam faciet calor animalis vel solis, absque speculis comburentibus.

21. Flammae autem et ignitorum plurimi sunt gradus in fortitudine et debilitate caloris. Verum de his nulla est facta diligens inquisitio; ut necesse sit ista leviter transmittere. Videtur autem ex flammis illa ex spiritu vini esse mollissima; nisi forte ignis fatuus, aut flammae seu coruscationes ex sudoribus animalium, sint molliores. Hanc sequi opinamur flammam ex vegetabilibus levibus et porosis, ut stramine, scirpis, et foliis arefactis, a quibus non multum differre flammam ex pilis aut plumis. Hanc sequitur fortasse flamma ex lignis, praesertim iis quae non multum habent ex resina aut pice; ita tamen ut flamma ex lignis quae parva sunt mole (quae vulgo colligantur in fasciculos) lenior sit quam quae fit ex truncis arborum et radicibus.

Id quod vulgo experiri licet in fornacibus quae ferrum excoquunt, in quibus ignis ex fasciculis et ramis arborum non est admodum utilis. Hanc sequitur (ut arbitramur) flamma ex oleo et sevo et cera, et hujusmodi oleosis et pinguibus, quae sunt sine magna acrimonia. Fortissimus autem calor reperitur in pice et resina; atque adhuc magis in sulphure et caphura, et naphtha et petrelaeo et salibus (postquam materia cruda eruperit), et in horum compositionibus, veluti pulvere tormentario, igne Graeco (quem vulgo ignem ferum vocant), et diversis ejus generibus, quae tam obstinatum habent calorem ut ab aquis non facile exstinguantur.

22. Existimamus etiam flammam, quae resultat ex nonnullis metallis imperfectis, esse valde robustam et acrem. Verum de istis omnibus inquiratur ulterius.

23. Videtur autem flamma fulminum potentiorum has omnes flammas superare; adeo ut ferrum ipsum perfectum aliquando colliquaverit in guttas, quod flammae illae alterae facere non possunt.

24. In ignitis autem diversi sunt etiam gradus caloris, de quibus etiam non facta est diligens inquisitio. Calorem maxime debilem existimamus esse ex linteo usto, quali ad flammae excitationem uti solemus; et similiter ex ligno illo spongioso aut funiculis arefactis qui ad tormentorum accensionem adhibentur. Post hunc sequitur carbo ignitus ex lignis et anthracibus, atque etiam ex lateribus

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wine, even when thin and not concentrated, can set straw, linen or paper alight. The heat of an animal or of the sun will never do this without burning glasses.

21. Flame and ignited things have very many degrees of strength and weakness of heat. But no careful inquiry has been made into these, so they must be passed over lightly. Of flames, that from spirit of wine seems the mildest, unless perhaps the will-o'-the-wisp, or the flames or flashes from animal sweat, are milder. Next, we believe, comes flame from light and porous plants, like straw, rushes and dried leaves; flame from hair or feathers does not differ much from this. Next, perhaps, comes flame from wood, especially wood without much resin or pitch. Even so, flame from small pieces of wood (which are commonly tied in bundles) is gentler than flame from tree trunks and roots.

This can be commonly observed in furnaces for smelting iron, where a fire of bundles and branches is not much use. Next (as we judge) comes flame from oil, tallow, wax and similar oily and fatty substances that lack great sharpness. The strongest heat is found in pitch and resin. It is stronger still in sulfur, camphor, naphtha, petroleum and salts (after the raw matter has burst out), and in compounds of these, such as gunpowder, Greek fire (commonly called wildfire) and its various kinds. Their heat is so stubborn that water does not easily put them out.[10]

22. We also think that the flame that comes from some imperfect metals is very strong and sharp. But let further inquiry be made into all these.

23. The flame of the more powerful lightning seems to surpass all these flames. It has sometimes melted even refined iron into drops, which those other flames cannot do.

24. Among ignited things there are also different degrees of heat, and no careful inquiry has been made into these either. We think the weakest heat is that of burnt linen, such as we use for kindling flame, and likewise that of the spongy wood or dried cords used to fire cannon. Next comes glowing charcoal from wood and coal, and also red-hot

10 Greek fire: an incendiary weapon of the Byzantine Empire, famous for burning even on water.

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ignitis, et similibus. Ignitorum autem vehementissime calida existimamus esse metalla ignita, ut ferrum et cuprum et caetera. Verum de his etiam facienda est ulterior inquisitio.

25. Inveniuntur ex ignitis nonnulla longe calidiora quam nonnullae ex flammis. Multo enim calidius est et magis adurens ferrum ignitum quam flamma spiritus vini.

26. Inveniuntur etiam ex illis quae ignita non sunt sed tantum ab igne calefacta, sicut aquae ferventes et aer conclusus in reverberatoriis, nonnulla quae superant calore multa ex flammis ipsis et ignitis.

27. Motus auget calorem; ut videre est in follibus et flatu; adeo ut duriora ex metallis non solvantur aut liquefiant per ignem mortuum aut quietum, nisi flatu excitetur.

28. Fiat experimentum per specula comburentia, in quibus (ut memini) hoc fit; ut si speculum ponatur (exempli gratia) ad distantiam spithamae ab objecto combustibili, non tantopere incendat aut adurat quam si positum fuerit speculum (exempli gratia) ad distantiam semi spithamae, et gradatim et lente trahatur ad distantiam spithamae. Conus tamen et unio radiorum eadem sunt, sed ipse motus auget operationem caloris.

29. Existimantur incendia illa, quae fiunt flante vento forti, majores progressus facere adversus ventum quam secundum ventum; quia scilicet flamma resilit motu perniciore, vento remittente, quam procedit, vento impellente.

30. Flamma non emicat aut generatur, nisi detur aliquid concavi in quo flamma movere possit et ludere; praeterquam in flammis flatuosis pulveris tormentarii, et similibus, ubi compressio et incarceratio flammae auget ejus furorem.

31. Incus per malleum calefit admodum; adeo ut si incus fuerit laminae tenuioris, existimemus illam per fortes et continuos ictus mallei posse rubescere, ut ferrum ignitum; sed de hoc fiat experimentum.

32. At in ignitis quae sunt porosa, ita ut detur spatium ad exercendum motum ignis, si cohibeatur hujusmodi motus per compressionem fortem, statim extinguitur ignis; veluti cum linteum ustum aut filum ardens candelae aut

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bricks and the like. Of all ignited things, we think the hottest are red-hot metals, like iron, copper and the rest. But further inquiry must be made into these too.

25. Some ignited things are found to be far hotter than some flames. For red-hot iron is much hotter and more scorching than the flame of spirit of wine.

26. Some things that are not ignited but only heated by fire, such as boiling water and air enclosed in reverberatory furnaces, are also found to surpass in heat many flames and ignited things.

27. Motion increases heat, as can be seen in bellows and in blowing. So much so that the harder metals are not dissolved or melted by a dead or still fire unless it is stirred up by blowing.

28. Let an experiment be made with burning glasses, in which (as I recall) the following happens. Suppose a glass is placed (for example) a span away from a combustible object. It will not set it alight or scorch it as much as a glass placed (for example) half a span away and then drawn gradually and slowly back to a span. The cone and union of the rays are the same, but the motion itself increases the action of the heat.

29. Fires that break out in a strong wind are thought to make greater progress against the wind than with it. The reason is that the flame springs back more swiftly when the wind slackens than it moves forward when the wind drives it.

30. Flame does not flash out or come into being unless there is some hollow space in which it can move and play. The exception is the explosive flames of gunpowder and the like, where compression and imprisonment of the flame increase its fury.

31. An anvil gets very hot under the hammer. So much so that if the anvil were of fairly thin plate, we think strong and continuous hammer blows could make it glow red like red-hot iron. But let an experiment be made on this.

32. But with ignited things that are porous, so that there is room for the fire to exercise its motion, the fire goes out at once if this motion is checked

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lampadis aut etiam carbo aut pruna ardens comprimitur per pressorium aut pedis conculcationem aut hujusmodi, statim cessant operationes ignis.

33. Approximatio ad corpus calidum auget calorem, pro gradu approximationis; quod etiam fit in lumine: nam quo propius collocatur objectum ad lumen eo magis est visibile.

34. Unio calorum diversorum auget calorem, nisi facta sit commistio corporum. Nam focus magnus et focus parvus in eodem loco nonnihil invicem augent calorem; at aqua tepida immissa in aquam ferventem refrigerat.

35. Mora corporis calidi auget calorem. Etenim calor perpetuo transiens et emanans commiscetur cum calore praeinexistente, adeo ut multiplicet calorem. Nam focus non aeque calefacit cubiculum per moram semihorae ac si idem focus duret per horam integram. At hoc non facit lumen; etenim lampas aut candela in aliquo loco posita non magis illuminat per moram diuturnam quam statim ab initio.

36. Irritatio per frigidum ambiens auget calorem; ut in focis videre est per gelu acre. Quod existimamus fieri non tantum per conclusionem et contractionem caloris, quae est species unionis, sed per exasperationem; veluti cum aer aut baculum violenter comprimitur aut flectitur, non ad punctum loci prioris resilit, sed ulterius in contrarium. Itaque fiat diligens experimentum per baculum vel simile aliquid immissum in flammam, utrum ad latera flammae non uratur citius quam in medio flammae.

37. Gradus autem in susceptione caloris sunt complures. Atque primo omnium notandum est, quam parvus et exilis calor etiam ea corpora, quae caloris minime omnium sunt susceptiva, immutet tamen et nonnihil calefaciat. Nam ipse calor manus globulum plumbi aut alicujus metalli paulisper detentum nonnihil calefacit. Adeo facile et in omnibus transmittitur et excitatur calor, corpore nullo modo ad apparentiam immutato.

38. Facillime omnium corporum apud nos et excipit et remittit calorem aer; quod optime cernitur in vitris

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by strong compression. For example, when burnt linen, or the burning wick of a candle or lamp, or even glowing charcoal or a live coal, is squeezed in a press or trodden underfoot or the like, the operations of the fire stop at once.

33. Nearness to a hot body increases heat in proportion to the degree of nearness. The same happens with light, for the closer an object is placed to a light, the more visible it is.

34. The union of different heats increases heat, unless the bodies are mixed together. For a large fire and a small fire in the same place somewhat increase each other's heat; but lukewarm water poured into boiling water cools it.

35. The duration of a hot body increases heat. For heat, continually passing over and flowing out, mixes with the heat already present, so that it multiplies the heat. A fire does not heat a room as much in half an hour as the same fire does if it lasts a whole hour. But light does not do this: a lamp or candle placed somewhere gives no more light after a long time than it does immediately at first.

36. Irritation by surrounding cold increases heat, as can be seen in fires during a sharp frost. We think this happens not only through the enclosing and contraction of heat, which is a kind of union, but through exasperation. It is like air or a stick that is violently compressed or bent: it springs back not just to its former position but beyond it, in the opposite direction. So let a careful experiment be made with a stick or something similar put into a flame, to see whether it burns more quickly at the sides of the flame than in the middle.

37. There are many degrees in the reception of heat. And first of all it should be noted how even a small and faint heat changes and somewhat warms the bodies least receptive of heat. For the mere heat of the hand warms a little a small ball of lead or some other metal held for a short while. So easily, and in everything, is heat transmitted and excited, with no apparent change in the body at all.

38. Of all the bodies around us, air both takes in and gives off heat most readily; this is best seen in

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calendaribus. Eorum confectio est talis: accipiatur vitrum ventre concavo, collo tenui et oblongo; resupinetur et demittatur hujusmodi vitrum, ore deorsum verso, ventre sursum, in aliud vasculum vitreum ubi sit aqua, tangendo fundum vasculi illius recipientis extremo ore vitri immissi, et incumbat paullulum vitri immissi collum ad os vitri recipientis, ita ut stare possit; quod ut commodius fiat, apponatur parum cerae ad os vitri recipientis; ita tamen ut non penitus obturetur os ejus, ne ob defectum aeris succedentis impediatur motus de quo jam dicetur, qui est admodum facilis et delicatus.

Oportet autem ut vitrum demissum, antequam inseratur in alterum, calefiat ad ignem a parte superiori, ventre scilicet. Postquam autem fuerit vitrum illud collocatum, ut diximus, recipiet et contrahet se aer (qui dilatatus erat per calefactionem), post moram sufficientem pro extinctione illius ascititii caloris, ad talem extensionem sive dimensionem qualis erit aeris ambientis aut communis tunc temporis quando immittitur vitrum, atque attrahet aquam in sursum ad hujusmodi mensuram. Debet autem appendi charta angusta et oblonga, et gradibus (quot libuerit) interstincta. Videbis autem, prout tempestas diei incalescit aut frigescit, aerem se contrahere in angustius per frigidum et extendere se in latius per calidum; id quod conspicietur per aquam ascendentem quando contrahitur aer, et descendentem sive depressum quando dilatatur aer.

Sensus autem aeris, quatenus ad calidum et frigidum, tam subtilis est et exquisitus ut facultatem tactus humani multum superet; adeo ut solis radius aliquis, aut calor anhelitus, multo magis calor manus, super vitri summitatem positus, statim deprimat aquam manifesto. Attamen existimamus spiritum animalium magis adhuc exquisitum sensum habere calidi et frigidi, nisi quod a mole corporea impediatur et hebetetur.

39. Post aerem, existimamus corpora esse maxime sensitiva caloris ea quae a frigore recenter immutata sint et compressa, qualia sunt nix et glacies; ea enim leni aliquo tepore solvi incipiunt et colliquari. Post illa sequitur fortasse argentum vivum. Post illud sequuntur corpora pinguia, ut oleum butyrum, et similia; deinde lignum; deinde aqua; postremo lapides et metalla, quae non facile calefiunt, praesertim interius. Illa tamen

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calendar glasses. They are made as follows. Take a glass with a hollow belly and a thin, long neck. Turn it upside down, mouth downward and belly upward, and lower it into another glass vessel containing water, so that the mouth of the inserted glass touches the bottom of the receiving vessel. Let the neck of the inserted glass rest slightly against the mouth of the receiving glass, so that it can stand. To make this easier, put a little wax on the mouth of the receiving glass—but without sealing its mouth completely. Otherwise the motion we shall now describe, which is very easy and delicate, would be hindered by the lack of air coming in.

Before the lowered glass is inserted into the other, it should be heated at the fire on its upper part, that is, the belly. Once the glass has been placed as described, the air (which had been expanded by the heating) will, after enough time for that acquired heat to die away, withdraw and contract. It will shrink to the same extent or volume as the surrounding or ordinary air at the time the glass is put in, and will draw the water up to that level. A narrow, oblong strip of paper should be attached, marked off with as many degrees as you like. You will then see that, as the day's weather grows warmer or colder, the air contracts into a smaller space with cold and expands into a larger one with heat. This will be seen from the water, which rises when the air contracts, and falls, or is pushed down, when the air expands.

The sensitivity of air to hot and cold is so fine and exact that it far exceeds the capacity of human touch. So a ray of sunlight, or the warmth of breath, and much more the warmth of a hand, placed on the top of the glass, at once visibly pushes the water down. Yet we think the spirit of animals has an even more exact sense of hot and cold, except that the bulk of the body impedes and dulls it.

39. After air, we think the bodies most sensitive to heat are those recently changed and compressed by cold, such as snow and ice; for they begin to dissolve and melt with some gentle warmth. After them, perhaps, comes quicksilver. After that come fatty bodies, like oil, butter and the like; then wood; then water; and last, stones and metals, which do not heat easily, especially inside. Yet

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	calorem semel susceptum diutissime retinent; ita ut later aut lapis aut ferrum ignitum in pelvim aquae frigidae immissum et demersum, per quartam partem horae (plus minus) retineat calorem, ita ut tangi non possit.	once they have taken on heat, they keep it for a very long time. So a brick, a stone or a piece of red-hot iron plunged and sunk in a basin of cold water keeps its heat for about a quarter of an hour, so that it cannot be touched.
	40. Quo minor est corporis moles, eo citius per corpus calidum approximatum incalescit; id quod demonstrat omnem calorem apud nos esse corpori tangibili quodammodo adversum.	40. The smaller the bulk of a body, the more quickly it grows hot when a hot body is brought near. This shows that all heat among us is in some way hostile to tangible body.
	41. Calidum, quatenus ad sensum et tactum humanum, res varia est et respectiva: adeo ut aqua tepida, si manus frigore occupetur, sentiatur esse calida; sin manus incaluerit, frigida.	41. Hot, as far as human sense and touch go, is a variable and relative thing. So much so that lukewarm water feels hot if the hand is cold, but cold if the hand is hot.
2.14	Quam inopes simus historiae quivis facile advertet, cum in tabulis superioribus, praeterquam quod loco historiae probatae et instantiarum certarum nonnunquam traditiones et relationes inseramus (semper tamen adjecta dubiae fidei et auctoritatis nota), saepenumero etiam hisce verbis, *fiat experimentum*, vel *inquiratur ulterius*, uti cogamur.	Anyone will easily notice how poor we are in history. In the tables above we sometimes insert traditions and reports in place of tested history and certain instances (though always with a note of their doubtful credit and authority). And we are often forced to use the words *let an experiment be made* or *let further inquiry be made*.

INDUCTION BY EXCLUSION

Only God knows forms directly; people must first reject every nature that fails to fit the tables.

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2.15	Atque opus et officium harum trium tabularum *Comparentiam instantiarum ad intellectum* vocare consuevimus. Facta autem *comparentia*, in opere ponenda est ipsa *inductio*. Invenienda est enim, super *comparentiam* omnium et singularum instantiarum, natura talis, quae cum natura data perpetuo adsit, absit, atque crescat, et decrescat; sitque (ut superius dictum est) limitatio naturae magis communis. Hoc si mens jam ab initio facere tentet affirmative (quod sibi permissa semper facere solet), occurrent phantasmata et opinabilia et notionalia male terminata et axiomata quotidie emendanda; nisi libeat (scholarum more) pugnare pro falsis. Ea tamen proculdubio erunt meliora aut praviora pro facultate et robore intellectus qui operatur. At omnino Deo (formarum inditori et opifici) aut fortasse angelis et intelligentiis competit formas per affirmationem immediate nosse, atque ab initio contemplationis.	The work and function of these three tables we usually call the *presentation of instances to the understanding*. Once the *presentation* has been made, *induction* itself must be put to work. For on the basis of the *presentation* of each and every instance, we must find a nature that is always present when the given nature is present, absent when it is absent, and increases and decreases with it; and that is (as was said above) a limitation of a more general nature. If the mind tries to do this affirmatively from the start (as it always tends to do when left to itself), there will arise phantoms, guesses, ill-defined notions, and axioms that need correcting every day—unless one prefers, as the schools do, to fight for falsehoods. These will no doubt be better or worse according to the ability and strength of the understanding at work. But it belongs only to God (the giver and maker of forms), and perhaps to angels and intelligences, to know forms immediately by affirmation, from the very beginning of contemplation.

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	Sed certe supra hominem est; cui tantum conceditur, procedere primo per *negativas*, et postremo loco desinere in *affirmativas*, post omnimodam exclusionem.	But this is certainly beyond man. He is allowed only to proceed first by *negatives*, and to end in *affirmatives* only at the last, after every kind of exclusion.
2.16	Itaque naturae facienda est prorsus solutio et separatio; non per ignem certe, sed per mentem, tanquam ignem divinum. Est itaque *inductionis* verae opus primum (quatenus ad inveniendas formas) *rejectio* sive *exclusiva* naturarum singularum, quae non inveniuntur in aliqua instantia, ubi natura data adest; aut inveniuntur in aliqua instantia, ubi natura data abest; aut inveniuntur in aliqua instantia crescere, cum natura data decrescat; aut decrescere, cum natura data crescat. Tum vero post *rejectionem* et *exclusivam* debitis modis factam, secundo loco (tanquam in fundo) manebit (abeuntibus in fumum opinionibus volatilibus) forma affirmativa, solida, et vera, et bene terminata. Atque hoc breve dictu est, sed per multas ambages ad hoc pervenitur. Nos autem nihil fortasse ex iis, quae ad hoc faciunt, praetermittemus.	So nature must be completely broken down and separated—not by fire, of course, but by the mind, as a kind of divine fire. The first task of true *induction* (as far as finding forms goes) is the *rejection* or *exclusion* of particular natures. These are natures that are not found in some instance where the given nature is present; or are found in some instance where the given nature is absent; or are found to increase in some instance when the given nature decreases, or to decrease when it increases. Then, after the *rejection* and *exclusion* have been properly made, there will remain in second place (as at the bottom of the vessel), once volatile opinions have gone up in smoke, an affirmative form: solid, true and well defined. This is quickly said, but it is reached only by many windings. We, however, will perhaps leave out nothing that helps toward it.
2.17	Cavendum autem est, et monendum quasi perpetuo, ne, cum tantae partes formis videantur a nobis tribui, trahantur ea, quae dicimus, ad formas eas, quibus hominum contemplationes et cogitationes hactenus assueverunt.	But we must take care, and give warning almost continually, on one point. Because we seem to assign so large a role to forms, what we say should not be taken to refer to the kind of forms that men's speculations and thoughts have been used to until now.
	Primo enim, de formis copulatis, quae sunt (ut diximus) naturarum simplicium conjugia ex cursu communi universi, ut leonis, aquilae, rosae, auri, et hujusmodi, impraesentiarum non loquimur. Tempus enim erit de iis tractandi, cum ventum fuerit ad *latentes processus*, et *latentes schematismos*, eorumque inventionem, prout reperiuntur in substantiis (quas vocant) seu naturis concretis.	First, we are not speaking here of conjoined forms. These (as we have said) are combinations of simple natures brought about by the common course of the universe, like those of the lion, the eagle, the rose, gold and the like. There will be time to deal with them when we come to *latent processes* and *latent configurations*, and how to discover them, as they are found in so-called substances, or concrete natures.
	Rursus vero, non intelligantur ea quae dicimus (etiam quatenus ad naturas simplices) de formis et ideis abstractis, aut in materia non determinatis, aut male determinatis. Nos enim, quum de formis loquimur, nil aliud intelligimus quam leges illas et determinationes actus puri, quae naturam aliquam simplicem ordinant et constituunt, ut calorem, lumen, pondus, in omnimoda materia et subjecto susceptibili. Itaque eadem res est forma calidi aut forma luminis, et lex calidi sive lex	Again, what we say (even with respect to simple natures) is not to be understood of abstract forms and ideas, either not determined in matter or badly determined. For when we speak of forms, we mean nothing other than those laws and determinations of pure act that order and constitute some simple nature—such as heat, light or weight—in every kind of matter and receptive subject. So the form of heat or the form of light is the same thing as the law of heat or the law of light. And we

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luminis; neque vero a rebus ipsis et parte operativa unquam nos abstrahimus aut recedimus.

Quare cum dicimus (exempli gratia) in inquisitione formae caloris, *Rejice tenuitatem*, aut *Tenuitas non est ex forma caloris;* idem est ac si dicamus, *Potest homo superinducere calorem in corpus densum,* aut contra, *Potest homo auferre aut arcere calorem a corpore tenui.*

Quod si cuiquam videantur etiam formae nostrae habere nonnihil abstracti, quod misceant et conjungant heterogenea (videntur enim valde esse heterogenea calor coelestium, et ignis; rubor fixus in rosa aut similibus, et apparens in iride aut radiis opalii aut adamantis; mors ex summersione, ex crematione, ex punctura gladii, ex apoplexia, ex atrophia; et tamen conveniunt ista in natura calidi, ruboris, mortis), is se habere intellectum norit consuetudine et integralitate rerum et opinionibus captum et detentum.

Certissimum enim est ista, utcunque heterogenea et aliena, coire in formam sive legem eam, quae ordinat calorem, aut ruborem, aut mortem; nec emancipari posse potentiam humanam et liberari a naturae cursu communi, et expandi et exaltari ad efficientia nova et modos operandi novos, nisi per revelationem et inventionem hujusmodi formarum; et tamen post istam unionem naturae, quae est res maxime principalis, de naturae divisionibus et venis, tam ordinariis quam interioribus et verioribus, suo loco postea dicetur.

2.18 Jam vero proponendum est exemplum *exclusionis* sive *rejectionis* naturarum, quae per *tabulas comparentiae* reperiuntur non esse ex forma calidi; illud interim monendo, non solum sufficere singulas *tabulas* ad *rejectionem* alicujus naturae, sed etiam unamquamque ex instantiis singularibus in illis contentis. Manifestum enim est ex iis, quae dicta sunt, omnem *instantiam contradictoriam* destruere opinabile de forma. Sed nihilominus quandoque perspicuitatis causa, et ut usus *tabularum* clarius demonstretur, *exclusivam* duplicamus aut repetimus.

Exemplum *exclusivae*, sive *rejectionis naturarum* a forma calidi.

1. Per radios solis, *rejice* naturam elementarem.

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never abstract ourselves or withdraw from things themselves and the operative part.

So when we say (for example), in investigating the form of heat, *Reject rarity*, or *Rarity is not part of the form of heat*, it is the same as saying, *Man can induce heat in a dense body*, or conversely, *Man can remove heat from a rare body, or keep it away*.

Someone may think that our forms, too, have something abstract about them, because they mix and join things that are heterogeneous. The heat of the heavenly bodies and fire seem very heterogeneous. So do the fixed red of a rose or the like and the apparent red of a rainbow or of the rays of an opal or diamond. So do death by drowning, by burning, by a sword thrust, by apoplexy, by wasting. And yet these agree in the nature of heat, of redness, of death. Anyone who thinks so should know that his understanding is captive to, and held back by, habit, by things taken as wholes, and by opinions.

For it is quite certain that these things, however heterogeneous and alien, come together in the form or law that orders heat, or redness, or death. It is equally certain that human power cannot be set free and released from the common course of nature, and expanded and raised to new effects and new ways of working, except by the revealing and discovery of such forms. And yet, after this unity of nature, which is the most important thing, we shall speak in their proper place of the divisions and veins of nature, both the ordinary ones and those that are more inward and truer.

Now we must set out an example of the *exclusion* or *rejection* of natures that the *tables of presentation* show not to belong to the form of heat. Meanwhile we note that each *table* by itself is enough for the *rejection* of some nature—and not only each table, but each single instance contained in them. For it is clear from what has been said that every *contradictory instance* destroys a conjecture about the form. Nevertheless, for the sake of clarity, and to show the use of the *tables* more plainly, we sometimes double or repeat the *exclusion*.

An example of *exclusion*, or the *rejection of natures* from the form of heat.

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	1. Because of the sun's rays, *reject* elemental nature.
2. Per ignem communem, et maxime per ignes subterraneos (qui remotissimi sunt, et plurimum intercluduntur a radiis coelestibus), *rejice* naturam coelestem.	2. Because of ordinary fire, and especially underground fires (which are the most remote and the most shut off from the heavenly rays), *reject* heavenly nature.
3. Per calefactionem omnigenum corporum (hoc est, mineralium, vegetabilium, partium exteriorum animalium, aquae, olei, aeris, et reliquorum) ex approximatione sola ad ignem aut aliud corpus calidum, *rejice* omnem varietatem sive subtiliorem texturam corporum.	3. Because bodies of every kind (minerals, plants, the outer parts of animals, water, oil, air and the rest) grow hot merely by being brought near a fire or other hot body, *reject* all variety or finer texture of bodies.
4. Per ferrum et metalla ignita, quae calefaciunt alia corpora, nec tamen omnino pondere aut substantia minuuntur, *rejice* inditionem sive mixturam substantiae alterius calidi.	4. Because of red-hot iron and metals, which heat other bodies yet lose nothing at all in weight or substance, *reject* the infusion or mixture of the substance of some other hot thing.
5. Per aquam ferventem atque aerem, atque etiam per metalla et alia solida calefacta, sed non usque ad ignitionem sive ruborem, *rejice* lucem et lumen.	5. Because of boiling water and air, and also metals and other solids heated but not to the point of glowing or redness, *reject* light and brightness.
6. Per radios lunae et aliarum stellarum (excepto sole), *rejice* etiam lucem et lumen.	6. Because of the rays of the moon and the other stars (except the sun), *reject* light and brightness too.
7. Per *comparativam* ferri igniti et flammae spiritus vini (ex quibus ferrum ignitum plus habet calidi et minus lucidi, flamma autem spiritus vini plus lucidi et minus calidi), *rejice* etiam lucem et lumen.	7. Because of the *comparison* between red-hot iron and the flame of spirit of wine (red-hot iron has more heat and less brightness, the flame of spirit of wine more brightness and less heat), *reject* light and brightness too.
8. Per aurum et alia metalla ignita, quae densissimi sunt corporis secundum totum, *rejice* tenuitatem.	8. Because of gold and other red-hot metals, which are of very dense body as a whole, *reject* rarity.
9. Per aerem, qui invenitur ut plurimum frigidus, et tamen manet tenuis, *rejice* etiam tenuitatem.	9. Because of air, which is generally found to be cold and yet remains rare, *reject* rarity too.
10. Per ferrum ignitum, quod non intumescit mole, sed manet intra eandem dimensionem visibilem, *rejice* motum localem aut expansivum secundum totum.	10. Because of red-hot iron, which does not swell in bulk but stays within the same visible dimensions, *reject* local or expansive motion of the body as a whole.
11. Per dilatationem aeris in vitris calendariis et similibus, qui movetur localiter et expansive manifesto, neque tamen colligit manifestum augmentum caloris, *rejice* etiam motum localem aut expansivum secundum totum.	11. Because of the expansion of air in calendar glasses and the like, which plainly moves locally and expansively and yet gains no noticeable increase of heat, *reject* local or expansive motion of the body as a whole too.
12. Per facilem tepefactionem omnium corporum, absque aliqua destructione aut alteratione notabili, *rejice*	12. Because all bodies warm easily without any destruction or notable alteration, *reject* destructive

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naturam destructivam aut inditionem violentam alicujus naturae novae.	nature, or the violent infusion of some new nature.
13. Per consensum et conformitatem operum similium quae eduntur a calore et a frigore, *rejice* motum tam expansivum quam contractivum secundum totum.	13. Because of the agreement and conformity of similar effects produced by heat and by cold, *reject* both expansive and contractive motion of the body as a whole.
14. Per accensionem caloris ex attritione corporum, *rejice* naturam principialem. Naturam principialem vocamus eam, quae positiva reperitur in natura, nec causatur a natura praecedente.	14. Because heat is kindled by the friction of bodies, *reject* primary nature. By primary nature we mean a nature that is found to exist positively in nature and is not caused by a preceding nature.
Sunt et aliae naturae: neque enim tabulas conficimus perfectas, sed exempla tantum.	There are other natures as well; for we are not making complete tables, only examples.
Omnes et singulae naturae praedictae non sunt ex forma calidi. Atque ab omnibus naturis praedictis liberatur homo in operatione super calidum.	None of the natures listed above, taken together or singly, belongs to the form of heat. And in working on heat, man is freed from all of them.
2.19 Atque in *exclusiva* jacta sunt fundamenta *inductionis* verae, quae tamen non perficitur donec sistatur in affirmativa. Neque vero ipsa *exclusiva* ullo modo perfecta est, neque adeo esse potest sub initiis. Est enim *exclusiva* (ut plane liquet) *rejectio* naturarum simplicium. Quod si non habeamus adhuc bonas et veras notiones naturarum simplicium, quomodo rectificari potest *exclusiva*? At nonnullae ex supradictis (veluti notio naturae elementaris, notio naturae coelestis, notio tenuitatis) sunt notiones vagae, nec bene terminatae. Itaque nos, qui nec ignari sumus nec obliti quantum opus aggrediamur (viz. ut faciamus intellectum humanum rebus et naturae parem), nullo modo acquiescimus in his, quae adhuc praecepimus: sed et rem in ulterius provehimus, et fortiora auxilia in usum intellectus machinamur et ministramus; quae nunc subjungemus.	In *exclusion* the foundations of true *induction* are laid; but induction is not completed until it comes to rest in an affirmative. Nor is *exclusion* itself by any means complete, nor can it be at the beginning. For *exclusion* (as is plain) is the *rejection* of simple natures. And if we do not yet have good and true notions of simple natures, how can *exclusion* be set right? Yet some of those mentioned above (such as the notion of elemental nature, the notion of heavenly nature, the notion of rarity) are vague notions, not well defined. We are neither ignorant nor forgetful of how great a work we are undertaking—namely, to make the human understanding equal to things and to nature. So we by no means rest content with the precepts we have laid down so far. We carry the matter further, and devise and supply stronger aids for the understanding's use, which we shall now add.
Et certe in *interpretatione naturae* animus omnino taliter est praeparandus et formandus, ut et sustineat se in gradibus debitis certitudinis, et tamen cogitet (praesertim sub initiis) ea quae adsunt multum pendere ex iis quae supersunt.	And certainly, in the *interpretation of nature* the mind must be prepared and shaped in such a way that it holds itself to the proper degrees of certainty, and yet bears in mind (especially at the beginning) that what we now have depends heavily on what is still to come.

THE FIRST VINTAGE

Bacon ventures a provisional definition: heat is an expansive, restrained motion working through the smaller particles of bodies.

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Attamen quia citius emergit veritas ex errore quam ex confusione, utile putamus, ut fiat permissio intellectui, post tres tabulas *comparentiae primae* (quales posuimus) factas et pensitatas, accingendi se et tentandi opus *interpretationis naturae* in affirmativa; tam ex instantiis tabularum, quam ex iis quae alias occurrent. Quod genus tentamenti, *permissionem intellectus*, sive *interpretationem inchoatam*, sive *vindemiationem primam* appellare consuevimus.

Vindemiatio prima de forma calidi.

Animadvertendum autem est, formam rei inesse (ut ex iis quae dicta sunt plane liquet) instantiis universis et singulis, in quibus res ipsa inest; aliter enim forma non esset: itaque nulla plane dari potest *instantia* contradictoria. Attamen longe magis conspicua invenitur forma et evidens in aliquibus *instantiis*, quam in aliis; in iis videlicet, ubi minus cohibita est natura formae et impedita et redacta in ordinem per naturas alias. Hujusmodi autem instantias, *elucescentias* vel *instantias ostensivas* appellare consuevimus. Pergendum itaque est ad *vindemiationem* ipsam *primam* de forma calidi.

Per universas et singulas *instantias*, natura cujus limitatio est calor videtur esse motus. Hoc autem maxime ostenditur in flamma, quae perpetuo movetur; et in liquoribus ferventibus aut bullientibus, qui etiam perpetuo moventur. Atque ostenditur etiam in incitatione sive incremento caloris facto per motum; ut in follibus, et ventis; de quo vide Instant. 29. Tab. 3. Atque similiter in aliis modis motus, de quibus vide Instant. 28. et 31. Tab. 3. Rursus ostenditur in extinctione ignis et caloris per omnem fortem compressionem, quae fraenat et cessare facit motum; de qua vide Instant. 30. et 32. Tab. 3.

Ostenditur etiam in hoc, quod omne corpus destruitur aut saltem insigniter alteratur ab omni igne et calore forti ac vehementi; unde liquido constat, fieri a calore tumultum et perturbationem et motum acrem in partibus internis corporis, qui sensim vergit ad dissolutionem.

Intelligatur hoc quod diximus de motu (nempe, ut sit instar generis ad calorem), non quod calor generet

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Yet because truth emerges more readily from error than from confusion, we think it useful to grant the understanding an indulgence. Once the three tables of *first presentation* (such as we have set out) have been made and weighed, it may gird itself and attempt the work of the *interpretation of nature* in the affirmative, drawing both on the instances in the tables and on any others that turn up. This kind of attempt we are accustomed to call the *indulgence of the understanding*, or the *beginning of interpretation*, or the *first vintage*.[11]

The first vintage concerning the form of heat.

It should be noted that the form of a thing (as is plain from what has been said) is present in each and every instance in which the thing itself is present; otherwise it would not be the form. So no contradictory *instance* at all can be given. Yet the form is found far more conspicuous and evident in some *instances* than in others. These are the instances in which the nature of the form is less restrained, hindered and brought to order by other natures. Instances of this kind we are accustomed to call *illuminations* or *striking instances*. We must go on, then, to the *first vintage* itself concerning the form of heat.

From each and every *instance*, the nature of which heat is a limitation seems to be motion. This is shown most of all in flame, which is always in motion, and in seething or boiling liquids, which are also always in motion. It is also shown in the stirring up or increase of heat by motion, as in bellows and winds (see Instance 29 in Table 3), and likewise by other kinds of motion (see Instances 28 and 31 in Table 3). Again, it is shown in the extinguishing of fire and heat by any strong compression, which curbs motion and makes it stop (see Instances 30 and 32 in Table 3).

It is also shown by the fact that every body is destroyed, or at least notably altered, by any strong and violent fire and heat. From this it is quite clear that heat causes a tumult, a disturbance and a sharp motion in the internal parts of a body, which gradually tends toward its dissolution.

What we have said about motion (namely, that it is like a genus in relation to heat) should be under-

11 First vintage: a first provisional conclusion, a working hypothesis to be tested and corrected by what follows.

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motum, aut quod motus generet calorem (licet et haec in aliquibus vera sint), sed quod ipsissimus calor, sive *quid ipsum* caloris, sit motus et nihil aliud; limitatus tamen per *differentias* quas mox subjungemus, postquam nonnullas cautiones adjecerimus ad evitandum aequivocum.

Calidum ad sensum res respectiva est, et in ordine ad hominem non ad universum; et ponitur recte ut effectus caloris tantum in spiritum animalem. Quin etiam in seipso res varia est, cum idem corpus (prout sensus praedisponitur) inducat perceptionem tam calidi quam frigidi; ut patet per Instant. 41. Tab. 3.

Neque vero communicatio caloris, sive natura ejus transitiva per quam corpus admotum corpori calido incalescit, confundi debet cum forma calidi. Aliud enim est calidum, aliud calefactivum. Nam per motum attritionis inducitur calor absque aliquo calido praecedente, unde excluditur calefactivum a forma calidi. Atque etiam ubi calidum efficitur per approximationem calidi, hoc ipsum non fit ex forma calidi, sed omnino pendet a natura altiore et magis communi; viz. ex natura assimilationis sive multiplicationis sui; de qua facienda est separatim inquisitio.

At notio ignis plebeia est, et nihil valet: composita enim est ex concursu qui fit calidi et lucidi in aliquo corpore; ut in flamma communi, et corporibus accensis usque ad ruborem.

Remoto itaque omni aequivoco, veniendum jam tandem est ad *differentias* veras, quae limitant motum et constituunt eum in formam calidi.

Prima igitur *differentia* ea est, quod calor sit motus expansivus, per quem corpus nititur ad dilatationem sui, et recipiendi se in majorem sphaeram sive dimensionem quam prius occupaverat. Haec autem *differentia* maxime ostenditur in flamma; ubi fumus sive halitus pinguis manifesto dilatatur et aperit se in flammam.

Ostenditur etiam in omni liquore fervente, qui manifesto intumescit, insurgit, et emittit bullas; atque urget processum expandendi se, donec vertatur in corpus longe magis extensum et dilatatum quam sit ipse liquor; viz. in vaporem aut fumum aut aerem.

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stood as follows. We do not mean that heat generates motion or that motion generates heat (though both are true in some cases). We mean that heat itself, the very *what* of heat, is motion and nothing else. It is limited, however, by the *differences* we shall add shortly, once we have added some cautions to avoid ambiguity.

Hot as perceived by the senses is a relative thing, related to man and not to the universe; it is rightly taken to be merely the effect of heat on the animal spirit. Moreover, it is variable in itself, since the same body (depending on how the sense is predisposed) produces the perception of both hot and cold, as is clear from Instance 41 in Table 3.

Nor should the communication of heat—its transitive nature, by which a body brought near a hot body becomes hot—be confused with the form of heat. For hot is one thing, heating another. Heat is induced by the motion of friction without any preceding hot thing, and so heating is excluded from the form of heat. And even where heat is produced by bringing a hot thing near, this does not come from the form of heat. It depends entirely on a higher and more general nature—namely, the nature of assimilation, or self-multiplication, which must be investigated separately.

The notion of fire, however, is a popular one and worthless. For it is made up of the coming together of heat and brightness in some body, as in ordinary flame and in bodies heated to redness.

So, with all ambiguity removed, we must now at last come to the true *differences* that limit motion and make it the form of heat.

The first *difference*, then, is that heat is an expansive motion, by which a body strives to dilate itself and to withdraw into a larger sphere or dimension than it occupied before. This *difference* is shown most clearly in flame, where smoke or fatty vapor plainly dilates and opens out into flame.

It is also shown in every boiling liquid. The liquid visibly swells, rises and throws up bubbles, and keeps pressing on with the process of expanding until it turns into a body far more extended and dilated than the liquid itself: namely vapor, smoke or air.

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Ostenditur etiam in omni ligno et combustibili; ubi fit aliquando exudatio, at semper evaporatio.

Ostenditur etiam in colliquatione metallorum, quae (cum sint corporis compactissimi) non facile intumescunt et se dilatant; sed tamen spiritus eorum, postquam fuerit in se dilatatus, et majorem adeo dilatationem concupierit, trudit plane et agit partes crassiores in liquidum. Quod si etiam calor fortius intendatur, solvit et vertit multum ex iis in volatile.

Ostenditur etiam in ferro aut lapidibus; quae licet non liquefiant aut fundantur, tamen emolliuntur. Quod etiam fit in baculis ligni; quae calefacta paululum in cineribus calidis fiunt flexibilia.

Optime autem cernitur iste motus in aere, qui per exiguum calorem se dilatat continuo et manifesto; ut per Instant. 38. Tab. 3.

Ostenditur etiam in natura contraria frigidi. Frigus enim omne corpus contrahit et cogit in angustius; adeo ut per intensa frigora clavi excidant ex parietibus, aera dissiliant, vitrum etiam calefactum et subito positum in frigido dissiliat et frangatur. Similiter aer per levem infrigidationem recipit se in angustius; ut per Instant. 38. Tab. 3. Verum de his fusius dicetur in inquisitione de Frigido.

Neque mirum est si calidum et frigidum edant complures actiones communes (de quo vide Instant. 32. Tab. 2), cum inveniantur duae ex sequentibus *differentiis* (de quibus mox dicemus) quae competunt utrique naturae; licet in hac *differentia* (de qua nunc loquimur) actiones sint ex diametro oppositae. Calidum enim dat motum expansivum et dilatantem, Frigidum autem dat motum contractivum et coeuntem.

Secunda differentia est modificatio prioris; haec videlicet, quod calor sit motus expansivus sive versus circumferentiam; hac lege tamen, ut una feratur corpus sursum. Dubium enim non est quin sint motus complures mixti. Exempli gratia; sagitta aut spiculum simul et progrediendo rotat, et rotando progreditur. Similiter et motus caloris simul est et expansivus et latio in sursum.

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It is also shown in all wood and combustible matter, where there is sometimes exudation, but always evaporation.

It is also shown in the melting of metals. Being the most compact of bodies, metals do not easily swell and dilate. Yet their spirit, once it has dilated within itself and craves still greater dilation, plainly thrusts and drives the grosser parts into a liquid state. And if the heat is intensified further, it dissolves much of them and turns it into something volatile.

It is also shown in iron and stones, which soften even though they do not liquefy or melt. The same happens with sticks of wood, which become pliable when heated a little in hot ashes.

But this motion is best seen in air, which dilates continuously and visibly with only a little heat; see Instance 38 in Table 3.

It is also shown in the contrary nature, cold. For cold contracts every body and forces it into a narrower space. In hard frosts nails fall out of walls and bronze cracks, and glass that has been heated and is suddenly put in the cold cracks and breaks. Likewise air, when slightly cooled, draws itself into a narrower space; see Instance 38 in Table 3. But these things will be discussed more fully in the inquiry into Cold.

Nor is it surprising that hot and cold produce many actions in common (on which see Instance 32 in Table 2). Two of the following *differences*, which we shall discuss shortly, belong to both natures, although in this *difference*, the one we are now discussing, their actions are diametrically opposed. For heat gives an expansive, dilating motion, while cold gives a contractive motion that draws together.

The *second difference* is a modification of the first. It is this: heat is an expansive motion, or a motion toward the circumference, but on this condition, that the body is at the same time carried upward. For there is no doubt that many motions are mixed. For example, an arrow or dart rotates as it advances and advances as it rotates. In the same way the motion of heat is at once expansive and an upward movement.

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Haec vero *differentia* ostenditur in forcipe, aut bacillo ferreo immisso in ignem: quia si immittatur perpendiculariter tenendo manum superius, cito manum adurit; sin ex latere aut inferius, omnino tardius.

Conspicua etiam est in distillationibus per descensorium; quibus utuntur homines ad flores delicatiores, quorum odores facile evanescunt. Nam hoc reperit industria, ut collocent ignem non subter sed supra, ut adurat minus. Neque enim flamma tantum vergit sursum, sed etiam omne calidum.

Fiat autem experimentum hujus rei in contraria natura frigidi: viz. utrum frigus non contrahat corpus descendendo deorsum, quemadmodum calidum dilatat corpus ascendendo sursum. Itaque adhibeantur duo bacilla ferrea, vel duo tubi vitrei, quoad caetera pares, et calefiant nonnihil; et ponatur spongia cum aqua frigida, vel nix, subter unam, et similiter super alteram. Existimamus enim celeriorem fore refrigerationem ad extremitates in eo bacillo ubi nix ponitur supra quam in eo ubi nix ponitur subter: contra ac fit in calido.

Tertia differentia ea est; ut calor sit motus, non expansivus uniformiter secundum totum, sed expansivus per particulas minores corporis; et simul cohibitus et repulsus et reverberatus, adeo ut induat motum alternativum et perpetuo trepidantem et tentantem et nitentem et ex repercussione irritatum; unde furor ille ignis et caloris ortum habet.

Ista vero *differentia* ostenditur maxime in flamma et liquoribus bullientibus; quae perpetuo trepidant, et in parvis portionibus tument, et rursus subsidunt.

Ostenditur etiam in iis corporibus, quae sunt tam durae compagis ut calefacta ut ignita non intumescant aut dilatentur mole; ut ferrum ignitum, in quo calor est acerrimus.

Ostenditur etiam in hoc, quod per frigidissimas tempestates focus ardeat acerrime.

Ostenditur etiam in hoc, quod cum extenditur aer in vitro calendari absque impedimento aut repulsione, uniformiter scilicet et aequaliter, non percipiatur calor. Etiam in ventis conclusis, licet erumpant vi maxima, tamen non percipitur calor insignis; quia scilicet motus

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This *difference* is shown with tongs or an iron rod put into the fire. If it is put in upright, with the hand holding it from above, it quickly burns the hand; if from the side or from below, much more slowly.

It is also conspicuous in distillation by descent, which people use for the more delicate flowers, whose scents easily vanish. Ingenuity has found that the fire should be placed not below but above, so that it scorches less. For it is not only flame that tends upward, but everything hot.

Let an experiment be made on this point with the contrary nature, cold: namely, whether cold does not contract a body by moving downward, just as heat dilates a body by moving upward. Take two iron rods, or two glass tubes, alike in all other respects, and warm them somewhat. Then put a sponge soaked in cold water, or some snow, beneath one of them, and likewise on top of the other. For we expect that the ends will cool more quickly in the rod with the snow on top than in the one with the snow beneath. This is the opposite of what happens with heat.

The *third difference* is this: heat is a motion that is expansive not uniformly throughout the whole, but through the smaller particles of the body. At the same time it is checked, repelled and beaten back, so that it takes on an alternating motion, perpetually quivering, trying, straining and provoked by the rebound. This is the origin of that fury of fire and heat.

This *difference* is shown above all in flame and in boiling liquids, which perpetually quiver, swell up in small portions and subside again.

It is also shown in bodies of so hard a structure that, when heated or made red-hot, they do not swell or increase in bulk. Red-hot iron, in which the heat is most intense, is an example.

It is also shown in the fact that a hearth fire burns most fiercely in the coldest weather.

It is also shown in the fact that no heat is perceived when the air in the calendar glass expands without hindrance or repulsion, that is, uniformly and evenly. Likewise with pent-up winds: al-

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fit secundum totum, absque motu alternante in particulis. Atque ad hoc fiat experimentum, utrum flamma non urat acrius versus latera quam in medio flammae.

Ostenditur etiam in hoc, quod omnis ustio transigatur per minutos poros corporis quod uritur; adeo ut ustio subruat et penetret et fodicet et stimulet, perinde ac si essent infinitae cuspides acus. Itaque ex hoc illud etiam fit, quod omnes aquae fortes (si proportionatae sint ad corpus in quod agunt) edant opera ignis, ex natura sua corrodente et pungente.

Atque ista *differentia* (de qua nunc dicimus) communis est cum natura frigidi; in quo cohibetur motus contractivus per renitentiam expandendi; quemadmodum in calido cohibetur motus expansivus per renitentiam contrahendi.

Itaque sive partes corporis penetrent versus interius sive penetrent versus exterius, similis est ratio; licet impar admodum sit fortitudo; quia non habemus hic apud nos in superficie terrae aliquid quod sit impense frigidum. Vide Instant. 27. Tab. 9.

Quarta differentia est modificatio prioris: haec scilicet, quod motus ille stimulationis aut penetrationis debeat esse nonnihil rapidus et minime lentus; atque fiat etiam per particulas, licet minutas; tamen non ad extremam subtilitatem, sed quasi majusculas.

Ostenditur haec *differentia* in comparatione operum quae edit ignis cum iis quae edit tempus sive aetas. Aetas enim sive tempus arefacit, consumit, subruit, et incinerat, non minus quam ignis; vel potius longe subtilius: sed quia motus ejusmodi est lentus admodum et per particulas valde exiles, non percipitur calor.

Ostenditur etiam in comparatione dissolutionum ferri et auri. Aurum enim dissolvitur absque calore excitato; ferrum autem cum vehementi excitatione caloris, licet simili fere intervallo quoad tempus. Quia scilicet in auro, ingressus aquae separationis est clemens et subtiliter insinuans, et cessio partium auri facilis; at in ferro, ingressus est asper et cum conflictu, et partes ferri habent obstinationem majorem.

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though they burst out with the greatest force, no notable heat is perceived, because the motion takes place in the whole, without alternating motion in the particles. On this point let an experiment be made: whether flame does not burn more fiercely at its sides than in its middle.

It is also shown in the fact that all burning works through the minute pores of the body being burned. Burning undermines, penetrates, pricks and stings, just as if there were countless needle points. Hence it also comes about that all strong acids (*aquae fortes*), if suited to the body they act on, do the work of fire, through their corroding and pricking nature.

This *difference*, the one we are now discussing, is shared with the nature of cold. In cold the contractive motion is checked by a resistance tending to expand, just as in heat the expansive motion is checked by a resistance tending to contract.

So whether the parts of a body penetrate inward or outward, the principle is similar, though the strength is very unequal, because here on the surface of the earth we have nothing intensely cold. See Instance 27 in Table 9.

The *fourth difference* is a modification of the preceding one. It is this: the motion of stinging or penetrating must be fairly rapid and by no means slow. It must also take place through particles that are minute, but not of the utmost fineness, somewhat larger.

This *difference* is shown by comparing the works of fire with the works of time or age. For age or time dries, consumes, undermines and reduces to ashes no less than fire does, or rather far more subtly. But because such motion is very slow and works through very tiny particles, no heat is perceived.

It is also shown by comparing how iron and gold are dissolved. Gold is dissolved without any heat being produced, but iron with a violent production of heat, though in about the same length of time. The reason is that in gold the separating acid (*aqua separationis*) enters gently and insinuates itself subtly, and the parts of the gold give way easily. In iron, by contrast, it enters harshly and with

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	a struggle, and the parts of the iron are more stubborn.
Ostenditur etiam aliquatenus in gangraenis nonnullis et mortificationibus carnium; quae non excitant magnum calorem aut dolorem, ob subtilitatem putrefactionis.	It is also shown to some extent in certain gangrenes and mortifications of the flesh. These produce no great heat or pain, because the putrefaction is so subtle.
Atque haec sit *Prima Vindemiatio*, sive *Interpretatio inchoata* de Forma Calidi, facta per *Permissionem Intellectus*.	Let this, then, be the *first vintage*, or *beginning of interpretation*, concerning the form of heat, made by way of the *indulgence of the understanding*.
Ex *Vindemiatione* autem ista *Prima*, forma sive definitio vera caloris (ejus qui est in ordine ad universum, non relativus tantummodo ad sensum) talis est, brevi verborum complexu: *Calor est motus expansivus, cohibitus, et nitens per partes minores*. Modificatur autem expansio: *ut expandendo in ambitum, nonnihil tamen inclinet versus superiora.* Modificatur autem et nixus ille per partes; *ut non sit omnino segnis, sed incitatus et cum impetu nonnullo.*	From this *first vintage* the form, or true definition, of heat, meaning heat in relation to the universe and not merely relative to the senses, is briefly this: *Heat is a motion that is expansive, checked, and straining through the smaller parts.* The expansion, however, is modified: *while expanding in all directions, it still tends somewhat upward.* The straining through the parts is also modified: *it is not at all sluggish, but quick and with some force.*
Quod vero ad Operativam attinet, eadem res est. Nam designatio est talis: *Si in aliquo corpore naturali poteris excitare motum ad se dilatandum aut expandendum; eumque motum ita reprimere et in se vertere, ut dilatatio illa non procedat aequaliter, sed partim obtineat, partim retrudatur; proculdubio generabis calidum:* non habita ratione, sive corpus illud sit elementare (ut loquuntur), sive imbutum a coelestibus; sive luminosum, sive opacum; sive tenue, sive densum; sive localiter expansum, sive intra claustra dimensionis primae contentum; sive vergens ad dissolutionem, sive manens in statu; sive animal, sive vegetabile, sive minerale, sive aqua, sive oleum, sive aer, aut aliqua alia substantia quaecunque susceptiva motus praedicti. Calidum autem ad sensum res eadem est; sed cum analogia, qualis competit sensui.	As for the operative side, it is the same thing. The direction for practice is this: *If in any natural body you can excite a motion to dilate or expand itself, and can so repress this motion and turn it back on itself that the dilation does not proceed evenly, but partly succeeds and is partly driven back, you will without doubt generate heat.* It makes no difference whether that body is elementary (as they say) or imbued with celestial influence. It may be luminous or opaque, rare or dense. It may be spatially expanded or confined within the bounds of its original dimension, tending toward dissolution or remaining in its state. It may be animal, vegetable or mineral; water, oil or air; or any other substance whatever that is capable of the motion described. Heat as perceived by the senses is the same thing, but with an analogy suited to the senses.
Nunc vero ad ulteriora auxilia procedendum est.	Now we must go on to further aids.

PREROGATIVE INSTANCES

Bacon lists the further aids to induction and begins with the kinds of instance that carry special weight.

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2.21 Post *Tabulas comparentiae primae* et *rejectionem* sive *exclusivam*, nec non vindemiationem primam factam secundum eas, pergendum est ad reliqua auxilia intellectus circa *interpretationem naturae* et *inductionem* veram ac perfectam. In quibus proponendis, ubi opus erit	We have had the *tables of first presentation*, the *rejection* or *exclusion*, and the first vintage made on their basis. Now we must proceed to the remaining aids of the understanding in the *interpretation of nature* and in true and perfect *induction*. In set-

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tabulis, procedemus super calidum et frigidum; ubi autem opus erit tantum exemplis paucioribus, procedemus per alia omnia: ut nec confundatur inquisitio, et tamen doctrina versetur minus in angusto.

Dicemus itaque primo loco, de *Praerogativis Instantiarum*: secundo, de *Adminiculis Inductionis*: tertio, de *Rectificatione Inductionis*: quarto, de *Variatione Inquisitionis pro Natura Subjecti*: quinto, de *Praerogativis Naturarum* quatenus ad inquisitionem, sive de eo quod inquirendum est prius et posterius: sexto, de *Terminis Inquisitionis*, sive de synopsi omnium naturarum in universo: septimo, de *Deductione ad Praxin,* sive de eo quod est in ordine ad Hominem: octavo, de *Parascevis ad Inquisitionem*: postremo autem, de *Scala Ascensoria et Descensoria Axiomatum*.

2.22 Inter *Praerogativas Instantiarum*, primo proponemus *Instantias Solitarias.* Eae autem sunt *solitariae*, quae exhibent naturam de qua fit inquisitio in talibus subjectis, quae nil habent commune cum aliis subjectis, praeter illam ipsam naturam; aut rursus quae non exhibent naturam de qua fit inquisitio in talibus subjectis, quae sunt similia per omnia cum aliis subjectis, praeterquam in illa ipsa natura. Manifestum enim est quod hujusmodi instantiae tollant ambages, atque accelerent et roborent *exclusivam*; adeo ut paucae ex illis sint instar multarum.

Exempli gratia: si fiat inquisitio de natura *Coloris, Instantiae Solitariae* sunt prismata, gemmae chrystallinae, quae reddunt colores non solum in se sed exterius supra parietem, item rores, etc. Istae enim nil habent commune cum coloribus fixis in floribus, gemmis coloratis, metallis, lignis, etc., praeter ipsum colorem. Unde facile colligitur, quod color nil aliud sit quam modificatio imaginis lucis immissae et receptae: in priore genere, per gradus diversos incidentiae; in posteriore, per texturas et schematismos varios corporis. Istae autem *Instantiae* sunt *Solitariae* quatenus ad similitudinem.

Rursus in eadem inquisitione, venae distinctae albi et nigri in marmoribus, et variegationes colorum in floribus

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ting these out, we shall work with heat and cold wherever tables are needed. Where only a few examples are needed, we shall draw on every other subject. In this way the inquiry will not be confused, and yet the teaching will not be confined to too narrow a range.

We shall therefore speak, first, of *Prerogative Instances*; second, of *Aids to Induction*; third, of the *Rectification of Induction*; fourth, of *Varying the Inquiry According to the Nature of the Subject*; fifth, of the *Prerogatives of Natures* with respect to inquiry, that is, of what should be inquired into first and what later; sixth, of the *Limits of Inquiry*, that is, a synopsis of all natures in the universe; seventh, of *Application to Practice*, that is, of what bears on man; eighth, of *Preparations for Inquiry*; and last, of the *Ascending and Descending Ladder of Axioms*.[12]

Among the *Prerogative Instances* we shall first put forward *Solitary Instances*. Those instances are *solitary* which display the nature under inquiry in subjects that have nothing in common with other subjects except that very nature. Conversely, they are also solitary when they fail to display the nature under inquiry in subjects that are like other subjects in every respect except that very nature. It is clear that instances of this kind cut out roundabout ways, and speed up and strengthen the *exclusion*, so that a few of them are worth many.

For example, if the inquiry is into the nature of *Color*, *Solitary Instances* are prisms and crystal gems, which show colors not only within themselves but outside them, on a wall; also dewdrops, and so on. These have nothing in common with the colors fixed in flowers, colored gems, metals, woods and so on, except color itself. From this one easily gathers that color is nothing but a modification of the image of light as it is sent in and received. In the former kind this happens through different degrees of incidence, in the latter through the various textures and configurations of the body. These *Instances* are *Solitary* with regard to resemblance.

Again, in the same inquiry, the distinct veins of white and black in marble, and the variegated colors in flowers of the same species, are *Solitary In-*

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ejusdem speciei, sunt *Instantiae Solitariae*. Album enim et nigrum marmoris, et maculae albi et purpurei in floribus garyophylli, conveniunt fere in omnibus praeter ipsum colorem. Unde facile colligitur, colorem non multum rei habere cum naturis alicujus corporis intrinsecis, sed tantum situm esse in positura partium crassiori et quasi mechanica. Istae autem *Instantiae* sunt *Solitariae*, quatenus ad discrepantiam. Utrunque autem genus *Instantias Solitarias* appellare consuevimus; aut *Ferinas*, sumpto vocabulo ab astronomis.

2.23 Inter praerogativas instantiarum, ponemus secundo loco *Instantias Migrantes*. Eae sunt, in quibus natura inquisita migrat ad generationem, cum prius non existeret; aut contra migrat ad corruptionem, cum prius existeret. Itaque in utraque antistrophe, instantiae tales sunt semper geminae; vel potius una instantia in motu sive transitu, producta ad periodum adversam. At hujusmodi instantiae non solum accelerant et roborant *exclusivam*, sed etiam compellunt *affirmativam* sive *formam* ipsam in angustum. Necesse est enim ut forma rei sit quippiam, quod per hujusmodi *migrationem* indatur, aut contra per hujusmodi *migrationem* tollatur et destruatur. Atque licet omnis exclusio promoveat *affirmativam*, tamen hoc magis directe fit in subjecto eodem quam in diversis. Forma autem (ut ex omnibus quae dicta sunt manifesto liquet) prodens se in uno ducit ad omnia.

Quo autem simplicior fuerit *migratio*, eo magis habenda est instantia in pretio. Praeterea *Instantiae Migrantes* magni sunt usus ad partem operativam; quia cum proponant formam copulatam cum efficiente aut privante, perspicue designant praxin in aliquibus; unde facilis etiam est transitus ad proxima. Subest tamen in illis nonnihil periculi, quod indiget cautione; hoc videlicet, ne formam nimis retrahant ad efficientem, et intellectum perfundant vel saltem perstringant falsa opinione de forma ex intuitu efficientis. Efficiens vero semper ponitur nil aliud esse quam vehiculum sive deferens formae. Verum huic rei, per *exclusivam* legitime factam, facile adhibetur remedium.

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stances. The white and black of marble, and the spots of white and purple in carnations, agree in almost everything except color itself. From this one easily gathers that color has little to do with the intrinsic natures of any body. It lies only in the coarser and, as it were, mechanical arrangement of the parts. These *Instances* are *Solitary* with regard to difference. We are accustomed to call both kinds *Solitary Instances*, or *Wild Instances*, borrowing the term from the astronomers.

Among the prerogative instances we shall put *Migrating Instances* in second place. These are instances in which the nature under inquiry migrates toward generation when it did not exist before, or, conversely, migrates toward destruction when it existed before. So in either direction such instances are always twofold. Or rather, each is a single instance in motion or transition, carried through to the opposite phase. Such instances not only speed up and strengthen the *exclusion*; they also narrow down the *affirmative*, or the *form* itself. For the form of a thing must be something that is conferred by such a *migration*, or conversely removed and destroyed by such a *migration*. Every exclusion advances the *affirmative*, but this happens more directly in one and the same subject than in different ones. And the form, as is plain from everything that has been said, once it reveals itself in one thing, leads to all.

The simpler the *migration*, the more highly the instance should be valued. Moreover, *Migrating Instances* are of great use for the operative part. They present the form coupled with the cause that produces it or the cause that takes it away, and so in some cases they clearly indicate what to do in practice; from there the passage to neighboring cases is easy too. Yet there is some danger in them that calls for caution. They may draw the form too far back toward the efficient cause, and fill the understanding, or at least tinge it, with a false opinion of the form drawn from looking at the efficient cause. But the efficient cause is always held to be nothing more than the vehicle or carrier of the form. This, however, is easily remedied by an exclusion properly made.

12 Prerogative instances are kinds of instance that carry special weight in an inquiry. The name recalls the "prerogative" century that voted first in Roman assemblies.

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Proponendum itaque est jam exemplum *instantiae migrantis*. Sit natura inquisita Candor sive Albedo: *instantia migrans* ad generationem est vitrum integrum et vitrum pulverizatum. Similiter, aqua simplex et aqua agitata in spumam. Vitrum enim integrum et aqua simplex diaphana sunt, non alba; at vitrum pulverizatum et aqua in spuma, alba, non diaphana. Itaque quaerendum quid acciderit ex ista *migratione* vitro aut aquae. Manifestum enim est formam albedinis deferri et invehi per istam contusionem vitri et agitationem aquae. Nihil autem reperitur accessisse, praeter comminutionem partium vitri et aquae, et aeris insertionem.

Neque vero parum profectum est ad inveniendam formam albedinis, quod corpora duo per se diaphana, sed secundum magis et minus (aer scilicet et aqua, aut aer et vitrum), simul posita per minutas portiones exhibeant albedinem, per refractionem inaequalem radiorum lucis.

Verum hac in re proponendum est etiam exemplum periculi et cautionis, de quibus diximus. Nimirum facile hic occurret intellectui ab hujusmodi efficientibus depravato, quod ad formam albedinis aer semper requiratur, aut quod albedo generetur tantum per corpora diaphana; quae omnino falsa sunt, et per multas exclusiones convicta. Quin potius apparebit (misso aere et hujusmodi) corpora omnino aequalia (secundum portiones opticas) dare diaphanum; corpora vero inaequalia per texturam simplicem, dare album; corpora inaequalia secundum texturam compositam, sed ordinatam, dare reliquos colores, praeter nigrum; corpora vero inaequalia per texturam compositam, sed omnino inordinatam et confusam, dare nigrum. Itaque de *instantia migrante* ad generationem in natura inquisita albedinis, propositum est jam exemplum. *Instantia* autem *migrans* ad corruptionem in eadem natura albedinis, est spuma dissoluta, aut nix dissoluta.

Exuit enim albedinem et induit diaphanum aqua, postquam fit integrale sine aere.

Neque vero illud ullo modo praetermittendum est, quod sub *Instantiis Migrantibus* comprehendi debeant non tantum illae quae *migrant* ad generationem et

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Now, then, we must give an example of a *migrating instance*. Let the nature under inquiry be Whiteness. A *migrating instance* toward generation is whole glass and powdered glass; likewise plain water and water whipped into foam. Whole glass and plain water are transparent, not white; but powdered glass and foamed water are white, not transparent. So we must ask what has happened to the glass or the water through this *migration*. Clearly the form of whiteness is carried and brought in by this pounding of the glass and agitation of the water. But nothing is found to have been added except the breaking up of the parts of the glass and water, and the insertion of air.

And no small progress has been made toward finding the form of whiteness by learning the following. Take two bodies, each transparent in itself though to a greater or lesser degree, such as air and water, or air and glass. When they are put together in minute portions, they display whiteness through the unequal refraction of the rays of light.

But here we must also give an example of the danger and the caution we spoke of. An understanding misled by efficient causes of this kind will readily suppose that air is always required for the form of whiteness, or that whiteness is generated only by transparent bodies. Both of these are quite false, and refuted by many exclusions. Instead it will become clear, setting aside air and the like, that bodies entirely uniform (in their optical portions) give transparency. Bodies non-uniform in a simple texture give white. Bodies non-uniform in a texture that is compound but regular give the other colors, except black. And bodies non-uniform in a texture that is compound but wholly irregular and confused give black. That, then, is our example of a *migrating instance* toward generation, with whiteness as the nature under inquiry. A *migrating instance* toward destruction in the same nature of whiteness is dissolved foam or melted snow.

For the water sheds its whiteness and takes on transparency once it becomes whole again, without air.

Nor should it by any means be overlooked that *Migrating Instances* should include not only those that *migrate* toward generation and privation, but also

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privationem, sed etiam illae quae migrant ad majorationem et minorationem; cum illae etiam tendant ad inveniendam formam, ut per definitionem formae superius factam et *tabulam graduum* manifesto liquet. Itaque papyrus, quae sicca cum fuerit alba est, at madefacta (excluso aere et recepta aqua) minus alba est et magis vergit ad diaphanum, similem habet rationem cum instantiis supradictis.

2.24 Inter praerogativas instantiarum, tertio loco ponemus *Instantias Ostensivas*, de quibus in *vindemiatione prima de Calido* mentionem fecimus; quas etiam *Elucescentias*, sive *Instantias Liberatas et Praedominantes,* appellare consuevimus. Eae sunt, quae ostendunt naturam inquisitam nudam et substantivam, atque etiam in exaltatione sua aut summo gradu potentiae suae; emancipatam scilicet, et liberatam ab impedimentis, vel saltem per fortitudinem suae virtutis dominantem super ipsa, eaque supprimentem et coercentem. Cum enim omne corpus suscipiat multas naturarum formas copulatas et in concreto, fit ut alia aliam retundat, deprimat, frangat, et liget; unde obscurantur formae singulae. Inveniuntur autem subjecta nonnulla in quibus natura inquisita prae aliis est in suo vigore, vel per absentiam impedimenti vel per praedominantiam virtutis. Hujusmodi autem *instantiae* sunt maxime *ostensivae* formae.

Verum et in his ipsis instantiis adhibenda est cautio, et cohibendus impetus intellectus. Quicquid enim ostentat formam, eamque trudit, ut videatur occurrere intellectui, pro suspecto habendum est, et recurrendum ad *exclusivam* severam et diligentem.

Exempli gratia; sit natura inquisita Calidum. *Instantia Ostensiva* motus expansionis, quae (ut superius dictum est) portio est praecipua formae calidi, est vitrum calendare aeris. Etenim flamma, licet manifesto exhibeat expansionem, tamen propter momentaneam extinctionem non ostendit progressum expansionis. Aqua autem fervens, propter facilem transitionem aquae in vaporem et aerem, non tam bene ostendit expansionem aquae in corpore suo. Rursus ferrum ignitum, et similia, tantum abest ut progressum ostendant, ut contra per retusionem et fractionem spiritus per partes compactas et crassas (quae domant et fraenant expansionem) ipsa expansio non sit omnino conspicua ad sensum. At vitrum

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those that migrate toward increase and decrease. These too help toward finding the form, as is plain from the definition of form given above and from the *table of degrees*. Take paper, which is white when dry. When wet, with the air excluded and water taken in, it is less white and tends more toward transparency. Paper therefore stands on the same footing as the instances above.

Among the prerogative instances we shall put *Striking Instances* in third place. We mentioned them in the *first vintage* concerning heat, and we also call them *Illuminations*, or *Freed and Predominant Instances*. These are the instances that show the nature under inquiry naked and standing on its own, and also at its height, in the highest degree of its power. Here it has been set free and released from impediments, or at least by the strength of its force it dominates them, suppressing and restraining them. For every body takes on many forms of natures, coupled together and in the concrete. So it happens that one blunts, depresses, breaks and binds another, and the individual forms are obscured. But some subjects are found in which the nature under inquiry is in its full vigor more than in others, either because an impediment is absent or because its force predominates. Instances of this kind show the form most strikingly.

Yet even with these instances caution is needed, and the rush of the understanding must be held in check. Whatever flaunts the form and thrusts it forward, so that it seems to present itself to the understanding, should be treated as suspect. We must then have recourse to a strict and careful *exclusion*.

For example, let the nature under inquiry be Heat. The motion of expansion is, as was said above, the chief part of the form of heat, and the *Striking Instance* of it is the calendar glass filled with air. Flame plainly displays expansion, but it does not show the progress of expansion, because it goes out in a moment. Boiling water passes so easily into vapor and air that it does not show so well the expansion of water within its own body. Red-hot iron and the like, again, are so far from showing the progress of expansion that the expansion itself is not perceptible to the senses at all. This is because the spirit is blunted and broken by the com-

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calendare clare ostendit expansionem in aere, et conspicuam et progredientem et durantem, neque transeuntem.

Rursus, exempli gratia, sit natura inquisita Pondus. *Instantia Ostensiva* ponderis est argentum vivum. Omnia enim superat pondere magno intervallo, praeter aurum; quod non multo gravius est. At praestantior instantia est ad indicandam formam ponderis argentum vivum quam aurum; quia aurum solidum est et consistens, quod genus referri videtur ad densum; at argentum vivum liquidum est et turgens spiritu, et tamen multis partibus exuperat gravitate diamantem, et ea quae putantur solidissima. Ex quo ostenditur formam gravis sive ponderosi dominari simpliciter in copia materiae, et non in arcta compage.

2.25 Inter praerogativas instantiarum ponemus quarto loco *Instantias Clandestinas*, quas etiam *Instantias Crepusculi* appellare consuevimus. Eae sunt veluti oppositae *instantiis ostensivis*. Exhibent enim naturam inquisitam in infirma virtute, et tanquam in incunabulis et rudimentis suis; tentantem et tanquam primo experientem, sed sub contraria natura latentem et subactam. Sunt autem hujusmodi *instantiae* magni omnino momenti ad inveniendas formas; quia sicut *ostensivae* ducunt facile ad differentias, ita *clandestinae* ducunt optime ad genera; id est, ad naturas illas communes, quarum naturae inquisitae nihil aliud sunt quam limitationes.

Exempli gratia; sit natura inquisita Consistens, sive se determinans; cujus contrarium est Liquidum, sive fluens. *Instantiae clandestinae* sunt illae quae exhibent gradum nonnullum debilem et infimum consistentis in fluido; veluti bulla aquae, quae est tanquam pellicula quaedam consistens et determinata, facta ex corpore aquae. Similiter stillicidia, quae, si adfuerit aqua quae succedat, producunt se in filum admodum tenue, ne discontinuetur aqua; at si non detur talis copia aquae quae succedere possit, cadit aqua in guttis rotundis, quae est figura quae optime aquam sustinet contra discontinuationem. At in ipso temporis articulo, cum desinit filum aquae et incipit descensus in guttis, resilit ipsa aqua sursum ad evitandam discontinuationem.

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pact, gross parts, which tame and bridle the expansion. But the calendar glass clearly shows expansion in air, and shows it perceptible, progressive and lasting, not passing.

Again, for example, let the nature under inquiry be Weight. A *Striking Instance* of weight is quicksilver. It outweighs everything by a wide margin except gold, which is not much heavier. Yet quicksilver is a better instance than gold for revealing the form of weight. Gold is solid and firm, a quality that seems to belong to density. But quicksilver is liquid and swelling with spirit, and yet it is many times heavier than the diamond and the things thought most solid. This shows that the form of heaviness or weight depends simply on the quantity of matter, and not on tightness of structure.

Among the prerogative instances we shall put *Clandestine Instances* in fourth place; we also call them *Instances of the Twilight*. They are, as it were, the opposite of *striking instances*. They display the nature under inquiry at its weakest, as if in its cradle and first beginnings. It is trying itself out and, as it were, testing its powers for the first time, but it lies hidden and subdued beneath a contrary nature. Such *instances* are of very great importance for discovering forms. Just as *striking* instances lead easily to differences, so *clandestine* instances lead best to genera, that is, to those common natures of which the natures under inquiry are nothing but limitations.

For example, let the nature under inquiry be the Firm, or self-bounding, whose contrary is the Liquid, or flowing. *Clandestine instances* are those that display some weak and lowest degree of firmness in a fluid. One is a bubble of water, which is a kind of firm, bounded film made from the substance of water. Another is dripping water. If there is more water to follow on, the drips draw themselves out into a very thin thread, so that the water is not broken apart. But if there is not enough water to follow on, the water falls in round drops, the shape that best preserves water against being broken apart. And at the very moment when the thread of water ends and the drops begin to fall, the water itself springs back upward to avoid being broken apart.

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Quin in metallis, quae cum funduntur sunt liquida sed magis tenacia, recipiunt se saepe guttae liquefactae sursum, atque ita haerent. Simile quoddam est instantia speculorum puerilium, quae solent facere pueruli in scirpis ex saliva, ubi cernitur etiam pellicula consistens aquae. At multo melius se ostendit hoc ipsum in altero illo ludicro puerili, quando capiunt aquam, per saponem factam paulo tenaciorem, atque inflant eam per calamum cavum, atque inde formant aquam tanquam in castellum bullarum; quae per interpositionem aeris inducit consistentiam eo usque ut se projici nonnihil patiatur absque discontinuatione. Optime autem cernitur hoc in spuma et nive, quae talem induunt consistentiam ut fere secari possint; cum tamen sint corpora formata ex aere et aqua, quae utraque sunt liquida.

Quae omnia non obscure innuunt Liquidum et Consistens esse notiones tantum plebeias, et ad sensum; inesse autem revera omnibus corporibus fugam et evitationem se discontinuandi; eam vero in corporibus homogeneis (qualia sunt liquida) esse debilem et infirmam, in corporibus vero, quae sunt composita ex heterogeneis, magis esse vividam et fortem; propterea quod admotio heterogenei constringit corpora, at subintratio homogenei solvit et relaxat.

Similiter, exempli gratia; sit natura inquisita Attractio, sive Coitio Corporum. *Instantia* circa formam ejus *ostensiva* maxime insignis est magnes. Contraria autem natura attrahenti est non attrahens, licet in substantia simili. Veluti ferrum, quod non attrahit ferrum, quemadmodum nec plumbum plumbum, nec lignum lignum, nec aquam aqua. *Instantia* autem *clandestina* est magnes ferro armatus, vel potius ferrum in magnete armato. Nam ita fert natura, ut magnes armatus in distantia aliqua non trahat ferrum fortius quam magnes non armatus. Verum si admoveatur ferrum, ita ut tangat ferrum in magnete armato, tunc magnes armatus longe majus pondus ferri sustinet quam magnes simplex et inermis, propter similitudinem substantiae ferri versus ferrum; quae operatio erat omnino *clandestina* et latens in ferro, antequam magnes accessisset.

Itaque manifestum est formam coitionis esse quippiam quod in magnete sit vividum et robustum, in ferro debile

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Indeed, in metals, which when melted are liquid but more tenacious, the melted drops often draw themselves back upward and hang there. Something similar is the instance of the children's mirrors that little boys make of spittle in rushes, where again a firm film of water is seen. But this is shown much better in that other children's game. They take water made a little more tenacious with soap and blow it through a hollow reed, forming the water into a sort of castle of bubbles. Through the admixture of air, this takes on such firmness that it lets itself be tossed a little without breaking apart. It is seen best of all in foam and snow, which acquire such firmness that they can almost be cut, although they are formed from air and water, both of which are liquid.

All of this strongly suggests that Liquid and Firm are merely popular notions, relative to the senses. In truth all bodies have an aversion to being broken apart and avoid it. This tendency is weak and feeble in homogeneous bodies, such as liquids, but livelier and stronger in bodies composed of heterogeneous parts. The reason is that the approach of something heterogeneous binds bodies together, while the entry of something homogeneous loosens and relaxes them.

Similarly, for example, let the nature under inquiry be Attraction, or the Coming Together of Bodies. The most notable *striking instance* of its form is the magnet. The nature contrary to the attracting is the non-attracting, even in a similar substance. Iron, for instance, does not attract iron, just as lead does not attract lead, nor wood wood, nor water water. But a *clandestine instance* is a magnet armed with iron, or rather the iron in an armed magnet. For nature is so ordered that an armed magnet does not attract iron at a distance more strongly than an unarmed one. But if iron is brought up until it touches the iron in the armed magnet, then the armed magnet holds up a far greater weight of iron than a simple, unarmed magnet does. This is because of the likeness of substance between iron and iron, an operation that was wholly *clandestine* and latent in the iron before the magnet came to it.[13]

So it is clear that the form of coming together is something lively and robust in the magnet, weak

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et latens. Itidem notatum est sagittas parvas ligneas absque cuspide ferrea, emissas ex sclopetis grandibus, altius penetrare in materiam ligneam (puta latera navium, et similia), quam easdem sagittas ferro acuminatas, propter similitudinem substantiae ligni ad lignum, licet hoc ante in ligno latuerit. Itidem, licet aer aerem aut aqua aquam manifesto non trahat in corporibus integris, tamen bulla approximata bullae facilius dissolvit bullam quam si bulla illa altera abesset, ob appetitum coitionis aquae cum aqua et aeris cum aere. Atque hujusmodi *Instantiae Clandestinae* (quae sunt usus nobilissimi, ut dictum est) in portionibus corporum parvis et subtilibus maxime se dant conspiciendas.

Quia massae rerum majores sequuntur formas magis catholicas et generales; ut suo loco dicetur.

2.26 Inter praerogativas instantiarum ponemus quinto loco *Instantias Constitutivas*, quas etiam *Manipulares* appellare consuevimus. Eae sunt quae constituunt unam speciem naturae inquisitae tanquam Formam Minorem. Cum enim formae legitimae (quae sunt semper convertibiles cum naturis inquisitis) lateant in profundo nec facile inveniantur, postulat res et infirmitas humani intellectus ut formae particulares, quae sunt congregativae *Manipulorum* quorundam instantiarum (neutiquam vero omnium) in notionem aliquam communem, non negligantur, verum diligentius notentur. Quicquid enim unit naturam, licet modis imperfectis, ad inventionem formarum viam sternit. Itaque instantiae, quae ad hoc utiles sunt non sunt contemnendae potestatis, sed habent nonnullam praerogativam.

Verum in his diligens est adhibenda cautio, ne intellectus humanus, postquam complures ex istis formis particularibus adinvenerit atque inde partitiones sive divisiones naturae inquisitae confecerit, in illis omnino acquiescat, atque ad inventionem legitimam Formae Magnae se non accingat, sed praesupponat naturam velut a radicibus esse multiplicem et divisam, atque ulteriorem naturae unionem, tanquam rem supervacuae subtilitatis et vergentem ad merum abstractum, fastidiat et rejiciat.

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and latent in iron. It has likewise been observed that small wooden arrows without iron points, shot from large guns, penetrate deeper into wood (the sides of ships, say, or the like) than the same arrows tipped with iron. This is because of the likeness of substance between wood and wood, although this was previously latent in the wood. Likewise, air does not visibly attract air, nor water water, in whole bodies. Yet a bubble brought close to another bubble dissolves it more easily than if that other bubble were absent, because of the appetite of water to come together with water, and of air with air. And *Clandestine Instances* of this kind, which as we said are of the noblest use, show themselves most in small and fine portions of bodies.

For the larger masses of things follow forms that are more universal and general, as will be explained in its place.

Among the prerogative instances we shall put *Constitutive Instances* in fifth place; we also call them *Bundled Instances*. These are the instances that constitute one species of the nature under inquiry, as a kind of Lesser Form. The legitimate forms, which are always convertible with the natures under inquiry, lie deep and are not easily found. The situation, and the weakness of the human understanding, therefore require that particular forms should not be neglected but noted all the more carefully. These particular forms gather certain *bundles* of instances, though by no means all of them, into some common notion. For whatever unifies nature, even imperfectly, paves the way to the discovery of forms. So the instances that serve this purpose are not of negligible power, but have a certain prerogative.

But here careful caution is needed. The human understanding may discover a number of these particular forms and make partitions or divisions of the nature under inquiry from them. It must not then rest content with them altogether and fail to gird itself for the legitimate discovery of the Great Form. Nor must it assume that nature is manifold and divided from its roots, and scorn and reject any further unification of nature as a matter of

13 An “armed” magnet is a lodestone fitted with iron caps, which greatly increases the weight it can lift.

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Exempli gratia; sit natura inquisita Memoria, sive Excitans et Adjuvans memoriam. *Instantiae constitutivae* sunt, ordo sive distributio, quae manifesto juvat memoriam; item Loci in memoria artificiali, qui aut possunt esse loci secundum proprium sensum, veluti janua, angulus, fenestra, et similia, aut possunt esse personae familiares et notae, aut possunt esse quidvis ad placitum (modo in ordine certo ponantur), veluti animalia, herbae; etiam verba, literae, characteres, personae historicae, et caetera; licet nonnulla ex his magis apta sint et commoda, alia minus. Hujusmodi autem Loci memoriam insigniter juvant, eamque longe supra vires naturales exaltant. Item carmina facilius haerent et discuntur memoriter quam prosa. Atque ex isto *manipulo* trium instantiarum, videlicet ordinis, locorum artificialis memoriae, et versuum, constituitur species una auxilii ad Memoriam.

Species autem illa *Abscissio Infiniti* recte vocari possit. Cum enim quis aliquid reminisci aut revocare in memoriam nititur, si nullam praenotionem habeat aut perceptionem ejus quod quaerit, quaerit certe et molitur et hac illac discurrit, tanquam in infinito. Quod si certam aliquam praenotionem habeat, statim abscinditur infinitum, et fit discursus memoriae magis in vicino. In tribus autem illis instantiis quae superius dictae sunt, praenotio perspicua est et certa. In prima videlicet, debet esse aliquid quod congruat cum ordine; in secunda debet esse imago quae relationem aliquam habeat sive convenientiam ad illa loca certa; in tertia, debent esse verba quae cadant in versum. Atque ita abscinditur infinitum.

Aliae autem instantiae dabunt hanc alteram speciem; ut quicquid deducat intellectuale ad feriendum sensum (quae ratio etiam praecipue viget in artificiali memoria) juvet memoriam. Aliae instantiae dabunt hanc alteram speciem; ut quae faciunt impressionem in affectu forti, incutientia scilicet metum, admirationem, pudorem, delectationem, juvent memoriam. Aliae instantiae dabunt hanc alteram speciem; ut quae maxime imprimuntur a mente pura et minus praeoccupata ante vel post, veluti quae discuntur in pueritia aut quae commentamur ante somnum, etiam primae quaeque

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needless subtlety tending toward mere abstraction.

For example, let the nature under inquiry be Memory, or what arouses and assists memory. *Constitutive instances* are, first, order or arrangement, which plainly helps memory. Next are the Places in artificial memory. These may be places in the proper sense, such as a door, a corner, a window and the like. Or they may be familiar, well-known persons. Or they may be anything you please, provided they are set in a fixed order, such as animals or plants; also words, letters, characters, historical persons and so on, though some of these are more suitable and convenient than others. Places of this kind help memory remarkably, and raise it far above its natural powers. Again, verse sticks more easily and is learned by heart more readily than prose. From this *bundle* of three instances, namely order, the places of artificial memory and verse, one species of aid to Memory is constituted.[14]

That species might rightly be called the Cutting Off of the Infinite. When someone tries to recall something or bring it back to memory without any prenotion or perception of what he is looking for, he searches, struggles and runs this way and that, as if in an infinite space. But if he has some definite prenotion, the infinite is at once cut off, and memory ranges within a narrower compass. In the three instances mentioned above, the prenotion is clear and definite. In the first, it must be something that fits the order. In the second, it must be an image that has some relation or correspondence to those fixed places. In the third, it must be words that fit the verse. And so the infinite is cut off.

Other instances will give this further species: whatever brings something intellectual to strike the senses helps memory (a principle that is also especially at work in artificial memory). Other instances will give this further species: things that make an impression through a strong emotion, striking fear, wonder, shame or delight, help memory. Other instances will give this further species: things impressed on a clear mind, less preoccupied before or after, stick more in

14 The classical "art of memory" fixes things to be remembered on images placed in an imagined sequence of places (*loci*).

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rerum vices, magis haereant in memoria. Aliae instantiae dabunt hanc alteram speciem; ut multitudo circumstantiarum sive ansarum juvet memoriam, veluti scriptio per partes non continuatas, lectio, sive recitatio voce alta. Aliae denique instantiae dabunt hanc alteram speciem; ut quae expectantur et attentionem excitant melius haereant, quam quae praetervolant.

Itaque si scriptum aliquod vicies perlegeris, non tam facile illud memoriter disces quam si illud legas decies, tentando interim illud recitare, et ubi deficit memoria inspiciendo librum. Ita ut sint veluti sex Formae Minores eorum quae juvant Memoriam; videlicet abscissio infiniti; deductio intellectualis ad sensibile; impressio in affectu forti; impressio in mente pura; multitudo ansarum; praeexpectatio.

Similiter, exempli gratia; sit natura inquisita Gustus, sive Gustatio. *Instantiae* quae sequuntur sunt *Constitutivae*: videlicet, quod qui non olfaciunt, sed sensu eo a natura destituti sunt, non percipiant aut gustu distinguant cibum rancidum aut putridum, neque similiter alliatum aut rosatum, aut hujusmodi. Rursus, illi, qui per accidens nares habent per descensum rheumatis obstructas, non discernunt aut percipiunt aliquid putridum aut rancidum aut aqua rosacea inspersum. Rursus, qui afficiuntur hujusmodi rheumate, si in ipso momento, cum aliquid foetidum aut odoratum habent in ore sive palato, emungant fortiter, in ipso instanti manifestam perceptionem habent rancidi vel odorati.

Quae instantiae dabunt et constituent hanc speciem, vel partem potius gustus; ut sensus gustationis ex parte nihil aliud sit quam olfactus interior, transiens et descendens a narium meatibus superioribus in os et palatum. At contra, salsum et dulce et acre et acidum et austerum et amarum, et similia, haec (inquam) omnia aeque sentiunt illi in quibus olfactus deest aut obturatur, ac quisquam alius; ut manifestum sit sensum gustus esse compositum quiddam ex olfactu interiori et tactu quodam exquisito; de quo nunc non est dicendi locus.

Similiter, exempli gratia; sit natura inquisita Communicatio Qualitatis absque Commistione

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memory. Examples are what is learned in childhood, what we think over before sleep, and the first time anything happens. Other instances will give this further species: a multitude of circumstances or handles helps memory, as with writing in separate, discontinuous parts, and reading or reciting aloud. Other instances, finally, will give this further species: things that are expected and arouse attention stick better than things that fly past.

Thus if you read a piece of writing through twenty times, you will not learn it by heart as easily as if you read it ten times, trying meanwhile to recite it and looking at the book where memory fails. So there are, as it were, six Lesser Forms of the things that help Memory: the cutting off of the infinite; the bringing of the intellectual down to the sensible; impression through a strong emotion; impression on a clear mind; a multitude of handles; and prior expectation.

Similarly, for example, let the nature under inquiry be Taste, or Tasting. The following *instances* are *Constitutive*. People who have no sense of smell, being deprived of it by nature, do not perceive or distinguish by taste food that is rancid or rotten, nor food flavored with garlic or rose water, or the like. Again, people whose nostrils happen to be blocked by a descending flow of phlegm do not discern or perceive anything rotten or rancid or sprinkled with rose water. Again, suppose people suffering from such a flow of phlegm have something foul-smelling or fragrant in their mouth or on their palate. If at that very moment they blow their nose hard, they instantly have a clear perception of the rancid or the fragrant.

These instances will give and constitute this species, or rather part, of taste: the sense of tasting is in part nothing other than an inner smelling, which passes and descends from the upper passages of the nostrils into the mouth and palate. On the other hand, salt, sweet, pungent, sour, astringent, bitter and the like are all perceived as well by those whose smell is lacking or blocked as by anyone else. So it is clear that the sense of taste is a compound of inner smell and a kind of exquisite touch; but this is not the place to discuss that.

Similarly, for example, let the nature under inquiry be the Communication of a Quality without

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Substantiae. Instantia Lucis dabit vel constituet unam speciem communicationis; Calor vero et Magnes alteram. Communicatio enim lucis est tanquam momentanea, et statim perit, amota luce originali. At calidum et virtus magnetica, postquam transmissa fuerint vel potius excitata in alio corpore, haerent et manent ad tempus non parvum, amoto primo movente.	Mixture of Substance. The instance of Light will give or constitute one species of communication; Heat and the Magnet will give another. The communication of light is practically instantaneous, and perishes at once when the original light is removed. But heat and magnetic power, once they have been transmitted to another body, or rather excited in it, cling and remain for no short time after the first mover is removed.
Denique magna est omnino praerogativa *instantiarum constitutivarum*, ut quae plurimum faciant et ad definitiones (praesertim particulares) et ad divisiones sive partitiones naturarum; de quo non male dixit Plato, *Quod habendus sit tanquam pro Deo, qui definire et dividere bene sciat.*	Finally, the prerogative of *constitutive instances* is very great indeed, since they contribute a great deal both to definitions, especially particular ones, and to divisions or partitions of natures. Plato put it well: *He who knows how to define and divide well should be regarded as a god.*[15]

RESEMBLANCES AND ODDITIES

Conformable, singular, deviating and bordering instances, and the masterworks of human art, prepare the understanding.

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2.27 Inter praerogativas instantiarum ponemus sexto loco *Instantias Conformes*, sive *Proportionatas*; quas etiam *Parallelas*, sive *Similitudines Physicas*, appellare consuevimus. Eae vero sunt, quae ostendunt similitudines et conjugationes rerum, non in formis minoribus (quod faciunt *instantiae constitutivae*) sed plane in concreto. Itaque sunt tanquam primi et infimi gradus ad unionem naturae. Neque constituunt aliquod axioma statim ab initio, sed indicant et observant tantum quendam consensum corporum. Attamen licet non multum promoveant ad inveniendas formas, nihilominus magna cum utilitate revelant partium universi fabricam, et in membris ejus exercent veluti anatomiam quandam; atque proinde veluti manu ducunt interdum ad axiomata sublimia et nobilia, praesertim illa quae ad mundi configurationem pertinent, potius quam ad naturas et formas simplices.	Among the prerogative instances we shall put *Conformable Instances*, or *Proportionate Instances*, in sixth place; we also call them *Parallels*, or *Physical Resemblances*. These are the instances that show resemblances and linkages between things, not in lesser forms (as *constitutive instances* do) but plainly in the concrete. So they are, as it were, the first and lowest steps toward the unity of nature. They do not establish any axiom right from the start, but only point out and note a certain agreement between bodies. They do not do much toward discovering forms, but they are very useful all the same. They reveal the structure of the parts of the universe and perform a kind of anatomy on its members. And so they sometimes lead us by the hand, as it were, to sublime and noble axioms, especially those that concern the configuration of the world rather than simple natures and forms.
Exempli gratia; Instantiae Conformes sunt quae sequuntur: speculum, et oculus; et similiter fabrica auris, et loca reddentia echo. Ex qua conformitate, praeter ipsam observationem similitudinis, quae ad multa utilis est, proclive est insuper colligere et formare illud axioma; videlicet, organa sensuum et corpora quae pariunt reflexiones ad sensus esse similis naturae. Rursus ex hoc ipso admonitus intellectus non aegre insurgit ad axioma	For example, the following are Conformable Instances: a mirror and the eye; and likewise the structure of the ear and places that return an echo. This conformity yields more than the bare observation of the resemblance, though that is useful for many purposes. From it one can easily go on to gather and form this axiom: the organs of the senses and the bodies that produce reflections to

15 A paraphrase of Plato, *Phaedrus* 266b, where Socrates says he follows such a man "as if in the footsteps of a god."

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quoddam altius et nobilius. Hoc nimirum; nihil interesse inter consensus sive sympathias corporum sensu praeditorum, et inanimatorum sine sensu, nisi quod in illis accedat spiritus animalis ad corpus ita dispositum, in his autem absit.

Adeo ut quot sint consensus in corporibus inanimatis, tot possint esse sensus in animalibus, si essent perforationes in corpore animato ad discursum spiritus animalis in membrum rite dispositum, tanquam in organum idoneum. Et rursus, quot sint sensus in animalibus, tot sint proculdubio motus in corpore inanimato ubi spiritus animalis abfuerit; licet necesse sit multo plures esse motus in corporibus inanimatis quam sensus in animatis, propter paucitatem organorum sensus. Atque hujus rei ostendit se exemplum valde manifestum in doloribus.

Etenim quum sint plura genera doloris in animalibus, et tanquam varii illius characteres (veluti alius est dolor ustionis, alius frigoris intensi, alius puncturae, alius compressionis, alius extensionis, et similium), certissimum est omnia illa, quoad motum, inesse corporibus inanimatis; veluti ligno aut lapidi, cum uritur, aut per gelu constringitur, aut pungitur, aut scinditur, aut flectitur, aut tunditur, et sic de aliis; licet non subintrent sensus, propter absentiam spiritus animalis.

Item *instantiae conformes* (quod mirum fortasse dictu) sunt radices et rami plantarum. Omne enim vegetabile intumescit, et extrudit partes in circumferentiam, tam sursum quam deorsum. Neque alia est differentia radicum et ramorum, quam quod radix includatur in terra, et rami exponantur aeri et soli. Si quis enim accipiat ramum tenerum et vegetum arboris, atque illum reflectat in aliquam terrae particulam, licet non cohaereat ipsi solo, gignit statim non ramum, sed radicem. Atque vice versa, si terra ponatur superius, atque ita obstruatur lapide aut aliqua dura substantia, ut planta cohibeatur nec possit frondescere sursum, edet ramos in aerem deorsum.

Item *instantiae conformes* sunt gummi arborum, et pleraeque gemmae rupium. Utraque enim nil aliud sunt

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the senses are of a similar nature. And prompted by this, the understanding rises without difficulty to a higher and nobler axiom. It is this: there is no difference between the agreements or sympathies of bodies endowed with sense and those of inanimate bodies without sense, except that in the former an animal spirit is added to a body so disposed, while in the latter it is absent.

So there might be as many senses in animals as there are agreements in inanimate bodies, if there were perforations in the animate body to let the animal spirit pass into a properly disposed member, as into a suitable organ. And conversely, however many senses there are in animals, there are without doubt as many motions in an inanimate body where the animal spirit is absent. Indeed, there must be many more motions in inanimate bodies than there are senses in animate ones, because the sense organs are so few. A very clear example of this is found in pains.

There are several kinds of pain in animals, with various characters, as it were. The pain of burning is one thing, the pain of intense cold another, and so too the pain of pricking, of pressure, of stretching and the like. It is quite certain that all of these, as far as motion is concerned, occur in inanimate bodies, in wood or stone for instance. They occur when it is burned, or contracted by frost, or pricked, or cut, or bent, or struck, and so on, although sensation does not enter in, because the animal spirit is absent.

Again, the roots and branches of plants are *conformable instances*, strange as that may sound. Every plant swells and pushes parts out toward its circumference, downward as well as upward. And the only difference between roots and branches is that the root is enclosed in the earth, while the branches are exposed to the air and sun. Take a tender, vigorous branch of a tree and bend it down into a clod of earth, even one not joined to the ground itself, and it will at once produce not a branch but a root. And conversely, suppose earth is placed on top and blocked with a stone or some hard substance, so that the plant is held back and cannot put out leaves upward. It will then send branches down into the air.

Again, the gums of trees and most gems of rocks are *conformable instances*. Both are nothing but ex-

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quam exudationes et percolationes succorum: in primo genere scilicet, succorum ex arboribus; in secundo, ex saxis; unde gignitur claritudo et splendor in utrisque, per percolationem nimirum tenuem et accuratam. Nam inde fit etiam, quod pili animalium non sint tam pulchri et tam vividi coloris quam avium plumae complures: quia succi non tam delicate percolantur per cutem quam per calamum.

Item *instantiae conformes* sunt scrotum in animalibus masculis, et matrix in femellis. Adeo ut nobilis illa fabrica per quam sexus differunt (quatenus ad animalia terrestria), nil aliud videatur esse, quam secundum exterius et interius; vi scilicet majore caloris genitalia in sexu masculo protrudente in exterius, ubi in femellis nimis debilis est calor quam ut hoc facere possit; unde accidit quod contineantur interius.

Item *instantiae conformes* sunt pinnae piscium, et pedes quadrupedum, aut pedes et alae volucrum; quibus addidit Aristoteles quatuor volumina in motu serpentum. Adeo ut in fabrica universi motus viventium plerunque videatur expediri per quaterniones artuum sive flexionum.

Item dentes in animalibus terrestribus, et rostra in avibus, sunt *instantiae conformes*; unde manifestum est, in omnibus animalibus perfectis fluere duram quandam substantiam versus os.

Item non absurda est similitudo et conformitas illa, ut homo sit tanquam planta inversa. Nam radix nervorum et facultatum animalium est caput; partes autem seminales sunt infirmae, non computatis extremitatibus tibiarum et brachiorum. At in planta, radix (quae instar capitis est) regulariter infimo loco collocatur; semina autem supremo.

Denique illud omnino praecipiendum est et saepius monendum; ut diligentia hominum in inquisitione et congerie Naturalis Historiae deinceps mutetur plane, et vertatur in contrarium ejus quod nunc in usu est. Magna enim hucusque atque adeo curiosa fuit hominum industria in notanda rerum varietate atque explicandis accuratis animalium, herbarum, et fossilium differentiis; quarum pleraeque magis sunt lusus naturae quam seriae alicujus utilitatis versus scientias. Faciunt certe

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udations and filterings of juices: in the first case, of juices from trees; in the second, from stones. Hence both have clarity and brilliance, from a fine and careful filtering. This is also why the hair of animals is not as beautiful or as vividly colored as the plumage of many birds: the juices are not filtered as delicately through the skin as through the quill.

Again, the scrotum in male animals and the womb in females are *conformable instances*. So the noble structure by which the sexes differ, at least in land animals, seems to be nothing but a matter of outside and inside. In the male sex a greater force of heat pushes the genitals outward, whereas in females the heat is too weak to do this, and so they are contained within.

Again, the fins of fish and the feet of quadrupeds, or the feet and wings of birds, are *conformable instances*; to these Aristotle added the four undulations in the motion of snakes. So in the structure of the universe the motion of living things seems mostly to be accomplished by sets of four limbs or bendings.[16]

Again, the teeth of land animals and the beaks of birds are *conformable instances*. From this it is clear that in all perfect animals some hard substance flows toward the mouth.

Again, there is nothing absurd in the resemblance and conformity by which man is a kind of inverted plant. In man the root of the nerves and of the animal faculties is the head, while the seminal parts are lowest, not counting the extremities of the legs and arms. But in the plant the root, which corresponds to the head, is regularly placed lowest, and the seeds highest.

Finally, this must by all means be laid down and repeatedly urged. The diligence people bring to investigating and amassing Natural History must from now on be completely changed, and turned to the opposite of what is now practiced. Until now people have taken great and even fussy pains to note the variety of things and to set out the precise differences between animals, plants and minerals. Most of these differences are sports of

16 Aristotle, *On the Progression of Animals* 708a, observes that snakes move by four flexions, as other animals move on four points of support.

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hujusmodi res ad delectationem, atque etiam quandoque ad praxin; verum ad introspiciendam naturam parum aut nihil. Itaque convertenda plane est opera ad inquirendas et notandas rerum similitudines et analoga, tam in integralibus quam partibus. Illae enim sunt quae naturam uniunt, et constituere scientias incipiunt.

Verum in his omnino est adhibenda cautio gravis et severa; ut accipiantur pro *instantiis conformibus* et *proportionatis* illae, quae denotant similitudines (ut ab initio diximus) physicas; id est, reales et substantiales et immersas in natura, non fortuitas et ad speciem; multo minus superstitiosas aut curiosas, quales naturalis magiae scriptores (homines levissimi, et in rebus tam seriis quales nunc agimus vix nominandi) ubique ostentant; magna cum vanitate et desipientia, inanes similitudines et sympathias rerum describentes atque etiam quandoque affingentes.

Verum his missis, etiam in ipsa configuratione mundi in majoribus non sunt negligendae *instantiae conformes*; veluti Africa, et regio Peruviana cum continente se porrigente usque ad Fretum Magellanicum. Utraque enim regio habet similes isthmos et similia promontoria, quod non temere accidit.

Item Novus et Vetus Orbis; in eo quod utrique orbes versus septentriones lati sunt et exporrecti, versus austrum autem angusti et acuminati.

Item *instantiae conformes* nobilissimae sunt frigora intensa in media (quam vocant) aeris regione, et ignes acerrimi qui saepe reperiuntur erumpentes ex locis subterraneis; quae duae res sunt ultimitates et extrema; naturae scilicet frigidi versus ambitum coeli, et naturae calidi versus viscera terrae; per antiperistasin, sive rejectionem naturae contrariae.

Postremo autem in axiomatibus scientiarum notatu digna est *conformitas instantiarum*. Veluti tropus rhetoricae, qui dicitur *Praeter Expectatum*, conformis est tropo musicae, qui vocatur *Declinatio Cadentiae*. Similiter, postulatum mathematicum, ut *quae eidem tertio aequalia sunt etiam*

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nature rather than of any serious use for the sciences. Such things certainly give pleasure, and sometimes they even help practice; but for seeing into nature they do little or nothing. So effort must be turned wholesale to investigating and noting the resemblances and analogies of things, both in wholes and in parts. For it is these that unify nature and begin to constitute the sciences.

But here a grave and strict caution must be observed. Only those instances should be taken as *conformable* and *proportionate* which denote resemblances that are physical, as we said at the beginning: that is, real, substantial and embedded in nature, not accidental and merely apparent. Still less should they be superstitious or fanciful, like those the writers on natural magic parade everywhere. Those writers are utterly frivolous people, hardly worth naming in matters as serious as those we are now dealing with. With great vanity and folly they describe empty resemblances and sympathies of things, and sometimes even invent them.

But leaving these aside: even in the configuration of the world at large, *conformable instances* should not be neglected. Examples are Africa, and the region of Peru with the continent stretching down to the Strait of Magellan. Both regions have similar isthmuses and similar promontories, and this is no accident.

Likewise the New World and the Old: both are broad and spread out toward the north, but narrow and pointed toward the south.

Again, very noble *conformable instances* are the intense cold in the so-called middle region of the air and the fiercest fires that are often found bursting out from underground. These two are limits and extremes: of the nature of cold toward the circuit of the heavens, and of the nature of heat toward the bowels of the earth. They arise by *antiperistasis*, or the repulsion of the contrary nature.

Lastly, the *conformity of instances* is worth noting in the axioms of the sciences. For instance, the rhetorical figure called *Surprise* is conformable to the musical figure called *Avoiding the Cadence*. Similarly, the mathematical postulate that *things equal*

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inter se sint aequalia, conforme est cum fabrica syllogismi in logica, qui unit ea quae conveniunt in medio. Denique multum utilis est in quamplurimis sagacitas quaedam in conquirendis et indagandis conformitatibus et similitudinibus physicis.

2.28 Inter *praerogativas instantiarum*, ponemus septimo loco *Instantias Monodicas*; quas etiam *Irregulares* sive *Heteroclitas* (sumpto vocabulo a grammaticis) appellare consuevimus. Eae sunt, quae ostendunt corpora in concreto, quae videntur esse extravagantia et quasi abrupta in natura, et minime convenire cum aliis rebus ejusdem generis. Etenim *instantiae conformes* sunt similes alterius, at *instantiae monodicae* sunt sui similes. Usus vero *instantiarum monodicarum* est talis qualis est *instantiarum clandestinarum*: viz. ad evehendam et uniendam naturam ad invenienda genera sive communes naturas, limitandas postea per differentias veras.

Neque enim desistendum ab inquisitione donec proprietates et qualitates, quae inveniuntur in hujusmodi rebus quae possunt censeri pro miraculis naturae, reducantur et comprehendantur sub aliqua forma sive lege certa: ut irregularitas sive singularitas omnis reperiatur pendere ab aliqua forma communi; miraculum vero illud sit tandem solummodo in differentiis accuratis et gradu et concursu raro, et non in ipsa specie: ubi nunc contemplationes hominum non procedant ultra quam ut ponant hujusmodi res pro secretis et magnalibus naturae, et tanquam incausabilibus, et pro exceptionibus regularum generalium.

Exempla *instantiarum monodicarum* sunt, sol et luna, inter astra; magnes, inter lapides; argentum vivum, inter metalla; elephas, inter quadrupedes; sensus veneris, inter genera tactus; odor venaticus in canibus, inter genera olfactus. Etiam S litera apud grammaticos, habetur pro monodica; ob facilem compositionem quam sustinet cum consonantibus, aliquando duplicibus, aliquando triplicibus; quod nulla alia litera facit. Plurimi autem faciendae sunt hujusmodi instantiae; quia acuunt et vivificant inquisitionem, et medentur intellectui depravato a consuetudine et ab iis quae fiunt plerunque.

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to the same third thing are also equal to each other is conformable to the structure of the syllogism in logic, which unites things that agree in a middle term. Finally, a certain shrewdness in searching out and tracking down physical conformities and resemblances is very useful in a great many matters.

Among the *prerogative instances* we shall put *Singular Instances* in seventh place. We also call them *Irregular* or *Heteroclite Instances*, borrowing the term from the grammarians. These are the instances that show bodies in the concrete that seem extravagant and, as it were, broken off in nature, and that scarcely agree with other things of the same kind. *Conformable instances* resemble something else, but *singular instances* resemble only themselves. The use of *singular instances* is the same as that of *clandestine instances*. They raise and unify nature for the discovery of genera or common natures, which are afterward to be limited by true differences.

For we must not give up the inquiry until the properties and qualities found in such things, which may be counted miracles of nature, are reduced to and comprehended under some form or definite law. Every irregularity or singularity should then be found to depend on some common form. The miracle will turn out in the end to lie only in precise differences, in degree and in rare concurrence, and not in the species itself. At present people's contemplation goes no further than to set such things down as secrets and wonders of nature, as though they had no cause, and as exceptions to general rules.

Examples of *singular instances* are the sun and moon among the heavenly bodies; the magnet among stones; quicksilver among metals; the elephant among quadrupeds; the sense of sexual pleasure among the kinds of touch; and the hunting scent of dogs among the kinds of smell. The grammarians, too, count the letter S as singular, because it combines so easily with consonants, sometimes two, sometimes three, which no other letter does. Instances of this kind should be valued very highly. They sharpen and quicken inquiry, and heal an understanding corrupted by habit and by what usually happens.

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Inter *praerogativas instantiarum*, ponemus loco octavo *Instantias Deviantes*; errores scilicet naturae, et vaga, ac monstra: ubi natura declinat et deflectit a cursu ordinario. Differunt enim errores naturae ab *instantiis monodicis* in hoc; quod monodicae sint miracula specierum, at errores sint miracula individuorum. Similis autem fere sunt usus; quia rectificant intellectum adversus consueta, et revelant formas communes. Neque enim in his etiam desistendum ab inquisitione donec inveniatur causa hujusmodi declinationis. Veruntamen causa illa non exurgit ad formam aliquam proprie, sed tantum ad *latentem processum* ad formam. Qui enim vias naturae noverit, is *deviationes* etiam facilius observabit. At rursus, qui *deviationes* noverit, is accuratius vias describet.

Atque in illo differunt etiam ab *instantiis monodicis*, quod multo magis instruant praxin et operativam. Nam novas species generare arduum admodum foret; at species notas variare, et inde rara multa ac inusitata producere, minus arduum. Facilis autem transitus est a miraculis naturae ad miracula artis. Si enim deprehendatur semel natura in variatione sua, ejusque ratio manifesta fuerit, expeditum erit eo deducere naturam per artem quo per casum aberraverit. Neque solum eo, sed et aliorsum; cum errores ex una parte monstrent et aperiant viam ad errores et deflexiones undequaque. Hic vero exemplis non est opus, propter eorundem copiam. Facienda enim est congeries sive historia naturalis particularis omnium monstrorum et partuum naturae prodigiosorum; omnis denique novitatis et raritatis et inconsueti in natura.

Hoc vero faciendum est cum severissimo delectu, ut constet fides. Maxime autem habenda sunt pro suspectis quae pendent quomodocunque a religione, ut prodigia Livii: nec minus, quae inveniuntur in scriptoribus magiae naturalis, aut etiam alchymiae, et hujusmodi hominibus; qui tanquam proci sunt et amatores fabularum. Sed depromenda sunt illa ex gravi et fida historia, et auditionibus certis.

2.30 Inter *praerogativas instantiarum*, ponemus loco nono *Instantias Limitaneas*; quas etiam *Participia* vocare

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Among the *prerogative instances* we shall put *Deviating Instances* in eighth place: errors of nature, that is, strays and monsters, where nature swerves and turns aside from its ordinary course. Errors of nature differ from *singular instances* in this: singular instances are miracles of species, while errors are miracles of individuals. Their use, however, is much the same, for they correct the understanding against what is habitual and reveal common forms. Here too we must not give up the inquiry until the cause of such a deviation is found. That cause, however, does not rise to a form in the proper sense, but only to the *latent process* leading to a form. For whoever knows the ways of nature will more easily observe her *deviations*; and conversely, whoever knows her *deviations* will describe her ways more accurately.

They also differ from *singular instances* in giving far more guidance to practice and the operative part. For to generate new species would be very hard; but to vary known species, and so produce many rare and unusual things, is less hard. And the passage from the miracles of nature to the miracles of art is easy. Once nature is caught in the act of varying and the reason for it is clear, it will be a simple matter to lead nature by art to the point where she strayed by chance. And not only there, but elsewhere too, since errors in one direction show and open the way to errors and deviations in every direction. There is no need for examples here, since they are so plentiful. A collection, or particular natural history, must be made of all monsters and prodigious births of nature, and in short of everything new, rare and unusual in nature.

But this must be done with the strictest selection, so that it can be trusted. Above all, anything that depends in any way on religion should be held suspect, like the prodigies in Livy. So too should what is found in the writers on natural magic, or even on alchemy, and people of that sort, who are, as it were, the suitors and lovers of fables. Such things should be drawn instead from serious and reliable history and from trustworthy reports.[17]

Among the *prerogative instances* we shall put *Bordering Instances* in ninth place; we also call them

17 Livy's history regularly records the portents reported in each year.

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	consuevimus. Eae vero sunt, quae exhibent species corporum tales, quae videntur esse compositae ex speciebus duabus, vel *rudimenta* inter speciem unam et alteram. Hae vero instantiae inter *instantias monodicas* sive *heteroclitas* recte numerari possunt: sunt enim in universitate rerum rarae et extraordinariae. Sed tamen ob dignitatem seorsim tractandae et ponendae sunt; optime enim indicant compositionem et fabricam rerum, et innuunt causas numeri et qualitatis specierum ordinariarum in universo, et deducunt intellectum ab eo quod est, ad id quod esse potest.	*Participles*. These are the instances that display kinds of bodies which seem to be compounded of two species, or to be *rudiments* between one species and another. These instances could rightly be counted among the *singular* or *heteroclite* instances, for in the whole of things they are rare and extraordinary. Yet because of their importance they should be treated and set out separately. They are excellent at indicating the composition and structure of things. They suggest the causes of the number and quality of the ordinary species in the universe, and they lead the understanding on from what is to what can be.[18]
	Harum exempla sunt: muscus, inter putredinem et plantam; cometae nonnulli, inter stellas et meteora ignita; pisces volantes, inter aves et pisces; vespertiliones, inter aves et quadrupedes; etiam	Examples of these are moss, between putrefaction and a plant; certain comets, between stars and fiery meteors; flying fish, between birds and fish; bats, between birds and quadrupeds; also
	'Simia quam similis turpissima bestia nobis;'	"the ape, that ugliest of beasts, how like us!"[19]
	et partus animalium biformes et commisti ex speciebus diversis; et similia.	and the two-formed offspring of animals, mixed from different species; and the like.
2.31	Inter *praerogativas instantiarum* ponemus decimo loco *Instantias Potestatis*, sive *Fascium* (sumpto vocabulo ab insignibus imperii), quas etiam *Ingenia*, sive *Manus Hominis* appellare consuevimus. Eae sunt opera maxime nobilia et perfecta, et tanquam ultima in unaquaque arte. Cum enim hoc agatur praecipue ut natura pareat rebus et commodis humanis; consentaneum est prorsus, ut opera, quae jampridem in potestate hominis fuerunt (quasi provinciae antea occupatae et subactae), notentur et numerentur; praesertim ea quae sunt maxime enucleata et perfecta: propterea quod ab istis proclivior et magis in propinquo sit transitus ad nova et hactenus non inventa.	Among the *prerogative instances* we shall put in tenth place *Instances of Power*, or *of the Fasces*, borrowing the term from the insignia of sovereignty. We also call them *Contrivances*, or *Hands of Man*. These are the noblest and most perfect works, the ultimate achievements, as it were, of each art. Our chief aim is to make nature serve human affairs and needs. So it is entirely fitting that the works which have long been in man's power, like provinces already occupied and subdued, should be noted and counted up, especially those that are most refined and perfect. For from them the passage to new things not yet discovered is easier and closer at hand.[20]
	Si quis enim ab horum contemplatione attenta propositum acriter et strenue urgere velit, fiet certe ut aut producat illa paulo longius, aut deflectat illa ad aliquid quod finitimum est, aut etiam applicet et transferat illa ad usum aliquem nobiliorem.	For suppose someone studies these works attentively and is willing to press on with his purpose keenly and vigorously. He will certainly either carry them a little further, or turn them aside to something neighboring, or even apply and transfer them to some nobler use.
	Neque hic finis. Verum quemadmodum ab operibus naturae raris et inconsuetis erigitur intellectus et elevatur ad inquirendas et inveniendas formas, quae	Nor is that all. Rare and unusual works of nature rouse the understanding and lift it to investigate and discover forms that can account for them too.

18 Named after the grammatical participle, which shares in the nature of both noun and verb.
19 A line of the Roman poet Ennius, quoted by Cicero (*On the Nature of the Gods* 1.97), with a play on *simia* (ape) and *similis* (like).
20 The fasces were the bundle of rods carried before Roman magistrates as a sign of their authority.

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etiam illorum sunt capaces, ita etiam in operibus artis egregiis et admirandis hoc usu-venit; idque multo magis; quia modus efficiendi et operandi hujusmodi miracula artis manifestus ut plurimum est, cum plerunque in miraculis naturae sit magis obscurus. Attamen in his ipsis cautio est adhibenda vel maxime, ne deprimant scilicet intellectum et eum quasi humo affigant.

Periculum enim est, ne per hujusmodi opera artis, quae videntur velut summitates quaedam et fastigia industriae humanae, reddatur intellectus attonitus et ligatus et quasi maleficiatus quoad illa, ita ut cum aliis consuescere non possit, sed cogitet nihil ejus generis fieri posse nisi eadem via qua illa effecta sunt, accedente tantummodo diligentia majore et praeparatione magis accurata.

Contra, illud ponendum est pro certo: vias et modos efficiendi res et opera, quae adhuc reperta sunt et notata, res esse plerunque pauperculas; atque omnem potentiam majorem pendere et ordine derivari a fontibus formarum, quarum nulla adhuc inventa est.

Itaque (ut alibi diximus) qui de machinis et arietibus, quales erant apud veteres, cogitasset, licet hoc fecisset obnixe atque aetatem in eo consumpsisset, nunquam tamen incidisset in inventum tormentorum igneorum operantium per pulverem pyrium. Neque rursus, qui in lanificiis et serico vegetabili observationem suam et meditationem collocasset, unquam per ea reperisset naturam vermis aut serici bombycini.

Quocirca omnia inventa, quae censeri possunt magis nobilia (si animum advertas), in lucem prodiere, nullo modo per pusillas enucleationes et extensiones artium, sed omnino per casum. Nihil autem repraesentat aut anticipat casum (cujus mos est ut tantum per longa saecula operetur), praeter inventionem formarum.

Exempla autem hujusmodi instantiarum particularia nihil opus est adducere, propter copiam eorundem. Nam hoc omnino agendum; ut visitentur et penitus introspiciantur omnes artes mechanicae, atque liberales etiam (quatenus ad opera), atque inde facienda est congeries sive historia particularis, tanquam magnalium et operum magistralium et maxime perfectorum in

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The same happens with outstanding and admirable works of art, and much more so. For the way such miracles of art are produced and brought about is for the most part evident, whereas with the miracles of nature it is usually more obscure. Yet with these very instances the greatest caution is needed, lest they weigh the understanding down and, as it were, pin it to the ground.

For such works of art seem like the summits and pinnacles of human industry, and there is a danger that the understanding may become astonished, bound and, as it were, bewitched by them. It may then be unable to get used to anything else, and think that nothing of the kind can be done except in the same way these were done, only with greater diligence and more careful preparation.

On the contrary, this should be taken as certain: the ways and means of producing things and works that have so far been discovered and noted are for the most part very poor things. All greater power depends on the sources of forms and is derived from them in due order, and none of these has yet been discovered.

So, as we have said elsewhere, someone who thought about machines and battering rams such as the ancients had would never have hit on the invention of cannon worked by gunpowder, even if he had thought strenuously and spent his whole life on it. Nor would someone who had fixed his observation and thought on the making of wool and vegetable silk ever have discovered through them the nature of the silkworm and its silk.

So all the inventions that can be counted among the nobler ones came to light, if you pay attention, not through petty refinements and extensions of the arts but entirely by chance. And nothing stands in for chance or anticipates it, since chance works only over long ages, except the discovery of forms.

There is no need to cite particular examples of instances of this kind, since there are so many of them. What must be done is this. All the mechanical arts, and the liberal arts too (so far as they concern works), should be visited and examined thoroughly. From them a collection, or particular history, should be made of the great achieve-

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unaquaque ipsarum, una cum modis effectionis sive operationis.

Neque tamen astringimus diligentiam, quae adhibenda est in hujusmodi collecta, ad ea quae censentur pro magisteriis et arcanis alicujus artis tantum, atque movent admirationem. Admiratio enim proles est raritatis; siquidem rara, licet in genere sint ex vulgatis naturis, tamen admirationem pariunt.

At contra, quae revera admirationi esse debent propter discrepantiam quae inest illis in specie collatis ad alias species, tamen si in usu familiari praesto sint leviter notantur. Debent autem notari *monodica* artis, non minus quam *monodica* naturae; de quibus antea diximus. Atque quemadmodum in *monodicis* naturae posuimus solem, lunam, magnetem, et similia, quae re vulgatissima sunt sed natura tamen fere singulari: idem et de *monodicis* artis faciendum est.

Exempli gratia; instantia *monodica* artis est papyrus; res admodum vulgata. At si diligenter animum advertas, materiae artificiales aut plane textiles sunt per fila directa et transversa; qualia sunt pannus sericus, aut laneus, et linteus, et hujusmodi: aut coagmentantur ex succis concretis; qualia sunt later, aut argilla figularis, aut vitrum, aut esmalta, aut porcellana, et similia; quae si bene uniantur splendent, sin minus, indurantur certe, sed non splendent. Attamen omnia talia, quae fiunt ex succis concretis, sunt fragilia, nec ullo modo haerentia et tenacia. At contra, papyrus est corpus tenax, quod scindi et lacerari possit; ita ut imitetur et fere aemuletur pellem sive membranam alicujus animalis, aut folium alicujus vegetabilis, et hujusmodi opificia naturae.

Nam neque fragilis est, ut vitrum; neque textilis, ut pannus; sed habet fibras certe, non fila distincta, omnino ad modum materiarum naturalium: ut inter artificiales materias vix inveniatur simile aliquod, sed sit plane *monodicum*. Atque praeferenda sane sunt in artificialibus ea quae maxime accedunt ad imitationem naturae, aut e contrario eam potenter regunt et invertunt.

Rursus, inter *ingenia* et *manus hominis*, non prorsus contemnenda sunt praestigiae et jocularia. Nonnulla enim ex istis, licet sint usu levia et ludicra, tamen informatione valida esse possunt.

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ments, the masterworks and the most finished works in each, together with the methods of producing or performing them.

Yet we do not confine the diligence needed for such a collection to what is regarded as the masterpieces and secrets of some art and excites wonder. For wonder is the offspring of rarity. Rare things give birth to wonder even when, in kind, they belong to common natures.

Conversely, things that really ought to be objects of wonder, because their species differs from other species, are only lightly noticed if they are at hand in familiar use. The *singular* things of art should be noted no less than the *singular* things of nature, which we discussed earlier. Among the *singular* things of nature we placed the sun, the moon, the magnet and the like, which are utterly common in fact but almost unique in nature. The same must be done for the *singular* things of art.

For example, paper is a *singular* instance of art, and a very common thing. But look carefully. Artificial materials are either plainly woven, with threads running lengthwise and crosswise, like silk, wool, linen cloth and so on. Or they are compacted from congealed juices, like brick, potter's clay, glass, enamel, porcelain and the like. These shine if they are well united; if not, they certainly harden, but they do not shine. Yet everything made from congealed juices is brittle, and in no way cohesive or tough. Paper, by contrast, is a tough body that can be cut and torn. It imitates and almost rivals the skin or membrane of an animal, or the leaf of a plant, and other handiwork of nature of that kind.

For it is neither brittle like glass nor woven like cloth. It certainly has fibers, but not distinct threads, just like natural materials. So hardly anything like it can be found among artificial materials, and it is plainly *singular*. Among artificial things, preference should certainly go to those that come closest to imitating nature, or, on the contrary, powerfully govern and invert it.

Again, among the *contrivances* and *hands of man*, conjuring tricks and amusements are not to be wholly despised. Some of them, though trivial and playful in use, can still be very valuable for information.

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Postremo, neque omnino omittenda sunt superstitiosa, et (prout vocabulum sensu vulgari accipitur) magica. Licet enim hujusmodi res sint in immensum obrutae grandi mole mendaciorum et fabularum, tamen inspiciendum paulisper si forte subsit et lateat in aliquibus earum aliqua operatio naturalis; ut in fascino, et fortificatione imaginationis, et consensu rerum ad distans, et transmissione impressionum a spiritu ad spiritum non minus quam a corpore ad corpus, et similibus.

2.32 Ex iis, quae ante dicta sunt, patet quod quinque illa instantiarum genera de quibus diximus (viz. *instantiarum conformium, instantiarum monodicarum, instantiarum deviantium, instantiarum limitanearum, instantiarum potestatis*) non debeant reservari, donec inquiratur natura aliqua certa (quemadmodum instantiae reliquae, quas primo loco proposuimus, nec non plurimae ex iis quae sequentur, reservari debent); sed statim jam ab initio facienda est earum collectio, tanquam historia quaedam particularis; eo quod digerant ea quae ingrediuntur intellectum, et corrigant pravam complexionem intellectus ipsius, quem omnino necesse est imbui et infici et demum perverti ac distorqueri ab incursibus quotidianis et consuetis.

Itaque adhibendae sunt eae instantiae tanquam praeparativum aliquod, ad rectificandum et expurgandum intellectum. Quicquid enim abducit intellectum a consuetis, aequat et complanat aream ejus ad recipiendum lumen siccum et purum notionum verarum.

Quin etiam hujusmodi instantiae sternunt et praestruunt viam ad operativam; ut suo loco dicemus, quando de *Deductionibus ad Praxin* sermo erit.

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Finally, superstitious things, and things that are magical in the popular sense of the word, should not be left out altogether. Such matters are buried deep under a vast heap of lies and fables. Still, they should be looked into a little, in case some natural operation lies hidden beneath some of them: as in fascination (the evil eye), the strengthening of the imagination, the sympathy of things at a distance, the transmission of impressions from spirit to spirit no less than from body to body, and the like.

From what has been said, it is clear that the five kinds of instances we have discussed (namely, *conformable instances, singular instances, deviating instances, bordering instances, instances of power*) should not be held back until some particular nature is under inquiry. The other instances we put forward first, and most of those that follow, must be held back in this way. These five, however, should be collected at once, right from the start, as a kind of particular history. For they sort out what enters the understanding. They also correct the faulty constitution of the understanding itself, which the impressions of daily, habitual experience are bound to imbue and taint, and finally pervert and distort.

These instances should therefore be used as a kind of preparative, to set right and purge the understanding. For whatever draws the understanding away from what is habitual also levels and smooths its ground to receive the dry, pure light of true notions.

Moreover, instances of this kind pave and prepare the way for the operative part, as we shall explain in its place when we come to speak of *Application to Practice*.

COMPANIONS AND ALLIANCES

Instances show which natures always go together, where their limits lie, and how supposedly different natures unite.

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2.33 Inter *praerogativas instantiarum* ponemus loco undecimo *Instantias Comitatus*, atque *Hostiles*; quas etiam *Instantias Propositionum Fixarum* appellare consuevimus. Eae sunt instantiae, quae exhibent aliquod corpus sive concretum tale, in quo natura inquisita perpetuo sequatur tanquam comes quidam individuus: aut contra, in quo natura

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Among the *prerogative instances* we shall place eleventh *Instances of Companionship* and *Hostile Instances*, which we also call *Instances of Fixed Propositions*. These are instances that present some body, or concrete thing, in which the nature under inquiry always follows as an inseparable compan-

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inquisita perpetuo fugiat atque ex comitatu excludatur, ut hostis et inimicus. Nam ex hujusmodi instantiis formantur propositiones certae et universales, aut *affirmativae* aut *negativae*; in quibus subjectum erit tale corpus in concreto, praedicatum vero natura ipsa inquisita. Etenim propositiones particulares omnino *fixae* non sunt, ubi scilicet natura inquisita reperitur in aliquo concreto fluxa et mobilis, viz. accedens sive acquisita, aut rursus recedens sive deposita. Quocirca particulares propositiones non habent *praerogativam* aliquam majorem, nisi tantum in casu *migrationis*; de quo antea dictum est.

Et nihilominus, etiam particulares illae propositiones comparatae et collatae cum universalibus multum juvant; ut suo loco dicetur. Neque tamen, etiam in universalibus istis propositionibus exactam aut absolutam affirmationem vel abnegationem requirimus. Sufficit enim ad id quod agitur, etiamsi exceptionem nonnullam singularem aut raram patiantur.

Usus autem *instantiarum comitatus* est ad angustiandam *affirmativam* formae. Quemadmodum enim in *instantiis migrantibus* angustiatur *affirmativa* formae; viz. ut necessario poni debeat forma rei esse aliquid quod per actum illum *migrationis* inditur aut destruitur; ita etiam in *instantiis comitatus* angustiatur *affirmativa* formae; ut necessario poni debeat forma rei esse aliquid quod talem concretionem corporis subingrediatur, aut contra ab eadem abhorreat; ut qui bene norit constitutionem aut schematismum hujusmodi corporis non longe abfuerit ab extrahenda in lucem forma naturae inquisitae.

Exempli gratia; sit natura inquisita Calidum. *Instantia comitatus* est flamma. Etenim in aqua, aere, lapide, metallo, et aliis quamplurimis, calor est mobilis, et accedere potest et recedere: at omnis flamma est calida, ita ut calor in concretione flammae perpetuo sequatur. At *instantia hostilis* calidi nulla reperitur apud nos. Nam de visceribus terrae nihil constat ad sensum; sed eorum corporum quae nobis nota sunt nulla prorsus est concretio quae non est susceptibilis caloris.

At rursus, sit natura inquisita Consistens. *Instantia hostilis* est aer. Etenim metallum potest fluere, potest consistere; similiter vitrum; etiam aqua potest consistere, cum

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ion. Or, conversely, they present one from which the nature under inquiry always flees and is shut out of its company, as an enemy and foe. From instances of this kind, certain and universal propositions are formed, either *affirmative* or *negative*. In these the subject will be such a body in the concrete, and the predicate the nature under inquiry itself. Particular propositions are not *fixed* at all, namely where the nature under inquiry is found in some concrete thing in a fluid and changeable state: arriving or acquired, or again departing or laid aside. Particular propositions therefore have no greater *prerogative*, except only in the case of *migration*, which was discussed earlier.

Even so, these particular propositions are of great help when compared and set beside the universal ones, as will be said in its place. And even in these universal propositions we do not require exact or absolute affirmation or denial. It is enough for our purpose if they admit some singular or rare exception.

The use of *instances of companionship* is to narrow the *affirmative* of the form. In *migrating instances* the *affirmative* of the form is narrowed, so that the form of the thing must necessarily be posited as something imparted or destroyed by that act of *migration*. In the same way, in *instances of companionship* the *affirmative* of the form is narrowed, so that the form of the thing must necessarily be posited as something that enters into such a concretion of body, or conversely shrinks from it. So anyone who knew well the constitution, or configuration, of such a body would not be far from bringing to light the form of the nature under inquiry.

For example, let the nature under inquiry be Heat. An *instance of companionship* is flame. In water, air, stone, metal and very many other things, heat is changeable: it can come and go. But all flame is hot, so heat always follows in the concretion of flame. No *hostile instance* of heat, however, is found among us. Nothing about the bowels of the earth is known to the senses, and among the bodies known to us there is absolutely no concretion that cannot take on heat.

Again, let the nature under inquiry be the Firm. A *hostile instance* is air. Metal can be fluid and can be firm; so can glass; even water can be firm when it

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conglaciatur: at impossibile est ut aer unquam consistat, aut exuat fluorem.

Verum de *instantiis* hujusmodi *propositionum fixarum* supersunt duo monita, quae utilia sunt ad id quod agitur. Primum, ut si defuerit plane universalis *affirmativa* aut *negativa*, illud ipsum diligenter notetur tanquam non-ens; sicut fecimus de calido, ubi universalis negativa (quatenus ad entia quae ad nostram notitiam pervenerint) in rerum natura deest. Similiter, si natura inquisita sit aeternum aut incorruptibile, deest affirmativa universalis hic apud nos. Neque enim praedicari potest *Aeternum* aut *Incorruptibile* de aliquo corpore eorum quae infra coelestia sunt, aut supra interiora terrae. Alterum monitum est, ut propositionibus universalibus, tam affirmativis quam negativis, de aliquo concreto, subjungantur simul ea concreta quae proxime videntur accedere ad id quod est ex non-entibus: ut in calore, flammae mollissimae et minimum adurentes; in incorruptibili, aurum, quod proxime accedit.

Omnia enim ista indicant terminos naturae inter ens et non-ens; et faciunt ad circumscriptiones formarum, ne gliscant et vagentur extra conditiones materiae.

2.34 Inter praerogativas instantiarum, ponemus loco duodecimo ipsas illas *Instantias Subjunctivas*, de quibus in superiori aphorismo diximus: quas etiam *Instantias Ultimitatis* sive *Termini* appellare consuevimus. Neque enim hujusmodi instantiae utiles sunt tantum, quatenus subjunguntur propositionibus fixis; verum etiam per se, et in proprietate sua. Indicant enim non obscure veras sectiones naturae, et mensuras rerum, et illud *Quousque* natura quid faciat et ferat, et deinde transitus naturae ad aliud. Talia sunt, aurum, in pondere; ferrum, in duritie; cete, in quantitate animalium; canis, in odore; inflammatio pulveris pyrii, in expansione celeri; et alia id genus. Nec minus exhibenda sunt ea quae sunt ultima gradu infimo, quam quae supremo; ut spiritus vini, in pondere; sericum, in mollitie; vermiculi cutis, in quantitate animalium; et caetera.

2.35 Inter *praerogativas instantiarum*, ponemus loco decimo tertio *Instantias Foederis* sive *Unionis*. Eae sunt, quae confundunt et adunant naturas, quae existimantur esse

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freezes. But air can never become firm or lose its fluidity.

Two cautions remain concerning *instances* of this kind, *of fixed propositions*, and they are useful to our purpose. First, if a universal *affirmative* or *negative* is entirely lacking, that very fact should be carefully noted as a non-being. We did this with heat, where a universal negative is lacking in the nature of things, so far as concerns the beings that have come to our knowledge. Similarly, if the nature under inquiry is the eternal or the incorruptible, a universal affirmative is lacking here among us. For *Eternal* or *Incorruptible* cannot be predicated of any body below the heavens or above the interior of the earth. The second caution is this. To universal propositions about some concrete thing, whether affirmative or negative, we should attach the concrete things that seem to come nearest to the non-beings. For heat, these are the gentlest flames, which burn least; for the incorruptible, gold, which comes nearest.

All these mark the boundaries of nature between being and non-being. They help to circumscribe the forms, so that the forms do not swell and wander beyond the conditions of matter.

Among the prerogative instances we shall place twelfth the very *Subjunctive Instances* mentioned in the preceding aphorism, which we also call *Instances of the Extreme* or *of the Limit*. Instances of this kind are useful not only when attached to fixed propositions, but also in themselves and in their own right. They show quite clearly the true divisions of nature and the measures of things. They show the *How far*: how far nature can do and bear something, and then where nature passes over into something else. Examples are gold, in weight; iron, in hardness; the whale, in the size of animals; the dog, in smell; the ignition of gunpowder, in rapid expansion; and others of the kind. Things that are extreme at the lowest degree should be shown no less than those at the highest: such as spirit of wine, in weight; silk, in softness; the little worms of the skin, in the size of animals; and so on.

Among the *prerogative instances* we shall place thirteenth *Instances of Alliance* or *of Union*. These are instances that mix and join together natures

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heterogeneae, et pro talibus notantur et signantur per divisiones receptas.

At *instantiae foederis* ostendunt operationes et effectus, quae deputantur alicui ex illis heterogeneis ut propria, competere etiam aliis ex heterogeneis; ut convincatur ista heterogenia (quae in opinione est) vera non esse aut essentialis, sed nil aliud esse quam modificatio naturae communis. Optimi itaque sunt usus ad elevandum et evehendum intellectum a differentiis ad genera; et ad tollendum larvas et simulachra rerum, prout occurrunt et prodeunt personatae in substantiis concretis.

Exempli gratia: sit natura inquisita Calidum. Omnino videtur esse divisio solennis et authentica, quod sint tria genera caloris; viz. calor coelestium, calor animalium, et calor ignis; quodque isti calores (praesertim unus ex illis comparatus ad reliquos duos) sint ipsa essentia et specie, sive natura specifica, differentes et plane heterogenei: quandoquidem calor coelestium et animalium generet et foveat, at calor ignis contra corrumpat et destruat. Est itaque *instantia foederis* experimentum illud satis vulgatum, cum recipitur ramus aliquis vitis intra domum ubi sit focus assiduus, ex quo maturescunt uvae etiam mense integro citius quam foras; ita ut maturatio fructus etiam pendentis super arborem fieri possit, scilicet ab igne, cum hoc ipsum videatur esse opus proprium solis.

Itaque ab hoc initio facile insurgit intellectus, repudiata heterogenia essentiali, ad inquirendum quae sint differentiae illae quae revera reperiuntur inter calorem solis et ignis, ex quibus fit ut eorum operationes sint tam dissimiles, utcunque illi ipsi participent ex natura communi.

Quae differentiae reperientur quatuor: viz. primo, quod calor solis respectu caloris ignis sit gradu longe clementior et lenior; secundo, quod sit (praesertim ut defertur ad nos per aerem) qualitate multo humidior; tertio (quod caput rei est), quod sit summe inaequalis, atque accedens et auctus, et deinceps recedens et diminutus; id quod maxime confert ad generationem corporum. Recte enim asseruit Aristoteles causam principalem generationum et corruptionum, quae fiunt hic apud nos in superficie terrae, esse viam obliquam solis per zodiacum; unde calor solis, partim per

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thought to be heterogeneous, which the accepted divisions mark and label as such.

Instances of alliance show that operations and effects ascribed to one of these heterogeneous natures as its own also belong to others among them. This proves that the heterogeneity, which exists in opinion, is neither true nor essential, but nothing more than a modification of a common nature. They are therefore extremely useful for raising the understanding from differences to genera. They also strip away the masks and phantoms of things, as these appear and come forward in disguise in concrete substances.

For example, let the nature under inquiry be Heat. It seems an entirely established and authoritative division that there are three kinds of heat: the heat of the heavenly bodies, the heat of animals and the heat of fire. These heats (especially one of them compared with the other two) are held to differ in their very essence and species, or specific nature, and to be plainly heterogeneous. For the heat of the heavenly bodies and of animals generates and nourishes, while the heat of fire, on the contrary, corrupts and destroys. An *instance of alliance*, then, is that well-known experiment in which a branch of a vine is brought inside a house where a fire is kept constantly burning. The grapes then ripen as much as a full month earlier than outdoors. So fruit can be ripened by fire even while it hangs on the tree, although this seems to be the sun's own proper work.

From this starting point, once essential heterogeneity has been rejected, the understanding easily rises to ask what differences really exist between the heat of the sun and the heat of fire. These differences make their operations so unlike, however much the two share in a common nature.

These differences will be found to be four. First, the heat of the sun, compared with the heat of fire, is far milder and gentler in degree. Second, it is much moister in quality, especially as it reaches us through the air. Third, and this is the heart of the matter, it is extremely unequal: now approaching and increasing, then receding and diminishing. This contributes most to the generation of bodies. Aristotle rightly asserted that the principal cause of the generations and corruptions that take

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vicissitudines diei et noctis, partim per successiones aestatis et hyemis, evadit miris modis inaequalis. Neque tamen desinit ille vir id quod ab eo recte inventum fuit statim corrumpere et depravare.

Nam ut arbiter scilicet naturae (quod illi in more est) valde magistraliter assignat causam generationis accessui solis, causam autem corruptionis recessui; cum utraque res (accessus videlicet solis et recessus) non respective, sed quasi indifferenter, praebeat causam tam generationi quam corruptioni; quandoquidem inaequalitas caloris generationi et corruptioni rerum, aequalitas conservationi tantum ministret. Est et quarta differentia inter calorem solis et ignis, magni prorsus momenti: viz. quod sol operationes suas insinuet per longa temporis spatia, ubi operationes ignis (urgente hominum impatientia) per breviora intervalla ad exitum perducantur.

Quod si quis id sedulo agat, ut calorem ignis attemperet et reducat ad gradum moderatiorem et leniorem (quod multis modis facile fit), deinde etiam inspergat et admisceat nonnullam humiditatem, maxime autem si imitetur calorem solis in inaequalitate, postremo si moram patienter toleret (non certe eam quae sit proportionata operibus solis, sed largiorem quam homines adhibere solent in operibus ignis), is facile missam faciet heterogeniam illam caloris, et vel tentabit vel exaequabit vel in aliquibus vincet opera solis, per calorem ignis. Similis *instantia foederis* est resuscitatio papilionum ex frigore stupentium et tanquam emortuarum, per exiguum teporem ignis; ut facile cernas non magis negatum esse igni vivificare animantia quam maturare vegetabilia.

Etiam inventum illud celebre Fracastorii de sartagine acriter calefacta, qua circundant medici capita apoplecticorum desperatorum, expandit manifeste spiritus animales ab humoribus et obstructionibus cerebri compressos et quasi extinctos, illosque ad motum excitat, non aliter quam ignis operatur in aquam aut aerem, et tamen per consequens vivificat. Etiam ova aliquando excluduntur per calorem ignis, id quod prorsus imitatur calorem animalem; et complura ejusmodi; ut nemo dubitare possit quin calor ignis in multis subjectis

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place here on the surface of the earth is the oblique path of the sun through the zodiac. As a result the sun's heat, partly through the alternation of day and night and partly through the succession of summer and winter, becomes wonderfully unequal. Yet that man does not fail at once to corrupt and distort what he had rightly discovered.

Acting, naturally, as the arbiter of nature (as is his habit), he very magisterially assigns the cause of generation to the sun's approach and the cause of corruption to its withdrawal. In fact both (the sun's approach and its withdrawal) supply a cause both of generation and of corruption, not respectively but almost indifferently. For inequality of heat serves the generation and corruption of things; equality serves only their preservation. There is also a fourth difference between the heat of the sun and of fire, of very great importance. The sun works its operations gradually over long stretches of time, whereas the operations of fire, driven by human impatience, are brought to completion in shorter intervals.

Suppose someone took pains to temper the heat of fire and bring it down to a more moderate and gentler degree, which is easily done in many ways. Suppose he then also sprinkled in and mixed some moisture; above all, that he imitated the heat of the sun in its inequality; and finally, that he patiently endured delay. This need not be a delay proportioned to the works of the sun, but longer than people usually allow in the works of fire. He would readily dismiss that heterogeneity of heat. With the heat of fire he would attempt the works of the sun, equal them, and in some cases surpass them. A similar *instance of alliance* is the reviving, by the slight warmth of a fire, of butterflies numbed by cold and seemingly dead. So you can readily see that fire is no more denied the power to bring animals to life than to ripen plants.

Take also Fracastoro's famous discovery of a fiercely heated pan, which physicians place around the heads of apoplectics who have been given up for lost. It plainly expands the animal spirits, which the humors and obstructions of the brain have compressed and almost extinguished, and rouses them to motion, just as fire acts on water or air; and so, as a consequence, it restores life. Eggs, too, are sometimes hatched by the heat of fire, which exactly imitates animal heat; and there

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modificari possit ad imaginem caloris coelestium et animalium.

Similiter sint naturae inquisitae Motus et Quies. Videtur esse divisio solennis atque ex intima philosophia, quod corpora naturalia vel rotent, vel ferantur recta, vel stent sive quiescant. Aut enim est motus sine termino, aut statio in termino, aut latio ad terminum. At motus ille perennis rotationis videtur esse coelestium proprius; statio sive quies videtur competere globo ipsi terrae; at corpora caetera (gravia quae vocant et levia, extra loca scilicet connaturalitatis suae sita) feruntur recta ad massas sive congregationes similium; levia sursum, versus ambitum coeli; gravia deorsum, versus terram. Atque ista pulchra dictu sunt.

At *instantia foederis* est cometa aliquis humilior; qui cum sit longe infra coelum, tamen rotat. Atque commentum Aristotelis de alligatione sive sequacitate cometae ad astrum aliquod jampridem explosum est; non tantum quia ratio ejus non est probabilis, sed propter experientiam manifestam discursus et irregularis motus cometarum per varia loca coeli.

At rursus alia *instantia foederis* circa hoc subjectum est motus aeris; qui intra tropicos (ubi circuli rotationis sunt majores) videtur et ipse rotare ab oriente in occidentem.

Et alia rursus *instantia* foret fluxus et refluxus maris, si modo aquae ipsae deprehendantur ferri motu rotationis (licet tardo et evanido) ab oriente in occidentem; ita tamen ut bis in die repercutiantur. Itaque, si haec ita se habeant, manifestum est motum istum rotationis non terminari in coelestibus, sed communicari aeri et aquae.

Etiam ista proprietas levium, nimirum ut ferantur sursum, vacillat nonnihil. Atque in hoc sumi potest pro *instantia foederis* bulla aquae. Si enim aer fuerit subter aquam, ascendit rapide versus superficiem aquae, per motum illum *plagae* (quam vocat Democritus), per quam aqua descendens percutit et attollit aerem sursum; non autem per contentionem aut nixum aeris ipsius. Atqui ubi ad superficiem ipsam aquae ventum fuerit, tum

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are many such cases. So no one can doubt that in many subjects the heat of fire can be modified into the likeness of the heat of the heavenly bodies and of animals.[21]

Similarly, let the natures under inquiry be Motion and Rest. It seems an established division, drawn from the depths of philosophy, that natural bodies either revolve, or move in a straight line, or stand still, that is, rest. For there is either motion without limit, or standing at a limit, or travel toward a limit. The perpetual motion of rotation seems proper to the heavenly bodies. Standing, or rest, seems to belong to the globe of the earth itself. Other bodies (called heavy and light, when they are outside their natural places) move in a straight line toward masses or aggregations of their like: the light upward, toward the circumference of the heavens; the heavy downward, toward the earth. This all sounds very fine.

But an *instance of alliance* is a lower comet, which revolves even though it is far below the heavens. Aristotle's fiction that a comet is tied to, or follows, some star was exploded long ago. His reasoning is not probable, and, more importantly, plain experience shows comets wandering with irregular motion through various regions of the sky.

Another *instance of alliance* on this subject is the motion of the air. Within the tropics, where the circles of rotation are larger, the air itself seems to revolve from east to west.

Yet another *instance* would be the flow and ebb of the sea, if only the waters themselves are found to be carried by a motion of rotation from east to west, however slow and faint, while being driven back twice a day. If this is so, it is clear that the motion of rotation does not stop at the heavenly bodies, but is communicated to air and water.

Even the property of light bodies to move upward wavers somewhat. On this point, a bubble of water can serve as an *instance of alliance*. If air is under water, it rises rapidly toward the surface by the motion of *impact* (as Democritus calls it), in which the descending water strikes the air and lifts it upward; the air itself does not strive or exert effort.

21 Girolamo Fracastoro (c. 1478–1553), Italian physician, poet and natural philosopher.

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cohibetur aer ab ulteriore ascensu, per levem resistentiam quam reperit in aqua non statim tolerante se discontinuari: ita ut exilis admodum sit appetitus aeris ad superiora.

Similiter sit natura inquisita Pondus. Est plane divisio recepta, ut densa et solida ferantur versus centrum terrae, rara autem et tenuia versus ambitum coeli; tanquam ad loca sua propria. Atque loca quod attinet, (licet in scholis hujusmodi res valeant) plane inepta et puerilis cogitatio est, locum aliquid posse. Itaque nugantur philosophi cum dicant quod, si perforata esset terra, corpora gravia se sisterent quando ventum esset ad centrum. Esset enim certe virtuosum plane et efficax genus nihili, aut puncti mathematici, quod aut alia afficeret, aut rursus quod alia appeterent: corpus enim non nisi a corpore patitur. Verum iste appetitus ascendendi et descendendi aut est in schematismo corporis quod movetur, aut in sympathia sive consensu cum alio corpore.

Quod si inveniatur aliquod corpus densum et solidum, quod nihilominus non feratur ad terram, confunditur hujusmodi divisio. At si recipiatur opinio Gilberti, quod magnetica vis terrae ad alliciendum gravia non extendatur ultra orbem virtutis suae (quae operatur semper ad distantiam certam, et non ultra), hocque per aliquam instantiam verificetur; ea demum erit *instantia foederis* circa hoc subjectum. Neque tamen occurrit impraesentiarum aliqua instantia super hoc certa et manifesta. Proxime videntur accedere cataractae coeli, quae in navigationibus per Oceanum Atlanticum versus Indias utrasque saepe conspiciuntur.

Tanta enim videtur esse vis et moles aquarum quae per hujusmodi cataractas subito effunditur, ut videatur collectio aquarum fuisse ante facta, atque in his locis haesisse et mansisse; et postea potius per causam violentam dejecta et detrusa esse, quam naturali motu gravitatis cecidisse; adeo ut conjici possit, corpoream molem densam atque compactam in magna distantia a terra fore pensilem tanquam terram ipsam, nec casuram nisi dejiciatur. Verum de hoc nil certi affirmamus. Interim in hoc et in multis aliis facile apparebit, quam

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But once the air reaches the very surface of the water, it is held back from rising further by the slight resistance it meets in the water, which does not at once allow itself to be broken apart. So the air's appetite for the regions above is very feeble.

Similarly, let the nature under inquiry be Weight. It is plainly an accepted division that dense and solid things move toward the center of the earth, and rare and thin things toward the circumference of the heavens, as to their own proper places. As for places, though such ideas carry weight in the schools, it is a plainly foolish and childish notion that a place can have any power. So the philosophers are talking nonsense when they say that if the earth were bored through, heavy bodies would stop on reaching the center. That would be a truly potent and effective kind of nothing, or mathematical point, able to act on other things or to be sought by them. But a body is acted on only by a body. In fact, the appetite for rising and falling lies either in the configuration of the body that is moved, or in its sympathy, or agreement, with another body.

If some dense and solid body were found that nevertheless does not move toward the earth, this division would be thrown into confusion. Gilbert holds that the earth's magnetic force to attract heavy bodies does not extend beyond the orb of its power, which always operates to a fixed distance and no further. If his opinion is accepted, and some instance verifies it, that will at last be an *instance of alliance* on this subject. At present, however, no certain and manifest instance of this occurs to us. The nearest seem to be the cataracts of the sky that are often seen on voyages across the Atlantic Ocean to the East and West Indies.[22]

The force and mass of water that suddenly pours out in such cataracts seem so great that the water appears to have been gathered beforehand and to have hung and remained in those places. It then seems to have been thrown and driven down by some violent cause rather than to have fallen by the natural motion of gravity. So one might conjecture that a dense and compact bodily mass, at a great distance from the earth, would hang suspended like the earth itself, and would not fall unless

22 Sudden torrential downpours or waterspouts; the phrase echoes the "windows (cataracts) of heaven" of the Flood in Genesis 7:11.

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inopes simus historiae naturalis; cum loco instantiarum certarum nonnunquam suppositiones afferre pro exemplis cogamur.	it were thrown down. But we affirm nothing certain about this. Meanwhile, this case and many others will readily show how poor we are in natural history, since we are sometimes forced to offer suppositions as examples instead of certain instances.
Similiter sit natura inquisita Discursus Ingenii. Videtur omnino divisio vera, rationis humanae et solertiae brutorum. Attamen sunt nonnullae instantiae actionum quae eduntur a brutis, per quas videntur etiam bruta quasi syllogizare: ut memoriae proditum est de corvo, qui per magnas siccitates fere enectus siti conspexit aquam in trunco cavo arboris; atque cum non daretur ei intrare propter angustias, non cessavit jacere multos lapillos, per quos surgeret et ascenderet aqua ut bibere posset; quod postea cessit in proverbium.	Similarly, let the nature under inquiry be Discursive Reasoning. The division between human reason and the cleverness of animals seems entirely true. Yet there are some instances of actions performed by animals in which even animals seem, as it were, to reason in syllogisms. One is recorded of a crow. In a great drought, almost dead of thirst, it spotted water in the hollow trunk of a tree. Since the opening was too narrow for it to get in, it kept dropping in pebble after pebble until the water rose high enough for it to drink. The story afterwards became proverbial.[23]
Similiter sit natura inquisita Visibile. Videtur omnino esse divisio vera et certa, lucis, quae est visibile originale et primam copiam facit visui, et coloris, qui est visibile secundarium et sine luce non cernitur, ita ut videatur nil aliud esse quam imago aut modificatio lucis. Attamen ex utraque parte circa hoc videntur esse *instantiae foederis;* scilicet, nix in magna quantitate, et flamma sulphuris; in quarum altera videtur esse color primulum lucens, in altera lux vergens ad colorem.	Similarly, let the nature under inquiry be the Visible. It seems an entirely true and certain division between light and color. Light is the primary visible and first offers itself to sight. Color is a secondary visible and is not seen without light, so that it seems to be nothing but an image or modification of light. Yet there seem to be *instances of alliance* on both sides of this division: namely, snow in large quantity, and the flame of sulfur. In the one there seems to be color just beginning to shine; in the other, light verging on color.

CRUCIAL INSTANCES

At a fork in the road one instance decides between rival causes, as with tides, weight and the compass.

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2.36 Inter *praerogativas instantiarum*, ponemus loco decimo quarto *Instantias Crucis*; translato vocabulo a *Crucibus*, quae erectae in biviis indicant et signant viarum separationes. Has etiam *Instantias Decisorias* et *Judiciales*, et in casibus nonnullis *Instantias Oraculi* et *Mandati*, appellare consuevimus. Earum ratio talis est. Cum in inquisitione naturae alicujus intellectus ponitur tanquam in aequilibrio, ut incertus sit utri naturarum e duabus, vel quandoque pluribus, causa naturae inquisitae attribui aut assignari debeat, propter complurium naturarum concursum frequentem et ordinarium, *instantiae crucis* ostendunt consortium unius ex naturis (quoad naturam	Among the *prerogative instances* we shall place fourteenth *Crucial Instances*. The term is taken from the *crosses* set up at forks in the road to show and mark where the ways divide. We also call them *Decisive* and *Judicial Instances*, and in some cases *Instances of the Oracle* and *of Command*. Their rationale is as follows. Sometimes, in investigating some nature, the understanding is held as if in balance. Because several natures frequently and ordinarily occur together, it cannot tell to which of two natures (or sometimes more) the cause of the nature under inquiry should be attributed or as-

23 The story is told in Aesop's fable of the crow and the pitcher and in Pliny's *Natural History*.

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inquisitam) fidum et indissolubile, alterius autem varium et separabile; unde terminatur quaestio, et recipitur natura illa prior pro causa, missa altera et repudiata.

Itaque hujusmodi instantiae sunt maximae lucis, et quasi magnae authoritatis; ita ut curriculum interpretationis quandoque in illas desinat, et per illas perficiatur. Interdum autem *Instantiae Crucis* illae occurrunt et inveniuntur inter jampridem notatas; at ut plurimum novae sunt, et de industria atque ex composito quaesitae et applicatae, et diligentia sedula et acri tandem erutae.

1. Exempli gratia; sit natura inquisita Fluxus et Refluxus Maris, ille bis repetitus in die atque sexhorarius in accessibus et recessibus singulis, cum differentia nonnulla quae coincidit in motum lunae. Bivium circa hanc naturam tale est.

Necesse prorsus est ut iste motus efficiatur, vel ab aquarum progressu et regressu, in modum aquae in pelvi agitatae, quae quando latus unum pelvis alluit, deserit alterum; vel a sublatione et subsidentia aquarum e profundo, in modum aquae ebullientis et rursus subsidentis. Utri vero causae fluxus et refluxus ille assignari debeat, oritur dubitatio. Quod si recipiatur prior assertio, necesse est ut cum sit fluxus in mari ex una parte, fiat sub idem tempus alicubi in mari refluxus ex alia. Itaque ad hoc reducitur inquisitio.

Atqui observavit Acosta, cum aliis nonnullis (diligenti facta inquisitione), quod ad litora Floridae et ad litora adversa Hispaniae et Africae, fiant fluxus maris ad eadem tempora, et refluxus itidem ad eadem tempora; non contra, quod cum fluxus fit ad littora Floridae, fiat refluxus ad littora Hispaniae et Africae. Attamen adhuc diligentius attendenti, non per hoc evincitur motus attolens, et abnegatur motus in progressu. Fieri enim potest, quod sit motus aquarum in progressu, et nihilominus inundet adversa littora ejusdem alvei simul; si aquae scilicet illae contrudantur et compellantur aliunde, quemadmodum fit in fluviis, qui fluunt et refluunt ad utrumque littus horis iisdem, cum tamen iste

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signed. *Crucial instances* show that one of these natures is faithfully and indissolubly partnered with the nature under inquiry, while the other's partnership is variable and separable. So the question is settled: the first nature is accepted as the cause, and the other is dismissed and rejected.[24]

Instances of this kind therefore shed the greatest light and carry, as it were, great authority. The course of interpretation sometimes ends in them and is completed by them. Sometimes these *Crucial Instances* turn up and are found among things already noted. But for the most part they are new: deliberately and purposely sought out and applied, and finally dug up by diligent and keen effort.

1. For example, let the nature under inquiry be the Flow and Ebb of the Sea. It is repeated twice a day, with six hours for each rise and fall, and with some variation that coincides with the motion of the moon. The fork in the road concerning this nature is as follows.

This motion must necessarily be produced in one of two ways. Either the waters advance and retreat, like water sloshed in a basin, which leaves one side of the basin when it washes against the other. Or the waters rise and sink from the depths, like water that boils up and then sinks back again. But to which of these causes the flow and ebb should be assigned is in doubt. If the first assertion is accepted, then when there is a flow on one side of the sea, there must necessarily be an ebb at the same time somewhere else in the sea, on another side. So the inquiry comes down to this.

Now Acosta, along with some others, observed after careful inquiry that on the coasts of Florida and on the opposite coasts of Spain and Africa, the flows of the sea occur at the same times, and the ebbs likewise at the same times. It is not the case that when there is a flow on the coasts of Florida there is an ebb on the coasts of Spain and Africa. Yet a still more careful observer will see that this does not establish the rising motion and refute the advancing one. The waters may move in an advancing motion and still flood the opposite shores of the same basin at once, if they are pushed and driven in from elsewhere. This happens in rivers,

24 Latin *crux*, "cross," here a signpost at a crossroads; Bacon's term is the source of the English phrase "crucial experiment."

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motus liquido sit motus in progressu, nempe aquarum ingredientium ostia fluminum ex mari.

Itaque simili modo fieri potest, ut aquae venientes magna mole ab Oceano Orientali Indico compellantur et trudantur in alveum Maris Atlantici, et propterea inundent utrumque latus simul. Quaerendum itaque est, an sit alius alveus per quem aquae possint iisdem temporibus minui et refluere. Atque praesto est Mare Australe, Mari Atlantico neutiquam minus, sed potius magis latum et extensum, quod ad hoc sufficere possit.

Itaque jam tandem perventum est ad *instantiam crucis* circa hoc subjectum. Ea talis est: si pro certo inveniatur, quod cum fit fluxus ad littora adversa tam Floridae quam Hispaniae in Mari Atlantico, fiat simul fluxus ad littora Peruviae et juxta dorsum Chinae in Mari Australi; tum certe per hanc *instantiam decisoriam* abjudicanda est assertio quod fluxus et refluxus maris, de quo inquiritur, fiat per motum progressivum: neque enim relinquitur aliud mare aut locus, ubi possit ad eadem tempora fieri regressus aut refluxus. Commodissime autem hoc sciri possit, si inquiratur ab incolis Panamae et Limae (ubi uterque Oceanus, Atlanticus et Australis, per parvum Isthmum separantur), utrum ad contrarias Isthmi partes fiat simul fluxus et refluxus maris, an e contra.

Verum haec decisio sive abjudicatio certa videtur, posito quod terra stet immobilis. Quod si terra rotet, fieri fortasse potest ut ex inaequali rotatione (quatenus ad celeritatem sive incitationem) terrae et aquarum maris, sequatur compulsio violenta aquarum in cumulum sursum, quae sit fluxus: et relaxatio earundem (postquam amplius cumulari non sustinuerint) in deorsum, quae sit refluxus. Verum de hoc facienda est inquisitio separatim. Attamen etiam hoc supposito, illud aeque manet fixum, quod necesse sit fieri alicubi refluxum maris ad eadem tempora quibus fiunt fluxus in aliis partibus.

Similiter, sit natura inquisita posterior ille motus ex duobus quos supposuimus, videlicet motus maris se

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which flow and ebb at both banks at the same hours, although this motion is clearly a motion of advance: the waters are entering the mouths of the rivers from the sea.[25]

In the same way, it may be that waters coming in great mass from the Eastern, or Indian, Ocean are driven and pushed into the basin of the Atlantic, and so flood both sides at once. We must therefore ask whether there is another basin in which the waters could decrease and ebb at the same times. And the South Sea is at hand. It is by no means less wide and extensive than the Atlantic, but rather more so, and it could suffice for this.[26]

So now at last we have arrived at the *crucial instance* on this subject. It is this. Suppose it is found for certain that when there is a flow on the opposite coasts of both Florida and Spain in the Atlantic, there is at the same time a flow on the coasts of Peru and along the back of China in the South Sea. Then this *decisive instance* must certainly rule out the assertion that the flow and ebb of the sea under inquiry takes place by an advancing motion. For no other sea or place is left where a return, or ebb, could occur at those same times. This could most conveniently be learned by asking the inhabitants of Panama and Lima, where the two oceans, the Atlantic and the South Sea, are separated by a narrow isthmus, whether the flow and the ebb of the sea take place at the same time on opposite sides of the isthmus, or the reverse.

But this decision, or ruling, seems certain only on the assumption that the earth stands motionless. If the earth revolves, it may perhaps happen that the earth and the waters of the sea rotate unequally, in speed or velocity. The waters might then be violently forced upward into a heap, which would be the flow; and when they could be heaped no higher, they would be released downward, which would be the ebb. But this must be investigated separately. Yet even on this supposition it remains equally fixed that there must be an ebb of the sea somewhere at the same times as the flows occur elsewhere.

Similarly, let the nature under inquiry be the second of the two motions we supposed, namely

25 José de Acosta (1540–1600), Spanish Jesuit, author of the *Natural and Moral History of the Indies* (1590).
26 The South Sea is the Pacific Ocean.

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attollens et rursus subsidens; si forte ita acciderit ut (diligenti facto examine) rejiciatur motus alter, de quo diximus, progressivus. Tum vero erit trivium circa hanc naturam tale.

Necesse est ut motus iste, per quem aquae in fluxibus et refluxibus se attollunt et rursus relabuntur, absque aliqua accessione aquarum aliarum quae advolvuntur, fiat per unum ex his tribus modis; vel quod ista aquarum copia emanet ex interioribus terrae et rursus in illa se recipiat; vel quod non sit aliqua amplior moles aquarum, sed quod eaedem aquae (non aucto quanto suo) extendantur sive rarefiant, ita ut majorem locum et dimensionem occupent, et rursus se contrahant; vel quod nec copia accedat major nec extensio amplior, sed eaedem aquae (prout sunt tam copia quam densitate aut raritate) per vim aliquam magneticam desuper eas attrahentem et evocantem, et per consensum, se attollant et deinde se remittant.

Itaque reducatur (si placet) jam inquisitio (missis duobus illis motibus prioribus) ad hunc ultimum; et inquiratur si fiat aliqua talis sublatio per consensum sive vim magneticam. Atqui primo manifestum est universas aquas, prout ponuntur in fossa sive cavo maris, non posse simul attolli, quia defuerit quod succedat in fundo; adeo ut si foret in aquis aliquis hujusmodi appetitus se attollendi, ille ipse tamen a nexu rerum, sive (ut vulgo loquuntur) ne detur vacuum, fractus foret et cohibitus. Relinquitur, ut attollantur aquae ex aliqua parte, et per hoc minuantur et cedant ex alia. Enimvero rursus necessario sequetur ut vis illa magnetica, cum super totum operari non possit, circa medium operetur intensissime; ita ut aquas in medio attollat, illae vero sublatae latera per successionem deserant et destituant.

Itaque jam tandem perventum est ad *instantiam crucis* circa hoc subjectum. Ea talis est: si inveniatur quod in refluxibus maris aquarum superficies in mari sit arcuata magis et rotunda, attollentibus se scilicet aquis in medio maris et deficientibus circa latera, quae sunt litora; et in fluxibus eadem superficies sit magis plana et aequa, redeuntibus scilicet aquis ad priorem suam positionem; tum certe per hanc *instantiam decisoriam* potest recipi sublatio per vim magneticam, aliter prorsus abjudicanda est. Hoc vero in fretis per lineas nauticas non difficile est experiri; videlicet utrum in refluxibus versus medium maris, mare non sit magis altum sive profundum quam in fluxibus.

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the motion of the sea rising and sinking again. This assumes that careful examination has rejected the other motion we spoke of, the advancing one. Then there will be a three-way crossroads concerning this nature, as follows.

In the flows and ebbs, the waters rise and fall back again without any addition of other waters rolling in. This motion must take place in one of three ways. Either this quantity of water issues from the interior of the earth and withdraws into it again. Or there is no greater mass of water, but the same waters, without increasing in quantity, are extended, or rarefied, so as to occupy a larger space and dimension, and then contract again. Or no greater quantity arrives and there is no greater extension, but the same waters, just as they are in quantity and in density or rarity, rise and then subside by sympathy, through some magnetic force that attracts and draws them up from above.

So let the inquiry now be reduced, if you please, to this last motion, setting aside the first two, and let us ask whether any such lifting takes place by sympathy or magnetic force. First, it is clear that all the waters, as they lie in the trench or hollow of the sea, cannot rise at once, because nothing would take their place at the bottom. Even if the waters had some such appetite to rise, it would be broken and checked by the connection of things, or, as people commonly say, to prevent a vacuum. It remains that the waters rise in one part and so diminish and give way in another. It will then necessarily follow that this magnetic force, since it cannot operate on the whole, operates most intensely around the middle. It lifts the waters in the middle, and they, once raised, in turn abandon and leave bare the sides.

So now at last we have arrived at the *crucial instance* on this subject. It is this. Suppose it is found that at the ebbs the surface of the waters in the sea is more arched and rounded, the waters rising in the middle of the sea and falling away around the sides, which are the shores. And suppose that at the flows the same surface is flatter and more level, the waters returning to their former position. Then this *decisive instance* allows lifting by magnetic force to be accepted; otherwise it must be ruled out entirely. This is not hard to test in straits with sounding lines: one checks whether, at

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Notandum autem est, si hoc ita sit, fieri (contra ac creditur) ut attollant se aquae in refluxibus, demittant se tantum in fluxibus, ita ut littora vestiant et inundent.

2. Similiter, sit natura inquisita Motus Rotationis spontaneus; et speciatim, utrum Motus Diurnus, per quem sol et stellae ad conspectum nostrum oriuntur et occidunt, sit motus rotationis verus in coelestibus, aut motus apparens in coelestibus, verus in terra. Poterit esse *instantia crucis* super hoc subjectum talis.

Si inveniatur motus aliquis in oceano ab oriente in occidentem, licet admodum languidus et enervatus; si idem motus reperiatur paulo incitatior in aere, praesertim intra tropicos, ubi propter majores circulos est magis perceptibilis; si idem motus reperiatur in humilioribus cometis, jam factus vivus et validus; si idem motus reperiatur in planetis, ita tamen dispensatus et graduatus ut quo propius absit a terra sit tardior, quo longius celerior, atque in coelo demum stellato sit velocissimus: tum certe recipi debet motus diurnus pro vero in coelis, et abnegandus est motus terrae; quia manifestum erit, motum ab oriente in occidentem esse plane cosmicum et ex consensu universi, qui in summitatibus coeli maxime rapidus gradatim labascat, et tandem desinat et extinguatur in immobili, videlicet terra.

Similiter, sit natura inquisita Motus Rotationis ille alter apud astronomos decantatus, renitens et contrarius Motui Diurno, videlicet ab occidente in orientem; quem veteres astronomi attribuunt planetis, etiam coelo stellato, at Copernicus et ejus sectatores terrae quoque; et quaeratur utrum inveniatur in rerum natura aliquis talis motus, an potius res conficta sit et supposita, ad compendia et commoditates calculationum, et ad pulchrum illud, scilicet de expediendis motibus coelestibus per circulos perfectos. Neutiquam enim evincitur iste motus esse in supernis verus et realis, nec per defectum restitutionis planetae in motu diurno ad idem punctum coeli stellati, nec per diversam polaritatem zodiaci, habito respectu ad polos mundi; quae duo nobis hunc motum pepererunt.

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the ebbs, the sea toward the middle is not higher, or deeper, than at the flows.

But it should be noted that if this is so, it follows, contrary to common belief, that the waters rise at the ebbs, and merely sink at the flows so as to cover and flood the shores.

2. Similarly, let the nature under inquiry be spontaneous Motion of Rotation. Specifically, is the Daily Motion, by which the sun and stars rise and set to our sight, a true motion of rotation in the heavenly bodies? Or is it a motion apparent in the heavenly bodies and real in the earth? A *crucial instance* on this subject could be as follows.

Suppose some motion is found in the ocean from east to west, though very faint and feeble. Suppose the same motion is found a little quicker in the air, especially within the tropics, where it is more perceptible because of the larger circles. Suppose it is found in the lower comets, now become lively and strong. And suppose it is found in the planets, but distributed and graduated so that the nearer a planet is to the earth, the slower it moves, and the farther away, the faster, until in the starry heaven it is swiftest of all. Then the daily motion must certainly be accepted as real in the heavens, and the motion of the earth denied. For it will be clear that the motion from east to west is plainly cosmic and arises from the consent of the universe. It is most rapid at the heights of the heavens, gradually weakens, and finally ceases and dies out in what is motionless, namely the earth.

Similarly, let the nature under inquiry be that other Motion of Rotation so much talked about among astronomers, running against and contrary to the Daily Motion, namely from west to east. The ancient astronomers attribute it to the planets and also to the starry heaven, and Copernicus and his followers to the earth as well. Let us ask whether any such motion is found in the nature of things, or whether it is rather invented and supposed for shortcuts and conveniences in calculation, and for the sake of that pretty notion of explaining the heavenly motions by perfect circles. This motion is by no means proved true and real in the heavens. It is not proved by the planet's failure, in its daily motion, to return to the same point of the starry heaven. Nor is it proved by the fact that the poles of the zodiac differ from the poles of the

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world. These are the two things that gave birth to this motion for us.

Primum enim phaenomenon per anteversionem et derelictionem optime salvatur; secundum per lineas spirales; adeo ut inaequalitas restitutionis et declinatio ad tropicos possint esse potius modificationes motus unici illius diurni, quam motus renitentes aut circa diversos polos. Et certissimum est, si paulisper pro plebeiis nos geramus (missis astronomorum et scholae commentis, quibus illud in more est ut sensui in multis immerito vim faciant, et obscuriora malint), talem esse motum istum ad sensum, qualem diximus; cujus imaginem per fila ferrea (veluti in machina) aliquando repraesentari fecimus.

For the first phenomenon is best accounted for by running ahead and falling behind, and the second by spiral lines. So the inequality of return and the declination toward the tropics may be modifications of that single daily motion, rather than contrary motions or motions about different poles. And it is quite certain that if we behave for a moment like ordinary people, setting aside the fictions of the astronomers and the schools, this motion is, to the senses, just as we have described. (The astronomers and the schools are in the habit of doing the senses undeserved violence in many things and preferring what is more obscure.) We once had an image of this motion represented with iron wires, as in a machine.

Verum *instantia crucis* super hoc subjectum poterit esse talis. Si inveniatur in aliqua historia fide digna, fuisse cometam aliquem vel sublimiorem vel humiliorem qui non rotaverit cum consensu manifesto (licet admodum irregulariter) motus diurni, sed potius rotaverit in contrarium coeli; tum certe hucusque judicandum est posse esse in natura aliquem talem motum. Sin nihil hujusmodi inveniatur, habendus est pro suspecto, et ad alias *instantias crucis* circa hoc confugiendum.

But a *crucial instance* on this subject could be as follows. Suppose some trustworthy history reports a comet, whether higher or lower, that did not revolve in manifest agreement with the daily motion (however irregularly), but revolved rather in the opposite direction to the heavens. Then it must certainly be judged, to that extent, that some such motion may exist in nature. But if nothing of the kind is found, the motion must be held suspect, and we must turn to other *crucial instances* on this matter.

3. Similiter, sit natura inquisita Pondus sive Grave. Bivium circa hanc naturam tale est. Necesse est ut gravia et ponderosa vel tendant ex natura sua ad centrum terrae, per proprium schematismum; vel ut a massa corporea ipsius terrae, tanquam a congregatione corporum connaturalium, attrahantur et rapiantur, et ad eam per consensum ferantur. At posterius hoc si in causa sit, sequitur ut quo propius gravia appropinquant ad terram, eo fortius et majore cum impetu ferantur ad eam; quo longius ab ea absint, debilius et tardius (ut fit in attractionibus magneticis); idque fieri intra spatium certum; adeo ut si elongata fuerint a terra tali distantia ut virtus terrae in ea agere non possit, pensilia mansura sint, ut et ipsa terra, nec omnino decasura.

3. Similarly, let the nature under inquiry be Weight, or Heaviness. The fork in the road concerning this nature is as follows. Either heavy and weighty things tend by their own nature toward the center of the earth, through their own configuration. Or they are attracted and seized by the bodily mass of the earth itself, as by an aggregation of kindred bodies, and are carried to it by sympathy. If the latter is the cause, then the nearer heavy things come to the earth, the more strongly and with the greater impetus they are carried to it; and the farther away they are, the more weakly and slowly (as happens in magnetic attractions). It also follows that this happens within a fixed range. So if they were removed so far from the earth that its power could not act on them, they would remain suspended, like the earth itself, and would not fall at all.

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Itaque talis circa hanc rem poterit esse *instantia crucis*. Sumatur horologium ex iis quae moventur per pondera plumbea, et aliud ex iis quae moventur per compressionem laminae ferreae; atque vere probentur, ne alterum altero velocius sit aut tardius; deinde ponatur horologium illud movens per pondera super fastigium alicujus templi altissimi, altero illo infra detento; et notetur diligenter si horologium in alto situm tardius moveatur quam solebat, propter diminutam virtutem ponderum. Idem fiat experimentum in profundis minerarum alte sub terra depressarum, utrum horologium hujusmodi non moveatur velocius quam solebat, propter auctam virtutem ponderum. Quod si inveniatur virtus ponderum minui in sublimi, aggravari in subterraneis, recipiatur pro causa ponderis attractio a massa corporea terrae.

4. Similiter, sit natura inquisita Verticitas Acus Ferreae, tactae magnete. Circa hanc naturam tale erit bivium. Necesse est ut tactus magnetis vel ex se indat ferro verticitatem ad septentriones et austrum; vel ut excitet ferrum tantummodo et habilitet, motus autem ipse indatur ex praesentia terrae; ut Gilbertus opinatur, et tanto conatu probare nititur. Itaque huc spectant ea, quae ille perspicaci industria conquisivit. Nimirum quod clavus ferreus, qui diu duravit in situ versus septentriones et austrum, colligat mora diutina verticitatem, absque tactu magnetis: ac si terra ipsa, quae ob distantiam debiliter operatur (namque superficies aut extima incrustatio terrae virtutis magneticae, ut ille vult, expers est), per moram tamen longam magnetis tactum suppleret, et ferrum exciret, deinde excitum conformaret et verteret.

Rursus, quod ferrum ignitum et cadens, si in extinctione sua exporrigatur inter septentriones et austrum, colligat quoque verticitatem absque tactu magnetis: ac si partes ferri in motu positae per ignitionem, et postea se recipientes, in ipso articulo extinctionis suae magis essent susceptivae et quasi sensitivae virtutis manantis a terra quam alias, et inde fierent tanquam excitae. Verum haec, licet bene observata, tamen non evincunt prorsus quod ille asserit.

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So a *crucial instance* on this matter could be as follows. Take two clocks, one driven by lead weights and the other by the compression of an iron spring. Test them thoroughly, so that neither runs faster or slower than the other. Then place the weight-driven clock on top of some very high church, keeping the other below. Note carefully whether the clock placed high runs more slowly than it used to, because the power of the weights is diminished. Make the same experiment in the depths of mines sunk far below the earth, to see whether a clock of this kind does not run faster than it used to, because the power of the weights is increased. If the power of the weights is found to be diminished on high and increased underground, then attraction by the bodily mass of the earth should be accepted as the cause of weight.

4. Similarly, let the nature under inquiry be the Polarity of an Iron Needle touched by a magnet. The fork in the road concerning this nature will be as follows. Either the touch of the magnet by itself imparts to the iron a polarity toward north and south. Or it merely excites the iron and makes it apt, while the motion itself is imparted by the presence of the earth, as Gilbert believes and strives so hard to prove. The facts he gathered with such perceptive industry bear on this. For example, an iron nail that has lain for a long time pointing north and south acquires polarity through that long stay, without the touch of a magnet. It is as if the earth itself, which acts only weakly because of the distance (for its surface, or outermost crust, has no magnetic power, as he holds), nevertheless over a long time supplied the place of the magnet's touch. It would thus excite the iron and then, once excited, shape and turn it.

Again, iron heated red-hot, if it is laid out between north and south while it cools, also acquires polarity without the touch of a magnet. It is as if the parts of the iron, set in motion by the heating and afterwards settling back, were at the very moment of cooling more receptive, and as it were more sensitive, to the power flowing from the earth than at other times, and so became as it were excited. But these observations, though well made, still do not fully prove what he asserts.

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Instantia crucis autem circa hoc subjectum poterit esse talis. Capiatur terrella ex magnete, et notentur poli ejus; et ponantur poli terrellae versus orientem et occasum, non versus septentriones et austrum, atque ita jaceant; deinde superponatur acus ferrea intacta, et permittatur ita manere ad dies sex aut septem. Acus vero (nam de hoc non dubitatur) dum manet super magnetem, relictis polis mundi, se vertet ad polos magnetis; itaque quamdiu ita manet, vertitur scilicet ad orientem et occidentem mundi.

Quod si inveniatur acus illa, remota a magnete et posita super versorium, statim se applicare ad septentriones et austrum, vel etiam paulatim se eo recipere, tum recipienda est pro causa, praesentia terrae; sin aut vertatur (ut prius) in orientem et occidentem, aut perdat verticitatem, habenda est illa causa pro suspecta, et ulterius inquirendum est.

5. Similiter, sit natura inquisita Corporea Substantia Lunae: an sit tenuis, flammea, sive aerea, ut plurimi ex priscis philosophis opinati sunt; an solida et densa, ut Gilbertus et multi moderni, cum nonnullis ex antiquis, tenent. Rationes posterioris istius opinionis fundantur in hoc maxime, quod luna radios solis reflectat; neque videtur fieri reflexio lucis nisi a solidis.

Itaque *instantiae crucis* circa hoc subjectum eae esse poterint (si modo aliquae sint) quae demonstrent reflexionem a corpore tenui, qualis est flamma, modo sit crassitiei sufficientis. Certe causa crepusculi, inter alias, est reflexio radiorum solis a superiore parte aeris. Etiam quandoque reflecti videmus radios solis temporibus vespertinis serenis a fimbriis nubium roscidarum, non minori splendore, sed potius illustriori et magis glorioso, quam qui redditur a corpore lunae; neque tamen constat eas nubes coaluisse in corpus densum aquae. Etiam videmus aerem tenebrosum pone fenestras noctu reflectere lucem candelae, non minus quam corpus densum. Tentandum etiam foret experimentum immissionis radiorum solis per foramen super flammam aliquam subfuscam et caeruleam.

Sane radii aperti solis, incidentes in flammas obscuriores, videntur eas quasi mortificare, ut conspiciantur magis

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A *crucial instance* on this subject could be as follows. Take a terrella made of lodestone and mark its poles. Set its poles toward east and west, not toward north and south, and let it lie so. Then place on it an iron needle that has not been touched by a magnet, and leave it there for six or seven days. While the needle stays on the magnet, it will leave the poles of the world and turn to the poles of the magnet; about this there is no doubt. So as long as it stays there, it points to the east and west of the world.[27]

Now suppose that the needle, removed from the magnet and placed on a pivot, is found to turn at once to north and south, or even to go back there gradually. Then the presence of the earth must be accepted as the cause. But if it either points east and west, as before, or loses its polarity, that cause must be regarded as suspect, and further inquiry must be made.

5. Similarly, let the nature under inquiry be the Bodily Substance of the Moon. Is it thin, fiery or airy, as most of the early philosophers believed? Or is it solid and dense, as Gilbert and many moderns hold, along with some of the ancients? The reasons for the latter opinion rest chiefly on this: the moon reflects the rays of the sun, and light seems to be reflected only by solid bodies.

So the *crucial instances* on this subject could be any (if there are any) that demonstrate reflection from a thin body, such as flame, provided it is thick enough. Certainly one of the causes of twilight is the reflection of the sun's rays from the upper part of the air. Sometimes, too, on clear evenings, we see the sun's rays reflected from the fringes of dewy clouds with no less brightness than the moon's body returns, and even with a brighter and more glorious one. Yet it is not established that those clouds have coalesced into a dense body of water. We also see that the dark air outside windows at night reflects candlelight no less than a dense body does. An experiment should also be tried of letting the sun's rays in through a hole onto some dusky, bluish flame.

Certainly the open rays of the sun, falling on rather dim flames, seem as it were to deaden

27 Gilbert's "little earth": a sphere of lodestone used as a model of the earth's magnetism.

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instar fumi albi quam flammae. Atque haec impraesentiarum occurrunt, quae sint ex natura *instantiarum crucis* circa hanc rem; et meliora fortasse reperiri possunt. Sed notandum semper est, reflexionem a flamma non esse expectandam, nisi a flamma alicujus profunditatis; nam aliter vergit ad diaphanum. Hoc autem pro certo ponendum, lucem semper in corpore aequali aut excipi et transmitti, aut resilire.

6. Similiter, sit natura inquisita Motus Missilium, veluti spiculorum, sagittarum, globulorum, per aerem. Hunc motum Schola (more suo) valde negligenter expedit; satis habens, si eum nomine motus violenti a naturali (quem vocant) distinguat; et quod ad primam percussionem sive impulsionem attinet, per illud, *(quod duo corpora non possint esse in uno loco, ne fiat penetratio dimensionum,)* sibi satisfaciat; et de processu continuato istius motus nihil curet. At circa hanc naturam bivium est tale: aut iste motus fit ab aere vehente et pone corpus emissum se colligente, instar fluvii erga scapham aut venti erga paleas; aut a partibus ipsius corporis non sustinentibus impressionem, sed ad eandem laxandam per successionem se promoventibus.

Atque priorem illum recipit Fracastorius, et fere omnes qui de hoc motu paulo subtilius inquisiverunt: neque dubium est, quin sint aeris partes in hac re nonnullae; sed alter motus proculdubio verus est, ut ex infinitis constat experimentis. Sed inter caeteras, poterit esse circa hoc subjectum *instantia crucis* talis; quod lamina, aut filum ferri paulo contumacius, vel etiam calamus sive penna in medio divisa, adducta et curvata inter pollicem et digitum exiliant. Manifestum enim est, hoc non posse imputari aeri se pone corpus colligenti, quia fons motus est in medio laminae vel calami, non in extremis.

7. Similiter sit natura inquisita motus ille rapidus et potens Expansionis Pulveris Pyrii in flammam; unde tantae moles subvertuntur, tanta pondera emittuntur, quanta in cuniculis majoribus et bombardis videmus. Bivium circa hanc naturam tale est. Aut excitatur iste motus a mero corporis appetitu se dilatandi, postquam fuerit inflammatum; aut ab appetitu mixto spiritus crudi, qui rapide fugit ignem, et ex eo circumfuso, tanquam ex

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them, so that they look more like white smoke than flame. These are the things of the nature of *crucial instances* on this matter that occur to us at present; perhaps better ones can be found. But it must always be noted that reflection from flame is to be expected only from flame of some depth; otherwise it verges on the transparent. This, however, may be taken as certain: in an even body, light is always either received and transmitted, or it bounces back.

6. Similarly, let the nature under inquiry be the Motion of Projectiles, such as javelins, arrows and balls, through the air. The School, as is its way, disposes of this motion very carelessly. It is content to distinguish it, under the name of violent motion, from what they call natural motion. As for the first stroke or impulse, it satisfies itself with the principle *that two bodies cannot be in one place, lest there be a penetration of dimensions,* and it cares nothing about how the motion continues. But the fork in the road concerning this nature is as follows. Either this motion is produced by the air, which carries the projected body and gathers behind it, as a river carries a boat or the wind carries straws. Or it is produced by the parts of the body itself, which cannot endure the impression and press forward in succession to relieve it.

The first of these is accepted by Fracastoro and by nearly everyone who has inquired into this motion with any subtlety. No doubt the air has some part in the matter. But the other motion is beyond doubt the true one, as countless experiments make clear. Among others, a *crucial instance* on this subject could be the following. A plate, or a rather stiff iron wire, or even a reed or quill split down the middle, springs away when bent and curved between thumb and finger. Clearly this cannot be put down to the air gathering behind the body, because the source of the motion is in the middle of the plate or reed, not at its ends.

7. Similarly, let the nature under inquiry be the rapid and powerful motion of the Expansion of Gunpowder into flame. It overturns such great masses and hurls such great weights, as we see in large mines and cannons. The fork in the road concerning this nature is as follows. Either this motion is aroused by the mere appetite of the body to expand once it has been ignited. Or it is aroused

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carcere, violenter erumpit. Schola autem et vulgaris opinio tantum versatur circa priorem illum appetitum. Putant enim homines se pulchre philosophari, si asserant flammam ex forma elementi necessitate quadam donari locum ampliorem occupandi quam idem corpus expleverat cum subiret formam pulveris, atque inde sequi motum istum.

Interim minime advertunt, licet hoc verum sit, posito quod flamma generetur, tamen posse impediri flammae generationem a tanta mole, quae illam comprimere et suffocare queat; ut non deducatur res ad istam necessitatem de qua loquuntur. Nam quod necesse sit fieri expansionem, atque inde sequi emissionem aut remotionem corporis quod obstat, si generetur flamma, recte putant. Sed ista necessitas plane evitatur, si moles illa solida flammam supprimat antequam generetur. Atque videmus flammam, praesertim in prima generatione, mollem esse et lenem, et requirere cavum in quo experiri et ludere possit. Itaque tanta violentia huic rei per se assignari non potest.

Sed illud verum; generationem hujusmodi flammarum flatulentarum, et veluti ventorum igneorum, fieri ex conflictu duorum corporum, eorumque naturae inter se plane contrariae; alterius admodum inflammabilis, quae natura viget in sulphure; alterius flammam exhorrentis, qualis est spiritus crudus qui est in nitro; adeo ut fiat conflictus mirabilis, inflammante se sulphure quantum potest (nam tertium corpus, nimirum carbo salicis, nil aliud fere praestat, quam ut illa duo corpora incorporet et commode uniat), et erumpente spiritu nitri quantum potest, et una se dilatante (nam hoc faciunt et aer, et omnia cruda, et aqua, ut a calore dilatentur), et per istam fugam et eruptionem interim flammam sulphuris, tanquam follibus occultis, undequaque exufflante.

Poterant autem esse *instantiae crucis* circa hoc subjectum duorum generum. Alterum eorum corporum quae maxime sunt inflammabilia, qualia sunt sulphur, caphura, naphtha, et hujusmodi, cum eorum misturis; quae citius et facilius concipiunt flammam quam pulvis pyrius, si non impediantur: ex quo liquet appetitum inflammandi per se effectum illum stupendum non operari. Alterum eorum quae flammam fugiunt et exhorrent, qualia sunt sales omnes. Videmus enim, si jaciantur in ignem, spiritum aqueum erumpere cum

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by the mixed appetite of a crude spirit, which flees fire rapidly and breaks violently out of the surrounding fire, as out of a prison. The School and common opinion deal only with the first of these appetites. People think they are philosophizing splendidly when they assert the following: flame, by the form of its element, is endowed by a certain necessity with the property of occupying a larger space than the same body filled when it had the form of powder, and the motion follows from this.

Meanwhile they fail to notice something. This is true if we assume that flame is generated. But a mass great enough to compress and smother the flame can prevent it from being generated, so that the matter never reaches the necessity they speak of. They are right to think that if flame is generated, it must necessarily expand, and the expulsion or removal of the obstructing body must follow. But this necessity is plainly avoided if the solid mass suppresses the flame before it is generated. And we see that flame, especially when first generated, is soft and gentle, and needs a hollow in which to try itself out and play. So such great violence cannot be assigned to this factor by itself.

The truth is this. Such windy flames, like fiery winds, are generated from the conflict of two bodies whose natures are plainly contrary to each other. One is highly inflammable, a nature that is strong in sulfur. The other abhors flame, like the crude spirit in saltpeter. So a wonderful conflict arises. The sulfur ignites as much as it can; the third body, willow charcoal, does little more than incorporate the other two and unite them conveniently. The spirit of the saltpeter bursts out as much as it can and at the same time expands, for air, all crude things and water all expand with heat. Meanwhile, by this flight and outburst, it blows up the flame of the sulfur on every side, as if with hidden bellows.

Crucial instances on this subject could be of two kinds. One kind consists of the most inflammable bodies, such as sulfur, camphor, naphtha and the like, with their mixtures. If not hindered, these catch fire more quickly and easily than gunpowder, which shows that the appetite to ignite does not by itself produce that astonishing effect. The other kind consists of things that flee and abhor flame, such as all salts. For we see that if they

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fragore antequam flamma concipiatur; quod etiam leniter fit in foliis paulo contumacioribus, parte aquea erumpente antequam oleosa concipiat flammam. Sed maxime cernitur hoc in argento vivo, quod non male dicitur aqua mineralis.

Hoc enim, absque inflammatione, per eruptionem et expansionem simplicem vires pulveris pyrii fere adaequat; quod etiam admixtum pulveri pyrio ejus vires multiplicare dicitur.

8. Similiter sit natura inquisita, Transitoria Natura Flammae, et Extinctio ejus Momentanea. Non enim videtur natura flammea hic apud nos figi et consistere, sed singulis quasi momentis generari, et statim extingui. Manifestum enim est in flammis, quae hic continuantur et durant, istam durationem non esse ejusdem flammae in individuo, sed fieri per successionem novae flammae seriatim generatae, minime autem manere eandem flammam numero; id quod facile perspicitur ex hoc, quod, subtracto alimento sive fomite flammae, flamma statim pereat. Bivium autem circa hanc naturam tale est.

Momentanea ista natura aut fit remittente se causa quae eam primo genuit, ut in lumine, sonis, et motibus (quos vocant) violentis; aut quod flamma in natura sua possit hic apud nos manere, sed a contrariis naturis circumfusis vim patiatur et destruatur.

Itaque poterit esse circa hoc subjectum *instantia crucis* talis. Videmus flammas in incendiis majoribus, quam alte in sursum ascendant. Quanto enim basis flammae est latior, tanto vertex sublimior. Itaque videtur principium extinctionis fieri circa latera, ubi ab aere flamma comprimitur et male habetur. At meditullia flammae, quae aer non contingit sed alia flamma undique circumdat, eadem numero manent, neque extinguuntur donec paulatim angustientur ab aere per latera circumfuso. Itaque omnis flamma pyramidalis est basi circa fomitem largior, vertice autem (inimicante aere, nec suppeditante fomite) acutior. At fumus angustior circa basin ascendendo dilatatur, et fit tanquam pyramis inversa; quia scilicet aer fumum recipit, flammam (neque enim quispiam somniet aerem esse flammam accensam, cum sint corpora plane heterogenea) comprimit.

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are thrown into the fire, the watery spirit bursts out with a crackle before flame is caught. This also happens gently in rather tough leaves, the watery part bursting out before the oily part catches flame. But it is seen most of all in quicksilver, which is not badly called a mineral water.

For quicksilver, without catching fire, by simple outburst and expansion, almost equals the power of gunpowder. It is also said to multiply gunpowder's power when mixed with it.

8. Similarly, let the nature under inquiry be the Transitory Nature of Flame and its Momentary Extinction. The nature of flame does not seem to be fixed and stable here among us, but to be generated almost moment by moment and immediately extinguished. In flames that continue and last here, it is clear that this duration does not belong to the same individual flame. It comes about through a succession of new flame generated in series; the numerically same flame by no means persists. This is easily seen from the fact that if the fuel, or nourishment, of the flame is withdrawn, the flame perishes at once. The fork in the road concerning this nature is as follows.

This momentary nature arises either because the cause that first generated it lapses, as in light, sounds and so-called violent motions; or because flame could by its nature last here among us, but suffers violence and is destroyed by the contrary natures surrounding it.

So a *crucial instance* on this subject could be as follows. We see how high flames rise in large fires: the broader the base of the flame, the higher its peak. So extinction seems to begin around the sides, where the air compresses and harasses the flame. But the central parts of the flame, which the air does not touch but other flame surrounds on all sides, remain numerically the same. They are not extinguished until the air surrounding them at the sides gradually narrows them. So every flame is pyramidal: broader at the base, around the fuel, and sharper at the peak, where the air is hostile and no fuel is supplied. Smoke, on the other hand, is narrower at the base and widens as it rises, becoming like an inverted pyramid. The reason is that the air receives smoke but compresses flame. (No one should dream that air is kindled flame, since they are plainly heterogeneous bodies.)

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Accuratior autem poterit esse *instantia crucis* ad hanc rem accommodata, si res forte manifestari possit per flammas bicolores. Capiatur igitur situla parva ex metallo, et in ea figatur parva candela cerea accensa; ponatur situla in patera, et circumfundatur spiritus vini in modica quantitate, quae ad labra situlae non attingat; tum accende spiritum vini. At spiritus ille vini exhibebit flammam magis scilicet caeruleam, lychnus candelae autem magis flavam. Notetur itaque utrum flamma lychni (quam facile est per colorem a flamma spiritus vini distinguere; neque enim flammae, ut liquores, statim commiscentur) maneat pyramidalis, an potius magis tendat ad formam globosam, cum nihil inveniatur quod eam destruat aut comprimat.

At hoc posterius si fiat, manere flammam eandem numero, quamdiu intra aliam flammam concludatur nec vim inimicam aeris experiatur, pro certo ponendum est.

Atque de *instantiis crucis* haec dicta sint. Longiores autem in iis tractandis ad hunc finem fuimus, ut homines paulatim discant et assuefiant de natura judicare per *instantias crucis* et experimenta lucifera, et non per rationes probabiles.

2.37 Inter *praerogativas instantiarum* ponemus loco decimo quinto *Instantias Divortii*; quae indicant separationes naturarum earum quae ut plurimum occurrunt. Differunt autem ab instantiis quae subjunguntur *instantiis comitatus*; quia illae indicant separationes naturae alicujus ab aliquo concreto cum quo illa familiariter consuescit, hae vero separationes naturae alicujus ab altera natura. Differunt etiam ab *instantiis crucis*; quia nihil determinant, sed monent tantum de separabilitate unius naturae ab altera. Usus autem earum est ad prodendas falsas formas, et dissipandas leves contemplationes ex rebus obviis orientes; adeo ut veluti plumbum et pondera intellectui addant.

Exempli gratia: sint naturae inquisitae quatuor naturae illae, quas *Contubernales* vult esse Telesius, et tanquam ex eadem camera; viz. calidum, lucidum, tenue, mobile sive promptum ad motum. At plurimae inveniuntur *instantiae divortii* inter ipsas. Aer enim tenuis est et habilis ad motum, non calidus aut lucidus; luna lucida, absque calore; aqua fervens calida, absque lumine; motus acus ferreae super versorium pernix et agilis, et tamen in corpore frigido, denso, opaco; et complura id genus.

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But a more exact *crucial instance* suited to this matter could be had if the point can perhaps be shown by two-colored flames. Take a small metal cup and fix a small lighted wax candle in it. Set the cup in a dish and pour a moderate amount of spirit of wine around it, not reaching the rim of the cup. Then light the spirit of wine. The spirit of wine will give a flame that is bluer, the candle's wick one that is yellower. Note, then, whether the flame of the wick stays pyramidal, or tends rather toward a globular shape, since nothing is found there to destroy or compress it. (It is easy to tell the wick's flame from the flame of the spirit of wine by its color, for flames do not mix at once as liquids do.)

If the latter happens, it must be taken as certain that flame remains numerically the same as long as it is enclosed within another flame and does not feel the hostile force of the air.

Let this be enough about *crucial instances*. We have treated them at some length for this purpose: that people may gradually learn and grow used to judging nature by *crucial instances* and experiments of light, and not by plausible arguments.

Among the *prerogative instances* we will put in fifteenth place *Instances of Divorce*. These show the separation of natures that usually occur together. They differ from the instances appended to *Instances of Companionship*: those show the separation of some nature from some concrete body with which it is regularly found, whereas these show the separation of one nature from another nature. They differ also from *Crucial Instances*, because they settle nothing and only warn that one nature can be separated from another. Their use is to expose false forms and to dispel flimsy speculations that arise from obvious things. In this way they add, as it were, lead and weights to the understanding.

For example, let the natures under inquiry be the four natures that Telesio holds to be *Messmates*, as if they came from the same chamber: namely hot, bright, rare, and mobile or ready to move. Yet very many *Instances of Divorce* are found among them. Air is rare and apt for motion, but not hot or bright. The moon is bright but without heat. Boiling water is hot but without light. The motion of an iron needle on its pivot is swift and nimble, and

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Similiter sint naturae inquisitae Natura Corporea et Actio Naturalis. Videtur enim non inveniri actio naturalis, nisi subsistens in aliquo corpore. Attamen possit fortasse esse circa hanc rem *instantia* nonnulla *divortii*. Ea est actio magnetica, per quam ferrum fertur ad magnetem, gravia ad globum terrae. Addi etiam possint aliae nonnullae operationes ad distans. Actio siquidem hujusmodi et in tempore fit, per momenta non in puncto temporis, et in loco, per gradus et spatia. Est itaque aliquod momentum temporis, et aliquod intervallum loci, in quibus ista virtus sive actio haeret in medio inter duo illa corpora quae motum cient.

Reducitur itaque contemplatio ad hoc; utrum illa corpora quae sunt termini motus disponant vel alterent corpora media, ut per successionem et tactum verum labatur virtus a termino ad terminum, et interim subsistat in corpore medio; an horum nihil sit, praeter corpora et virtutem et spatia? Atque in radiis opticis et sonis et calore et aliis nonnullis operantibus ad distans, probabile est media corpora disponi et alterari: eo magis, quod requiratur medium qualificatum ad deferendam operationem talem. At magnetica illa sive coitiva virtus admittit media tanquam adiaphora, nec impeditur virtus in omnigeno medio.

Quod si nil rei habeat virtus illa aut actio cum corpore medio, sequitur quod sit virtus aut actio naturalis ad tempus nonnullum et in loco nonnullo subsistens sine corpore; cum neque subsistat in corporibus terminantibus, nec in mediis. Quare actio magnetica poterit esse *instantia divortii* circa naturam corpoream et actionem naturalem. Cui hoc adjici potest tanquam corollarium aut lucrum non praetermittendum: viz. quod etiam secundum sensum philosophanti sumi possit probatio quod sint entia et substantiae separatae et incorporeae. Si enim virtus et actio naturalis, emanans a corpore, subsistere possit aliquo tempore et aliquo loco omnino sine corpore; prope est ut possit etiam emanare in origine sua a substantia incorporea.

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yet it occurs in a cold, dense, opaque body. There are many more of this sort.

Similarly, let the natures under inquiry be Bodily Nature and Natural Action. It seems that no natural action is found except as subsisting in some body. Yet perhaps there may be some *Instance of Divorce* on this point. That instance is magnetic action, by which iron is drawn to a magnet and heavy bodies to the globe of the earth. Some other operations at a distance may be added as well. Action of this kind takes place in time, by moments and not in an instant, and in space, by degrees and distances. There is therefore some moment of time and some interval of space in which this power or action hangs midway between the two bodies that produce the motion.

The inquiry therefore comes down to this. Either the bodies at the two ends of the motion dispose or alter the intervening bodies, so that the power passes from end to end by succession and actual contact and meanwhile subsists in the intervening body. Or there is nothing of the sort, but only the bodies, the power, and the distances. With rays of light, sounds, heat, and some other things that operate at a distance, it is probable that the intervening bodies are disposed and altered. This is all the more likely because a medium with suitable qualities is required to carry such an operation. But the magnetic or uniting power treats media as indifferent, and no kind of medium blocks it.

If that power or action has nothing to do with the intervening body, it follows that a natural power or action subsists for some time and in some place without a body, since it subsists neither in the bodies at either end nor in those between. Magnetic action may therefore be an *Instance of Divorce* between bodily nature and natural action. To this may be added a corollary, a gain not to be passed over. Even someone who philosophizes according to the senses may derive from it a proof that there are separate and incorporeal beings and substances. For if a natural power and action emanating from a body can subsist for some time and in some place entirely without a body, it comes close to showing that it can also emanate, at its origin, from an incorporeal substance.

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	Videtur enim non minus requiri natura corporea ad actionem naturalem sustentandam et devehendam, quam ad excitandam aut generandam.	For bodily nature seems to be required no less to sustain and convey natural action than to arouse or generate it.

INSTANCES OF THE LAMP

Five kinds of instances help the senses, from microscopes and telescopes to signs of hidden processes.

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2.38	Sequuntur quinque ordines *instantiarum*, quas uno vocabulo generali *Instantias Lampadis* sive *Informationis Primae* appellare consuevimus. Eae sunt quae auxiliantur sensui. Cum enim omnis *interpretatio naturae* incipiat a sensu, atque a sensuum perceptionibus recta, constanti, et munita via ducat ad perceptiones intellectus, quae sunt notiones verae et axiomata; necesse est ut, quanto magis copiosae et exactae fuerint repraesentationes sive praebitiones ipsius sensus, tanto omnia cedant facilius et foelicius.	Next come five orders of instances, which we usually call by one general name: *Instances of the Lamp*, or *of First Information*. These are the instances that aid the senses. All *interpretation of nature* begins from the senses. It leads by a straight, steady, and secure road from the perceptions of the senses to the perceptions of the understanding, which are true notions and axioms. It follows that the more abundant and exact the representations or offerings of the senses themselves are, the more easily and successfully everything will go.
	Harum autem quinque *instantiarum lampadis*, primae roborant, ampliant, et rectificant actiones sensus immediatas; secundae deducunt non-sensibile ad sensibile; tertiae indicant processus continuatos sive series earum rerum et motuum quae (ut plurimum) non notantur nisi in exitu aut periodis; quartae aliquid substituunt sensui in meris destitutionibus; quintae excitant attentionem sensus et advertentiam, atque una limitant subtilitatem rerum. De his autem singulis jam dicendum est.	Of these five kinds of *Instances of the Lamp*, the first strengthen, enlarge, and correct the immediate actions of the senses. The second bring the non-sensible within reach of the senses. The third reveal continuous processes, or series, of things and motions that are for the most part noticed only at their end or at intervals. The fourth give the senses some substitute when they fail altogether. The fifth rouse the attention and alertness of the senses and at the same time set limits to the subtlety of things. We must now speak of each of them.
2.39	Inter *praerogativas instantiarum* ponemus loco decimo sexto *Instantias Januae* sive *Portae*: eo enim nomine eas appellamus quae juvant actiones sensus immediatas. Inter sensus autem manifestum est partes primas tenere Visum, quoad informationem; quare huic sensui praecipue auxilia conquirenda. Auxilia autem triplicia esse posse videntur: vel ut percipiat non visa; vel ut majore intervallo; vel ut exactius et distinctius.	Among the *prerogative instances* we will put in sixteenth place *Instances of the Door*, or *Gate*. That is the name we give to the instances that assist the immediate actions of the senses. Among the senses, sight plainly holds first place as far as information goes, so aids should be sought for this sense above all. The aids seem to be of three kinds: they let it perceive what is not seen, or see at a greater distance, or see more exactly and distinctly.
	Primi generis sunt (missis bis-oculis et hujusmodi, quae valent tantum ad corrigendam et levandam infirmitatem visus non bene dispositi, atque ideo nihil amplius informant) ea quae nuper inventa sunt perspicilla; quae latentes et invisibiles corporum minutias, et occultos	Spectacles and the like only correct and relieve the weakness of defective sight and so add no further information; we leave them aside. Of the first kind, then, are the recently invented glasses that reveal the hidden and invisible minute parts of

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schematismos et motus (aucta insigniter specierum magnitudine) demonstrant; quorum vi, in pulice, musca, vermiculis, accurata corporis figura et lineamenta, necnon colores et motus prius non conspicui, non sine admiratione cernuntur. Quinetiam aiunt lineam rectam calamo vel penicillo descriptam, per hujusmodi perspicilla inaequalem admodum et tortuosam cerni: quia scilicet nec motus manus, licet per regulam adjutae, nec impressio atramenti aut coloris revera aequalia existant; licet illae inaequalitates tam minutae sint ut sine adjumento hujusmodi perspicillorum conspici nequeant.

Etiam superstitiosam quandam observationem in hac re (ut fit in rebus novis et miris) addiderunt homines: viz. quod hujusmodi perspicilla opera naturae illustrent, artis dehonestent. Illud vero nihil aliud est quam quod texturae naturales multo subtiliores sint quam artificiosae. Perspicillum enim illud ad minuta tantum valet: quale perspicillum si vidisset Democritus, exiluisset forte, et modum videndi atomum (quem ille invisibilem omnino affirmavit) inventum fuisse putasset. Verum incompetentia hujusmodi perspicillorum, praeterquam ad minutias tantum (neque ad ipsas quoque, si fuerint in corpore majusculo), usum rei destruit.

Si enim inventum extendi posset ad corpora majora, aut corporum majorum minutias, adeo ut textura panni lintei conspici posset tanquam rete, atque hoc modo minutiae latentes et inaequalitates gemmarum, liquorum, urinarum, sanguinis, vulnerum, et multarum aliarum rerum, cerni possent, magnae proculdubio ex eo invento commoditates capi possent.

Secundi generis sunt illa altera perspicilla quae memorabili conatu adinvenit Galilaeus; quorum ope, tanquam per scaphas aut naviculas, aperiri et exerceri possint propiora cum coelestibus commercia. Hinc enim constat, galaxiam esse nodum sive coacervationem stellarum parvarum, plane numeratarum et distinctarum; de qua re apud antiquos tantum suspicio fuit. Hinc demonstrari videtur, quod spatia orbium (quos vocant) planetarum non sint plane vacua aliis stellis, sed quod coelum incipiat stellescere antequam ad coelum ipsum stellatum ventum sit; licet stellis minoribus quam ut sine perspicillis istis conspici possint. Hinc choreas

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bodies, and their concealed configurations and motions, by greatly magnifying their images. Through them the precise shape and outlines of the body of a flea, a fly, or small worms, as well as colors and motions not seen before, are observed, not without wonder. People even say that a straight line drawn with a pen or brush looks very uneven and crooked through such glasses. The reason is that neither the motion of the hand, even guided by a ruler, nor the impression of the ink or paint is really even. Those irregularities are so minute that they cannot be seen without the help of such glasses.[28]

People have also added a rather superstitious observation on this subject, as happens with new and marvelous things: that such glasses show off the works of nature and disgrace the works of art. But this means nothing more than that natural textures are much finer than artificial ones. The glass is effective only for minute things. If Democritus had seen such a glass, he might have leapt for joy, thinking that a way of seeing the atom, which he declared wholly invisible, had been found. But these glasses are useless for anything except minute things, and even for those only when they are not part of a somewhat larger body. This destroys their usefulness.

Suppose the invention could be extended to larger bodies, or to the minute parts of larger bodies. Then the texture of linen cloth could be seen like a net, and the hidden minute parts and irregularities of gems, liquids, urine, blood, wounds, and many other things could be observed. Great benefits would doubtless be gained from that invention.

Of the second kind are those other glasses that Galileo devised with memorable effort. With their help, as if by boats or small ships, closer dealings with the heavens can be opened up and carried on. From them it is established that the Milky Way is a cluster or heap of small stars, clearly counted and distinct, a thing the ancients only suspected. From them it seems to be shown that the spaces of the planetary orbs, as they call them, are not wholly empty of other stars. The heaven begins to be starry before one reaches the starry heaven it-

28 Bacon means the compound microscope, developed in the Netherlands in the early seventeenth century.

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illas stellarum parvarum circa planetam Jovis (unde conjici possit esse in motibus stellarum plura centra) intueri licet. Hinc inaequalitates luminosi et opaci in luna distinctius cernuntur et locantur; adeo ut fieri possit quaedam seleno-graphia.

Hinc maculae in sole, et id genus: omnia certe inventa nobilia, quatenus fides hujusmodi demonstrationibus tuto adhiberi possit. Quae nobis ob hoc maxime suspectae sunt, quod in istis paucis sistatur experimentum, neque alia complura investigatu aeque digna eadem ratione inventa sint.

Tertii generis sunt bacilla illa ad terras mensurandas, astrolabia, et similia; quae sensum videndi non ampliant, sed rectificant et dirigunt. Quod si sint aliae instantiae quae reliquos sensus juvent in ipsorum actionibus immediatis et individuis, tamen si ejusmodi sint quae informationi ipsi nihil addant plus quam jam habetur, ad id quod nunc agitur non faciunt. Itaque earum mentionem non fecimus.

2.40 Inter *praerogativas instantiarum* ponemus loco decimo septimo *Instantias Citantes*, sumpto vocabulo a foris civilibus, quia citant ea ut compareant quae prius non comparuerunt; quas etiam *Instantias Evocantes* appellare consuevimus. Eae deducunt non-sensibile ad sensibile.

Sensum autem fugiunt res, vel propter distantiam objecti locati; vel propter interceptionem sensus per corpora media; vel quia objectum non est habile ad impressionem in sensu faciendam; vel quia deficit quantum in objecto pro feriendo sensu; vel quia tempus non est proportionatum ad actuandum sensum; vel quia objecti percussio non toleratur a sensu; vel quia objectum ante implevit et possedit sensum, ut novo motui non sit locus. Atque haec praecipue ad visum pertinent, et deinde ad tactum. Nam hi duo sensus sunt informativi ad largum, atque de communibus objectis; ubi reliqui tres non informent fere, nisi immediate et de propriis objectis.

In primo genere non fit deductio ad sensibile, nisi rei, quae cerni non possit propter distantiam, adjiciatur aut

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self, though with stars too small to be seen without those glasses. With them we can watch those dances of small stars around the planet Jupiter, from which one might conjecture that the motions of the stars have several centers. With them the unevenness of light and dark on the moon is more distinctly seen and located, so that a kind of selenography can be made.[29]

From them, too, come the spots on the sun, and the like. All these are certainly noble discoveries, so far as such demonstrations can safely be trusted. We are suspicious of them chiefly because the experiment stops at these few things, and many other things equally worth investigating have not been discovered by the same means.

Of the third kind are the rods used for measuring land, astrolabes, and the like. They do not enlarge the sense of sight but correct and direct it. There may be other instances that help the remaining senses in their immediate and individual actions. But if they add nothing to information beyond what we already have, they do not bear on our present business, so we have not mentioned them.

Among the *prerogative instances* we will put in seventeenth place *Summoning Instances*, taking the word from the law courts, because they summon to appear what did not appear before. We also call them *Evoking Instances*. They bring the non-sensible to the senses.

Things escape the senses for several reasons. The object may be too distant. The senses may be blocked by intervening bodies. The object may not be fit to make an impression on the senses. The object may lack the quantity needed to strike the senses. The time may not be proportioned to activate the senses. The senses may be unable to bear the impact of the object. Or the object may already have filled and occupied the senses, so that there is no room for a new motion. These causes concern chiefly sight, and next touch. These two senses inform broadly and about common objects, whereas the other three hardly inform us except directly and about their own proper objects.

In the first kind, a thing that cannot be seen because of its distance is brought to the senses only if something else is added to it or put in its place

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substituatur alia res quae sensum magis e longinquo provocare et ferire possit: veluti in significatione rerum per ignes, campanas, et similia.

In secundo genere fit deductio, cum ea quae interius propter interpositionem corporum latent, nec commode aperiri possunt, per ea quae sunt in superficie, aut ab interioribus effluunt, perducuntur ad sensum: ut status humanorum corporum per pulsus, et urinas, et similia.

At tertii et quarti generis deductiones ad plurima spectant, atque undique in rerum inquisitione sunt conquirendae. Hujus rei exempla sunt. Patet quod aer, et spiritus, et hujusmodi res quae sunt toto corpore tenues et subtiles, nec cerni nec tangi possint. Quare in inquisitione circa hujusmodi corpora deductionibus omnino est opus.

Sit itaque natura inquisita Actio et Motus Spiritus qui includitur in corporibus tangibilibus. Omne enim tangibile apud nos continet spiritum invisibilem et intactilem, eique obducitur atque eum quasi vestit. Hinc fons triplex potens ille et mirabilis processus spiritus in corpore tangibili. Spiritus enim in re tangibili, emissus, corpora contrahit et desiccat; detentus, corpora intenerat et colliquat; nec prorsus emissus nec prorsus detentus, informat, membrificat, assimilat, egerit, organizat, et similia. Atque haec omnia deducuntur ad sensibile per effectus conspicuos.

Etenim in omni corpore tangibili inanimato, spiritus inclusus primo multiplicat se, et tanquam depascit partes tangibiles eas quae sunt maxime ad hoc faciles et praeparatae, easque digerit et conficit et vertit in spiritum, et deinde una evolant. Atque haec confectio et multiplicatio spiritus deducitur ad sensum per diminutionem ponderis. In omni enim desiccatione, aliquid defluit de quanto; neque id ipsum ex spiritu tantum praeinexistente, sed ex corpore quod prius fuit tangibile et noviter versum est: spiritus enim non ponderat. Egressus autem sive emissio spiritus deducitur ad sensibile in rubigine metallorum, et aliis putrefactionibus ejus generis quae sistunt se antequam

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that can stimulate and strike the senses from farther off. This is how things are signaled by fires, bells, and the like.

In the second kind, things lie hidden inside because of intervening bodies and cannot conveniently be opened up. They are brought to the senses through what is on the surface or flows out from the interior. The condition of human bodies is known in this way through the pulse, urine, and the like.

But bringing things to the senses in the third and fourth kinds extends to a great many cases and must be sought everywhere in the investigation of things. Here are examples. Air, spirit, and similar things that are rare and subtle throughout their whole body plainly can be neither seen nor touched. So in inquiry about such bodies it is absolutely necessary to bring them to the senses.

Let the nature under inquiry, then, be the Action and Motion of the Spirit enclosed in tangible bodies. Every tangible thing among us contains an invisible and intangible spirit, which it covers over and, as it were, clothes. From this comes the threefold source of the powerful and wonderful process of spirit in a tangible body. When spirit in a tangible thing is emitted, it contracts and dries bodies. When it is retained, it softens and melts them. When it is neither wholly emitted nor wholly retained, it shapes them, forms limbs, assimilates, excretes, organizes, and the like. All these things are brought to the senses through visible effects.

In every inanimate tangible body, the enclosed spirit first multiplies itself. It feeds, as it were, on the tangible parts that are most readily available and prepared for this. It digests them, works them up, and turns them into spirit, and then they fly off together. This working-up and multiplication of spirit is brought to the senses by the decrease in weight. In all drying something is lost from the quantity. This loss comes not only from the spirit already present, but from the body that was previously tangible and has been newly converted, for spirit has no weight. The going out, or emission, of

29 Galileo Galilei (1564–1642) reported his telescopic discoveries, including the moons of Jupiter, in *Sidereus Nuncius* (1610). Selenography is the mapping of the moon.

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pervenerint ad rudimenta vitae; nam illae ad tertium genus processus pertinent.

Etenim in corporibus magis compactis spiritus non invenit poros et meatus per quos evolet: itaque cogitur partes ipsas tangibiles protrudere et ante se agere, ita ut illae simul exeant; atque inde fit rubigo, et similia. At contractio partium tangibilium, postquam aliquid de spiritu fuerit emissum (unde sequitur illa desiccatio), deducitur ad sensibile tum per ipsam duritiem rei auctam, tum multo magis per scissuras, angustiationes, corrugationes, et complicationes corporum, quae inde sequuntur. Etenim partes ligni desiliunt et angustiantur; pelles corrugantur; neque id solum, sed (si subita fuerit emissio spiritus per calorem ignis) tantum properant ad contractionem ut se complicent et convolvant.

At contra, ubi spiritus detinetur, et tamen dilatatur et excitatur per calorem aut ejus analoga (id quod fit in corporibus magis solidis aut tenacibus), tum vero corpora emolliuntur, ut ferrum candens; fluunt, ut metalla; liquefiunt, ut gummi, cera, et similia. Itaque contrariae illae operationes caloris (ut ex eo alia durescant, alia liquescant) facile conciliantur; quia in illis spiritus emittitur, in his agitatur et detinetur: quorum posterius est actio propria caloris et spiritus; prius, actio partium tangibilium tantum per occasionem spiritus emissi.

Ast ubi spiritus nec detinetur prorsus nec prorsus emittitur, sed tantum inter claustra sua tentat et experitur, atque nacta est partes tangibiles obedientes et sequaces in promptu, ita ut quo spiritus agit eae simul sequantur; tum vero sequitur efformatio in corpus organicum, et membrificatio, et reliquae actiones vitales, tam in vegetabilibus quam in animalibus. Atque haec maxime deducuntur ad sensum per notationes diligentes primorum incoeptuum et rudimentorum sive tentamentorum vitae in animalculis ex putrefactione natis: ut in ovis formicarum, vermibus, muscis, ranis post imbrem, etc. Requiritur autem ad vivificationem et lenitas caloris et lentor corporis; ut spiritus nec per festinationem erumpat, nec per contumaciam partium coerceatur, quin potius ad cerae modum illas plicare et effingere possit.

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spirit is brought to the senses in the rusting of metals and in other putrefactions of that kind that stop before they reach the rudiments of life. Those that reach life belong to the third kind of process.

In more compact bodies the spirit does not find pores and passages through which to fly off. So it is compelled to push out the tangible parts themselves and drive them before it, so that they go out together; hence rust and the like. After some of the spirit has been emitted, the tangible parts contract, and this is what produces drying. That contraction is brought to the senses both by the increased hardness of the thing itself and much more by the cracks, shrinkings, wrinklings, and foldings of bodies that follow. The parts of wood split apart and shrink; skins wrinkle. If the emission of spirit is sudden, through the heat of fire, they even hurry so fast to contract that they fold and roll themselves up.

On the other hand, the spirit may be retained and yet expanded and stirred up by heat or its analogues, which happens in more solid or tenacious bodies. Then bodies are softened, like red-hot iron; flow, like metals; or melt, like gums, wax, and the like. So the contrary operations of heat, by which some things harden and others melt, are easily reconciled. In the first case the spirit is emitted; in the second it is agitated and retained. The second is the proper action of heat and spirit. The first is the action of the tangible parts alone, occasioned by the emission of the spirit.

But sometimes the spirit is neither wholly retained nor wholly emitted, but only tries and tests itself within its enclosures, and has at hand tangible parts that are obedient and ready to follow wherever it acts. Then the body is shaped into an organic body, limbs are formed, and the other vital actions follow, in plants as well as in animals. These things are brought to the senses above all by careful observation of the first beginnings, rudiments, or attempts of life in little animals born from putrefaction: in ants' eggs, worms, flies, frogs after rain, and so on. Vivification requires both gentle heat and a pliant body. Then the spirit neither bursts out through haste nor is confined by the stubbornness of the parts, but can fold and mold them like wax.

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Rursus, differentia illa spiritus, maxime nobilis et ad plurima pertinens (viz. spiritus abscissi, ramosi simpliciter, ramosi simul et cellulati; ex quibus prior est spiritus omnium corporum inanimatorum, secundus vegetabilium, tertius animalium), per plurimas instantias deductorias tanquam sub oculos ponitur.

Similiter patet, quod subtiliores texturae et schematismi rerum (licet toto corpore visibilium aut tangibilium) nec cernantur nec tangantur. Quare in his quoque per deductionem procedit informatio. At differentia schematismorum maxime radicalis et primaria sumitur ex copia vel paucitate materiae quae subit idem spatium sive dimensum. Reliqui enim schematismi (qui referuntur ad dissimilaritates partium, quae in eodem corpore continentur, et collocationes ac posituras earundem) prae illo altero sunt secundarii.

Sit itaque natura inquisita Expansio sive Coitio Materiae in corporibus respective: viz. quantum materiae impleat quantum dimensum in singulis. Etenim nil verius in natura quam propositio illa gemella, *ex nihilo nihil fieri*, neque *quicquam in nihilum redigi:* verum quantum ipsum materiae sive summam totalem constare, nec augeri aut minui. Nec illud minus verum, *ex quanto illo materiae sub iisdem spatiis sive dimensionibus, pro diversitate corporum, plus et minus contineri:* ut in aqua plus, in aere minus; adeo ut si quis asserat aliquod contentum aquae in par contentum aeris verti posse, idem sit ac si dicat aliquid posse redigi in nihilum; contra, si quis asserat aliquod contentum aeris in par contentum aquae verti posse, idem sit ac si dicat aliquid posse fieri ex nihilo.

Atque ex copia ista et paucitate materiae notiones illae *densi* et *rari*, quae varie et promiscue accipiuntur, proprie abstrahuntur. Assumenda est et assertio illa tertia, etiam satis certa: quod hoc de quo loquimur plus et minus materiae in corpore hoc vel illo ad calculos (facta collatione) et proportiones exactas aut exactis propinquas reduci possit. Veluti si quis dicat inesse in dato contento auri talem coacervationem materiae, ut opus habeat spiritus vini, ad tale quantum materiae

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Again, there is a distinction among spirits that is most noble and bears on a great many things. Spirit may be discontinuous, simply branching, or both branching and celled. The first is the spirit of all inanimate bodies, the second that of plants, the third that of animals. This distinction is placed, as it were, before our eyes by a great many instances that bring it to the senses.

Likewise, the finer textures and configurations of things plainly can be neither seen nor touched, though the bodies as a whole are visible or tangible. So here too information proceeds by bringing things to the senses. The most radical and primary difference of configurations is taken from the abundance or scarcity of matter occupying the same space or dimension. The other configurations are secondary compared with this one. They relate to the dissimilarity of the parts contained in the same body, and to the arrangement and position of those parts.

Let the nature under inquiry, then, be the Expansion or Contraction of Matter in bodies relative to one another: that is, how much matter fills how much space in each. Nothing in nature is truer than the twin proposition *that nothing is made from nothing*, and *that nothing is reduced to nothing*. Rather, the quantity of matter itself, its total sum, stays constant and is neither increased nor diminished. It is no less true that *out of that quantity of matter more or less is contained in the same spaces or dimensions, according to the difference of bodies*: more in water, for instance, and less in air. So if someone asserts that some volume of water can be turned into an equal volume of air, it is the same as saying that something can be reduced to nothing. Conversely, if someone asserts that some volume of air can be turned into an equal volume of water, it is the same as saying that something can be made from nothing.

From this abundance and scarcity of matter the notions of *dense* and *rare*, which are used in varied and confused ways, are properly abstracted. A third assertion, also quite certain, must be adopted as well. This greater and lesser amount of matter in one body or another can, by comparison, be reduced to calculation and to exact or nearly exact ratios. Someone might say, for instance, that a giv-

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aequandum, spatio vicies et semel majore quam implet aurum, non erraverit.

Coacervatio autem materiae et rationes ejus deducuntur ad sensibile per pondus. Pondus enim respondet copiae materiae, quoad partes rei tangibilis; spiritus autem, et ejus quantum ex materia, non venit in computationem per pondus; levat enim pondus potius quam gravat. At nos hujus rei tabulam fecimus satis accuratam; in qua pondera et spatia singulorum metallorum, lapidum praecipuorum, lignorum, liquorum, oleorum, et plurimorum aliorum corporum tam naturalium quam artificialium, excepimus: rem polychrestam, tam ad lucem informationis quam ad normam operationis; et quae multas res revelet omnino praeter expectatum.

Neque illud pro minimo habendum est, quod demonstret omnem varietatem quae in corporibus tangibilibus nobis notis versatur (intelligimus autem corpora bene unita, nec plane spongiosa et cava et magna ex parte aere impleta) non ultra rationes partium 21 excedere: tam finita scilicet est natura, aut saltem illa pars ejus cujus usus ad nos maxime pertinet.

Etiam diligentiae nostrae esse putavimus, experiri si forte capi possint rationes corporum non tangibilium sive pneumaticorum, respectu corporum tangibilium. Id quod tali molitione aggressi sumus. Phialam vitream accepimus, quae unciam fortasse unam capere possit; parvitate vasis usi, ut minori cum calore posset fieri evaporatio sequens. Hanc phialam spiritu vini implevimus fere ad collum; eligentes spiritum vini, quod per tabulam priorem eum esse ex corporibus tangibilibus (quae bene unita, nec cava sunt) rarissimum, et minimum continens materiae sub suo dimenso, observavimus. Deinde pondus aquae cum phiala ipsa exacte notavimus. Postea vesicam accepimus, quae circa duas pintas contineret.

Ex ea aerem omnem, quoad fieri potuit, expressimus eo usque ut vesicae ambo latera essent contigua: etiam prius vesicam oleo oblevimus cum fricatione leni, quo vesica esset clausior: ejus, si qua erat, porositate oleo obturata. Hanc vesicam circa os phialae, ore phialae intra os

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en volume of gold contains so great an accumulation of matter that spirit of wine would need a space twenty-one times larger than the gold fills to match that quantity of matter. He would not be wrong.

The accumulation of matter and its ratios are brought to the senses by weight. Weight corresponds to the quantity of matter as regards the parts of the tangible thing. Spirit, however, and its quantity of matter, do not enter into a calculation by weight, since spirit lightens weight rather than adding to it. We have made a fairly accurate table of this. In it we recorded the weights and volumes of the individual metals, the principal stones, woods, liquids, oils, and a great many other bodies, both natural and artificial. It is a thing of many uses, both for the light it gives to information and as a rule for operation, and it reveals many things wholly beyond expectation.

Nor should it be counted a small thing that the table shows the limits of variety in the tangible bodies known to us. We mean bodies that are well compacted, not wholly spongy and hollow and largely filled with air. All their variety does not exceed the ratio of 21 to 1. So finite is nature, or at least the part of it whose use chiefly concerns us.

We also thought it part of our diligence to test whether the ratios of non-tangible, or pneumatic, bodies to tangible bodies could be obtained. We went about it by the following device. We took a glass vial that might hold about one ounce. We used a small vessel so that the evaporation to follow could be done with less heat. We filled the vial with spirit of wine almost up to the neck. We chose spirit of wine because we had observed from the earlier table that, among tangible bodies that are well compacted and not hollow, it is the rarest and contains the least matter within its volume. Next we noted exactly the weight of the water together with the vial itself. Then we took a bladder that held about two pints.[30]

We squeezed all the air out of the bladder, as far as possible, until its two sides were touching. We had first rubbed it gently with oil to make it tighter, so that the oil would stop up any porosity it had. We tied the bladder firmly around the mouth of the

30 Bacon writes “water” here, though the vial holds spirit of wine.

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vesicae recepto, fortiter ligavimus; filo parum cerato, ut melius adhaeresceret et arctius ligaret. Tum demum phialam supra carbones ardentes in foculo collocavimus. At paulo post vapor sive aura spiritus vini, per calorem dilatati et in pneumaticum versi, vesicam paulatim sufflavit, eamque universam veli instar undequaque extendit. Id postquam factum fuit, continuo vitrum ab igne removimus, et super tapetem posuimus ne frigore disrumperetur; statim quoque in summitate vesicae foramen fecimus, ne vapor, cessante calore, in liquorem restitutus resideret, et rationes confunderet.

Tum vero vesicam ipsam sustulimus, et rursus pondus excepimus spiritus vini qui remanebat. Inde quantum consumptum fuisset in vaporem seu pneumaticum computavimus: et facta collatione quantum locum sive spatium illud corpus implesset quando esset spiritus vini in phiala, et rursus quantum spatium impleverit postquam factum fuisset pneumaticum in vesica, rationes subduximus: ex quibus manifeste liquebat, corpus istud ita versum et mutatum expansionem centuplo majorem quam antea habuisset acquisivisse.

Similiter sit natura inquisita Calor aut Frigus; ejus nempe gradus, ut a sensu non percipiantur ob debilitatem. Haec deducuntur ad sensum per vitrum calendare, quale superius descripsimus. Calor enim et frigus, ipsa non percipiuntur ad tactum; at calor aerem expandit, frigus contrahit. Neque rursus illa expansio et contractio aeris percipitur ad visum; at aer ille expansus aquam deprimit, contractus attollit; ac tum demum fit deductio ad visum, non ante, aut alias.

Similiter sit natura inquisita Mistura Corporum: viz. quid habeant ex aqueo, quid ex oleoso, quid ex spiritu, quid ex cinere et salibus, et hujusmodi; vel etiam (in particulari) quid habeat lac butyri, quid coaguli, quid seri, et hujusmodi. Haec deducuntur ad sensum per artificiosas et peritas separationes, quatenus ad tangibilia. At natura spiritus in ipsis, licet immediate non percipiatur, tamen deprehenditur per varios motus et nixus corporum tangibilium in ipso actu et processu separationis suae; atque etiam per acrimonias, corrosiones, et diversos colores, odores, et sapores eorundem corporum post separationem.

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vial, with the mouth of the vial inside the mouth of the bladder. We used a lightly waxed thread so that it would stick better and bind more tightly. Then at last we set the vial over burning coals in a brazier. Shortly afterward the vapor or breath of the spirit of wine, expanded by the heat and turned pneumatic, gradually inflated the bladder and stretched it out on every side like a sail. As soon as this happened, we removed the glass from the fire and set it on a carpet so that the cold would not crack it. At once we also made a hole in the top of the bladder. This was so that the vapor, once the heat stopped, would not return to liquid, settle back, and confuse the ratios.

Then we took off the bladder and weighed the spirit of wine that remained. From that we calculated how much had been consumed into vapor, or pneumatic body. We compared how much place or space that body had filled as spirit of wine in the vial with how much space it filled after it had become pneumatic in the bladder, and worked out the ratios. These plainly showed that the body, thus converted and changed, had acquired an expansion a hundred times greater than before.

Similarly, let the nature under inquiry be Heat or Cold, specifically degrees of them too weak to be perceived by the senses. These are brought to the senses by the calendar glass we described above. Heat and cold themselves are not perceived by touch in such cases, but heat expands air and cold contracts it. Nor, again, is that expansion and contraction of air perceived by sight. But the expanded air pushes the water down and the contracted air draws it up. Only then is the change brought to sight, not before or otherwise.

Similarly, let the nature under inquiry be the Mixture of Bodies: what they contain of the watery, the oily, spirit, ash and salts, and the like. Or, in a particular case, how much butter milk contains, how much curd, how much whey, and so on. As far as the tangible parts go, these are brought to the senses by skilled and expert separations. The nature of the spirit in them is not perceived directly. Yet it is detected by the various motions and strivings of the tangible bodies in the very act and process of their separation. It is also detected by the sharpness, corrosiveness, and various colors, smells, and tastes of those bodies after separation.

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Atque in hac parte, per distillationes atque artificiosas separationes, strenue sane ab hominibus elaboratum est; sed non multo foelicius quam in caeteris experimentis, quae adhuc in usu sunt: modis nimirum prorsus palpatoriis, et viis caecis, et magis operose quam intelligenter; et (quod pessimum est) nulla cum imitatione aut aemulatione naturae, sed cum destructione (per calores vehementes aut virtutes nimis validas) omnis subtilioris schematismi, in quo occultae rerum virtutes et consensus praecipue sitae sunt. Neque illud etiam, quod alias monuimus, hominibus in mentem aut observationem venire solet in hujusmodi separationibus: hoc est, plurimas qualitates, in corporum vexationibus tam per ignem quam alios modos, indi ab ipso igne iisque corporibus quae ad separationem adhibentur, quae in composito prius non fuerunt; unde mirae fallaciae.

Neque enim scilicet vapor universus, qui ex aqua emittitur per ignem, vapor aut aer antea fuit in corpore aquae; sed factus est maxima ex parte per dilatationem aquae ex calore ignis.

Similiter in genere omnes exquisitae probationes corporum sive naturalium sive artificialium, per quas vera dignoscuntur ab adulterinis, meliora a vilioribus, huc referri debent: deducunt enim non-sensibile ad sensibile. Sunt itaque diligenti cura undique conquirendae.

5. Quintum vero genus latitantiae quod attinet, manifestum est actionem sensus transigi in motu, motum in tempore. Si igitur motus alicujus corporis sit vel tam tardus, vel tam velox, ut non sit proportionatus ad momenta in quibus transigitur actio sensus, objectum omnino non percipitur; ut in motu indicis horologii, et rursus in motu pilae sclopeti. Atque motus qui ob tarditatem non percipitur, facile et ordinario deducitur ad sensum per summas motus; qui vero ob velocitatem, adhuc non bene mensurari consuevit; sed tamen postulat inquisitio naturae ut hoc fiat in aliquibus.

6. Sextum autem genus, ubi impeditur sensus propter nobilitatem objecti, recipit deductionem, vel per elongationem majorem objecti a sensu; vel per hebetationem objecti per interpositionem medii talis, quod objectum debilitet, non annihilet; vel per

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In this area people have certainly worked hard at distillations and skilled separations. But they have had little more success than in the other experiments still in use. Their methods are wholly groping, their paths blind, and their work more laborious than intelligent. Worst of all, they do not imitate or emulate nature. Instead, by violent heats or overly strong agents, they destroy all the subtler configuration in which the hidden virtues and sympathies of things chiefly reside. There is also a point we have made elsewhere that does not usually enter people's minds or observation in such separations. When bodies are tortured by fire or by other means, many qualities are imparted by the fire itself and by the bodies used for the separation, qualities that were not in the compound before. This gives rise to remarkable errors.

Not all the vapor given off from water by fire, of course, was vapor or air in the body of the water before. Most of it was made by the expansion of the water through the heat of the fire.

Similarly, all the refined tests of bodies in general, natural or artificial, belong here: the tests by which the genuine is told from the counterfeit and the better from the worse. They bring the non-sensible to the senses and should therefore be sought out everywhere with careful diligence.

5. As for the fifth kind of concealment, the action of the senses plainly takes place in motion, and motion in time. So if the motion of some body is either so slow or so fast that it is not proportioned to the moments in which the senses act, the object is not perceived at all. Examples are the motion of the hand of a clock and, again, the motion of a musket ball. Motion that is not perceived because of its slowness is easily and routinely brought to the senses by summing up the motion. Motion that is not perceived because of its speed has not yet usually been well measured. Yet the inquiry into nature requires that this be done in some cases.

6. In the sixth kind, the senses are hindered by the overpowering strength of the object. Such an object can be brought to the senses in three ways. It can be moved farther away from the senses. It can be dulled by placing between it and the senses a medium that weakens it without destroying it. Or,

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admissionem et exceptionem objecti reflexi, ubi percussio directa sit nimis fortis, ut solis in pelvi aquae.

7. Septimum autem genus latitantiae, ubi sensus ita oneratur objecto ut novae admissioni non sit locus, non habet fere locum nisi in olfactu et odoribus; nec ad id quod agitur multum pertinet. Quare de deductionibus non-sensibilis ad sensibile, haec dicta sint.

Quandoque tamen deductio fit non ad sensum hominis, sed ad sensum alicujus alterius animalis cujus sensus in aliquibus humanum excellet: ut nonnullorum odorum, ad sensum canis; lucis, quae in aere non extrinsecus illuminato latenter existit, ad sensum felis, noctuae, et hujusmodi animalium quae cernunt noctu. Recte enim notavit Telesius, etiam in aere ipso inesse lucem quandam originalem, licet exilem et tenuem, et maxima ex parte oculis hominum aut plurimorum animalium non inservientem; qui illa animalia, ad quorum sensum hujusmodi lux est proportionata, cernant noctu; id quod vel sine luce fieri, vel per lucem internam, minus credibile est.

Atque illud utique notandum est, de destitutionibus sensuum eorumque remediis hic nos tractare. Nam fallaciae sensuum ad proprias inquisitiones de sensu et sensibili remittendae sunt: excepta illa magna fallacia sensuum nimirum quod constituant lineas rerum ex analogia hominis, et non ex analogia universi; quae non corrigitur nisi per rationem et philosophiam universalem.

2.41 Inter *praerogativas instantiarum* ponemus loco decimo octavo *Instantias Viae*, quas etiam *Instantias Itinerantes* et *Instantias Articulatas* appellare consuevimus. Eae sunt quae indicant naturae motus gradatim continuatos. Hoc autem genus instantiarum potius fugit observationem quam sensum. Mira enim est hominum circa hanc rem indiligentia. Contemplantur siquidem naturam tantummodo desultorie et per periodos, et postquam corpora fuerint absoluta ac completa, et non in operatione sua. Quod si artificis alicujus ingenia et industriam explorare et contemplari quis cuperet, is non tantum materias rudes artis atque deinde opera perfecta conspicere desideraret, sed potius praesens esse cum artifex operatur et opus suum promovet. Atque simile quiddam circa naturam faciendum est.

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where the direct impact is too strong, it can be admitted and received by reflection, as when the sun is viewed in a basin of water.

7. In the seventh kind of concealment, the senses are so burdened by an object that there is no room to admit a new one. This occurs hardly anywhere except in smell and odors, and it does not much concern our present business. So much, then, for bringing the non-sensible to the senses.

Sometimes, however, a thing is brought not to the senses of man but to those of some other animal whose senses surpass the human in certain respects. Certain smells are brought to the sense of a dog in this way. So is the light that exists latently in air not illuminated from outside, which reaches the senses of the cat, the owl, and similar animals that see at night. Telesio rightly observed that air itself contains a certain original light, slight and feeble, and for the most part of no use to the eyes of men or of most animals. For the animals whose senses are proportioned to this kind of light see at night. That they should do so either without light or by an internal light is less credible.

It should certainly be noted that we are dealing here with the failures of the senses and their remedies. The deceptions of the senses belong to the special inquiries into sense and the sensible. There is one exception, the great deception of the senses: they draw the outlines of things on the analogy of man and not on the analogy of the universe. This is corrected only by reason and universal philosophy.

Among the *prerogative instances* we will put in eighteenth place *Instances of the Road*, which we also call *Traveling Instances* and *Articulated Instances*. These are the instances that show the motions of nature continued step by step. This kind of instance escapes observation rather than the senses, for people are astonishingly careless on this point. They study nature only fitfully and at intervals, after bodies have been finished and completed, and not while nature is at work. Yet anyone wishing to explore and study the skill and industry of a craftsman would not be content to see the raw materials of the craft and then the finished works. He would rather be present while the craftsman is at work and moving his work for-

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ward. Something similar must be done with nature.

Exempli gratia; si quis de vegetatione plantarum inquirat, ei inspiciendum est ab ipsa satione seminis alicujus (id quod per extractionem, quasi singulis diebus, seminum quae per biduum, triduum, quatriduum, et sic deinceps, in terra manserunt, eorumque diligentem intuitum, facile fieri potest), quomodo et quando semen intumescere et turgere incipiat et veluti spiritu impleri; deinde quomodo corticulam rumpere et emittere fibras, cum latione nonnulla sui interim sursum, nisi terra fuerit admodum contumax; quomodo etiam emittat fibras, partim radicales deorsum, partim cauliculares sursum, aliquando serpendo per latera, si ex ea parte inveniat terram apertam et magis facilem; et complura id genus.

For example, someone inquiring into the growth of plants must watch from the very sowing of a seed. This can easily be done by taking out, almost every day, seeds that have lain in the earth for two days, three days, four days, and so on, and examining them carefully. He must watch how and when the seed begins to swell and puff up and, as it were, fill with spirit. Then he must see how it begins to break its little skin and put out fibers, meanwhile rising somewhat upward unless the earth is very stubborn. He must also see how it puts out fibers, some root-fibers downward and some stem-fibers upward, sometimes creeping sideways if it finds the earth open and easier on that side. And there are many more things of that kind.

Similiter facere oportet circa exclusionem ovorum; ubi facile conspici dabitur processus vivificandi et organizandi, et quid et quae partes fiant ex vitello, quid ex albumine ovi, et alia. Similis est ratio circa animalia ex putrefactione. Nam circa animalia perfecta et terrestria, per exectiones foetuum ex utero, minus humanum esset ista inquirere; nisi forte per occasiones abortuum, et venationum, et similium. Omnino igitur vigilia quaedam servanda est circa naturam, ut quae melius se conspiciendam praebeat noctu quam interdiu. Istae enim contemplationes tanquam nocturnae censeri possint, ob lucernae parvitatem et perpetuationem.

The same should be done with the hatching of eggs. There the process of vivifying and organizing will easily be seen, and which parts are made from the yolk, which from the white, and other things. The case is similar with animals born from putrefaction. With perfect animals that live on land, it would be less humane to investigate these things by cutting fetuses from the womb, except perhaps when occasion is offered by miscarriages, hunting, and the like. In general, then, a kind of watch must be kept over nature, since she lets herself be seen better by night than by day. These studies may be reckoned nocturnal, as it were, because the lamp is small and kept burning continuously.

Quin et in inanimatis idem tentandum est; id quod nos fecimus in inquirendis aperturis liquorum per ignem. Alius enim est modus aperturae in aqua, alius in vino, alius in aceto, alius in omphacio; longe alius in lacte, et oleo, et caeteris. Id quod facile cernere erat per ebullitionem super ignem lenem, et in vase vitreo, ubi omnia cerni perspicue possint. Verum haec brevius perstringimus; fusius et exactius de iis sermones habituri, cum ad inventionem *latentis* rerum *processus* ventum erit. Semper enim memoria tenendum est, nos hoc loco non res ipsas tractare, sed exempla tantum adducere.

The same must be attempted with inanimate things too. We did this in investigating how liquids open up under fire. The manner of opening is one in water, another in wine, another in vinegar, another in verjuice, and quite different again in milk, oil, and the rest. This was easy to see by boiling them over a gentle fire in a glass vessel, where everything could be seen clearly. But we touch on these things briefly. We intend to speak of them more fully and exactly when we come to the discovery of the *latent process* of things. It must always be remembered that we are not treating the things themselves here, but only offering examples.

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Inter *praerogativas instantiarum* ponemus loco decimo nono *Instantias Supplementi*, sive *Substitutionis*; quas etiam *Instantias Perfugii* appellare consuevimus. Eae sunt, quae supplent informationem ubi sensus plane destituitur; atque idcirco ad eas confugimus cum instantiae propriae haberi non possint. Dupliciter autem fit substitutio; aut per Graduationem, aut per Analoga. Exempli gratia: non invenitur medium quod inhibeat prorsus operationem magnetis in movendo ferrum; non aurum interpositum, non argentum, non lapis, non vitrum, lignum, aqua, oleum, pannus aut corpora fibrosa, aer, flamma, et caetera.

Attamen per probationem exactam fortasse inveniri possit aliquod medium, quod hebetet virtutem ipsius plus quam aliquod aliud, comparative et in aliquo gradu: veluti quod non trahat magnes ferrum per tantam crassitiem auri quam per par spatium aeris; aut per tantum argentum ignitum quam per frigidum; et sic de similibus. Nam de his nos experimentum non fecimus; sed sufficit tamen ut proponantur loco exempli. Similiter non invenitur hic apud nos corpus quod non suscipiat calidum igni approximatum. Attamen longe citius suscipit calorem aer quam lapis. Atque talis est substitutio quae fit per Gradus.

Substitutio autem per Analoga, utilis sane, sed minus certa est; atque idcirco cum judicio quodam adhibenda. Ea fit, cum deducitur non-sensibile ad sensum, non per operationes sensibiles ipsius corporis insensibilis, sed per contemplationem corporis alicujus cognati sensibilis. Exempli gratia: si inquiratur de Mistura Spirituum, qui sunt corpora non-visibilia, videtur esse cognatio quaedam inter corpora et fomites sive alimenta sua. Fomes autem flammae videtur esse oleum et pinguia; aeris, aqua et aquea: flammae enim multiplicant se super halitus olei, aer super vapores aquae. Videndum itaque de mistura aquae et olei, quae se manifestat ad sensum; quandoquidem mistura aeris et flammei generis fugiat sensum.

At oleum et aqua inter se per compositionem aut agitationem imperfecte admodum miscentur: eadem in herbis, et sanguine, et partibus animalium, accurate et delicate miscentur. Itaque simile quiddam fieri possit circa misturam flammei et aerei generis in spiritalibus: quae per confusionem simplicem non bene sustinent misturam, eadem tamen in spiritibus plantarum et animalium misceri videntur; praesertim cum omnis

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Among the *prerogative instances* we will put in nineteenth place *Supplementary Instances*, or *Instances of Substitution*, which we also call *Instances of Refuge*. These supply information where the senses fail entirely, so we take refuge in them when proper instances cannot be had. Substitution takes place in two ways: by gradation or by analogues. For example, no medium is found that entirely blocks the operation of a magnet in moving iron. Gold placed between them does not, nor does silver, stone, glass, wood, water, oil, cloth or fibrous bodies, air, flame, and the rest.

Yet exact testing might perhaps find some medium that dulls the magnet's power more than another does, comparatively and to some degree. Perhaps a magnet does not attract iron through as great a thickness of gold as through an equal space of air, or through as much red-hot silver as cold silver, and so on. We have not made the experiment on these, but it is enough to put them forward as examples. Similarly, no body is found here among us that does not take on heat when brought near fire. Yet air takes on heat far more quickly than stone. Such is substitution by degrees.

Substitution by analogues is certainly useful, but less certain, and so must be used with some judgment. It takes place when the non-sensible is brought to the senses not through the sensible operations of the imperceptible body itself, but through the study of some related body that is perceptible. Suppose, for example, the inquiry is into the Mixture of Spirits, which are invisible bodies. There seems to be a certain kinship between bodies and their fuels or nourishment. The fuel of flame seems to be oil and fatty things; that of air, water and watery things. Flames multiply themselves over the exhalations of oil, and air over the vapors of water. So we must look at the mixture of water and oil, which shows itself to the senses, since the mixture of air and the flame-like kind escapes the senses.

Now oil and water mix very imperfectly with each other when combined or shaken together. Yet in herbs, blood, and the parts of animals they mix precisely and delicately. So something similar may happen with the mixture of the flame-like and airy kinds among spirit-like bodies. They do not readily admit mixture by simple blending, yet

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spiritus animatus depascat humida utraque, aquea et pinguia, tanquam fomites suos.

Similiter si non de perfectioribus misturis spiritalium, sed de compositione tantum inquiratur; nempe, utrum facile inter se incorporentur, an potius (exempli gratia) sint aliqui venti et exhalationes, aut alia corpora spiritalia, quae non miscentur cum aere communi, sed tantum haerent et natant in eo, in globulis et guttis, et potius franguntur ac comminuuntur ab aere quam in ipsum recipiuntur et incorporantur: hoc in aere communi et aliis spiritalibus, ob subtilitatem corporum, percipi ad sensum non potest; attamen imago quaedam hujus rei, quatenus fiat, concipi possit in liquoribus argenti vivi, olei, aquae; atque etiam in aere, et fractione ejus, quando dissipatur et ascendit in parvis portiunculis per aquam; atque etiam in fumis crassioribus; denique in pulvere excitato et haerente in aere; in quibus omnibus non fit incorporatio.

Atque repraesentatio praedicta in hoc subjecto non mala est, si illud primo diligenter inquisitum fuerit, utrum possit esse talis heterogenia inter spiritalia qualis invenitur inter liquida; nam tum demum haec simulacra per Analogiam non incommode substituentur.

Atque de *instantiis* istis *supplementi*, quod diximus informationem ab iis hauriendam esse, quando desint instantiae propriae, loco *perfugii*; nihilominus intelligi volumus, quod illae etiam magni sint usus etiam cum propriae instantiae adsint; ad roborandam scilicet informationem una cum propriis. Verum de his exactius dicemus quando ad *Adminicula Inductionis* tractanda sermo ordine dilabetur.

2.43 Inter *praerogativas instantiarum* ponemus loco vicesimo *Instantias Persecantes*; quas etiam *Instantias Vellicantes* appellare consuevimus, sed diversa ratione. *Vellicantes* enim eas appellamus, quia vellicant intellectum, *persecantes*, quia persecant naturam: unde etiam illas quandoque *Instantias Democriti* nominamus. Eae sunt, quae de admirabili et exquisita subtilitate naturae intellectum submonent, ut excitetur et expergiscatur ad attentionem et observationem et inquisitionem debitam.

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they seem to be mixed in the spirits of plants and animals. This is especially likely because all animate spirit feeds on both kinds of moisture, watery and fatty, as its fuel.

Similarly, the inquiry may concern not the more perfect mixtures of spirit-like bodies but only their combination. Do they readily incorporate with one another? Or are there, for example, some winds and exhalations, or other spirit-like bodies, that do not mix with common air? Perhaps they only hang and float in it in globules and drops, and are broken up and scattered by the air rather than received and incorporated into it. Because these bodies are so fine, this cannot be perceived by the senses in common air and other spirit-like bodies. Yet some image of it, so far as it happens, may be conceived in liquids such as quicksilver, oil, and water. It may also be seen in air, and in the way air breaks up when it is scattered and rises through water in small portions. It may be seen in thicker smokes, and finally in dust stirred up and hanging in the air. In none of these does incorporation occur.

This representation is not a bad one for the subject, provided it has first been carefully investigated whether spirit-like bodies can differ in kind as much as liquids do. Then, and only then, these likenesses may properly be substituted by analogy.

We have said that information is to be drawn from these *Supplementary Instances* as a *refuge* when proper instances are lacking. Nonetheless we want it understood that they are also of great use even when proper instances are available, namely to strengthen the information along with the proper instances. But we will speak of these more exactly when the discussion reaches, in due order, the *Aids to Induction*.

Among the *prerogative instances* we will put in twentieth place *Dissecting Instances*, which we also call *Nudging Instances*, though for a different reason. We call them *Nudging* because they nudge the understanding, and *Dissecting* because they dissect nature. For this reason we also sometimes name them *Instances of Democritus*. These are the instances that hint to the understanding at the admirable and exquisite subtlety of nature, so that it

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is roused and awakened to proper attention, observation, and inquiry.

Exempli gratia: quod parum guttulae atramenti ad tot literas vel lineas extendatur; quod argentum, exterius tantum inauratum, ad tantam longitudinem fili inaurati continuetur; quod pusillus vermiculus, qualis in cute invenitur, habeat in se spiritum simul et figuram dissimilarem partium; quod parum croci etiam dolium aquae colore inficiat; quod parum zibethi aut aromatis longe majus contentum aeris odore; quod exiguo suffitu tanta excitetur nubes fumi; quod sonorum tam accuratae differentiae, quales sint voces articulatae, per aerem undequaque vehantur, atque per foramina et poros etiam ligni et aquae (licet admodum extenuatae) penetrent, quin etiam repercutiantur, idque tam distincte et velociter;

For example: that a tiny drop of ink stretches to so many letters or lines; that silver gilded only on the outside can be drawn out into so great a length of gilded wire; that a tiny worm, such as is found in the skin, has in it both spirit and a structure of dissimilar parts; that a little saffron colors even a whole cask of water; that a little civet or spice perfumes a far larger volume of air; that so great a cloud of smoke is raised by a little incense; that such exact differences of sounds as articulate words are carried through the air in every direction, and penetrate the holes and pores even of wood and water (though much weakened), and are even echoed back, and all this so distinctly and swiftly;

quod lux et color, etiam tanto ambitu et tam perniciter, per corpora solida vitri, aquae, et cum tanta et tam exquisita varietate imaginum permeent, etiam refringantur et reflectantur; quod magnes per corpora omnigena, etiam maxime compacta, operetur: sed (quod magis mirum est) quod in his omnibus, in medio adiaphoro (quale est aer) unius actio aliam non magnopere impediat; nempe quod eodem tempore per spatia aeris devehantur et visibilium tot imagines, et vocis articulatae tot percussiones, et tot odores specificati, ut violae, rosae; etiam calor et frigus et virtutes magneticae; omnia (inquam) simul, uno alterum non impediente, ac si singula haberent vias et meatus suos proprios separatos, neque unum in alterum impingeret aut incurreret.

that light and color pass so widely and so swiftly through the solid bodies of glass and water, with so great and so exquisite a variety of images, and are even refracted and reflected; that the magnet operates through bodies of every kind, even the most compact. But more wonderful still, in all these cases the action of one thing does not much impede another in an indifferent medium such as air. At the same time there are carried through the spaces of the air so many images of visible things, so many impulses of articulate voice, so many specific odors, such as those of the violet and the rose, as well as heat and cold and magnetic powers. All of them, I say, travel at once, none impeding another, as if each had its own separate roads and passages and none struck or ran into another.

Solemus tamen utiliter hujusmodi *instantiis persecantibus* subjungere instantias, quas *Metas Persecationis* appellare consuevimus; veluti quod in iis, quae diximus, una actio in diverso genere aliam non perturbet aut impediat, cum tamen in eodem genere una aliam domet et extinguat: veluti, lux solis, lucem cicindelae; sonitus bombardae, vocem; fortior odor, delicatiorem; intensior calor, remissiorem; lamina ferri interposita inter magnetem et aliud ferrum, operationem magnetis. Verum de his quoque inter *Adminicula Inductionis* erit proprius dicendi locus.

It is useful, however, to append to such *Dissecting Instances* the instances we call *Limits of Dissection*. In the cases we have mentioned, one action does not disturb or impede another of a different kind. Yet within the same kind one overpowers and extinguishes another. The light of the sun extinguishes that of the glow-worm; the report of a cannon drowns the voice; a stronger smell overpowers a more delicate one, and a more intense heat a milder one; a plate of iron placed between a magnet and another piece of iron blocks the operation of the magnet. But the proper place to speak of these too will be among the *Aids to Induction*.

PRACTICAL INSTANCES

Instances that measure the powers of bodies by distance, time, quantity and the struggle between motions.

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2.44 Atque de instantiis quae juvant sensum, jam dictum est; quae praecipui usus sunt ad Partem Informativam. Informatio enim incipit a sensu. At universum negotium desinit in Opera; atque quemadmodum illud principium, ita hoc finis rei est. Sequentur itaque instantiae praecipui usus ad *partem operativam*. Eae genere duae sunt, numero septem; quas universas, generali nomine, *Instantias Practicas* appellare consuevimus. *Operativae* autem *partis*, vitia duo; totidemque dignitates instantiarum in genere. Aut enim fallit operatio, aut onerat nimis. Fallit operatio maxime (praesertim post diligentem naturarum inquisitionem) propter male determinatas et mensuratas corporum vires et actiones.

Vires autem et actiones corporum circumscribuntur et mensurantur, aut per spatia loci, aut per momenta temporis, aut per unionem quanti, aut per praedominantiam virtutis; quae quatuor nisi fuerint probe et diligenter pensitata, erunt fortasse scientiae speculatione quidem pulchrae, sed opere inactivae. Instantias vero quatuor itidem, quae huc referuntur, uno nomine *Instantias Mathematicas* vocamus, et *Instantias Mensurae.*

Onerosa autem fit praxis, vel propter misturam rerum inutilium, vel propter multiplicationem instrumentorum, vel propter molem materiae et corporum quae ad aliquod opus requiri contigerint. Itaque eae instantiae in pretio esse debent, quae aut dirigunt operativam ad ea quae maxime hominum intersunt; aut quae parcunt instrumentis; aut quae parcunt materiae sive supellectili. Eas autem tres instantias quae huc pertinent, uno nomine *Instantias Propitias* sive *Benevolas* vocamus. Itaque de his septem instantiis jam sigillatim dicemus; atque cum iis partem illam de Praerogativis sive Dignitatibus Instantiarum claudemus.

2.45 Inter *praerogativas instantiarum* ponemus loco vicesimo primo *Instantias Virgae*, sive *Radii*; quas etiam *Instantias Perlationis*, vel *de Non Ultra* appellare consuevimus. Virtutes enim rerum et motus operantur et expediuntur per spatia non indefinita aut fortuita, sed finita et certa; quae ut in singulis naturis inquisitis teneantur et notentur plurimum interest practicae, non solum ad hoc, ut non fallat, sed etiam ut magis sit aucta et potens.

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So much for the instances that help the senses, which are chiefly useful for the Informative Part. Information begins from the senses. But the whole business ends in works; as the one is the beginning, the other is the end. Next, then, come the instances chiefly useful for the *operative part*. They are of two kinds and seven in number, and we call them all by the general name *Practical Instances*. The *operative part* has two faults, and instances in general have as many corresponding merits. Operation either fails or is too burdensome. It fails chiefly, especially after a careful inquiry into natures, because the forces and actions of bodies have been badly determined and measured.

The forces and actions of bodies are delimited and measured by distances in space, by moments of time, by concentration of quantity, or by predominance of power. Unless these four have been properly and carefully weighed, we will perhaps have sciences that are fine in speculation but inactive in practice. The four instances that belong here we call by one name *Mathematical Instances*, or *Instances of Measure*.

Practice becomes burdensome through the admixture of useless things, through the multiplication of instruments, or through the bulk of material and bodies that a work happens to require. So those instances should be valued that direct the operative part to what most concerns people, or that save on instruments, or that save on material and equipment. The three instances that belong here we call by one name *Propitious* or *Benevolent Instances*. We will now speak of these seven instances one by one, and with them close the part on the Prerogatives, or Merits, of Instances.

Among the *prerogative instances* we will put in twenty-first place *Instances of the Rod*, or *Rule*, which we also call *Instances of Range*, or *of No Further*. The powers and motions of things operate and take effect over distances that are not indefinite or random but finite and fixed. To track and note these distances in each nature under inquiry is of the greatest importance for practice. It keeps practice from failing and also makes it greater and

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Etenim interdum datur virtutes producere, et distantias tanquam retrahere in propius; ut in perspecillis.

Atque plurimae virtutes operantur et afficiunt tantum per tactum manifestum; ut fit in percussione corporum, ubi alterum non summovet alterum, nisi impellens impulsum tangat. Etiam medicinae quae exterius applicantur, ut unguenta, emplastra, non exercent vires suas nisi per tactum corporis. Denique objecta sensuum tactus et gustus non feriunt nisi contigua organis.

Sunt et aliae virtutes quae operantur ad distantiam, verum valde exiguam, quarum paucae adhuc notatae sunt, cum tamen plures sint quam homines suspicentur: ut (capiendo exempla ex vulgatis) cum succinum aut gagates trahunt paleas; bullae approximatae solvunt bullas; medicinae nonnullae purgativae eliciunt humores ex alto, et hujusmodi. At virtus illa magnetica per quam ferrum et magnes, vel magnetes invicem, coeunt, operatur intra orbem virtutis certum, sed parvum; ubi contra, si sit aliqua virtus magnetica emanans ab ipsa terra (paulo nimirum interiore) super acum ferream, quatenus ad verticitatem, operatio fiat ad distantiam magnam.

Rursus, si sit aliqua vis magnetica quae operetur per consensum inter globum terrae et ponderosa, aut inter globum lunae et aquas maris (quae maxime credibilis videtur in fluxibus et refluxibus semi-menstruis), aut inter coelum stellatum et planetas, per quam evocentur et attollantur ad sua apogaea; haec omnia operantur ad distantias admodum longinquas. Inveniuntur et quaedam inflammationes sive conceptiones flammae, quae fiunt ad distantias bene magnas, in aliquibus materiis; ut referunt de naphtha Babylonica. Calores etiam insinuant se per distantias amplas, quod etiam faciunt frigora; adeo ut habitantibus circa Canadam moles sive massae glaciales, quae abrumpuntur et natant per oceanum septentrionalem et deferuntur per Atlanticum versus illas oras, percipiantur et incutiant frigora e longinquo.

Odores quoque (licet in his videatur semper esse quaedam emissio corporea) operantur ad distantias notabiles; ut evenire solet navigantibus juxta litora

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more powerful. For it is sometimes possible to extend powers and, as it were, draw distances in closer, as with optical glasses.

Many powers operate and have effect only by manifest contact. This happens in the collision of bodies, where one does not move another unless the impelling body touches the one impelled. Medicines applied externally, such as ointments and plasters, likewise exert their powers only through contact with the body. Finally, the objects of touch and taste strike those senses only when they adjoin the organs.

There are other powers that operate at a distance, though a very small one. Few of these have yet been noted, though there are more than people suspect. To take common examples: amber or jet attract straws; bubbles brought close to each other break each other; certain purgative medicines draw humors from deep within; and the like. The magnetic power by which iron and magnet, or magnets with each other, come together operates within a fixed but small sphere of activity. By contrast, there may be some magnetic power emanating from the earth itself, from a little below its surface, that acts on an iron needle and gives it its polarity. If so, that operation takes place at a great distance.

Again, there may be some magnetic force that operates by sympathy between the globe of the earth and heavy bodies. There may be one between the globe of the moon and the waters of the sea, which seems highly credible given the fortnightly flows and ebbs. There may be one between the starry heaven and the planets, by which they are called up and raised to their apogees. All these operate at very great distances. Certain inflammations, or kindlings of flame, are also found in some materials that happen at quite great distances, as is reported of Babylonian naphtha. Heat also works its way over wide distances, and so does cold. The icebergs or masses of ice break off, float through the northern ocean, and are carried through the Atlantic toward the shores around Canada. The inhabitants there feel their chill from far off.

Smells too operate at notable distances, though they always seem to involve some bodily emission. This usually happens to those sailing along

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Floridae, aut etiam nonnulla Hispaniae, ubi sunt sylvae totae ex arboribus limonum, arantiorum, et hujusmodi plantarum odoratarum, aut frutices rorismarini, majoranae, et similium. Postremo radiationes lucis et impressiones sonorum operantur scilicet ad distantias spatiosas.

Verum haec omnia, utcunque operentur ad distantias parvas sive magnas, operantur certe ad finitas et naturae notas, ut sit quiddam *Non Ultra*: idque pro rationibus, aut molis seu quanti corporum; aut vigoris et debilitatis virtutum; aut favoribus et impedimentis mediorum; quae omnia in computationem venire et notari debent. Quinetiam mensurae motuum violentorum (quos vocant), ut missilium, tormentorum, rotarum, et similium, cum hae quoque manifesto suos habeant limites certos, notandae sunt.

Inveniuntur etiam quidam motus et virtutes contrariae illis, quae operantur per tactum et non ad distans; quae operantur scilicet ad distans et non ad tactum; et rursus, quae operantur remissius ad distantiam minorem et fortius ad distantiam majorem. Etenim visio non bene transigitur ad tactum, sed indiget medio et distantia. Licet meminerim me audisse ex relatione cujusdam fide digni, quod ipse in curandis oculorum suorum cataractis (erat autem cura talis, ut immitteretur festuca quaedam parva argentea intra primam oculi tunicam, quae pelliculam illam cataractae removeret et truderet in angulum oculi) clarissime vidisset festucam illam supra ipsam pupillam moventem. Quod utcunque verum esse possit, manifestum est majora corpora non bene aut distincte cerni nisi in cuspide coni, coeuntibus radiis objecti ad nonnullam distantiam.

Quin etiam in senibus oculus melius cernit remoto objecto paulo longius, quam propius. In missilibus autem certum est percussionem non fieri tam fortem ad distantiam nimis parvam, quam paulo post. Haec itaque et similia in mensuris motuum quoad distantias notanda sunt.

Est et aliud genus mensurae localis motuum, quod non praetermittendum est. Illud vero pertinet ad motus non progressivos, sed sphaericos; hoc est, ad expansionem corporum in majorem sphaeram, aut contractionem in minorem. Inquirendum enim est inter mensuras istas motuum, quantam compressionem aut extensionem

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the coasts of Florida, or even along some coasts of Spain. There are whole forests of lemon and orange trees and similar fragrant plants there, or bushes of rosemary, marjoram, and the like. Finally, radiations of light and impressions of sound operate, of course, over wide distances.

But whether all these operate at small or great distances, they certainly operate at distances that are finite and known to nature, so that there is a certain *No Further*. This depends on the ratios of the mass or quantity of the bodies, on the strength or weakness of the powers, or on the help and hindrance of the media. All of these must be taken into account and noted. The measures of violent motions, as they call them, such as those of projectiles, guns, wheels, and the like, should also be noted, since these too plainly have their fixed limits.

Some motions and powers are also found that are the reverse of those that operate by contact and not at a distance. These operate at a distance and not by contact. Others again operate more weakly at a lesser distance and more strongly at a greater one. Sight, for instance, does not function well by contact but needs a medium and a distance. I do remember hearing an account from a trustworthy person who had his cataracts treated. The treatment involved inserting a small silver needle within the first coat of the eye, to remove the film of the cataract and push it into the corner of the eye. He said he had very clearly seen that needle moving right over the pupil. However true that may be, larger bodies are plainly not seen well or distinctly except at the apex of a cone, where the rays from the object meet at some distance.

Indeed, in old people the eye sees better when the object is moved a little farther away than when it is closer. And with projectiles the impact is certainly not as strong at too short a distance as a little farther on. These and similar things must be noted in the measures of motions as regards distances.

There is also another kind of spatial measure of motions that must not be passed over. It concerns motions that are not progressive but spherical: the expansion of bodies into a larger sphere or their contraction into a smaller one. Among these meas-

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corpora (pro natura ipsorum) facile et libenter patiantur, et ad quem terminum reluctari incipiant, adeo ut ad extremum *Non Ultra* ferant; ut cum vesica inflata comprimitur, sustinet illa compressionem nonnullam aeris, sed si major fuerit, non patitur aer, sed rumpitur vesica.

At nos hoc ipsum subtiliore experimento magis exacte probavimus. Accepimus enim campanulam ex metallo, leviorem scilicet et tenuiorem, quali ad excipiendum salem utimur; eamque in pelvim aquae immisimus, ita ut deportaret secum aerem qui continebatur in concavo usque ad fundum pelvis. Locaveramus autem prius globulum in fundo pelvis, super quem campanula imponenda esset. Quare illud eveniebat, ut si globulus ille esset minusculus (pro ratione concavi), reciperet se aer in locum minorem, et contruderetur solum, non extruderetur. Quod si grandioris esset magnitudinis quam ut aer libenter cederet, tum aer majoris pressurae impatiens campanulam ex aliqua parte elevabat, et in bullis ascendebat.

Etiam ad probandum qualem extensionem (non minus quam compressionem) pateretur aer, tale quippiam practicavimus. Ovum vitreum accepimus, cum parvo foramine in uno extremo ovi. Aerem per foramen exuctione forti attraximus, et statim digito foramen illud obturavimus, et ovum in aquam immersimus, et dein digitum removimus. Aer vero tensura illa per exuctionem facta tortus et magis quam pro natura sua dilatatus, ideoque se recipere et contrahere nitens (ita ut si ovum illud in aquam non fuisset immersum, aerem ipsum traxisset cum sibilo), aquam traxit ad tale quantum quale sufficere posset ad hoc, ut aer antiquam recuperaret sphaeram sive dimensionem.

Atque certum est corpora tenuiora (quale est aer) pati contractionem nonnullam notabilem, ut dictum est; at corpora tangibilia (quale est aqua) multo aegrius et ad minus spatium patiuntur compressionem. Qualem autem patiatur, tali experimento inquisivimus.

Fieri fecimus globum ex plumbo cavum, qui duas circiter pintas vinarias contineret; eumque satis per latera crassum, ut majorem vim sustineret. In illum aquam immisimus, per foramen alicubi factum; atque foramen

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ures of motions we must inquire how much compression or extension bodies undergo easily and willingly, according to their nature. We must also find at what limit they begin to resist, until at last they will bear *No Further*. When an inflated bladder is squeezed, for instance, it tolerates some compression of the air. But if the compression is greater, the air does not endure it and the bladder bursts.

We tested this very point more exactly by a subtler experiment. We took a small metal bell, light and thin, of the kind we use to hold salt. We let it down into a basin of water so that it carried the air in its hollow down to the bottom of the basin. We had previously placed a small ball at the bottom of the basin, over which the bell was to be set. The result was this. If the ball was fairly small in proportion to the hollow, the air withdrew into a smaller space and was merely squeezed together, not squeezed out. But if the ball was too large for the air to yield willingly, the air could not bear the greater pressure. It lifted the bell on one side and rose in bubbles.

To test what extension air would endure, as well as what compression, we did the following. We took a glass egg with a small hole at one end. We drew air out through the hole by strong suction and immediately stopped the hole with a finger. We plunged the egg into water and then removed the finger. The suction had strained the air and expanded it beyond its natural state, so it strove to withdraw and contract. Had the egg not been plunged into water, it would have drawn in air with a hiss. Instead it drew in as much water as was needed for the air to recover its former sphere, or dimension.

It is certain that thinner bodies such as air admit a considerable degree of contraction, as has been said. Tangible bodies such as water submit to compression with much greater difficulty and within a smaller range. We investigated how much compression they do submit to by the following experiment.

We had a hollow ball of lead made that held about two wine pints, with walls thick enough to withstand considerable force. We filled it with water through a hole made at some point. Once the ball

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illud, postquam globus aqua impletus fuisset, plumbo liquefacto obturavimus, ut globus deveniret plane consolidatus. Dein globum forti malleo ad duo latera adversa complanavimus; ex quo necesse fuit aquam in minus contrahi, cum sphaera figurarum sit capacissima. Deinde, cum malleatio non amplius sufficeret, aegrius se recipiente aqua, molendino seu torculari usi sumus; ut tandem aqua, impatiens pressurae ulterioris, per solida plumbi (instar roris delicati) exstillaret. Postea, quantum spatii per eam compressionem imminutum foret computavimus; atque tantam compressionem passam esse aquam (sed violentia magna subactam) intelleximus.

At solidiora, sicca, aut magis compacta, qualia sunt lapides et ligna, necnon metalla, multo adhuc minorem compressionem aut extensionem, et fere imperceptibilem ferunt; sed vel fractione, vel progressione, vel aliis pertentationibus se liberant: ut in curvationibus ligni aut metalli, horologiis moventibus per complicationem laminae, missilibus, malleationibus, et innumeris aliis motibus apparet. Atque haec omnia cum mensuris suis in indagatione naturae notanda et exploranda sunt, aut in certitudine sua, aut per aestimativas, aut per comparativas, prout dabitur copia.

2.46 Inter *praerogativas instantiarum* ponemus loco vicesimo secundo *Instantias Curriculi*, quas etiam *Instantias ad Aquam* appellare consuevimus; sumpto vocabulo a clepsydris apud antiquos, in quas infundebatur aqua, loco arenae. Eae mensurant naturam per momenta temporis, quemadmodum *Instantiae Virgae* per gradus spatii. Omnis enim motus sive actio naturalis transigitur in tempore; alius velocius, alius tardius, sed utcunque momentis certis et naturae notis. Etiam illae actiones quae subito videntur operari, et in ictu oculi (ut loquimur), deprehenduntur recipere majus et minus quoad tempus.

Primo itaque videmus restitutiones corporum coelestium fieri per tempora numerata; etiam fluxus et refluxus maris. Latio autem gravium versus terram et levium versus ambitum coeli fit per certa momenta, pro ratione corporis quod fertur, et medii. At velificationes navium, motus animalium, perlationes missilium, omnes fiunt itidem per tempora (quantum ad summas) numerabilia. Calorem vero quod attinet, videmus pueros per hyemem

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was full, we stopped the hole with molten lead, so that the ball was completely sealed. Then we flattened the ball on two opposite sides with a heavy hammer. This necessarily forced the water into less space, since the sphere is the most capacious of figures. When hammering was no longer enough and the water yielded with more difficulty, we used a mill or press. At last the water, unable to bear further pressure, oozed out through the solid lead like a fine dew. Afterward we calculated how much space had been lost by that compression. In this way we learned that the water had undergone that much compression, though only when subdued by great violence.

More solid, dry, or compact bodies, such as stones and wood, as well as metals, bear much less compression or extension still, almost imperceptible. They free themselves instead by breaking, by moving forward, or by other struggles. This appears in the bending of wood or metal, in clocks driven by a coiled spring, in projectiles, in hammering, and in countless other motions. All these, with their measures, must be noted and explored in the investigation of nature. This may be done with certainty, by estimate, or by comparison, as opportunity allows.

Among *prerogative instances* we will put in twenty-second place *Instances of the Course*, which we have also been accustomed to call *Instances by Water*. The name comes from the water clocks of the ancients, into which water was poured instead of sand. These instances measure nature by moments of time, just as *Instances of the Rod* measure it by degrees of space. For every natural motion or action takes place in time, some faster, some slower, but in any case in definite moments known to nature. Even actions that seem to work suddenly, in the twinkling of an eye (as we say), are found to admit of more and less as regards time.

First, then, we see that the heavenly bodies return to their positions over measured periods of time, and so do the ebb and flow of the sea. The motion of heavy things toward the earth and of light things toward the circumference of the heavens takes place in definite times, according to the nature of the body carried and of the medium. The sailing of ships, the movements of animals and the

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manus in flamma lavare, nec tamen uri; et joculatores vasa plena vino vel aqua, per motus agiles et aequales, vertere deorsum et sursum recuperare, non effuso liquore; et multa hujusmodi. Nec minus ipsae compressiones et dilatationes et eruptiones corporum fiunt, aliae velocius, aliae tardius, pro natura corporis et motus, sed per momenta certa.

Quinetiam in explosione plurium bombardarum simul, quae exaudiuntur quandoque ad distantiam triginta milliarium, percipitur sonus prius ab iis qui prope absunt a loco ubi fit sonitus, quam ab iis qui longe. At in visu (cujus actio est pernicissima) liquet etiam requiri ad eum actuandum momenta certa temporis: idque probatur ex iis quae propter motus velocitatem non cernuntur; ut ex latione pilae ex sclopeto. Velocior enim est praetervolatio pilae quam impressio speciei ejus quae deferri poterat ad visum.

Atque hoc, cum similibus, nobis quandoque dubitationem peperit plane monstrosam: videlicet, utrum coeli sereni et stellati facies ad idem tempus cernatur quando vere existit, an potius aliquanto post; et utrum non sit (quatenus ad visum coelestium) non minus tempus verum et tempus visum, quam locus verus et locus visus, qui notatur ab astronomis in parallaxibus. Adeo incredibile nobis videbatur, species sive radios corporum coelestium per tam immensa spatia milliarium subito deferri posse ad visum; sed potius debere eas in tempore aliquo notabili delabi.

Verum illa dubitatio (quoad majus aliquod intervallum temporis inter tempus verum et visum) postea plane evanuit: reputantibus nobis jacturam illam infinitam et diminutionem quanti, quatenus ad apparentiam, inter corpus stellae verum et speciem visam, quae causatur a distantia; atque simul notantibus ad quantam distantiam (sexaginta scilicet ad minimum milliariorum) corpora, eaque tantum albicantia, subito hic apud nos cernantur; cum dubium non sit lucem coelestium, non tantum albedinis vividum colorem, verum etiam omnis flammae (quae apud nos nota est) lucem, quoad vigorem radiationis, multis partibus excedere. Etiam immensa illa velocitas in ipso corpore, quae cernitur in motu diurno (quae etiam viros graves ita obstupefecit ut mallent

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flight of missiles likewise all take place in times that can be counted, at least in total. As for heat, we see boys in winter bathe their hands in flame without being burned. We see jugglers turn vessels full of wine or water upside down and back up again with quick, even movements, without spilling the liquid, and many things of this kind. No less do the compressions, dilations and eruptions of bodies take place in definite moments, some faster, some slower, according to the nature of the body and of the motion.

Again, when several cannon are fired at once, the report can sometimes be heard thirty miles away, and it is perceived sooner by those near the place where it is made than by those far off. And in sight, whose action is extremely swift, it is clear that definite moments of time are needed to bring it about. This is proved by things that cannot be seen because of the speed of their motion, such as a ball fired from a musket. For the ball flies past faster than the impression of its image that might be carried to the sight.

This, and things like it, once raised in us a doubt that was frankly monstrous. We wondered whether the face of a clear, starry sky is seen at the moment it actually exists, or rather somewhat later. We wondered whether, in seeing the heavenly bodies, there is not a true time and an apparent time, just as there is a true place and an apparent place, which astronomers take into account in parallaxes. So incredible did it seem to us that the images or rays of the heavenly bodies could be carried to the sight instantly across such immense distances. We thought, rather, that they must take some appreciable time to travel down.

But that doubt, at least as to any considerable interval between the true time and the apparent, later vanished entirely. We considered the infinite loss and diminution of size, as far as appearance goes, between the true body of a star and its seen image, which is caused by distance. We noted at the same time at what distance, sixty miles at least, bodies that are merely white are seen instantly here among us. And there is no doubt that the light of the heavenly bodies far exceeds in strength of radiation not only the vivid color of white but the light of every flame known to us. Again, the immense speed of the heavenly body it-

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credere motum terrae), facit motum illum ejaculationis radiorum ab ipsis (licet celeritate, ut diximus, mirabilem) magis credibilem.

Maxime vero omnium nos movit, quod si interponeretur intervallum temporis aliquod notabile inter veritatem et visum, foret ut species per nubes interim orientes et similes medii perturbationes interciperentur saepenumero, et confunderentur. Atque de mensuris temporum simplicibus haec dicta sint.

Verum non solum quaerenda est mensura motuum et actionum simpliciter, sed multo magis comparative: id enim eximii est usus, et ad plurima spectat. Atque videmus flammam alicujus tormenti ignei citius cerni, quam sonitus audiatur; licet necesse sit pilam prius aerem percutere, quam flamma quae pone erat exire potuerit; fieri hoc autem propter velociorem transactionem motus lucis, quam soni. Videmus etiam species visibiles a visu citius excipi quam dimitti; unde fit quod nervi fidium, digito impulsi, duplicentur aut triplicentur quoad speciem, quia species nova recipitur, antequam prior demittatur; ex quo etiam fit, ut annuli rotati videantur globosi, et fax ardens, noctu velociter portata, conspiciatur caudata.

Etiam ex hoc fundamento inaequalitatis motuum quoad velocitatem, excogitavit Galilaeus causam fluxus et refluxus maris; rotante terra velocius, aquis tardius; ideoque accumulantibus se aquis in sursum, et deinde per vices se remittentibus in deorsum, ut demonstratur in vase aquae incitatius movente. Sed hoc commentus est concesso non concessibili (quod terra nempe moveatur), ac etiam non bene informatus de oceani motu sexhorario.

At exemplum hujus rei de qua agitur, videlicet, de comparativis mensuris motuum, neque solum rei ipsius, sed et usus insignis ejus (de quo paulo ante loquuti sumus), eminet in cuniculis subterraneis, in quibus collocatur pulvis pyrius; ubi immensae moles terrae, aedificiorum, et similium, subvertuntur, et in altum jaciuntur, a pusilla quantitate pulveris pyrii. Cujus causa pro certo illa est, quod motus dilatationis pulveris, qui impellit, multis partibus sit pernicior, quam motus

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self, seen in its daily motion, so astonished serious men that they preferred to believe that the earth moves. That speed makes the darting of rays from those bodies more credible, even though, as we said, its swiftness is amazing.

But what moved us most of all was this. If there were any appreciable interval of time between the reality and the sight, the images would often be intercepted and confused in the meantime by clouds rising up and by similar disturbances of the medium. So much for simple measures of time.

The measure of motions and actions must be sought not only simply, however, but much more comparatively; for this is of outstanding use and bears on a great many things. We see that the flash of a gun is seen sooner than its report is heard, although the ball must strike the air before the flame behind it can come out. This happens because the motion of light travels faster than that of sound. We also see that visible images are received by the sight faster than they are released. This is why the strings of an instrument, plucked with the finger, appear doubled or tripled: a new image is received before the previous one is let go. It is also why rings spun round look like globes, and why a burning torch carried quickly at night seems to have a tail.

It was also on this basis, the inequality of motions in speed, that Galileo devised his explanation of the ebb and flow of the sea. The earth, he held, turns faster and the waters more slowly, so the waters pile up and then in turn fall back down, as can be shown in a vessel of water moved briskly. But he contrived this by granting what cannot be granted, namely that the earth moves; and he was also not well informed about the six-hourly motion of the ocean.[31]

A striking example of the subject in hand, the comparative measures of motions, and not only of the thing itself but of its remarkable usefulness (of which we spoke a little earlier), is found in underground mines packed with gunpowder. There immense masses of earth, buildings and the like are overturned and hurled into the air by a tiny quantity of gunpowder. The cause is certainly this: the motion of dilation of the powder, which does the

31 Galileo set out this tidal theory in a treatise of 1616 and developed it in his *Dialogue* (1632).

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gravitatis per quem fieri possit aliqua resistentia; adeo ut primus motus perfunctus sit, antequam motus adversus inceperit; ut in principiis nullitas quaedam sit resistentiae. Hinc etiam fit, quod in omni missili, ictus, non tam robustus quam acutus et celer, ad perlationem potissimum valeat.

Neque etiam fieri potuisset, ut parva quantitas spiritus animalis in animalibus, praesertim in tam vastis corporibus qualia sunt balaenae aut elephanti, tantam molem corpoream flecteret et regeret, nisi propter velocitatem motus spiritus, et hebetudinem corporeae molis, quatenus ad expediendam suam resistentiam.

Denique, hoc unum ex praecipuis fundamentis est experimentorum magicorum, de quibus mox dicemus; ubi scilicet parva moles materiae longe majorem superat et in ordinem redigit: hoc, inquam, si fieri possit anteversio motuum per velocitatem unius, antequam alter se expediat.

Postremo, hoc ipsum *Prius* et *Posterius* in omni actione naturali notari debet; veluti quod in infusione rhabarbari eliciatur purgativa vis prius, astrictiva post; simile quiddam etiam in infusione violarum in acetum experti sumus; ubi primo excipitur suavis et delicatus floris odor; post, pars floris magis terrea, quae odorem confundit. Itaque si infundantur violae per diem integrum, odor multo languidius excipitur: quod si infundantur per partem quartam horae tantum, et extrahantur; et (quia paucus est spiritus odoratus qui subsistit in viola) infundantur post singulas quartas horae violae novae et recentes ad sexies; tum demum nobilitatur infusio, ita ut licet non manserint violae, utcunque renovatae, plus quam ad sesquihoram, tamen permanserit odor gratissimus, et viola ipsa non inferior, ad annum integrum.

Notandum tamen est, quod non se colligat odor ad vires suas plenas, nisi post mensem ab infusione. In distillationibus vero aromatum maceratorum in spiritu vini patet quod surgat primo phlegma aqueum et inutile, deinde aqua plus habens ex spiritu vini, deinde post aqua plus habens ex aromate. Atque hujus generis quamplurima inveniuntur in distillationibus notatu digna. Verum haec sufficiant ad exempla.

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driving, is many times swifter than the motion of gravity through which some resistance could be offered. The first motion is therefore over before the opposing motion has begun, so that at the start there is, in effect, no resistance at all. This is also why, with every missile, a blow that is not so much strong as sharp and quick counts most toward sending it far.

Nor could a small quantity of animal spirit in animals, especially in such huge bodies as whales or elephants, bend and govern so great a bodily mass, were it not for the speed of the spirit's motion and the sluggishness of the bodily mass in bringing its resistance into play.

Finally, this is one of the chief foundations of the magical experiments of which we shall speak shortly, in which a small mass of matter overcomes a far greater one and brings it into order. This is possible, I say, if one motion, by its speed, can get ahead of another before the other gets going.

Lastly, this very *Before* and *After* should be noted in every natural action. For instance, in an infusion of rhubarb the purgative power is drawn out first and the astringent afterward. We have found something similar in steeping violets in vinegar: first the sweet and delicate scent of the flower is taken up, and afterward the more earthy part of the flower, which muddies the scent. So if violets are steeped for a whole day, the scent is taken up much more faintly. But suppose they are steeped for only a quarter of an hour and then taken out; and suppose (since the fragrant spirit residing in the violet is small) that fresh violets are put in after every quarter of an hour, up to six times. Then at last the infusion is ennobled. Although the violets, however often renewed, have not stayed in it longer than an hour and a half, a most pleasing scent, no weaker than the violet itself, lasts for a whole year.

It should be noted, however, that the scent does not gather its full strength until a month after steeping. In distilling spices macerated in spirit of wine, it is clear that first a watery, useless phlegm rises, then water with more of the spirit of wine in it, and after that water with more of the spice. Many things of this kind worth noting are found in distillations. But let these suffice as examples.

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2.47 Inter *praerogativas instantiarum* ponemus loco vicesimo tertio *Instantias Quanti*, quas etiam *Doses Naturae* (sumpto vocabulo a Medicinis) vocare consuevimus. Eae sunt quae mensurant virtutes per *Quanta* corporum, et indicant quid *Quantum Corporis* faciat ad *Modum Virtutis*. Ac primo sunt quaedam virtutes quae non subsistunt nisi in *quanto cosmico*, hoc est, tali *quanto* quod habeat consensum cum configuratione et fabrica universi. Terra enim stat; partes ejus cadunt. Aquae in maribus fluunt et refluunt; in fluviis minime, nisi per ingressum maris. Deinde etiam omnes fere virtutes particulares secundum *multum* aut *parum* corporis operantur. Aquae largae non facile corrumpuntur; exiguae cito. Mustum et cervisia maturescunt longe citius, et fiunt potabilia, in utribus parvis, quam in doliis magnis.

Si herba ponatur in majore portione liquoris, fit infusio, magis quam imbibitio; si in minore, fit imbibitio, magis quam infusio. Aliud igitur erga corpus humanum est balneum, aliud levis irroratio. Etiam parvi rores in aere nunquam cadunt, sed dissipantur et cum aere incorporantur. Et videre est in anhelitu super gemmas, parum illud humoris, quasi nubeculam vento dissipatam, continuo solvi. Etiam frustum ejusdem magnetis non trahit tantum ferri, quantum magnes integer. Sunt etiam virtutes in quibus parvitas *quanti* magis potest; ut in penetrationibus, stylus acutus citius penetrat, quam obtusus; adamas punctuatus sculpit in vitro; et similia.

Verum non hic morandum est in indefinitis, sed etiam de *rationibus quanti* corporis erga modum virtutis inquirendum. Proclive enim foret credere, quod rationes quanti rationes virtutis adaequarent; ut si pila plumbea unius unciae caderet in tali tempore, pila unciarum duarum deberet cadere duplo celerius, quod falsissimum est. Nec eaedem rationes in omni genere virtutum valent, sed longe diversae. Itaque hae mensurae ex rebus ipsis petendae sunt, et non ex verisimilitudine aut conjecturis.

Denique in omni inquisitione naturae *Quantum* corporis requiratur ad aliquod effectum, tanquam dosis, notandum; et cautiones de *Nimis* et *Parum* aspergendae.

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Among *prerogative instances* we will put in twenty-third place *Instances of Quantity*, which we have also been accustomed to call *Doses of Nature*, borrowing the term from medicine. These are the instances that measure powers by the *quantities* of bodies, and show what the *quantity of a body* contributes to the *mode of its power*. First, there are some powers that exist only in a *cosmic quantity*, that is, a *quantity* in agreement with the configuration and structure of the universe. For the earth stands still, while its parts fall. The waters of the seas ebb and flow; those of rivers do not, except where the sea comes in. Then too, almost all particular powers operate according to *much* or *little* of the body. Large bodies of water do not easily go bad; small ones do so quickly. New wine and beer mature and become drinkable far sooner in small skins than in large casks.

If an herb is put into a larger quantity of liquid, the result is an infusion rather than an absorption; if into a smaller, an absorption rather than an infusion. So a bath is one thing for the human body and a light sprinkling another. Again, small dews in the air never fall, but are dispersed and incorporated with the air. And when we breathe on gems, the little moisture can be seen dissolving at once, like a small cloud scattered by the wind. Again, a piece of a magnet does not draw as much iron as the whole magnet. There are also powers in which smallness of *quantity* is more effective. In piercing, a sharp point penetrates sooner than a blunt one; a pointed diamond engraves glass; and so on.

But we must not dwell here on the indefinite; we must also inquire into the *ratios of the quantity* of a body to the mode of its power. For it would be easy to believe that ratios of quantity match ratios of power: that if a lead ball of one ounce fell in a given time, a ball of two ounces ought to fall twice as fast—which is quite false. Nor do the same ratios hold for every kind of power; they differ widely. These measures must therefore be sought from things themselves, not from probability or conjecture.

Finally, in every inquiry into nature one should note what *quantity* of a body is required for a given

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	effect, as a kind of dose, and add warnings here and there about *Too Much* and *Too Little*.

THE KINDS OF MOTION

Bacon catalogs nineteen kinds of motion, from the resistance of matter to repose, and how they prevail.

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2.48 Inter *praerogativas instantiarum* ponemus loco vicesimo quarto *Instantias Luctae*; quas etiam *Instantias Praedominantiae* appellare consuevimus. Eae indicant praedominantiam et cessionem virtutum ad invicem; et quae ex illis sit fortior et vincat, quae infirmior et succumbat. Sunt enim motus et nixus corporum compositi, decompositi, et complicati, non minus quam corpora ipsa. Proponemus igitur primum species praecipuas motuum sive virtutum activarum; ut magis perspicua sit ipsarum comparatio in robore, et exinde demonstratio atque designatio *instantiarum luctae* et *praedominantiae*.	Among *prerogative instances* we will put in twenty-fourth place *Instances of Struggle*, which we have also been accustomed to call *Instances of Predominance*. These show how powers prevail over one another and give way to one another: which is stronger and wins, which weaker and succumbs. For the motions and strivings of bodies are compound, doubly compound and intertwined, no less than bodies themselves. We will therefore first set out the principal kinds of motions, or active powers. This will make their comparison in strength clearer, and so also the demonstration and designation of *instances of struggle* and *predominance*.
1. Motus Primus sit Motus *Antitypiae* materiae, quae inest in singulis portionibus ejus; per quem plane annihilari non vult: ita ut nullum incendium, nullum pondus aut depressio, nulla violentia, nulla denique aetas aut diuturnitas temporis possit redigere aliquam vel minimam portionem materiae in nihilum; quin illa et sit aliquid, et loci aliquid occupet, et se (in qualicunque necessitate ponatur), vel formam mutando vel locum, liberet, vel (si non detur copia) ut est subsistat; neque unquam res eo deveniat, ut aut nihil sit, aut nullibi. Quem motum Schola (quae semper fere et denominat et definit res potius per effectus et incommoda quam per causas interiores) vel denotat per illud axioma, quod *Duo corpora non possint esse in uno loco*; vel vocat motum *Ne fiat penetratio dimensionum*.	1. Let the First Motion be the Motion of *Antitypy* [resistance] of matter, which is present in every portion of it, and by which it absolutely refuses to be annihilated. No fire, no weight or pressure, no violence, and finally no age or length of time can reduce any portion of matter, however small, to nothing. It remains something and occupies some space. In whatever constraint it is placed, it either frees itself by changing its form or its place, or, if that is not possible, subsists as it is. It never comes to be either nothing or nowhere. The School, which nearly always names and defines things by their effects and inconveniences rather than by their inner causes, either expresses this motion by the axiom that *Two bodies cannot be in one place*, or calls it the motion *To prevent penetration of dimensions*.
Neque hujus motus exempla proponi consentaneum est: inest enim omni corpori.	There is no point in giving examples of this motion, for it is present in every body.
2. Sit Motus Secundus, Motus (quem appellamus) *Nexus*; per quem corpora non patiuntur se ulla ex parte sui dirimi a contactu alterius corporis, ut quae mutuo nexu et contactu gaudeant. Quem motum Schola vocat Motum *Ne detur vacuum*: veluti cum aqua attrahitur sursum exuctione, aut per fistulas; caro per ventosas; aut cum aqua sistitur nec effluit in hydriis perforatis, nisi os	2. Let the Second Motion be what we call the Motion of *Connection*, by which bodies do not allow themselves to be separated at any point from contact with another body, since they delight in mutual connection and contact. The School calls this the Motion *To prevent a vacuum*. Examples are water drawn upward by suction or through pipes; flesh drawn up by cupping glasses; water that

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hydriae ad immittendum aerem aperiatur; et innumera id genus.

3. Sit Motus Tertius, Motus (quem appellamus) *Libertatis*; per quem corpora se liberare nituntur a pressura aut tensura praeter-naturali, et restituere se in dimensum corpori suo conveniens. Cujus motus etiam innumera sunt exempla: veluti (quatenus ad liberationem a pressura) aquae in natando, aeris in volando; aquae in remigando, aeris in undulationibus ventorum; laminae in horologiis. Nec ineleganter se ostendit motus aeris compressi in sclopettis ludicris puerorum, cum alnum aut simile quiddam excavant, et infarciunt frusto alicujus radicis succulentae, vel similium, ad utrosque fines; deinde per embolum trudunt radicem vel hujusmodi farcimentum in foramen alterum; unde emittitur et ejicitur radix cum sonitu ad foramen alterum, idque antequam tangatur a radice aut farcimento citimo, aut embolo.

Quatenus vero ad liberationem a tensura, ostendit se hic motus in aere post exuctionem in ovis vitreis remanente, in chordis, in corio, et panno, resilientibus post tensuras suas, nisi tensurae illae per moram invaluerint, etc. Atque hunc motum Schola sub nomine Motus ex *Forma Elementi* innuit: satis quidem inscite, cum hic motus non tantum ad aerem, aquam, aut flammam pertineat, sed ad omnem diversitatem consistentiae; ut ligni, ferri, plumbi, panni, membranae, etc., in quibus singula corpora suae habent dimensionis modulum, et ab eo aegre ad spatium aliquod notabile abripiuntur. Verum quia motus iste libertatis omnium est maxime obvius, et ad infinita spectans, consultum fuerit eum bene et perspicue distinguere.

Quidam enim valde negligenter confundunt hunc motum cum gemino illo motu *antitypiae* et *nexus*; liberationem scilicet a pressura, cum motu *antitypiae*; a tensura, cum motu *nexus*; ac si ideo cederent aut se dilatarent corpora compressa, ne sequeretur *penetratio dimensionum*; ideo resilirent et contraherent se corpora tensa, ne sequeretur *vacuum*. Atqui si aer compressus se vellet recipere in densitatem aquae, aut lignum in densitatem lapidis, nil opus foret *penetratione dimensionum*; et nihilominus longe major posset esse compressio illorum, quam illa ullo modo patiuntur. Eodem modo si aqua se dilatare vellet in raritatem aeris, aut lapis in raritatem ligni, non opus

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stays put in perforated jars and does not flow out unless the mouth of the jar is opened to let in air; and countless things of that kind.

3. Let the Third Motion be what we call the Motion of *Liberty*, by which bodies strive to free themselves from unnatural pressure or tension and to restore themselves to the dimensions suited to their body. Of this motion too there are countless examples. As regards release from pressure, there is water in swimming and air in flying; water in rowing and air in the undulations of the winds; the spring in clocks. The motion of compressed air shows itself quite neatly in children's popguns. They hollow out an alder stick or something similar and plug it at both ends with a piece of some juicy root or the like. Then with a rod they push the root or other plug into one end, and the root at the other end is shot out with a bang—and this before it is touched by the nearer root or plug, or by the rod.

As regards release from tension, this motion shows itself in the air left in glass eggs after suction, and in strings, leather and cloth, which spring back after being stretched unless the stretching has taken hold through long duration, and so on. The School hints at this motion under the name of Motion from the *Form of the Element*—clumsily enough, since this motion belongs not only to air, water or flame but to every variety of consistency: to wood, iron, lead, cloth, parchment and so on. In each of these, every body has its own measure of dimension and is drawn away from it only with difficulty to any notable extent. But since this motion of liberty is the most obvious of all and bears on countless things, it will be wise to distinguish it properly and clearly.

For some very carelessly confuse this motion with the two motions of *antitypy* and *connection*: release from pressure with the motion of *antitypy*, release from tension with the motion of *connection*. They argue as if compressed bodies yielded or expanded so that *penetration of dimensions* should not follow, and stretched bodies sprang back and contracted so that a *vacuum* should not follow. Yet if compressed air were willing to shrink to the density of water, or wood to the density of stone, there would be no need of *penetration of dimensions*; and still they could be compressed far more than they

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foret *vacuo*; et tamen longe major posset fieri extensio eorum, quam illa ullo modo patiuntur.

Itaque non reducitur res ad *penetrationem dimensionum* et *vacuum*, nisi in ultimitatibus condensationis et rarefactionis; cum tamen isti motus longe citra eas sistant et versentur, neque aliud sint quam desideria corporum conservandi se in consistentiis suis (sive, si malint, in formis suis), nec ab iis recedendi subito, nisi per modos suaves ac per consensum alterentur. At longe magis necessarium est (quia multa secum trahit), ut intimetur hominibus, motum violentum (quem nos *mechanicum*, Democritus, qui in motibus suis primis expediendis etiam infra mediocres philosophos ponendus est, motum *plagae* vocavit) nil aliud esse quam Motum Libertatis, scilicet a compressione ad relaxationem. Etenim in omni sive simplici protrusione sive volatu per aerem, non fit summotio aut latio localis, antequam partes corporis praeter-naturaliter patiantur et comprimantur ab impellente.

Tum vero partibus aliis alias per successionem trudentibus, fertur totum; nec solum progrediendo, sed etiam rotando simul; ut etiam hoc modo partes se liberare, aut magis ex aequo tolerare possint. Atque de hoc motu hactenus.

4. Sit Motus Quartus, motus cui nomen dedimus Motus *Hyles*: qui motus antistrophus est quodammodo Motui, de quo diximus, Libertatis. Etenim in Motu Libertatis, corpora novum dimensum sive novam sphaeram sive novam dilatationem aut contractionem (haec enim verborum varietas idem innuit) exhorrent, respuunt, fugiunt, et resilire ac veterem consistentiam recuperare totis viribus contendunt. At contra in hoc Motu Hyles, corpora novam sphaeram sive dimensum appetunt; atque ad illud libenter et propere, et quandoque valentissimo nixu (ut in pulvere pyrio) aspirant. Instrumenta autem hujus motus, non sola certe, sed potentissima, aut saltem frequentissima, sunt calor et frigus. Exempli gratia: aer, si per tensuram (velut per exuctionem in ovis vitreis) dilatetur, magno laboret desiderio seipsum restituendi.

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will in any way endure. In the same way, if water were willing to expand to the rarity of air, or stone to the rarity of wood, there would be no need of a *vacuum*; and yet they could be extended far more than they will in any way endure.

So the matter does not come down to *penetration of dimensions* and *vacuum* except at the extremes of condensation and rarefaction. These motions, by contrast, stop and operate far short of those extremes. They are nothing but the desires of bodies to keep themselves in their consistencies (or, if people prefer, in their forms), and not to depart from them suddenly unless they are altered by gentle means and with their consent. But it is far more necessary, because much follows from it, to let people know that violent motion is nothing but the Motion of Liberty, namely from compression to release. We call this motion *mechanical*; Democritus—who in explaining his first motions ranks below even mediocre philosophers—called it the motion of *impact*. For in every simple push, or flight through the air, there is no displacement or local motion until the parts of the body are unnaturally acted upon and compressed by what drives it.

Then, as the parts push one another in succession, the whole is carried along—not only moving forward but rotating at the same time, so that in this way too the parts may free themselves, or bear the strain more evenly. So much for this motion.

4. Let the Fourth Motion be the motion we have named the Motion of *Hyle* [matter]. This motion is in a way the counterpart of the Motion of Liberty just described. For in the Motion of Liberty, bodies dread, reject and flee a new dimension, or new sphere, or new dilation or contraction (these different words mean the same thing), and strive with all their strength to spring back and recover their old consistency. In this Motion of Hyle, on the contrary, bodies seek a new sphere or dimension, and aspire to it willingly and swiftly, and sometimes with a most powerful effort, as in gunpowder. The instruments of this motion—certainly not the only ones, but the most powerful, or at least the most frequent—are heat and cold. For example, air expanded by tension (as by suction in glass eggs) labors under a great desire to restore itself.

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At admoto calore, e contra appetit dilatari, et concupiscet novam sphaeram, et transit et migrat in illam libenter, tanquam in novam formam (ut loquuntur); nec post dilatationem nonnullam de reditu curat, nisi per admotionem frigidi ad eam invitetur; quae non reditus est, sed transmutatio repetita. Eodem modo et aqua, si per compressionem arctetur, recalcitrat; et vult fieri qualis fuit, scilicet latior. At si interveniat frigus intensum et continuatum, mutat se sponte sua et libenter in condensationem glaciei; atque si plane continuetur frigus, nec a teporibus interrumpatur (ut fit in speluncis et cavernis paulo profundioribus), vertitur in crystallum aut materiam similem, nec unquam restituitur.

5. Sit Motus Quintus, Motus *Continuationis*. Intelligimus autem non continuationis simplicis et primariae, cum corpore aliquo altero (nam ille est Motus *Nexus*); sed continuationis sui, in corpore certo. Certissimum enim est, quod corpora omnia solutionem continuitatis exhorreant; alia magis, alia minus, sed omnia aliquatenus. Nam ut in corporibus duris (veluti chalybis, vitri) reluctatio contra discontinuationem est maxime robusta et valida, ita etiam in liquoribus, ubi cessare aut languere saltem videtur motus ejusmodi, tamen non prorsus reperitur privatio ejus; sed plane inest ipsis in gradu tanquam infimo, et prodit se in experimentis plurimis; sicut in bullis, in rotunditate guttarum, in filis tenuioribus stillicidiorum, et in sequacitate corporum glutinosorum, et ejusmodi. Sed maxime omnium se ostendit appetitus iste, si discontinuatio tentetur usque ad fractiones minores.

Nam in mortariis, post contusionem ad certum gradum, non amplius operatur pistillum; aqua non subintrat rimas minores; quin et ipse aer, non obstante subtilitate corporis ipsius, poros vasorum paulo solidiorum non pertransit subito, nec nisi per diuturnam insinuationem.

6. Sit Motus Sextus, motus quem nominamus Motum *ad Lucrum*, sive Motum *Indigentiae*. Is est, per quem corpora, quando versantur inter plane heterogenea et quasi inimica, si forte nanciscantur copiam aut commoditatem evitandi illa heterogenea et se applicandi ad magis cognata, (licet illa ipsa cognata talia fuerint quae non habeant arctum consensum cum ipsis) tamen statim ea amplectuntur, et tanquam potiora malunt: et lucri loco (unde vocabulum sumpsimus) hoc ponere videntur,

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But when heat is applied, it now seeks to be expanded, craves a new sphere, and passes and migrates into it willingly, as into a new form (as they say). After some expansion it has no wish to return, unless it is invited to do so by the application of cold —and that is not a return but a repeated transformation. In the same way water, if confined by compression, resists and wants to become what it was, that is, larger. But if intense and continued cold intervenes, it changes of its own accord and willingly into the condensed state of ice. And if the cold is maintained steadily and not interrupted by warmth (as happens in grottoes and fairly deep caves), it turns into crystal or a similar material and is never restored.

5. Let the Fifth Motion be the Motion of *Continuity*. We do not mean simple and primary continuity with some other body (that is the Motion of *Connection*), but continuity with itself within a particular body. For it is quite certain that all bodies dread a breach of continuity—some more, some less, but all to some degree. In hard bodies such as steel and glass the resistance to being broken apart is extremely strong and firm. In liquids, where a motion of this kind seems to cease or at least to be weak, it is nevertheless not found to be entirely absent. It is plainly present in them in almost the lowest degree, and shows itself in a great many experiments: in bubbles, in the roundness of drops, in the thin threads of drips, in the stickiness of glutinous bodies, and the like. But this appetite shows itself most of all when one tries to break a body down into smaller fragments.

For in mortars, after pounding to a certain degree, the pestle has no further effect; water does not get into the finer cracks; and even air, for all the subtlety of its body, does not pass through the pores of fairly solid vessels quickly, but only by slow infiltration over a long time.

6. Let the Sixth Motion be the motion we name the Motion *for Gain*, or the Motion *of Need*. By this motion bodies placed among things entirely heterogeneous and, as it were, hostile, if they happen to find an opportunity or means of avoiding them and attaching themselves to things more akin, at once embrace these and prefer them as better—even if those akin things are not in close agreement with them. They seem to count this as gain

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tanquam talium corporum indiga. Exempli gratia: aurum, aut aliud metallum foliatum non delectatur aere circumfuso. Itaque si corpus aliquod tangibile et crassum nanciscatur (ut digitum, papyrum, quidvis aliud), adhaeret statim, nec facile divellitur. Etiam papyrus, aut pannus, et hujusmodi, non bene se habent cum aere qui inseritur et commistus est in ipsorum poris.

Itaque aquam aut liquorem libenter imbibunt, et aerem exterminant. Etiam saccharum, aut spongia infusa in aquam aut vinum, licet pars ipsorum emineat et longe attollatur supra vinum aut aquam, tamen aquam aut vinum paulatim et per gradus attrahunt in sursum.

Unde optimus canon sumitur aperturae et solutionum corporum. Missis enim corrosivis et aquis fortibus, quae viam sibi aperiunt, si possit inveniri corpus proportionatum et magis consentiens et amicum corpori alicui solido quam illud cum quo tanquam per necessitatem commiscetur, statim se aperit et relaxat corpus, et illud alterum intro recipit, priore excluso aut summoto. Neque operatur aut potest iste *motus ad lucrum* solummodo ad tactum. Nam electrica operatio (de qua Gilbertus et alii post eum tantas excitarunt fabulas) non alia est quam corporis per fricationem levem excitati appetitus; qui aerem non bene tolerat, sed aliud tangibile mavult, si reperiatur in propinquo.

7. Sit motus Septimus, Motus (quem appellamus) *Congregationis Majoris*; per quem corpora feruntur ad massas connaturalium suorum: gravia, ad globum terrae; levia, ad ambitum coeli. Hunc Schola nomine *Motus Naturalis* insignivit: levi contemplatione, quia scilicet nil spectabile erat ab extra quod eum motum cieret (itaque rebus ipsis innatum atque insitum putavit); aut forte quia non cessat. Nec mirum: semper enim praesto sunt coelum et terra; cum e contra causae et origines plurimorum ex reliquis motibus interdum absint, interdum adsint. Itaque hunc, quia non intermittit sed caeteris intermittentibus statim occurrit, perpetuum et proprium; reliquos ascititios posuit. Est autem iste motus revera satis infirmus et hebes, tanquam is qui (nisi sit moles corporis major) caeteris motibus, quamdiu operantur, cedat et succumbat.

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(hence our term), as though they needed such bodies. For example, gold or another metal beaten into leaf does not enjoy the air around it. So if it gets hold of some tangible, dense body—a finger, paper, anything else—it sticks to it at once and is not easily pulled off. Paper, too, and cloth and the like, do not get on well with the air that has entered and mixed into their pores.

So they readily soak up water or other liquid and drive out the air. Again, sugar, or a sponge put into water or wine, even if part of it sticks out and rises well above the wine or water, still draws the water or wine upward little by little.

From this we derive an excellent rule for opening and dissolving bodies. Leave aside corrosives and strong acids (*aquae fortes*), which open a way for themselves. If a body can be found that is proportioned to some solid body, and more in agreement and more friendly with it than the body with which it is mixed as if by necessity, the solid body at once opens and loosens itself and admits the other within, the former being shut out or removed. Nor does this *motion for gain* work, or have force, only on contact. For electrical action (about which Gilbert, and others after him, have stirred up such tales) is nothing but the appetite of a body excited by gentle rubbing, which does not tolerate air well and prefers some other tangible body, if one is found close by.[32]

7. Let the Seventh Motion be what we call the Motion of *Greater Congregation*, by which bodies are carried toward the masses of things of their own nature: heavy bodies toward the globe of the earth, light ones toward the circumference of the heavens. The School gave this the name *Natural Motion*, on slight consideration: because nothing visible from outside set this motion going, and so it thought the motion innate and implanted in things themselves; or perhaps because it never stops. No wonder, for heaven and earth are always there, whereas the causes and origins of most of the other motions are sometimes absent and sometimes present. So because this motion does not let up, but comes into play the moment the others let up, the School declared it perpetual and proper, and the others adventitious. In fact this

32 Gilbert coined the Latin term *electricus* in *De Magnete* (1600).

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Atque cum hic motus hominum cogitationes ita impleverit ut fere reliquos motus occultaverit, tamen parum est quod homines de eo sciunt, sed in multis circa illum erroribus versantur.

8. Sit Motus Octavus, Motus *Congregationis Minoris;* per quem partes homogeneae in corpore aliquo separant se ab heterogeneis, et coeunt inter sese; per quem etiam corpora integra ex similitudine substantiae se amplectuntur et fovent, et quandoque ad distantiam aliquam congregantur, attrahuntur, et conveniunt: veluti cum in lacte flos lactis post moram aliquam supernatat; in vino faeces et tartarum subsidunt. Neque enim haec fiunt per motum gravitatis et levitatis tantum, ut aliae partes summitatem petant, aliae ad imum vergant; sed multo magis per desiderium homogeneorum inter se coeundi et se uniendi. Differt autem iste motus a motu *indigentiae*, in duobus.

Uno, quod in motu *indigentiae* sit stimulus major naturae malignae et contrariae; at in hoc motu (si modo impedimenta et vincula absint) uniuntur partes per amicitiam, licet absit natura aliena quae litem moveat: altero, quod arctior sit unio, et tanquam majore cum delectu. In illo enim, modo evitetur corpus inimicum, corpora etiam non admodum cognata concurrunt; at in hoc coeunt substantiae, germana plane similitudine devinctae, et conflantur tanquam in unum. Atque hic motus omnibus corporibus compositis inest; et se facile conspiciendum in singulis daret, nisi ligaretur et fraenaretur per alios corporum appetitus et necessitates, quae istam coitionem disturbant.

Ligatur autem motus iste plerumque tribus modis: torpore corporum; fraeno corporis dominantis; et motu externo. Ad torporem corporum quod attinet; certum est inesse corporibus tangibilibus pigritiam quandam secundum magis et minus, et exhorrentiam motus localis; ut, nisi excitentur, malint statu suo (prout sunt) esse contenta quam in melius se expedire. Discutitur autem iste torpor triplici auxilio: aut per calorem, aut per virtutem alicujus cognati corporis eminentem, aut per motum vividum et potentem. Atque primo quoad

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motion is fairly weak and dull: unless the mass of the body is large, it yields and gives way to the other motions for as long as they are operating.

Yet although this motion has so filled people's thoughts that it has almost hidden the other motions from view, they know little about it and are caught up in many errors concerning it.

8. Let the Eighth Motion be the Motion of *Lesser Congregation*. By this motion the homogeneous parts in a body separate themselves from the heterogeneous and come together among themselves. By it, too, whole bodies, through likeness of substance, embrace and cherish one another, and sometimes gather, are attracted and meet across some distance. So in milk the cream rises to the top after a while, and in wine the dregs and tartar settle. These things do not happen only by the motion of heaviness and lightness, some parts seeking the top and others sinking to the bottom, but much more by the desire of homogeneous things to come together and unite. This motion differs from the motion of *need* in two ways.

First, in the motion of *need* there is a greater stimulus from a hostile and contrary nature; whereas in this motion, provided impediments and bonds are absent, the parts unite through friendship, even without an alien nature to stir up strife. Second, the union here is tighter, and made, so to speak, with greater selectivity. For in the former, so long as the hostile body is avoided, even bodies not very closely akin come together; but in this one, substances bound by a truly kindred likeness come together and are fused, as it were, into one. This motion is present in all compound bodies. It would readily show itself in each of them, were it not bound and reined in by other appetites and necessities of bodies that disturb this coming together.

This motion is usually bound in three ways: by the torpor of bodies, by the curb of a dominant body, and by external motion. As for the torpor of bodies, it is certain that tangible bodies have a certain laziness, greater or less, and an aversion to local motion. Unless they are stirred up, they prefer to be content with their state as it is rather than to better themselves. This torpor is shaken off by three kinds of help: by heat, by the outstanding power of some kindred body, or by lively and

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auxilium caloris; hinc fit, quod calor pronuntietur esse illud quod *separet heterogenea, congreget homogenea.* Quam definitionem Peripateticorum merito derisit Gilbertus; dicens eam esse perinde ac si quis diceret ac definiret hominem illud esse quod serat triticum et plantet vineas: esse enim definitionem tantum per effectus, eosque particulares.

Sed adhuc magis culpanda est illa definitio; quia etiam effectus illi (quales quales sunt) non sunt ex proprietate caloris, sed tantum per accidens (idem enim facit frigus, ut postea dicemus), nempe ex desiderio partium homogenearum coeundi, adjuvante tantum calore ad discutiendum torporem, qui torpor desiderium illud antea ligaverat. Quoad vero auxilium virtutis inditae a corpore cognato; illud mirabiliter elucescit in magnete armato, qui excitat in ferro virtutem detinendi ferrum per similitudinem substantiae, discusso torpore ferri per virtutem magnetis. Quoad vero auxilium motus; conspicitur illud in sagittis ligneis, cuspide etiam lignea, quae altius penetrant in alia ligna quam si fuissent armatae ferro, per similitudinem substantiae, discusso torpore ligni per motum celerem: de quibus duobus experimentis etiam in aphorismo de *instantiis clandestinis* diximus.

Ligatio vero motus *congregationis minoris*, quae fit per fraenum corporis dominantis, conspicitur in solutione sanguinis et urinarum per frigus. Quamdiu enim repleta fuerint corpora illa spiritu agili, qui singulas eorum partes cujuscunque generis ipse ut dominus totius ordinat et cohibet, tamdiu non coeunt heterogenea propter fraenum; sed postquam ille spiritus evaporaverit, aut suffocatus fuerit per frigus, tum solutae partes a fraeno coeunt secundum desiderium suum naturale. Atque ideo fit, ut omnia corpora quae continent spiritum acrem (ut sales, et hujusmodi) durent et non solvantur, ob fraenum permanens et durabile spiritus dominantis et imperiosi.

Ligatio vero motus *congregationis minoris*, quae fit per motum externum, maxime conspicitur in agitationibus corporum per quas arcetur putrefactio. Omnis enim putrefactio fundatur in congregatione homogeneorum; unde paulatim fit corruptio prioris (quam vocant) formae, et generatio novae. Nam putrefactionem, quae sternit viam ad generationem novae formae, praecedit

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powerful motion. First, as regards the help of heat: this is why heat is declared to be that which *separates heterogeneous things and gathers homogeneous ones*. Gilbert rightly mocked this definition of the Peripatetics. He said it was as if someone were to define man as that which sows wheat and plants vineyards: it is a definition only by effects, and particular ones at that.

But that definition deserves still more blame. Even those effects, such as they are, do not come from a property of heat but only incidentally (for cold does the same, as we shall say later). They come from the desire of homogeneous parts to come together, heat only helping to shake off the torpor that had previously bound that desire. As regards the help of a power imparted by a kindred body, this shines out wonderfully in the armed magnet, which excites in iron the power of holding iron through likeness of substance, the torpor of the iron being shaken off by the power of the magnet. As regards the help of motion, it is seen in wooden arrows with wooden points, which penetrate other wood more deeply than if they had been tipped with iron, through likeness of substance, the torpor of the wood being shaken off by swift motion. We have spoken of these two experiments also in the aphorism on *clandestine instances*.

The binding of the motion of *lesser congregation* by the curb of a dominant body is seen in the breaking up of blood and urine by cold. As long as those bodies are filled with an active spirit, which as lord of the whole orders and restrains each of their parts of whatever kind, the heterogeneous parts do not come together, because of the curb. But once that spirit has evaporated or been stifled by cold, the parts, freed from the curb, come together according to their natural desire. This is why all bodies containing a sharp spirit, such as salts and the like, last and do not break up: the curb of a dominant and commanding spirit is permanent and lasting.

The binding of the motion of *lesser congregation* by external motion is seen most in the agitation of bodies, which prevents putrefaction. For all putrefaction is founded on the congregation of homogeneous parts, from which comes, little by little, the corruption of the prior form (as they call it) and the generation of a new one. Putrefaction,

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solutio veteris; quae est ipsa coitio ad homogeniam. Ea vero, si non impedita fuerit, fit solutio simplex: sin occurrant varia quae obstant, sequuntur putrefactiones quae sunt rudimenta generationis novae.

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which paves the way for the generation of a new form, is preceded by the dissolution of the old one, and this is itself a coming together toward homogeneity. If this is not impeded, it is a simple dissolution; but if various obstacles arise, putrefactions follow, which are the rudiments of a new generation.

Quod si (id quod nunc agitur) fiat agitatio frequens per motum externum, tum vero motus iste coitionis (qui est delicatus et mollis et indiget quiete ab externis) disturbatur et cessat; ut fieri videmus in innumeris: veluti cum quotidiana agitatio aut profluentia aquae arceat putrefactionem; venti arceant pestilentiam aeris; grana in granariis versa et agitata maneant pura; omnia denique agitata exterius non facile putrefiant interius.

But if there is frequent agitation by external motion (which is the point at issue), then this motion of coming together, which is delicate and gentle and needs to be left in peace by outside things, is disturbed and ceases. We see this happen in countless cases. Daily agitation or flowing of water prevents putrefaction; winds prevent pestilence in the air; grain turned and stirred in granaries stays pure; in short, things agitated from outside do not easily putrefy within.

Superest ut non omittatur coitio illa partium corporum, unde fit praecipue induratio et desiccatio. Postquam enim spiritus, aut humidum in spiritum versum, evolaverit in aliquo corpore porosiore (ut in ligno, osse, membrana, et hujusmodi), tum partes crassiores majore nixu contrahuntur et coeunt, unde sequitur induratio aut desiccatio: quod existimamus fieri, non tam ob motum *nexus*, ne detur vacuum, quam per motum istum amicitiae et unionis.

We must not leave out the coming together of the parts of bodies that is the main cause of hardening and drying. For once the spirit, or moisture turned into spirit, has flown out of a fairly porous body (such as wood, bone, parchment and the like), the coarser parts contract and come together with greater effort, and hardening or drying follows. We think this happens not so much by the motion of *connection*, to prevent a vacuum, as by this motion of friendship and union.

Ad coitionem vero ad distans quod attinet, ea infrequens est et rara; et tamen in pluribus inest quam quibus observatur. Hujus simulacra sunt, cum bulla solvat bullam; medicamenta ex similitudine substantiae trahant humores; chorda in diversis fidibus ad unisonum moveat chordam; et hujusmodi. Etiam in spiritibus animalium hunc motum vigere existimamus, sed plane incognitum. At eminet certe in magnete, et ferro excito. Cum autem de motibus magnetis loquimur, distinguendi plane sunt. Quatuor enim virtutes sive operationes sunt in magnete, quae non confundi, sed separari debent; licet admiratio hominum et stupor eas commiscuerit. Una, coitionis magnetis ad magnetem, vel ferri ad magnetem, vel ferri exciti ad ferrum. Secunda, verticitatis ejus ad septentriones et austrum, atque simul declinationis ejus. Tertia, penetrationis ejus per aurum, vitrum, lapidem, omnia.

As for coming together at a distance, it is infrequent and rare; and yet it is present in more cases than those in which it is observed. Images of it are when one bubble dissolves another; when medicines draw humors by likeness of substance; when a string on one instrument sets a string on another moving in unison; and the like. We think this motion is active also in the spirits of animals, but it is wholly unknown there. It certainly stands out in the magnet and in excited iron. When we speak of the motions of the magnet, however, they must be clearly distinguished. For there are four powers or operations in the magnet which should not be confused but kept apart, although people's wonder and amazement have mixed them together. The first is the coming together of magnet with magnet, or of iron with magnet, or of excited iron with iron. The second is its verticity toward north and south, and with it its declination. The third is its penetration through gold, glass, stone, everything.

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Quarta, communicationis virtutis ejus de lapide in ferrum, et de ferro in ferrum, absque communicatione substantiae. Verum hoc loco de prima virtute ejus tantum loquimur, videlicet coitionis. Insignis etiam est motus coitionis argenti vivi et auri: adeo ut aurum alliciat argentum vivum, licet confectum in unguenta; atque operarii inter vapores argenti vivi soleant tenere in ore frustum auri, ad colligendas emissiones argenti vivi, alias crania et ossa eorum invasuras; unde etiam frustum illud paulo post albescit. Atque de motu *congregationis minoris* haec dicta sint.

9. Sit Motus Nonus, *Motus Magneticus*; qui licet sit ex genere motus *congregationis minoris,* tamen si operetur ad distantias magnas et super massas rerum magnas, inquisitionem meretur separatam; praesertim si nec incipiat a tactu, quemadmodum plurimi, nec perducat actionem ad tactum, quemadmodum omnes motus congregativi; sed corpora tantum elevet, aut ea intumescere faciat, nec quicquam ultra. Nam si luna attollat aquas, aut turgescere aut intumescere faciat humida; aut coelum stellatum attrahat planetas versus sua apogaea; aut sol alliget astra Veneris et Mercurii, ne longius absint a corpore ejus quam ad distantiam certam; videntur hi motus nec sub *congregatione majore* nec sub *congregatione minore* bene collocari, sed esse tanquam congregativa media et imperfecta, ideoque speciem debere constituere propriam.

10. Sit Motus Decimus, *Motus Fugae;* motus scilicet motui *congregationis minoris* contrarius; per quem corpora ex antipathia fugiunt et fugant inimica, seque ab illis separant, aut cum illis miscere se recusant. Quamvis enim videri possit in aliquibus hic motus esse motus tantum per accidens aut per consequens, respectu motus *congregationis minoris,* quia nequeunt coire homogenea, nisi heterogeneis exclusis et remotis; tamen ponendus est motus iste per se, et in speciem constituendus, quia in multis appetitus *fugae* cernitur magis principalis quam appetitus coitionis.

Eminet autem hic motus insigniter in excretionibus animalium; nec minus etiam in sensuum nonnullorum

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The fourth is the communication of its power from the stone to iron, and from iron to iron, without any communication of substance. Here, however, we are speaking only of its first power, that of coming together. Remarkable too is the motion of coming together of quicksilver and gold. Gold attracts quicksilver even when the quicksilver has been made into ointments; and workmen amid the fumes of quicksilver usually keep a piece of gold in their mouths to collect its emanations, which would otherwise invade their skulls and bones—and so the piece soon turns white. So much for the motion of *lesser congregation*.

9. Let the Ninth Motion be the *Magnetic Motion*. Although it belongs to the genus of the motion of *lesser congregation*, it deserves a separate inquiry if it operates across great distances and upon great masses of things. This is especially so if it neither begins from contact, as most motions do, nor brings the action to contact, as all congregative motions do, but merely raises bodies or makes them swell, and nothing more. Suppose the moon lifts the waters, or makes moist things swell and rise; or the starry heaven draws the planets toward their apogees; or the sun holds the planets Venus and Mercury so that they are never farther from its body than a certain distance. These motions seem not to fit well under either *greater* or *lesser congregation*. They seem to be intermediate and imperfect congregative motions, and so ought to form a kind of their own.

10. Let the Tenth Motion be the *Motion of Flight*: a motion contrary to the motion of *lesser congregation*, by which bodies, out of antipathy, flee and put to flight hostile things, and separate themselves from them, or refuse to mix with them. In some cases this motion may seem to be only incidental to, or a consequence of, the motion of *lesser congregation*, since homogeneous things cannot come together unless heterogeneous ones are shut out and removed. Still, this motion should be posited in its own right and made a kind of its own, because in many cases the appetite for *flight* is seen to be more fundamental than the appetite for coming together.

This motion stands out conspicuously in the excretions of animals, and no less in things offensive

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odiosis objectis, praecipue in olfactu et gustu. Odor enim foetidus ita rejicitur ab olfactu, ut etiam inducat in os stomachi motum expulsionis per consensum; sapor amarus et horridus ita rejicitur a palato aut gutture, ut inducat per consensum capitis conquassationem et horrorem. Veruntamen etiam in aliis locum habet iste motus. Conspicitur enim in antiperistasibus nonnullis; ut in aeris media regione, cujus frigora videntur esse rejectiones naturae frigidae ex confiniis coelestium; quemadmodum etiam videntur magni illi fervores et inflammationes, quae inveniuntur in locis subterraneis, esse rejectiones naturae calidae ab interioribus terrae.

Calor enim et frigus, si fuerint in quanto minore, se invicem perimunt; sin fuerint in massis majoribus et tanquam justis exercitibus, tum vero per conflictum se locis invicem summovent et ejiciunt. Etiam tradunt cinamomum et odorifera, sita juxta latrinas et loca foetida, diutius odorem retinere; quia recusant exire et commisceri cum foetidis. Certe argentum vivum, quod alias se reuniret in corpus integrum, prohibetur per salivam hominis, aut axungiam porci, aut terebinthinam, et hujusmodi, ne partes ejus coeant; propter malum consensum quem habent cum hujusmodi corporibus; a quibus undique circumfusis se retrahunt; adeo ut fortior sit earum *fuga* ab istis interjacentibus quam desiderium uniendi se cum partibus sui similibus; id quod vocant *mortificationem* argenti vivi.

Etiam quod oleum cum aqua non misceatur, non tantum in causa est differentia levitatis, sed malus ipsorum consensus: ut videre est in spiritu vini, qui cum levior sit oleo, tamen se bene miscet cum aqua. At maxime omnium insignis est motus *fugae* in nitro, et hujusmodi corporibus crudis, quae flammam exhorrent; ut in pulvere pyrio, argento vivo, necnon in auro. *Fuga* vero ferri ab altero polo magnetis a Gilberto bene notatur non esse *fuga* propria, sed conformitas, et coitio ad situm magis accommodatum.

11. Sit Motus Undecimus, *Motus Assimilationis*, sive *Multiplicationis sui,* sive etiam *Generationis Simplicis. Generationem* autem *simplicem* dicimus non corporum integralium, ut in plantis, aut animalibus; sed corporum similarium. Nempe per hunc motum corpora similaria vertunt corpora alia affinia, aut saltem bene disposita et praeparata, in substantiam et naturam suam: ut flamma,

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to some of the senses, especially smell and taste. A foul odor is so rejected by the sense of smell that by sympathy it even sets up a motion of expulsion in the mouth of the stomach. A bitter and harsh taste is so rejected by the palate or throat that by sympathy it causes a shaking of the head and a shudder. But this motion has a place in other things too. It is seen in certain antiperistases, as in the middle region of the air, whose cold seems to be the nature of cold rejected from the borders of the heavens; just as the great heats and fires found underground seem to be the nature of heat rejected from the interior of the earth.

For heat and cold, when they are in smaller quantity, destroy each other; but when they are in larger masses, like regular armies, they fight and drive each other out of their places. It is also reported that cinnamon and other fragrant things placed near latrines and foul-smelling places keep their scent longer, because they refuse to go out and mix with the foul smells. Certainly quicksilver, which would otherwise reunite into a single body, is prevented from letting its parts come together by human saliva, pork lard, turpentine and the like. This is because of the bad agreement they have with such bodies; the parts draw back from them when these are spread all around, so that their *flight* from the intervening substances is stronger than their desire to unite with parts like themselves. This is what is called the *mortification* of quicksilver.

Again, the cause of oil's not mixing with water is not only the difference in lightness but their bad agreement. This can be seen in spirit of wine, which, though lighter than oil, mixes well with water. But the motion of *flight* is most conspicuous of all in niter and similar crude bodies that dread flame, as in gunpowder, quicksilver, and gold too. The *flight* of iron from one pole of the magnet, however, is rightly noted by Gilbert to be not *flight* proper but conformity, a coming together toward a more suitable position.

11. Let the Eleventh Motion be the *Motion of Assimilation,* or *of Self-Multiplication,* or again *of Simple Generation*. By *simple generation* we mean the generation not of whole organized bodies, as in plants or animals, but of uniform bodies. By this motion uniform bodies turn other bodies that are akin to

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quae super halitus et oleosa multiplicat se, et generat novam flammam; aer, qui super aquam et aquea multiplicat se, et generat novum aerem; spiritus vegetabilis et animalis, qui super tenuiores partes tam aquei quam oleosi in alimentis suis multiplicat se, et generat novum spiritum; partes solidae plantarum et animalium, veluti folium, flos, caro, os, et sic de caeteris, quae singulae ex succis alimentorum assimilant et generant substantiam successivam et epiusiam.

Neque enim quenquam cum Paracelso delirare juvet, qui (distillationibus suis scilicet occaecatus) nutritionem per separationem tantum fieri voluit; quodque in pane vel cibo lateat oculus, nasus cerebrum, jecur; in succo terrae radix, folium, flos. Etenim sicut faber ex rudi massa lapidis vel ligni, per separationem et rejectionem superflui, educit folium, florem, oculum, nasum, manum, pedem, et similia; ita *Archaeum* illum Fabrum internum ex alimento per separationem et rejectionem educere singula membra et partes asserit ille. Verum missis nugis, certissimum est partes singulas, tam similares quam organicas, in vegetabilibus et animalibus, succos alimentorum suorum fere communes, aut non multum diversos, primo attrahere cum nonnullo delectu, deinde assimilare, et vertere in naturam suam.

Neque *assimilatio* ista, aut *generatio simplex*, fit solum in corporibus animatis, verum et inanimata ex hac re participant; veluti de flamma et aere dictum est. Quinetiam spiritus emortuus, qui in omni tangibili animato continetur, id perpetuo agit, ut partes crassiores digerat et vertat in spiritum, qui deinde exeat; unde fit diminutio ponderis et exsiccatio, ut alibi diximus. Neque etiam respuenda est in *assimilatione* accretio illa, quam vulgo ab alimentatione distinguunt; veluti cum lutum inter lapillos concrescit, et vertitur in materiam lapideam; squammae circa dentes vertuntur in substantiam non minus duram quam sunt dentes ipsi, etc. Sumus enim in ea opinione, inesse corporibus omnibus desiderium assimilandi, non minus quam coeundi ad homogenea; verum ligatur ista virtus, sicut et illa, licet non iisdem modis.

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them, or at least well disposed and prepared, into their own substance and nature. So flame multiplies itself upon vapors and oily things and generates new flame. Air multiplies itself upon water and watery things and generates new air. Vegetable and animal spirit multiplies itself upon the finer parts, watery and oily alike, of its food and generates new spirit. And the solid parts of plants and animals—leaf, flower, flesh, bone and the rest—each assimilate from the juices of their food and generate a successive substance, an *epiusia* [added substance].

Let no one be tempted to rave with Paracelsus, who, blinded no doubt by his distillations, held that nutrition takes place by separation alone: that in bread or food there lie hidden eye, nose, brain and liver, and in the juice of the earth root, leaf and flower. A craftsman, from a rough block of stone or wood, brings out a leaf, a flower, an eye, a nose, a hand, a foot and so on by separating and rejecting what is superfluous. In the same way, he asserts, that internal Craftsman, the *Archeus*, brings out the individual members and parts from food by separation and rejection. But leaving such trifles aside, it is quite certain that the individual parts in plants and animals, uniform and organic alike, first attract with some selectivity the juices of their food, which are almost the same for all or not very different, and then assimilate them and turn them into their own nature.[33]

Nor does this *assimilation*, or *simple generation*, take place only in animate bodies; inanimate ones share in it too, as has been said of flame and air. Indeed, the lifeless spirit contained in every tangible animate body is constantly at work digesting the coarser parts and turning them into spirit, which then escapes; hence come loss of weight and drying out, as we have said elsewhere. Nor should we exclude from *assimilation* the accretion that is commonly distinguished from nourishment: as when mud between pebbles hardens and turns into stony matter, or the scale around the teeth turns into a substance as hard as the teeth themselves, and so on. For we hold that there is in all bodies a desire to assimilate, no less than a desire to come together with homogeneous things.

33 Paracelsus (1493–1541), Swiss physician and alchemist; his *Archeus* was an inner vital principle directing the processes of each body.

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Sed modos illos, necnon solutionem ab iisdem, omni diligentia inquirere oportet, quia pertinent ad senectutis refocillationem. Postremo videtur notatu dignum, quod in novem illis motibus, de quibus diximus, corpora tantum naturae suae conservationem appetere videntur; in hoc decimo autem propagationem.

12. Sit Motus Duodecimus, *Motus Excitationis*; qui motus videtur esse ex genere *assimilationis*, atque eo nomine quandoque a nobis promiscue vocatur. Est enim motus diffusivus, et communicativus, et transitivus, et multiplicativus, sicut et ille; atque effectu (ut plurimum) consentiunt, licet efficiendi modo et subjecto differant. Motus enim *assimilationis* procedit tanquam cum imperio et potestate; jubet enim et cogit assimilatum in assimilantem verti et mutari. At motus *excitationis* procedit tanquam arte et insinuatione et furtim; et invitat tantum, et disponit excitatum ad naturam excitantis. Etiam motus *assimilationis* multiplicat et transformat corpora et substantias; veluti, plus fit flammae, plus aeris, plus spiritus, plus carnis. At in motu *excitationis*, multiplicantur et transeunt virtutes tantum; et plus fit calidi, plus magnetici, plus putridi.

Eminet autem iste motus praecipue in calido et frigido. Neque enim calor diffundit se in calefaciendo per communicationem primi caloris; sed tantum per *excitationem* partium corporis ad motum illum qui est Forma Calidi; de quo in *vindemiatione prima de natura calidi* diximus. Itaque longe tardius et difficilius excitatur calor in lapide aut metallo quam in aere, ob inhabilitatem et impromptitudinem corporum illorum ad motum illum; ita ut verisimile sit posse esse interius versus viscera terrae materias quae calefieri prorsus respuant; quia ob condensationem majorem spiritu illo destituuntur a quo motus iste *excitationis* plerunque incipit. Similiter magnes induit ferrum nova partium dispositione et motu conformi; ipse autem nihil ex virtute perdit.

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But this power is bound, as that one is, though not in the same ways.

Those ways, however, and how to be released from them, must be investigated with all diligence, because they bear on renewing the vigor of old age. Lastly, it seems worth noting that in the nine motions we have described, bodies seem to seek only the preservation of their nature, but in this tenth one its propagation.[34]

12. Let the Twelfth Motion be the *Motion of Excitation*. This motion seems to belong to the genus of *assimilation*, and we sometimes use that name for it indiscriminately. For it is a motion that spreads, communicates, passes on and multiplies, as the other does; and for the most part they agree in effect, though they differ in their manner of acting and in their subject. The motion of *assimilation* proceeds as if with command and authority: it orders and compels the thing assimilated to be turned and changed into the thing assimilating it. The motion of *excitation* proceeds as if by art, by insinuation and by stealth: it merely invites the excited body, and disposes it toward the nature of the exciting one. Again, the motion of *assimilation* multiplies and transforms bodies and substances, so that there comes to be more flame, more air, more spirit, more flesh. But in the motion of *excitation* only powers are multiplied and passed on, so that there comes to be more that is hot, more that is magnetic, more that is putrid.

This motion stands out chiefly in hot and cold. For heat does not spread itself in heating by communicating the original heat, but only by *exciting* the parts of the body to the motion that is the Form of Heat, of which we spoke in the *first vintage concerning the nature of heat*. So heat is excited far more slowly and with more difficulty in stone or metal than in air, because those bodies are ill-suited to that motion and slow to take it up. It is even probable that deeper down, toward the bowels of the earth, there may be materials that altogether refuse to be heated, because their greater condensation deprives them of the spirit with which this motion of *excitation* generally begins. Similarly, the magnet endows iron with a new disposition of

34 So Bacon counts; in his list this is in fact the eleventh motion.

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its parts and a conforming motion, while losing nothing of its own power.

Similiter fermentum panis, et flos cervisiae, et coagulum lactis, et nonnulla ex venenis, excitant et invitant motum in massa farinaria, aut cervisia, aut caseo, aut corpore humano, successivum et continuatum; non tam ex vi excitantis quam ex praedispositione et facili cessione excitati.

Similarly, the leaven of bread, the yeast of beer, the rennet of milk and some poisons excite and invite a successive and continuous motion in the dough, the beer, the cheese or the human body. This comes not so much from the force of the exciting body as from the predisposition and ready yielding of the excited one.

13. Sit Motus Decimus Tertius, *Motus Impressionis*; qui motus est etiam ex genere motus *assimilationis*, estque ex diffusivis motibus subtilissimus. Nobis autem visum est eum in speciem propriam constituere, propter differentiam insignem quam habet erga priores duos. Motus enim *assimilationis* simplex corpora ipsa transformat; ita ut si tollas primum movens nihil intersit ad ea quae sequuntur. Neque enim prima accensio in flammam, aut prima versio in aerem, aliquid facit ad flammam aut aerem in generatione succedentem. Similiter, motus *excitationis* omnino manet, remoto primo movente, ad tempora bene diuturna; ut in corpore calefacto, remoto primo calore; in ferro excito, remoto magnete; in massa farinaria, remoto fermento.

13. Let the Thirteenth Motion be the *Motion of Impression*. This motion too belongs to the genus of the motion of *assimilation*, and it is the subtlest of the motions that spread. We have seen fit to make it a kind of its own because of the marked difference between it and the previous two. The simple motion of *assimilation* transforms the bodies themselves, so that if you take away the first mover it makes no difference to what follows. The first kindling into flame, or the first turning into air, contributes nothing to the flame or air generated afterward. Similarly, the motion of *excitation* persists fully for quite a long time after the first mover is removed: in a heated body when the original heat is removed; in excited iron when the magnet is removed; in dough when the leaven is removed.

At Motus *Impressionis*, licet sit diffusivus, et transitivus, tamen perpetuo pendere videtur ex primo movente; adeo ut, sublato aut cessante illo, statim deficiat et pereat; itaque etiam momento, aut saltem exiguo tempore, transigitur. Quare motus illos *assimilationis* et *excitationis, motus generationis Jovis,* quia generatio manet; hunc autem motum *Motum Generationis Saturni*, quia natus statim devoratur et absorbetur, appellare consuevimus. Manifestat se vero hic motus in tribus; in lucis radiis; sonorum percussionibus; et magneticis, quatenus ad communicationem. Etenim amota luce, statim pereunt colores et reliquae imagines ejus; amota percussione prima et quassatione corporis inde facta, paulo post perit sonus. Licet enim soni etiam in medio per ventos tanquam per undas agitentur; tamen diligentius notandum est, quod sonus non tam diu durat quam fit resonatio.

But the Motion of *Impression*, though it spreads and passes on, seems always to depend on the first mover, so that when the first mover is taken away or ceases, it at once fails and perishes. It is therefore accomplished in a moment, or at least in a very short time. So we have been accustomed to call the motions of *assimilation* and *excitation motions of the generation of Jupiter*, because the offspring survives; but this one the *Motion of the Generation of Saturn*, because what is born is at once devoured and swallowed up. This motion shows itself in three things: in rays of light, in the strokes that make sounds, and in magnetic things, as regards communication. For when light is removed, colors and its other images perish at once. When the first stroke is removed, and the vibration of the body it caused, the sound perishes shortly after. Sounds are indeed tossed about in the medium by winds, as if by waves; but it should be noted more carefully that the sound does not last for as long as the resonance goes on.[35]

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Etenim impulsa campana, sonus ad bene magnum tempus continuari videtur; unde quis facile in errorem labatur, si existimet toto illo tempore sonum tanquam natare et haerere in aere; quod falsissimum est. Etenim illa resonatio non est idem sonus numero, sed renovatur. Hoc autem manifestatur ex sedatione sive cohibitione corporis percussi. Si enim sistatur et detineatur campana fortiter et fiat immobilis, statim perit sonus nec resonat amplius; ut in chordis, si post primam percussionem tangatur chorda, vel digito ut in lyra, vel calamo ut in espinetis, statim desinit resonatio. Magnete autem remoto, statim ferrum decidit. Luna autem a mari non potest removeri; nec terra a ponderoso dum cadit. Itaque de illis nullum fieri potest experimentum; sed ratio eadem est.

14. Sit Motus Decimus Quartus, *Motus Configurationis*, aut *Situs*; per quem corpora appetere videntur, non coitionem aut separationem aliquam, sed situm, et collocationem, et *configurationem* cum aliis. Est autem iste motus valde abstrusus, nec bene inquisitus. Atque in quibusdam videtur quasi incausabilis; licet revera (ut existimamus) non ita sit. Etenim si quaeratur cur potius coelum volvatur ab oriente in occidentem quam ab occidente in orientem; aut cur vertatur circa polos positos juxta Ursas potius quam circa Orionem, aut ex alia aliqua parte coeli: videtur ista quaestio tanquam quaedam extasis, cum ista potius ab experientia, et ut positiva recipi debeant. At in natura profecto sunt quaedam ultima et incausabilia; verum hoc ex illis non esse videtur.

Etenim hoc fieri existimamus ex quadam harmonia et consensu mundi, qui adhuc non venit in observationem. Quod si recipiatur motus terrae ab occidente in orientem, eaedem manent quaestiones. Nam et ipsa super aliquos polos movetur. Atque cur tandem debeant isti poli collocari magis ubi sunt quam alibi? Item verticitas, et directio, et declinatio magnetis ad hunc motum referuntur. Etiam inveniuntur in corporibus tam naturalibus quam artificialibus, praesertim consistentibus et non fluidis, collatio quaedam et positura partium, et tanquam villi et fibrae, quae diligenter investigandae sunt; utpote sine quarum inventione corpora illa commode tractari aut regi non

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For when a bell is struck, the sound seems to continue for quite a long time. From this one might easily fall into the error of thinking that all that time the sound somehow floats and hangs in the air—which is quite false. That resonance is not the same individual sound, but is constantly renewed. This is shown by quieting or checking the body that was struck. If the bell is held firmly and kept motionless, the sound perishes at once and resounds no more. So with strings: if after the first stroke the string is touched, either with the finger as on the lyre or with the quill as on spinets, the resonance stops at once. And when the magnet is removed, the iron drops at once. The moon, however, cannot be removed from the sea, nor the earth from a heavy body while it falls. So no experiment can be made concerning them; but the principle is the same.

14. Let the Fourteenth Motion be the *Motion of Configuration*, or *of Position*, by which bodies seem to seek not any coming together or separation, but position, placement and *configuration* in relation to others. This motion is very obscure and has not been well investigated. In some cases it seems to have no cause, though in truth, we think, this is not so. Suppose it is asked why the heavens revolve from east to west rather than from west to east, or why they turn on poles placed near the Bears rather than around Orion or some other part of the sky. Such a question seems almost a kind of delirium, since these things ought rather to be accepted from experience, as given. In nature there are indeed certain ultimate things that have no cause; but this does not seem to be one of them.

For we think this arises from a certain harmony and consent of the universe that has not yet come under observation. And if the motion of the earth from west to east is accepted, the same questions remain, for the earth too moves on certain poles. And why, after all, should those poles be placed where they are rather than elsewhere? The verticity, direction and declination of the magnet are likewise to be referred to this motion. There is also found in bodies, both natural and artificial, especially those that are firm and not fluid, a certain arrangement and placing of parts, a sort of grain

35 In myth Saturn (Cronus) swallowed his children as soon as they were born; Jupiter's offspring survived.

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possunt. At circulationes illas in liquidis, per quas illa dum pressa sint, antequam se liberare possunt, se invicem relevant, ut compressionem illam ex aequo tolerent, motui libertatis verius assignamus.

15. Sit Motus Decimus Quintus, *Motus Pertransitionis*, sive *Motus secundum Meatus*; per quem virtutes corporum magis aut minus impediuntur aut provehuntur a mediis ipsorum, pro natura corporum et virtutum operantium, atque etiam medii. Aliud enim medium luci convenit, aliud sono, aliud calori et frigori, aliud virtutibus magneticis, necnon aliis nonnullis respective.

16. Sit Motus Decimus Sextus, *Motus Regius* (ita enim eum appellamus) sive *Politicus*; per quem partes in corpore aliquo praedominantes et imperantes reliquas partes fraenant, domant, subigunt, ordinant, et cogunt eas adunari, separari, consistere, moveri, collocari, non ex desideriis suis, sed prout in ordine sit et conducat ad bene esse partis illius imperantis; adeo ut sit quasi *Regimen* et *Politia* quaedam, quam exercet pars regens in partes subditas. Eminet autem hic motus praecipue in spiritibus animalium, qui motus omnes partium reliquarum, quamdiu ipse in vigore est, contemperat. Invenitur autem in aliis corporibus in gradu quodam inferiore; quemadmodum dictum est de sanguine et urinis, quae non solvuntur donec spiritus, qui partes earum commiscebat et cohibebat, emissus fuerit aut suffocatus.

Neque iste motus omnino spiritibus proprius est, licet in plerisque corporibus spiritus dominentur ob motum celerem et penetrationem. Veruntamen in corporibus magis condensatis, nec spiritu vivido et vigente (qualis inest argento vivo et vitriolo) repletis, dominantur potius partes crassiores; adeo ut nisi fraenum et jugum hoc arte aliqua excutiatur, de nova aliqua hujusmodi corporum transformatione minime sperandum sit. Neque vero quispiam nos oblitos esse existimet ejus quod nunc agitur; quia cum ista series et distributio motuum ad nil aliud spectet, quam ut illorum *praedominantia* per *instantias luctae* melius inquiratur, jam inter motus ipsos *praedominantiae* mentionem faciamus. Non enim in descriptione motus istius *regii*, de *praedominantia* motuum aut virtutum tractamus, sed *praedominantia* partium in

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and fibers. These must be carefully investigated, since without discovering them we cannot conveniently handle or control those bodies. But the circulations in liquids, by which, while under pressure and before they can free themselves, they relieve one another so as to bear the compression evenly, we more properly assign to the motion of liberty.

15. Let the Fifteenth Motion be the *Motion of Passage*, or *Motion along Channels*, by which the powers of bodies are more or less hindered or helped along by their media, according to the nature of the bodies, of the powers at work, and of the medium. For one medium suits light, another sound, another heat and cold, another magnetic powers, and so on for certain others.

16. Let the Sixteenth Motion be the *Royal Motion* (for so we call it), or *Political Motion*. By it the predominant and commanding parts in a body curb, tame, subdue and order the remaining parts, and compel them to unite, separate, stay still, move and take their places—not according to their own desires, but as fits the order of things and serves the well-being of the commanding part. It is, as it were, a kind of *Government* and *Polity* exercised by the ruling part over the subject parts. This motion stands out chiefly in the spirits of animals, which, so long as they are vigorous, regulate all the motions of the other parts. It is found in other bodies too, in a lower degree, as was said of blood and urine, which do not break up until the spirit that mixed and held their parts together has been released or stifled.

Nor is this motion peculiar to spirits alone, though in most bodies spirits dominate because of their swift motion and power of penetration. In more condensed bodies, however, which are not filled with a lively and vigorous spirit (such as quicksilver and vitriol have), it is rather the coarser parts that dominate. So much so that unless this curb and yoke is thrown off by some art, there is little hope of any new transformation of such bodies. And let no one think we have forgotten the matter in hand because we now mention *predominance* among the motions themselves, when the whole point of this series and classification of motions is to inquire better into their *predominance* by means of *instances of struggle*. For in describing this *royal*

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corporibus. Haec enim ea est *praedominantia*, quae speciem istam motus peculiarem constituit.

17. Sit Motus Decimus Septimus, *Motus Rotationis Spontaneus*; per quem corpora motu gaudentia, et bene collocata, natura sua fruuntur, atque seipsa sequuntur, non aliud, et tanquam proprios petunt amplexus. Etenim videntur corpora aut movere sine termino; aut plane quiescere; aut ferri ad terminum, ubi pro natura sua aut rotent aut quiescant. Atque quae bene collocata sunt, si motu gaudeant, movent per circulum: motu scilicet aeterno et infinito. Quae bene collocata sunt, et motum exhorrent, prorsus quiescunt. Quae non bene collocata sunt, movent in linea recta (tanquam tramite brevissimo) ad consortia suorum connaturalium. Recipit autem motus iste *rotationis* differentias novem.

Primam, centri sui, circa quod corpora movent: secundam, polorum suorum, supra quos movent: tertiam, circumferentiae sive ambitus sui, prout distant a centro: quartam, incitationis suae, prout celerius aut tardius rotant: quintam, consequutionis motus sui, veluti ab oriente in occidentem, aut ab occidente in orientem: sextam, declinationis a circulo perfecto per spiras longius aut propius distantes a centro suo: septimam, declinationis a circulo perfecto per spiras longius aut propius distantes a polis suis: octavam, distantiae proprioris aut longioris spirarum suarum ad invicem: nonam et ultimam, variationis ipsorum polorum, si sint mobiles: quae ipsa ad rotationem non pertinet, nisi fiat circulariter. Atque iste motus communi et inveterata opinione habetur pro proprio coelestium.

Attamen gravis de illo motu lis est inter nonnullos tam ex antiquis quam modernis, qui *rotationem* terrae attribuerunt. At multo fortasse justior movetur controversia (si modo res non sit omnino extra controversiam), an motus videlicet iste (concesso quod terra stet) coeli finibus contineatur, an potius descendat, et communicetur aeri et aquis. Motum autem *rotationis* in missilibus, ut in spiculis, sagittis, pilis sclopetorum, et similibus, omnino ad motum *libertatis* rejicimus.

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motion we are dealing not with the *predominance* of motions or powers, but with the *predominance* of parts in bodies. That is the *predominance* which makes this a distinct kind of motion.

17. The Seventeenth Motion is the *Spontaneous Motion of Rotation*. By it, bodies that delight in motion and are well placed enjoy their own nature. They follow themselves and nothing else, and seek, as it were, their own embraces. For bodies seem either to move without limit, or to rest completely, or to be carried toward a limit, where, according to their nature, they either rotate or rest. Those that are well placed, if they delight in motion, move in a circle, with a motion that is eternal and infinite. Those that are well placed and abhor motion rest completely. Those that are not well placed move in a straight line, the shortest path, toward the company of things of their own nature. This motion of *rotation* admits nine differences.

First, of its center, around which the bodies move. Second, of its poles, on which they move. Third, of its circumference or compass, according to their distance from the center. Fourth, of its speed, according as they rotate faster or slower. Fifth, of the direction of its motion, as from east to west or from west to east. Sixth, of its deviation from a perfect circle by spirals more or less distant from its center. Seventh, of its deviation from a perfect circle by spirals more or less distant from its poles. Eighth, of the greater or lesser distance of its spirals from one another. Ninth and last, of the variation of the poles themselves, if they are movable; this has nothing to do with rotation unless it takes place in a circle. This motion is held, by common and long-established opinion, to be proper to the heavenly bodies.

Yet there is a serious dispute about this motion among some, ancient as well as modern, who have attributed *rotation* to the earth. But a much fairer controversy is perhaps raised, if indeed the matter is not wholly beyond controversy. Granting that the earth stands still, is this motion confined within the limits of the heavens, or does it rather descend and pass to the air and the waters? As for the motion of *rotation* in projectiles such as darts, arrows, musket balls and the like, we refer it entirely to the motion of *liberty*.[36]

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18. Sit Motus Decimus Octavus, *Motus Trepidationis*, cui (ut ab astronomis intelligitur) non multum fidei adhibemus. Nobis autem corporum naturalium appetitus ubique serio perscrutantibus occurrit iste motus; et constitui debere videtur in speciem. Est autem hic motus veluti aeternae cujusdam captivitatis. Videlicet ubi corpora non omnino pro natura sua bene locata, et tamen non prorsus male se habentia, perpetuo trepidant, et irrequiete se agant, nec statu suo contenta, nec ulterius ausa progredi. Talis invenitur motus in corde et pulsibus animalium; et necesse est ut sit in omnibus corporibus, quae statu ancipiti ita degunt inter commoda et incommoda, ut distracta liberare se tentent, et denuo repulsam patiantur, et tamen perpetuo experiantur.

19. Sit Motus Decimus Nonus et postremus, motus ille cui vix nomen motus competit, et tamen est plane motus. Quem motum, *Motum Decubitus*, sive *Motum Exhorrentiae Motus*, vocare licet. Per hunc motum terra stat mole sua, moventibus se extremis suis in medium; non ad centrum imaginativum, sed ad unionem. Per hunc etiam appetitum omnia majorem in modum condensata motum exhorrent, atque illis pro omni appetitu est non moveri; et licet infinitis modis vellicentur et provocentur ad motum, tamen naturam suam (quoad possunt) tuentur. Quod si ad motum compellantur, tamen hoc agere semper videntur ut quietem et statum suum recuperent, neque amplius moveant. Atque circa hoc certe se agilia praebent, et satis perniciter et rapide (ut pertaesa et impatientia omnis morae) contendunt.

Hujus autem appetitus imago ex parte tantum cerni potest; quia hic apud nos, ex subactione et concoctione coelestium, omne tangibile non tantum non condensatum est ad ultimitatem, sed etiam cum spiritu nonnullo miscetur.

Proposuimus itaque jam species sive elementa simplicia motuum, appetituum, et virtutum activarum, quae sunt in natura maxime catholica. Neque parum scientiae naturalis sub illis adumbratum est. Non negamus tamen et alias species fortasse addi posse, atque istas ipsas

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18. The Eighteenth Motion is the *Motion of Trepidation*, in which, as astronomers understand it, we place little faith. But as we seriously search out the appetites of natural bodies everywhere, this motion presents itself, and it seems that it should be set up as a species. This motion is like a kind of perpetual captivity. It occurs when bodies that are not altogether well placed according to their nature, and yet not entirely badly off, tremble constantly and stir restlessly. They are neither content with their state nor daring to advance further. Such motion is found in the heart and pulse of animals. It must also exist in all bodies that live in so doubtful a state between advantages and disadvantages that, pulled both ways, they try to free themselves, are repulsed again, and yet keep on trying.[37]

19. The Nineteenth and last Motion is one to which the name of motion hardly applies, and which is nevertheless plainly motion. It may be called the *Motion of Repose*, or the *Motion of Abhorrence of Motion*. By this motion the earth stands still in its mass, while its extremities move toward the middle, not toward an imaginary center but toward union. By this appetite, too, all things that are highly condensed abhor motion. Their whole appetite is not to move. Although they are plucked at and provoked to motion in countless ways, they still defend their nature as far as they can. And if they are forced into motion, they still always seem intent on recovering their rest and their state and moving no more. In this respect they certainly show themselves nimble, and strive quickly and swiftly enough, as if weary and impatient of all delay.

Only a partial image of this appetite can be seen, however. Here among us, because of the subduing and concoction worked by the heavenly bodies, everything tangible is not only short of the utmost condensation but is also mixed with some spirit.

We have now set out the species, or simple elements, of the motions, appetites and active powers that are most universal in nature. And no small part of natural science has been sketched under them. We do not deny that other species may per-

36 Bacon has in mind ancient Pythagoreans such as Philolaus and, among the moderns, Copernicus and William Gilbert.
37 In astronomy "trepidation" was a supposed slow back-and-forth oscillation of the equinoxes, assumed in medieval theory.

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divisiones secundum veriores rerum venas transferri, denique in minorem numerum posse redigi. Neque tamen hoc de divisionibus aliquibus abstractis intelligimus: veluti si quis dicat corpora appetere vel conservationem, vel exaltationem, vel propagationem, vel fruitionem naturae suae; aut si quis dicat motus rerum tendere ad conservationem et bonum, vel universi, ut *antitypiam* et *nexum*; vel universitatum magnarum, ut motus *congregationis majoris, rotationis*, et *exhorrentiae motus;* vel formarum specialium, ut reliquos.

Licet enim haec vera sint, tamen nisi terminentur in materia et fabrica secundum veras lineas, speculativa sunt, et minus utilia. Interim sufficient et boni erunt usus ad pensitandas *praedominantias* virtutum et exquirendas *instantias luctae*; id quod nunc agitur.

Etenim ex his quos proposuimus motibus alii prorsus sunt invincibiles; alii aliis sunt fortiores, et illos ligant, fraenant, disponunt; alii aliis longius jaculantur; alii alios tempore et celeritate praevertunt; alii alios fovent, roborant, ampliant, accelerant.

Motus *antitypiae* omnino est adamantinus et invincibilis. Utrum vero Motus nexus sit invincibilis adhuc haeremus. Neque enim pro certo affirmaverimus utrum detur Vacuum, sive coacervatum sive permistum. At de illo nobis constat, rationem illam, propter quam introductum est Vacuum a *Leucippo* et *Democrito* (videlicet quod absque eo non possent eadem corpora complecti et implere majora et minora spatia), falsam esse. Est enim plane *plica materiae* complicantis et replicantis se per spatia, inter certos fines, absque interpositione vacui; neque est in aere ex vacuo bis millies (tantum enim esse oportet) plus quam in auro. Id quod ex potentissimis corporum pneumaticorum virtutibus (quae aliter tanquam pulveris minuti natarent in vacuo), et multis aliis demonstrationibus, nobis satis liquet.

Reliqui vero Motus regunt et reguntur invicem, pro rationibus vigoris, quanti, incitationis, ejaculationis, necnon tum auxiliorum tum impedimentorum quae occurrunt.

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haps be added. These very divisions may be shifted to follow the truer veins of things, and finally reduced to a smaller number. We do not mean this, however, of any abstract divisions. Someone might say, for instance, that bodies desire the preservation, or the exaltation, or the propagation, or the enjoyment of their nature. Or someone might say that the motions of things tend to the preservation and good of the universe, like *antitypy* and *connection*; or of great wholes, like the motions of *greater congregation*, of *rotation*, and of *abhorrence of motion*; or of special forms, like the rest.

Although these things are true, unless they terminate in matter and structure along true lines, they are speculative and of little use. Meanwhile they will suffice, and will serve well, for weighing the *predominances* of powers and searching out *instances of struggle*, which is our present business.

For of the motions we have set out, some are wholly invincible. Some are stronger than others, and bind, curb and arrange them. Some carry farther than others. Some outstrip others in time and speed. Some foster, strengthen, enlarge and accelerate others.

The motion of *antitypy* is entirely adamantine and invincible. Whether the motion of connection is invincible, we are still unsure. For we would not affirm with certainty whether there is a vacuum, either gathered in one place or interspersed. But of this we are sure: the reason for which *Leucippus* and *Democritus* introduced the vacuum is false. Their reason was that without it the same bodies could not embrace and fill larger and smaller spaces. But there is plainly a *folding of matter*, which folds and unfolds itself through spaces, within certain limits, without any vacuum between. Nor is there two thousand times more vacuum in air than in gold, as there would have to be. This is clear enough to us from the very powerful forces of pneumatic bodies, which would otherwise float in the vacuum like fine dust, and from many other demonstrations.

The remaining motions govern and are governed by one another, according to their vigor, quantity, speed and projection, and also according to the aids and impediments they meet.

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Exempli gratia: magnes armatus nonnullus detinet et suspendit ferrum, ad sexagecuplum pondus ipsius; eo usque dominatur motus *congregationis minoris* super motum *congregationis majoris;* quod si majus fuerit pondus, succumbit. Vectis tanti roboris sublevabit tantum pondus; eo usque dominatur motus *libertatis* super motum *congregationis majoris;* sin majus fuerit pondus, succumbit. Corium tensum ad tensuram talem non rumpitur; eo usque dominatur motus *continuationis* super motum *tensurae*; quod si ulterior fuerit tensura, rumpitur corium, et succumbit motus *continuationis*. Aqua per rimam perforationis talis effluit; eo usque dominatur motus *congregationis majoris* super motum *continuationis*; quod si minor fuerit rima, succumbit, et vincit motus *continuationis*. In pulvere sulphuris solius immissi in sclopetum cum pila, et admoto igne, non emittitur pila; in eo motus *congregationis majoris* vincit motum *hyles*.

At in pulvere pyrio immisso vincit motus *hyles* in sulphure, adjutus motibus *hyles* et *fugae* in nitro. Et sic de caeteris. Etenim *instantiae luctae* (quae indicant *praedominantiam* virtutum, et secundum quas rationes et calculos praedominentur et succumbant) acri et sedula diligentia undique sunt conquirendae.

Etiam modi et rationes ipsius succumbentiae motuum diligenter sunt introspiciendae. Nempe, an omnino cessent, vel potius usque nitantur, sed ligentur. Etenim in corporibus hic apud nos, nulla vera est quies, nec in integris nec in partibus; sed tantum secundum apparentiam. Quies autem ista apparens causatur aut per *aequilibrium*, aut per absolutam *praedominantiam* motuum. Per *aequilibrium*, ut in bilancibus, quae stant si aequa sint pondera. Per *praedominantiam*, ut in hydriis perforatis, ubi quiescit aqua et detinetur a decasu, per *praedominantiam* motus *nexus*. Notandum tamen est (ut diximus) quatenus nitantur motus illi succumbentes. Etenim si quis per luctam detineatur extensus in terra, brachiis et tibiis vinctis, aut aliter detentis; atque ille tamen totis viribus resurgere nitatur; non est minor nixus, licet non proficiat.

Hujus autem rei conditio (scilicet utrum per *praedominantiam* motus succumbens quasi annihiletur, an

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For example, a certain armed magnet holds and suspends iron up to sixty times its own weight. To that point the motion of *lesser congregation* prevails over the motion of *greater congregation*; if the weight is greater, it gives way. A lever of a given strength will lift a given weight. To that point the motion of *liberty* prevails over the motion of *greater congregation*; if the weight is greater, it gives way. Leather stretched to a certain tension does not break. To that point the motion of *continuity* prevails over the motion of *tension*; if the tension is greater, the leather breaks and the motion of *continuity* gives way. Water flows out through a crack of a certain size. To that point the motion of *greater congregation* prevails over the motion of *continuity*; if the crack is smaller, it gives way and the motion of *continuity* wins. When sulfur powder alone is put into a musket with a ball and fire is applied, the ball is not shot out. In that case the motion of *greater congregation* overcomes the motion of *hyle*.

But in gunpowder the motion of *hyle* in the sulfur wins, aided by the motions of *hyle* and of *flight* in the saltpeter. And so with the rest. *Instances of struggle* show the *predominance* of powers, and by what ratios and reckonings they prevail and give way. They must therefore be sought out everywhere with keen and unremitting diligence.

The modes and manners in which motions give way must also be carefully examined: whether they cease altogether, or rather go on striving but are held bound. For in bodies here among us there is no true rest, either in wholes or in parts, but only the appearance of it. This apparent rest is caused either by *equilibrium* or by the absolute *predominance* of motions. By *equilibrium*, as in scales, which stand still if the weights are equal. By *predominance*, as in perforated water jars, where the water rests and is held back from falling by the *predominance* of the motion of *connection*. It must be noted, however, as we have said, how far those yielding motions keep striving. Suppose someone is pinned stretched out on the ground in wrestling, with arms and legs tied or otherwise held, and yet strives with all his strength to rise. His effort is no less, though it achieves nothing.

The question is whether through *predominance* the yielding motion is, as it were, annihilated, or

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potius continuetur nixus, licet non conspiciatur), quae latet in conflictibus, apparebit fortasse in concurrentiis. Exempli gratia; fiat experimentum in sclopetis, utrum sclopetus, pro tanto spatio quo emittat pilam in linea directa, sive (ut vulgo loquuntur) in puncto blanco, debiliorem edat percussionem ejaculando in supra, ubi Motus Ictus est simplex, quam desuper, ubi Motus Gravitatis concurrit cum Ictu.

Etiam canones *praedominantiarum* qui occurrunt colligendi sunt. Veluti, quod quo communius est bonum quod appetitur, eo motus est fortior ut motus *nexus*, qui respicit communionem universi, fortior est motu gravitatis, qui respicit communionem densorum. Etiam quod appetitus qui sunt boni privati, non praevalent plerunque contra appetitus boni magis publici, nisi in parvis quantis. Quae utinam obtinerent in civilibus.

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whether its effort rather continues, though unseen. What lies hidden in conflicts will perhaps appear in concurrences. For example, let an experiment be made with muskets. Over the distance at which a musket sends a ball in a straight line, or point-blank, as people commonly say, does it deliver a weaker blow when fired upward, where the Motion of Impact is simple, than when fired downward, where the Motion of Gravity concurs with the Impact?

Rules of *predominance* that come to light must also be collected. For instance: the more general the good that is sought, the stronger the motion. Thus the motion of *connection*, which looks to the community of the universe, is stronger than the motion of gravity, which looks to the community of dense bodies. Again, appetites for a private good do not generally prevail against appetites for a more public good, except in small quantities. Would that this held in civil affairs!

INSTANCES OF MANY USES

Bacon sets out seven chief ways in which people work on bodies, including sealing, pressure, heat, cold and time.

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2.49 Inter *praerogativas instantiarum* ponemus loco vicesimo quinto *Instantias Innuentes*; eas scilicet, quae commoda hominum innuunt aut designant. Etenim ipsum *Posse* et ipsum *Scire* naturam humanam amplificant, non beant. Itaque decerpenda sunt ex universitate rerum ea quae ad usus vitae maxime faciunt. Verum de iis erit magis proprius dicendi locus, cum *Deductiones ad Praxim* tractabimus. Quinetiam in ipso opere Interpretationis circa singula subjecta, locum semper *Chartae Humanae*, sive *Chartae Optativae*, assignamus. Etenim et quaerere et optare non inepte, pars scientiae est.

2.50 Inter *praerogativas instantiarum* ponemus loco vicesimo sexto *Instantias Polychrestas*. Eae sunt, quae pertinent ad varia et saepius occurrunt; ideoque operae et novis probationibus haud parum parcunt. Atque de instrumentis ipsis atque ingeniationibus proprius erit dicendi locus, cum Deductiones ad Praxim et Experimentandi Modos tractabimus. Quinetiam quae adhuc cognita sunt et in usum venerunt, in Historiis Particularibus singularum artium describentur. In

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Among the *prerogative instances* we will put in the twenty-fifth place *Intimating Instances*: those, namely, which intimate or point out what is useful to mankind. For mere *Power* and mere *Knowledge* enlarge human nature but do not make it happy. So we must pick out from the whole of things those that most serve the uses of life. But there will be a more proper place to speak of these when we treat of *Application to Practice*. Moreover, in the actual work of Interpretation on particular subjects, we always assign a place to the *Human Chart*, or *Chart of Things to Be Wished For*. For to inquire and to wish with good sense is itself part of knowledge.

Among the *prerogative instances* we will put in the twenty-sixth place *Polychrest Instances*, or instances of many uses. These bear on a variety of matters and occur frequently, and therefore save a good deal of labor and of new trials. On instruments and contrivances as such there will be a more proper place to speak when we treat of Application to Practice and the Modes of Experimenting. Those already known and in use will be de-

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praesenti autem subjungemus quaedam catholica circa ea pro exemplis tantum *polychresti*.

Operatur igitur homo super corpora naturalia (praeter ipsam admotionem et amotionem corporum simplicem) septem praecipue modis: nempe, vel per exclusionem eorum quae impediunt et disturbant; vel per compressiones, extensiones, agitationes, et hujusmodi; vel per calorem et frigus; vel per moram in loco convenienti; vel per fraenum et regimen motus; vel per consensus speciales; vel per alternationem tempestivam et debitam, atque seriem et successionem horum omnium; aut saltem nonnullorum ex illis.

1. Ad primum igitur quod attinet; aer communis qui undique praesto est et se ingerit, atque radii coelestium, multum turbant. Quae itaque ad illorum exclusionem faciunt, merito haberi possint pro *polychrestis*. Huc igitur pertinent materies et crassities vasorum, in quibus corpora ad operationem praeparata reponuntur. Similiter, modi accurati obturationis vasorum, per consolidationem et *lutum sapientiae*, ut loquuntur chymici. Etiam clausura per liquores in extimis, utilissima res est; ut cum infundunt oleum super vinum aut succos herbarum, quod expandendo se in summitate instar operculi, optime ea conservat illaesa ab aere. Neque pulveres res malae sunt; qui, licet contineant aerem permistum, tamen vim aeris coacervati et circumfusi arcent: ut fit in conservatione uvarum et fructuum intra arenam, et farinam.

Etiam cera, mel, pix, et hujusmodi tenacia, recte obducuntur ad clausuram perfectiorem, et ad summovendum aerem et coelestia. Etiam nos experimentum quandoque fecimus, ponendo vas, necnon aliqua alia corpora, intra argentum vivum, quod omnium longe densissimum est ex iis quae circumfundi possunt. Quinetiam specus et cavernae subterraneae magni usus sunt ad prohibendum insolationem et aerem istum apertum praedatorium; qualibus utuntur Germani Septentrionales pro granariis.

Necnon repositio corporum in fundo aquarum ad hoc spectat: ut memini me quippiam audisse de utribus vini

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scribed in the Particular Histories of the individual arts. For the present we will add some general remarks about them, merely as examples of the *polychrest*.[38]

Man, then, works upon natural bodies in seven chief ways, apart from simply bringing bodies together and taking them apart. He works by excluding what hinders and disturbs; by compressions, extensions, agitations and the like; by heat and cold; by leaving a body for a time in a suitable place; by curbing and regulating motion; by special affinities; or by the timely and proper alternation, series and succession of all these, or at least of some of them.

1. As regards the first, then: the common air, which is present everywhere and forces its way in, and the rays of the heavenly bodies cause much disturbance. Whatever helps to exclude them may rightly be counted as *polychrest*. To this belong the material and thickness of the vessels in which bodies prepared for an operation are placed. So do careful methods of sealing vessels, by fusing them shut and by *lutum sapientiae* ("lute of wisdom"), as the chemists call it. Sealing with a liquid on the surface is also most useful, as when oil is poured over wine or the juices of herbs. Spreading over the top like a lid, it preserves them excellently from the air. Nor are powders a bad thing. Although they contain air mixed in, they still keep off the force of the massed air around them, as happens when grapes and fruits are preserved in sand and flour.[39]

Wax, honey, pitch and similar sticky substances are also usefully spread over to make the seal more perfect and to keep out the air and the heavenly influences. We have also sometimes made an experiment by placing a vessel, and some other bodies, inside quicksilver, which is by far the densest of all the substances that can be poured around things. Caves and underground hollows are also of great use for keeping out the sun's heat and that open, predatory air. The northern Germans use such places as granaries.

Placing bodies at the bottom of water also serves this purpose. I remember hearing of skins of wine

38 "Polychrest" is from Greek *polychrēstos*, "useful for many things," a term used by apothecaries.
39 Lute was a clay or paste used by chemists to seal vessels airtight.

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demissis in profundum puteum, ad infrigidationem scilicet, sed casu et per neglectum ac oblivionem ibidem remanentibus per multos annos, et deinde extractis; unde vinum factum est non solum non vapidum aut emortuum, sed multo magis nobile ad gustum, per commixtionem partium suarum (ut videtur) magis exquisitam. Quod si postulet res ut corpora demittantur ad fundum aquarum, veluti intra fluvios aut mare, neque tamen aquas tangant, nec in vasibus obturatis concludantur, sed aere tantum circumdentur; bonus est usus vasis illius quod adhibitum est nonnunquam ad operandum subter aquis super navigia demersa, ut urinatores diutius manere possint sub aquis, et per vices ad tempus respirare. Illud hujusmodi erat.

Conficiebatur dolium ex metallo concavum, quod demittebatur aequabiliter ad superficiem aquae, atque sic deportabat totum aerem qui continebatur in dolio secum in fundum maris. Stabat autem super pedes tres (instar tripodis), qui longitudinis erant aliquanto minoris statura hominis; ita ut urinator posset cum anhelitus deficeret, immittere caput in cavum dolii, et respirare, et deinde opus continuare. Atque audivimus inventam esse jam machinam aliquam naviculae aut scaphae, quae homines subter aquis vehere possit ad spatia nonnulla. Verum sub tali vase, quale modo diximus, corpora quaevis facile suspendi possint; cujus causa hoc experimentum adduximus.

Est et alius usus diligentis et perfectae clausurae corporum: nempe, non solum ut prohibeatur aditus aeris per exterius (de quo jam dictum est), verum etiam ut cohibeatur exitus spiritus corporis, super quod fit operatio per interius. Necesse est enim ut operanti circa corpora naturalia constet de summis suis: viz. quod nihil expirarit aut effluxerit. Fiunt enim profundae alterationes in corporibus, quando, natura prohibente annihilationem, ars prohibeat etiam deperditionem aut evolationem alicujus partis. Atque hac de re invaluit opinio falsa (quae si vera esset, de ista conservatione summae certae absque diminutione esset fere desperandum): viz. spiritus corporum, et aerem majori gradu caloris attenuatum, nullis vasorum claustris posse contineri, quin per poros vasorum subtiliores evolent.

Atque in hanc opinionem adducti sunt homines per vulgata illa experimenta, poculi inversi super aquam cum candela aut charta inflammata, ex quo fit ut aqua sursum attrahatur; atque similiter ventosarum, quae super

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let down into a deep well to cool, which by chance, through neglect and forgetfulness, stayed there for many years and were then drawn out. The wine had become not only not flat or dead, but much finer in taste, owing, it seems, to a more exquisite mingling of its parts. Sometimes the matter requires bodies to be let down to the bottom of water, as in rivers or the sea, without touching the water or being shut in sealed vessels, but surrounded only by air. For this there is good use in the vessel sometimes employed for working underwater on sunken ships, so that divers could stay longer underwater and breathe from time to time. It was of this kind.

A hollow cask was made of metal and let down level with the surface of the water, so that it carried all the air it contained down with it to the bottom of the sea. It stood on three feet, like a tripod, somewhat shorter than a man's height. So the diver, when his breath failed, could put his head into the hollow of the cask, breathe, and then go on working. We have also heard that a machine has now been invented, a small boat or skiff that can carry men underwater for some distance. But under a vessel such as we have just described, any bodies could easily be suspended; and that is why we have brought in this experiment.[40]

There is another use for the careful and complete sealing of bodies: not only to keep air from getting in from outside, as already mentioned, but also to keep the spirit of the body being worked on from escaping from inside. For anyone working on natural bodies must be sure of his totals, that is, that nothing has evaporated or flowed away. Profound alterations take place in bodies when, nature forbidding annihilation, art also forbids the loss or escape of any part. On this point a false opinion has prevailed, which, if it were true, would make us almost despair of keeping a fixed total without diminution. It holds that the spirits of bodies, and air rarefied by a high degree of heat, cannot be held by any sealing of vessels, but escape through the finer pores of the vessels.

People have been led to this opinion by those familiar experiments. One is a cup turned upside down over water with a lit candle or burning pa-

40 Probably the submarine of the Dutch inventor Cornelis Drebbel, demonstrated on the Thames around 1620.

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flammam calefactae trahunt carnes. Existimant enim in utroque experimento aerem attenuatum emitti, et inde *quantum* ipsius minui, ideoque aquam aut carnes per *nexum* succedere. Quod falsissimum est. Aer enim non *quanto* diminuitur, sed spatio contrahitur; neque incipit motus iste successionis aquae, antequam fiat extinctio flammae aut refrigeratio aeris: adeo ut medici, quo fortius attrahant ventosae, ponant spongias frigidas aqua madefactas super ventosas. Itaque non est cur homines multum sibi metuant de facili exitu aeris aut spirituum.

Licet enim verum sit etiam solidissima corpora habere suos poros, tamen aegre patitur aer aut spiritus comminutionem sui ad tantam subtilitatem; quemadmodum et aqua exire recusat per rimam minusculam.

2. De secundo vero modo ex septem praedictis illud imprimis notandum est, valere certe compressiones et hujusmodi violentias ad motum localem, atque alia id genus, potentissime; ut in machinis et missilibus: etiam ad destructionem corporis organici, atque earum virtutum quae consistunt plane in motu. Omnis enim vita, immo etiam omnis flamma et ignitio destruitur per compressiones; ut et omnis machina corrumpitur et confunditur per easdem. Etiam ad destructionem virtutum quae consistunt in posituris, et dissimilaritate partium paulo crassiore; ut in coloribus (neque enim idem color floris integri et contusi, neque succini integri et pulverizati); etiam in saporibus (neque enim idem sapor pyri immaturi, et ejusdem compressi ac subacti; nam manifesto dulcedinem majorem concipit).

Verum ad transformationes et alterationes nobiliores corporum similarium non multum valent istae violentiae; quia corpora per eas non acquirunt consistentiam aliquam novam constantem et quiescentem, sed transitoriam, et nitentem semper ad restitutionem et liberationem sui. Attamen non abs re foret hujus rei facere experimenta aliqua diligentiora; ad hoc scilicet, utrum condensatio corporis bene similaris (qualia sunt aer, aqua, oleum, et hujusmodi), aut rarefactio similiter per violentiam indita, possint fieri constantes et fixae et quasi mutatae in naturam. Id quod primo experiendum per moram simplicem; deinde per auxilia et consensus. Atque illud nobis in promptu fuisset (si modo in mentem

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per inside, which makes the water rise. Another is cupping glasses, which, heated over a flame, draw up the flesh. In both experiments, they think, the rarefied air is driven out and its *quantity* thus lessened, so that the water or the flesh moves in to take its place by *connection*. This is quite false. The air is not lessened in *quantity* but contracted in space. Nor does the water begin to move in until the flame is put out or the air cools. That is why physicians, to make cupping glasses draw more strongly, lay cold sponges soaked in water on them. There is therefore no reason for people to be much afraid of air or spirits escaping easily.

For although it is true that even the most solid bodies have pores, air or spirit does not readily submit to being broken up so finely, just as water refuses to pass through a very tiny crack.

2. As for the second of the seven ways named above, it must first be noted that compressions and similar violent actions are certainly most powerful for local motion and the like, as in machines and projectiles. They are also powerful for destroying an organic body, and those powers that consist entirely in motion. For all life, and indeed all flame and burning, is destroyed by compression, just as every machine is wrecked and thrown into disorder by it. They are powerful as well for destroying powers that consist in arrangements and in a somewhat coarse dissimilarity of parts. This holds for colors: a whole flower and a crushed one do not have the same color, nor do whole and powdered amber. It holds too for tastes: an unripe pear does not taste the same as the same pear squeezed and kneaded, for it plainly gains in sweetness.

But for the nobler transformations and alterations of uniform bodies these violent actions are of little avail. By them bodies do not acquire a new consistency that is constant and at rest, but a transitory one, always striving to restore and free itself. Yet it would not be amiss to make some more careful experiments on this point. Take the condensation of a thoroughly uniform body, such as air, water, oil and the like, or its rarefaction, likewise induced by violence. Can it be made constant and fixed and, as it were, changed into its nature? This should be tried first by simple lapse of time, then with aids and affinities. And it would have been

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venisset), cum aquam (de qua alibi) per malleationes et pressoria condensavimus, antequam erumperet.

Debueramus enim sphaeram complanatam per aliquot dies sibi permisisse, et tum demum aquam extraxisse; ut fieret experimentum, utrum statim impletura fuisset talem dimensionem, qualem habebat ante condensationem. Quod si non fecisset aut statim, aut certe paulo post, constans videlicet facta videri potuisset ista condensatio; sin minus, apparuisset factam fuisse restitutionem, et compressionem fuisse transitoriam. Etiam simile quiddam faciendum erat circa extensionem aeris in ovis vitreis. Etenim debuerat fieri, post exuctionem fortem, subita et firma obturatio; deinde debuerant ova illa manere ita obturata per nonnullos dies; et tum demum experiendum fuisset, utrum aperto foramine attractus fuisset aer cum sibilo, aut etiam attracta fuisset tanta quantitas aquae post immersionem, quanta fuisset ab initio, si nulla adhibita fuisset mora.

Probabile enim, aut saltem dignum probatione est, haec fieri potuisse et posse; propterea quod in corporibus paulo magis dissimilaribus similia efficiat mora temporis. Etenim baculum per compressionem curvatum post aliquod tempus non resilit; neque id imputandum est alicui deperditioni ex quanto ligni per moram; nam idem fiet in lamina ferri (si augeatur mora), quae non est expirabilis. Quod si non succedat experimentum per moram simplicem, tamen non deserendum est negotium, sed auxilia alia adhibenda. Non enim parum lucri fit, si per violentias indi possint corporibus naturae fixae et constantes. Hac enim ratione aer possit verti in aquam per condensationes, et complura alia id genus. Dominus enim est homo motuum violentorum, magis quam caeterorum.

3. At tertius ex septem modis refertur ad magnum illud organum, tam naturae quam artis, quoad operandum; videlicet calidum et frigidum. Atque in hac parte claudicat plane potentia humana, tanquam ex uno pede. Habemus enim calorem ignis, qui caloribus solis (prout ad nos deferuntur) et caloribus animalium quasi infinitis partibus potentior est et intensior. At deest frigus, nisi quale per tempestates hyemales, aut per cavernas, aut per circundationes nivis et glaciei, haberi potest: quod in

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easy for us, if only it had occurred to us, when we condensed water (of which elsewhere) by hammering and pressing, before it burst out.[41]

We ought to have left the flattened sphere to itself for some days, and only then drawn off the water, to find out whether it would at once have filled the same volume as before condensation. If it had not done so, either at once or at least soon after, that condensation might have seemed to have become constant. If it had, it would have been clear that a restoration had taken place and that the compression had been transitory. Something similar ought also to have been done with the expansion of air in glass eggs. After strong suction there should have been a sudden and firm sealing. Then the eggs should have been left sealed for some days. Only then should it have been tried whether, when the hole was opened, air would be drawn in with a hiss; or whether, after immersion, as much water would be drawn in as there would have been at the outset if no time had been allowed to pass.

For it is probable, or at least worth testing, that these things could have been done and can be, because in somewhat more dissimilar bodies lapse of time produces similar effects. A stick bent by compression does not spring back after some time. This is not to be put down to any loss in the quantity of the wood over time, for the same will happen in a strip of iron, which does not evaporate, if the time is lengthened. If the experiment does not succeed through simple lapse of time, the undertaking should not be abandoned, but other aids brought in. For there is no small gain if fixed and constant natures can be induced in bodies by violence. In this way air might be turned into water by condensation, and many other things of the kind. For man is master of violent motions more than of the others.

3. The third of the seven ways refers to that great instrument of working, of nature as much as of art: hot and cold. Here human power plainly limps, as if on one foot. We have the heat of fire, which is almost infinitely more powerful and intense than the sun's heat as it reaches us and the heat of animals. But we lack cold, except such as can be had in winter weather, in caves, or by pack-

41 Described at 2.45, where water sealed in a hollow lead sphere was hammered and pressed until it sweated through the metal.

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comparatione aequari potest cum calore fortasse solis meridiano in regione aliqua ex torridis, aucto insuper per reverberationes montium et parietum; nam hujusmodi utique tam calores quam frigora ab animalibus ad tempus exiguum tolerari possunt. Nihili autem sunt fere prae calore fornacis ardentis, aut alicujus frigoris quod huic gradui respondeat.

Itaque omnia hic apud nos vergunt ad rarefactionem, et desiccationem, et consumptionem: nihil fere ad condensationem et intenerationem, nisi per misturas et modos quasi spurios. Quare Instantiae Frigoris omni diligentia sunt conquirendae: quales videntur inveniri in expositione corporum super turres quando gelat acriter; in cavernis subterraneis; circundationibus nivis et glaciei in locis profundioribus, et ad hoc excavatis; demissione corporum in puteos; sepulturis corporum in argento vivo et metallis; immersione corporum in aquis, quae vertunt ligna in lapides; defossione corporum in terra (qualis fertur apud Chinenses esse confectio porcellanae, ubi massae ad hoc factae dicuntur manere intra terram per quadraginta aut quinquaginta annos, et transmitti ad haeredes, tanquam minerae quaedam artificiales); et hujusmodi.

Quinetiam quae interveniunt in natura condensationes, factae per frigora, similiter sunt investigandae; ut, causis eorum cognitis, transferri possint in artes. Quales cernuntur in exudatione marmoris et lapidum; in rorationibus super vitra per interius fenestrarum, sub auroram, post gelu noctis; in originibus et collectionibus vaporum in aquas sub terra, unde saepe scaturiunt fontes; et quaecunque sunt hujus generis.

Inveniuntur autem, praeter illa quae sunt frigida ad tactum, quaedam alia potestate frigida, quae etiam condensant; veruntamen operari videntur super corpora animalium tantum, et vix ultra. Hujus generis se ostendunt multa in medicinis et emplastris. Alia autem condensant carnes et partes tangibiles; qualia sunt medicamenta astringentia, atque etiam inspissantiae: alia condensant spiritus; id quod maxime cernitur in soporiferis. Duplex autem est modus condensationis spirituum, per medicamenta soporifera, sive provocantia somnum: alter per sedationem motus; alter per fugam spirituum. Etenim viola, rosa sicca, lactuca, et hujusmodi benedicta sive benigna, per vapores suos amicos et moderate refrigerantes, invitant spiritus ut se uniant, et ipsorum acrem et inquietum motum compescunt.

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ing with snow and ice. This may perhaps be compared with the midday heat of the sun in some region of the torrid zone, further increased by reflection from mountains and walls. For heats and colds of this kind can indeed be endured by animals for a short time. But they are almost nothing compared with the heat of a blazing furnace, or with any cold that would match that degree.

So everything here among us tends toward rarefaction, drying and consumption, and almost nothing toward condensation and softening, except by mixtures and what are, so to speak, spurious means. Instances of Cold must therefore be sought out with all diligence. Such seem to be found in exposing bodies on towers in hard frost; in underground caves; in packing with snow and ice in deeper places dug for the purpose; in letting bodies down into wells; in burying bodies in quicksilver and metals; in immersing bodies in waters that turn wood into stone; and in burying bodies in the earth. This is said to be how the Chinese make porcelain: lumps made for the purpose are said to stay in the ground for forty or fifty years and to be handed down to heirs like a kind of artificial mine. And so on.

Moreover, the condensations by cold that occur in nature must likewise be investigated, so that, once their causes are known, they can be transferred to the arts. Such are seen in the sweating of marble and stones; in the dew on the inside of window glass toward dawn after a night frost; in the origin and gathering of vapors into water under the earth, from which springs often gush; and whatever else is of this kind.

Besides things that are cold to the touch, there are others that are cold in potency, and these too condense. But they seem to act only on the bodies of animals and hardly beyond. Many of this kind appear among medicines and plasters. Some condense flesh and tangible parts, such as astringent and thickening medicines. Others condense the spirits, which is seen most of all in soporifics. There are two ways in which soporific, or sleep-inducing, medicines condense the spirits: one by calming their motion, the other by putting them to flight. Violets, dried roses, lettuce and similar blessed or benign things, by their friendly and moderately cooling vapors, invite the spirits to

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Etiam aqua rosacea, apposita ad nares in deliquiis animae, spiritus resolutos et nimium relaxatos se recipere facit, et tanquam alit. At opiata et eorum affinia spiritus plane fugant, ex qualitate sua maligna et inimica. Itaque si applicentur parti exteriori, statim aufugiunt spiritus ab illa parte, nec amplius libenter influunt: sin sumantur interius, vapores eorum, ascendentes ad caput, spiritus in ventriculis cerebri contentos undequaque fugant; cumque se retrahant spiritus neque in aliam partem effugere possint, per consequens coeunt et condensantur; et quandoque plane extinguuntur et suffocantur; licet rursus eadem opiata moderate sumpta, per accidens secundarium (videlicet condensationem illam quae a coitione succedit), confortent spiritus, eosque reddant magis robustos, et retundant eorum inutiles et incensivos motus, ex quo ad curas morborum, et vitae prolongationem haud parum conferant.

Etiam praeparationes corporum ad excipiendum frigus non sunt omittendae; veluti quod aqua parum tepida facilius conglacietur quam omnino frigida, et hujusmodi.

Praeterea, quia natura frigus tam parce suppeditat, faciendum est quemadmodum pharmacopolae solent; qui, quando simplex aliquod haberi non possit, capiunt succedaneum ejus, et *quid* pro *quo*, ut vocant: veluti lignum aloes pro xylobalsamo, cassiam pro cinamomo. Simili modo diligenter circumspiciendum est, si quae sint succedanea frigoris; videlicet quibus modis fieri possint condensationes in corporibus, aliter quam per frigus, quod illas efficit ut opus suum proprium. Illae autem condensationes videntur intra quaternum numerum (quantum adhuc liquet) contineri. Quarum prima videtur fieri per contrusionem simplicem; quae parum potest ad densitatem constantem (resiliunt enim corpora) sed nihilominus forte res auxiliaris esse queat.

Secunda fit per contractionem partium crassiorum in corpore aliquo, post evolationem aut exitum partium tenuiorum, ut fit in indurationibus per ignem, et repetitis extinctionibus metallorum, et similibus. Tertia fit per coitionem partium homogenearum, quae sunt maxime solidae in corpore aliquo, atque antea fuerant distractae, et cum minus solidis commistae: veluti in restitutione mercurii sublimati, qui in pulvere longe majus occupat

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unite, and restrain their sharp and restless motion.

Rose water, too, held to the nostrils in fainting fits, makes the dispersed and overly relaxed spirits gather themselves, and as it were nourishes them. But opiates and related drugs put the spirits flatly to flight by their malignant and hostile quality. If they are applied to an outer part, the spirits at once flee from that part and no longer flow into it willingly. If they are taken internally, their vapors rise to the head and drive away on every side the spirits contained in the ventricles of the brain. Since the spirits withdraw and cannot escape to any other part, they come together and are condensed, and sometimes are completely extinguished and suffocated. Yet the same opiates, taken in moderation, have a secondary effect: the condensation that follows from this coming together. Through it they strengthen the spirits, make them more robust, and check their useless and inflammatory motions. Hence they contribute not a little to curing diseases and prolonging life.

Nor should the preparation of bodies to receive cold be omitted: for example, that slightly warm water freezes more easily than water that is quite cold, and the like.

Further, since nature supplies cold so sparingly, we must do as apothecaries usually do. When some simple cannot be had, they take a substitute for it, a *quid* pro *quo*, as they call it: aloe wood for balsam wood, for instance, or cassia for cinnamon. In the same way we must look around carefully for any substitutes for cold, that is, for ways of producing condensations in bodies other than by cold, whose proper work they are. These condensations seem, as far as is yet clear, to be limited to four. The first seems to come about by simple compression. This does little for lasting density, since bodies spring back, but it may still perhaps serve as an aid.

The second comes about by the contraction of the coarser parts in a body after the finer parts have evaporated or escaped, as happens in hardening by fire, in the repeated quenching of metals, and the like. The third comes about when the most solid homogeneous parts in a body, which had been scattered and mixed with less solid ones, come together. This happens in the restoration of sublim-

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spatium quam mercurius simplex, et similiter in omni repurgatione metallorum a scoriis suis. Quarta fit per consensus, admovendo quae ex vi corporum occulta condensant; qui consensus adhuc raro se ostendunt; quod mirum minime est, quoniam antequam inventio succedat formarum et schematismorum, de inquisitione consensuum non multum sperandum est.

Certe quoad corpora animalium, dubium non est quin sint complures medicinae, tam interius quam exterius sumptae, quae condensant tanquam per consensum, ut paulo ante diximus. Sed inanimatis rara est hujusmodi operatio. Percrebuit sane, tam scriptis quam fama, narratio de arbore in una ex insulis sive Terceris sive Canariis (neque enim bene memini), quae perpetuo stillat; adeo ut inhabitantibus nonnullam commoditatem aquae praebeat. Paracelsus autem ait, herbam vocatam *Rorem Solis* meridie et fervente sole rore impleri, cum aliae herbae undique sint siccae. At nos utramque narrationem fabulosam esse existimamus. Omnino autem illae instantiae nobilissimi forent usus, et introspectione dignissimae, si essent verae.

Etiam rores illos mellitos, et instar mannae, qui super foliis quercus inveniuntur mense Maio, non existimamus fieri et densari a consensu aliquo, sive a proprietate folii quercus; sed cum super aliis foliis pariter cadant, contineri scilicet et durare in foliis quercus, quia sunt bene unita, nec spongiosa, ut plurima ex aliis.

Calorem vero quod attinet, copia et potestas nimirum homini abunde adest; observatio autem et inquisitio deficit in nonnullis, iisque maxime necessariis, utcunque spagyrici se venditent. Etenim caloris intensioris opificia exquiruntur et conspiciuntur; remissioris vero, quae maxime in vias naturae incidunt, non tentantur, ideoque latent. Itaque videmus per vulcanos istos qui in pretio sunt, spiritus corporum magnopere exaltari, ut in aquis fortibus, et nonnullis aliis oleis chymicis; partes tangibiles indurari, et, emisso volatili, aliquando figi; partes homogeneas separari; etiam corpora heterogenea grosso modo incorporari et commisceri; maxime autem compages corporum compositorum et subtiliores schematismos destrui et confundi.

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ated mercury, which as a powder takes up far more space than plain mercury, and likewise in every purging of metals from their dross. The fourth comes about through affinities, by applying things that condense by some hidden power of bodies. These affinities rarely show themselves as yet. That is not surprising, since until the discovery of forms and configurations succeeds, there is little to hope for from the investigation of affinities.

Certainly, as regards the bodies of animals, there is no doubt that many medicines, taken internally as well as externally, condense as if through affinity, as we said a little earlier. But in inanimate things such action is rare. There is indeed a story, widespread in writings and by report, of a tree on one of the islands, either the Azores or the Canaries (I do not remember well), which drips constantly and so provides the inhabitants with a useful supply of water. Paracelsus says that the herb called *ros solis* fills with dew at midday in the blazing sun, when all the other herbs around are dry. But we consider both stories fables. Yet those instances would be of the noblest use, and most worth examining, if they were true.[42]

Nor do we think that the honeyed, manna-like dews found on oak leaves in May are made and condensed by some affinity, or by some property of the oak leaf. Rather, since they fall equally on other leaves, they are retained and last on oak leaves because these are compact and not spongy, like most of the others.

As for heat, man certainly has plenty of it and power over it in abundance. But observation and inquiry are lacking in some areas, and those the most necessary, however much the spagyrists advertise themselves. The works of intense heat are sought out and observed; but those of gentler heat, which fall most in with the ways of nature, are not tried and so remain hidden. So we see that by those much-prized Vulcans of theirs, the spirits of bodies are greatly exalted, as in aqua fortis and similar acids and some other chemical oils. Tangible parts are hardened and, once the volatile part is driven off, sometimes fixed. Homogeneous parts are separated. Heterogeneous bodies are

42 *Ros solis*, "dew of the sun," is the sundew, whose leaves bear glistening sticky drops.

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crudely incorporated and mixed. But above all, the structures of compound bodies and their subtler configurations are destroyed and confounded.[43]

Debuerant autem opificia caloris lenioris tentari et exquiri; unde subtiliores misturae et schematismi ordinati gigni possint et educi, ad exemplum naturae et imitationem operum solis; quemadmodum in aphorismo de instantiis *foederis* quaedam adumbravimus. Opificia enim naturae transiguntur per longe minores portiones, et posituras magis exquisitas et varias, quam opificia ignis, prout nunc adhibetur. Tum vero videatur homo revera auctus potestate, si per calores et potentias artificiales opera naturae possint specie repraesentari, virtute perfici, copia variari; quibus addere oportet accelerationem temporis. Nam rubigo ferri longo tempore procedit, at versio in crocum Martis subito; et similiter de aerugine et cerussa. Christallum longo tempore conficitur, vitrum subito conflatur. Lapides longo tempore concrescunt, lateres subito coquuntur, etc.

What ought to have been tried and explored are the works of gentler heat. From them subtler mixtures and ordered configurations could be produced and drawn out, after the pattern of nature and in imitation of the works of the sun, as we sketched in the aphorism on instances of *alliance*. For the works of nature are carried out in far smaller portions, and in more exquisite and varied arrangements, than the works of fire as it is now used. Then indeed would man seem truly increased in power, if by artificial heats and forces the works of nature could be reproduced in form, perfected in power, and varied in quantity. To these must be added the speeding up of time. The rusting of iron takes a long time, but its conversion into *crocus Martis* is quick; and likewise with verdigris and white lead. Crystal forms over a long time; glass is fused quickly. Stones grow together over a long time; bricks are baked quickly; and so on.[44]

Interim (quod nunc agitur) omnes diversitates caloris cum effectibus suis respective diligenter et industrie undique sunt colligendae et exquirendae: coelestium, per radios suos directos, reflexos, refractos, et unitos in speculis comburentibus; fulguris, flammae, ignis carbonum; ignis ex diversis materiis; ignis aperti, conclusi, angustiati, et inundantis, denique per diversas fabricas fornacium qualificati; ignis flatu exciti, quieti et non exciti; ignis ad majorem aut minorem distantiam remoti; ignis per varia media permeantis; calorum humidorum, ut balnei Mariae, fimi, caloris animalium per exterius, caloris animalium per interius, foeni conclusi; calorum aridorum, cineris, calcis, arenae tepidae; denique calorum cujusvis generis cum gradibus eorum.

Meanwhile, and this is our present business, all the varieties of heat, with their respective effects, must be diligently and industriously collected and investigated from every quarter. There is the heat of the heavenly bodies, through their rays direct, reflected, refracted, and concentrated in burning glasses. There is the heat of lightning, of flame, of charcoal fire; of fire from various materials; of fire open, enclosed, confined and overflowing, and modified by the various constructions of furnaces; of fire roused by blowing, and fire still and unroused; of fire set at a greater or lesser distance; of fire passing through various media. There are moist heats, such as the bain-marie (balneum Mariae), dung, the external and the internal heat of animals, and enclosed hay. There are dry heats, of ashes, lime and warm sand. In short, there are heats of every kind, with their degrees.

Praecipue vero tentanda est inquisitio et inventio effectuum et opificiorum caloris accedentis et recedentis graduatim, et ordinatim, et periodice, et per debita spatia et moras. Ista enim inaequalitas ordinata revera filia coeli

Above all, we must attempt to inquire into and discover the effects and works of heat that approaches and recedes by degrees, in order, periodically, and at proper intervals and times. For such

43 "Spagyric" was a Paracelsian name for alchemical chemistry; the "Vulcans" are their furnaces.
44 *Crocus Martis*, "saffron of Mars," was a red iron oxide prepared by chemists.

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est, et generationis mater; neque a calore aut vehementi, aut praecipiti, aut subsultorio, aliquid magni expectandum est. Etenim et in vegetabilibus hoc manifestissimum est; atque etiam in uteris animalium magna est caloris inaequalitas, ex motu, somno, alimentationibus et passionibus foemellarum quae uterum gestant; denique in ipsis matricibus terrae, iis nimirum in quibus metalla et fossilia efformantur, locum habet et viget ista inaequalitas. Quo magis notanda est inscitia aliquorum alchymistarum ex reformatis, qui per calores aequabiles lampadum et hujusmodi, perpetuo uno tenore ardentium, se voti compotes fore existimarunt.

Atque de opificiis et effectibus caloris haec dicta sint. Neque vero tempestivum est illa penitus scrutari, antequam rerum formae et corporum schematismi ulterius investigati fuerint, et in lucem prodierint. Tum enim quaerenda et adoperanda et aptanda sunt instrumenta, quando de exemplaribus constiterit.

4. Quartus modus operandi est per moram, quae certe et promus et condus naturae est, et quaedam dispensatrix. Moram appellamus, cum corpus aliquod sibi permittitur ad tempus notabile, munitum interim et defensum ab aliqua vi externa. Tum enim motus intestini se produnt et perficiunt, cum motus extranei et adventitii cessant. Opera autem aetatis sunt longe subtiliora quam ignis. Neque enim possit fieri talis clarificatio vini per ignem, qualis fit per moram; neque etiam incinerationes per ignem tam sunt exquisitae, quam resolutiones et consumptiones per saecula. Incorporationes etiam, et mistiones subitae et praecipitatae per ignem, longe inferiores sunt illis, quae fiunt per moram. At dissimilares et varii schematismi, quos corpora per moras tentant (quales sunt putredines), per ignem aut calorem vehementiorem destruuntur.

Illud interim non abs re fuerit notare; motus corporum penitus conclusorum habere nonnihil ex violento. Incarceratio enim illa impedit motus spontaneos corporis. Itaque mora in vase aperto plus facit ad separationes; in vase penitus clauso ad commistiones; in vase nonnihil clauso, sed subintrante aere, ad putrefactiones. Utcunque de opificiis et effectibus morae undique sunt diligenter conquirendae instantiae.

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ordered inequality is truly the daughter of the heavens and the mother of generation. Nothing great is to be expected from heat that is violent, sudden or fitful. This is very clear in plants. In the wombs of animals too there is great inequality of heat, from the movement, sleep, feeding and emotions of the pregnant females. And finally, in the very wombs of the earth, those in which metals and minerals are formed, this inequality has its place and force. All the more notable is the ignorance of some of the reformed alchemists, who thought they would attain their wish by the even heat of lamps and the like, burning steadily at one level.

So much for the works and effects of heat. It is not yet timely to examine them thoroughly, before the forms of things and the configurations of bodies have been further investigated and brought to light. For instruments are to be sought, employed and adapted only when the patterns are established.

4. The fourth way of working is by lapse of time, which is indeed nature's storekeeper, laying up and bringing out, and a kind of steward. We call it lapse of time when a body is left to itself for a considerable time, while being protected and defended from any external force. For internal motions show themselves and complete their work when foreign and adventitious motions cease. The works of age are far subtler than those of fire. Wine cannot be clarified by fire as it is by time. Nor are incinerations by fire as exquisite as the dissolutions and consumptions wrought over centuries. Sudden and hasty incorporations and mixtures by fire are also far inferior to those made by time. But the dissimilar and varied configurations that bodies attempt over time, such as putrefactions, are destroyed by fire or stronger heat.

Meanwhile it would not be amiss to note that the motions of bodies completely enclosed have something of violence about them. That imprisonment hinders the spontaneous motions of the body. So time in an open vessel does more for separations; in a completely closed vessel, for mixtures; in a vessel partly closed but letting air in, for putrefactions. In any case, instances of the works and effects of time must be diligently collected from every quarter.

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5. At regimen motus (quod est quintus ex modis operandi) non parum valet. Regimen autem motus vocamus, cum corpus aliud occurrens corporis alterius motum spontaneum impedit, repellit, admittit, dirigit. Hoc vero plerunque in figuris et situ vasorum consistit. Etenim conus erectus juvat ad condensationem vaporum in alembicis; at conus inversus juvat defaecationem sacchari in vasis resupinatis. Aliquando autem sinuatio requiritur, et angustiatio, et dilatatio per vices, et hujusmodi. Etiam omnis percolatio huc spectat; scilicet cum corpus occurrens uni parti corporis alterius viam aperit, alteri obstruit. Neque semper percolatio aut aliud regimen motus fit per extra; sed etiam per corpus in corpore: ut cum lapilli immittuntur in aquas ad colligendam limositatem ipsarum; syrupi clarificantur cum albuminibus ovorum, ut crassiores partes adhaerescant, et postea separari possint.

Etiam huic regimini motus satis leviter et inscite attribuit Telesius figuras animalium, ob rivulos scilicet et loculos matricis. Debuerat autem notare similem efformationem in testis ovorum, ubi non sunt rugae aut inaequalitas. At verum est regimen motus efformationes perficere in modulis et proplasticis.

6. Operationes vero per consensus aut fugas (qui sextus modus est) latent saepenumero in profundo. Istae enim (quas vocant) proprietates occultae, et specificae, et sympathiae, et antipathiae, sunt magna ex parte corruptelae philosophiae. Neque de consensibus rerum inveniendis multum sperandum est, ante inventionem formarum et schematismorum simplicium. Consensus enim nil aliud est quam symmetria formarum et schematismorum ad invicem.

Atqui majores et magis catholici rerum consensus non prorsus obscuri sunt. Itaque ab iis ordiendum. Eorum prima et summa diversitas ea est; ut quaedam corpora copia et raritate materiae admodum discrepent, schematismis consentiant: alia contra copia et raritate materiae consentiant, schematismis discrepent. Nam non male notatum est a chymicis, in principiorum suorum triade, sulphur et mercurium quasi per universitatem rerum permeare. (Nam de sale inepta ratio est, sed introducta ut possit comprehendere corpora terrea, sicca, et fixa.) At certe in illis duobus videtur consensus quidam naturae ex maxime catholicis conspici. Etenim consentiunt sulphur; oleum, et exhalatio pinguis; flamma; et fortasse corpus stellae. Ex altera parte

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5. The regulation of motion, the fifth of the ways of working, is also of no small power. We call it regulation of motion when one body, meeting another, hinders, repels, admits or directs its spontaneous motion. This mostly consists in the shapes and positions of vessels. An upright cone helps the condensation of vapors in alembics, while an inverted cone helps the refining of sugar in upturned vessels. Sometimes winding is required, and narrowing and widening by turns, and the like. All filtering also belongs here, when the body met opens a way to one part of another body and blocks it to another. Nor is filtering or other regulation of motion always done from outside; it is also done by a body within a body. So small stones are put into water to collect its sediment, and syrups are clarified with egg whites so that the coarser parts stick to them and can afterward be separated.

Telesio, too, rather lightly and ignorantly attributed the shapes of animals to this regulation of motion, on account of the channels and cells of the womb. He should have noticed a similar formation in eggshells, where there are no folds or unevenness. But it is true that regulation of motion completes formations in molds and models.

6. Operations by affinities or aversions, the sixth way, often lie deep. For these so-called occult and specific properties, sympathies and antipathies, are for the most part corruptions of philosophy. Nor is much to be hoped for in discovering the affinities of things before the discovery of forms and simple configurations. For affinity is nothing other than the mutual symmetry of forms and configurations.

Yet the greater and more universal affinities of things are not wholly obscure, so we must begin with them. Their first and chief difference is this. Some bodies differ greatly in quantity and rarity of matter but agree in configuration. Others, on the contrary, agree in quantity and rarity of matter but differ in configuration. The chemists, in their triad of principles, have not observed badly that sulfur and mercury run, as it were, through the whole universe of things. (Their reasoning about salt is foolish; it was brought in to cover earthy, dry and fixed bodies.) But in those two there certainly seems to be visible one of the most

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consentiunt mercurius; aqua et vapores aquei; aer; et fortasse aether purus et interstellaris.

Attamen istae quaterniones geminae, sive magnae rerum tribus (utraque intra ordines suos), copia materiae atque densitate immensum differunt, sed schematismo valde conveniunt; ut in plurimis se produnt. At contra metalla diversa copia et densitate multum conveniunt (praesertim respectu vegetabilium, etc.), sed schematismo multifariam differunt; et similiter vegetabilia et animalia diversa schematismis quasi infinitis variantur, sed intra copiam materiae sive densitatem paucorum graduum continentur.

Sequitur consensus maxime post priorem catholicus, videlicet corporum principalium et fomitum suorum; videlicet menstruorum, et alimentorum. Itaque exquirendum, sub quibus climatibus, et in qua tellure, et ad quam profunditatem metalla singula generentur; et similiter de gemmis, sive ex rupibus, sive inter mineras natis; in qua gleba terrae, arbores singulae, et frutices, et herbae potissimum proveniant, et tanquam gaudeant; et insimul quae impinguationes, sive per stercorationes cujuscunque generis, sive per cretam, arenam maris, cineres, etc., maxime juvent; et quae sint ex his pro varietate glebarum magis aptae et auxiliares. Etiam insitio et inoculatio arborum et plantarum, earumque ratio, quae scilicet plantae super quas foelicius inserantur, etc., multum pendet de consensu.

In qua parte non injucundum foret experimentum, quod noviter audivimus esse tentatum, de insitione arborum sylvestrium (quae hucusque in arboribus hortensibus fieri consuevit), unde folia et glandes majorem in modum amplificantur, et arbores fiunt magis umbrosae. Similiter, alimenta animalium respective notanda sunt in genere, et cum negativis. Neque enim carnivora sustinent herbis nutriri; unde etiam Ordo Folitanorum (licet voluntas humana plus possit quam animantium caeterorum super corpus suum), post experientiam factam (ut aiunt), tanquam ab humana natura non tolerabilis, fere evanuit. Etiam materiae diversae putrefactionum, unde animalcula generantur, notandae sunt.

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universal affinities of nature. For sulfur, oil and fatty exhalation, flame, and perhaps the body of a star agree together. On the other side, mercury, water and watery vapors, air, and perhaps the pure ether between the stars agree together.[45]

Yet these twin sets of four, or great tribes of things, each within its own ranks, differ immensely in quantity of matter and density, but agree closely in configuration, as appears in very many ways. On the contrary, the various metals agree closely in quantity and density, especially compared with plants, etc., but differ in configuration in many ways. Likewise the various plants and animals vary in almost infinite configurations, but are contained within a few degrees of quantity of matter or density.

Next comes the affinity most universal after the first: that of principal bodies with what feeds them, that is, with their menstruums and their nourishment. So we must inquire under what climates, in what soil and at what depth each metal is generated; and likewise of gems, whether born in rocks or among ores. We must ask in what kind of soil each tree, shrub and herb chiefly grows and, as it were, delights; and at the same time what enrichments help most, whether manuring of any kind, or chalk, sea sand, ashes, etc., and which of these are more suitable and helpful for different soils. The grafting and budding of trees and plants, too, and its principle, namely on which plants each is most successfully grafted, etc., depends much on affinity.

In this area an experiment would not be unpleasant which we have lately heard has been tried: grafting forest trees, which hitherto has usually been done only with garden trees. By this the leaves and acorns are greatly enlarged, and the trees give more shade. Similarly, the foods of each kind of animal should be noted in general, together with the negatives. Carnivores cannot bear to be fed on herbs. Hence the Order of the Feuillants, after making the trial (as they say), almost disappeared, as if the practice were intolerable to human nature, although the human will has more power over its own body than that of other animals. The various materials of putrefaction from

45 The Paracelsian chemists held that all bodies are composed of three principles: salt, sulfur and mercury.

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which small animals are generated should also be noted.[46]

Atque consensus corporum principalium erga subordinata sua (tales enim ii possint censeri quos notavimus) satis in aperto sunt. Quibus addi possunt sensuum consensus erga objecta sua. Qui consensus, cum manifestissimi sint, bene notati, et acriter excussi, etiam aliis consensibus qui latent magnam praebere possint lucem.

The affinities of principal bodies toward their subordinates, for such we may consider those we have noted, are fairly plain. To these may be added the affinities of the senses toward their objects. Since these affinities are most manifest, they can, when well noted and keenly examined, shed great light on other affinities that lie hidden.

At interiores corporum consensus et fugae, sive amicitiae et lites (taedet enim nos fere vocabulorum sympathiae et antipathiae, propter superstitiones et inania), aut falso ascriptae, aut fabulis conspersae, aut per neglectum rarae admodum sunt. Etenim si quis asserat inter vineam et brassicam esse dissidium, quia juxta sata minus laete proveniunt, praesto ratio est: quod utraque planta succulenta sit et depraedatrix, unde altera alteram defraudat. Si quis asserat esse consensum et amicitiam inter segetes et cyaneum, aut papaver sylvestre, quia herbae illae fere non proveniunt nisi in arvis cultis: debuit is potius asserere dissidium esse inter ea, quia papaver et cyaneus emittuntur et creantur ex tali succo terrae qualem segetes reliquerint et repudiaverint; adeo ut satio segetum terram praeparet ad eorum proventum.

But the inner affinities and aversions of bodies, or their friendships and quarrels (we are almost tired of the words sympathy and antipathy, because of the superstitions and empty notions attached to them), are either falsely ascribed, or sprinkled with fables, or, through neglect, very rarely observed. Suppose someone asserts that there is enmity between the vine and the cabbage, because they grow less vigorously when planted side by side. The explanation is ready: both plants are juicy and plundering, so one robs the other. Suppose someone asserts that there is affinity and friendship between grain crops and the cornflower or wild poppy, because those herbs hardly grow except in cultivated fields. He should rather have asserted that there is enmity between them. The poppy and cornflower are produced and brought forth from such juice of the earth as the crops have left and rejected, so that sowing crops prepares the ground for their growth.

Atque hujusmodi falsarum ascriptionum magnus est numerus. Quoad fabulas vero, illae omnino sunt exterminandae. Restat tenuis certe copia eorum consensuum, qui certo probati sunt experimento; quales sunt magnetis et ferri, atque auri et argenti vivi, et similium. At in experimentis chymicis circa metalla inveniuntur et alii nonnulli observatione digni. Maxima vero frequentia eorum (ut in tanta paucitate) invenitur in medicinis nonnullis, quae, ex proprietatibus suis occultis (quas vocant) et specificis, respiciunt aut membra, aut humores, aut morbos, aut quandoque naturas individuas. Neque omittendi sunt consensus inter motus et affectus lunae et passiones corporum inferiorum, prout ex experimentis agriculturae, nauticae, et medicinae, aut alias cum delectu severo et sincero colligi et recipi possint.

There is a great number of false ascriptions of this kind. As for fables, they must be driven out entirely. There remains a slender supply of affinities that have been proved by sure experiment, such as those of the magnet and iron, of gold and quicksilver, and the like. In chemical experiments on metals some others worth observing are also found. But they are found most frequently, given their scarcity, in certain medicines. By their so-called occult and specific properties, these relate to particular limbs, or humors, or diseases, or sometimes individual constitutions. Nor should we omit the affinities between the motions and phases of the moon and the changes undergone by lower bodies, so far as they can be gathered and accepted, with strict and honest selection, from

46 The Feuillants, a strict reformed Cistercian order founded in France in the 1570s, at first lived on bread and herbs; the rule was relaxed after many members died.

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experiments in agriculture, navigation and medicine, or elsewhere.

Verum instantiae universae consensuum secretiorum, quo magis sunt infrequentes, eo majori cum diligentia sunt inquirendae, per traditiones, et narrationes fidas et probas; modo hoc fiat absque ulla levitate, aut credulitate, sed fide anxia et quasi dubitabunda. Restat consensus corporum modo operandi tanquam inartificialis, sed usu polychrestus, qui nullo modo omittendus est, sed sedula observatione investigandus. Is est coitio sive unio corporum, proclivis aut difficilis, per compositionem, sive appositionem simplicem. Etenim corpora nonnulla facile et libenter commiscentur et incorporantur, alia autem aegre et perverse: veluti pulveres melius incorporantur cum aquis; calces et cineres, cum oleis; et sic de similibus.

But all instances of the more secret affinities, the rarer they are, must be sought out with the greater diligence, through traditions and trustworthy, reliable reports. This must be done without any levity or credulity, with an anxious and, as it were, doubting faith. There remains an affinity of bodies which is, so to speak, artless in its manner of working but polychrest in use. It must by no means be omitted, but investigated with careful observation. This is the coming together or union of bodies, easy or difficult, by composition or simple juxtaposition. Some bodies mix and incorporate easily and willingly, others reluctantly and stubbornly. Powders, for example, incorporate better with water, and limes and ashes with oils; and so with similar cases.

Neque tantum sunt colligendae instantiae *propensionis* aut *aversionis* corporum erga misturam, sed etiam collocationis partium, et distributionis, et digestionis, postquam commista sint; denique et praedominantiae post misturam transactam.

Nor must we collect only instances of the *propensity* or *aversion* of bodies to mixture. We must also collect instances of the arrangement, distribution and digestion of the parts after they have been mixed, and finally of the predominance once the mixture is complete.

7. Superest ultimo loco ex modis septem operandi septimus et postremus: operatio scilicet per alternationem et vicissitudines priorum sex; de quo antequam in singulos illos paulo altius fuerit inquisitum, tempestivum non foret exempla proponere. Series autem sive catena hujusmodi alternationis, prout ad singula effecta accommodari possit, res est et cognitu maxime difficilis, et ad opera maxime valida. Summa autem detinet et occupat homines impatientia hujusmodi tam inquisitionis, quam praxeos; cum tamen sit instar fili labyrinthi, quoad opera majora. Atque haec sufficiant ad exemplum Polychresti.

7. There remains, in the last place among the seven ways of working, the seventh and final one: working by the alternation and succession of the previous six. It would not be timely to give examples of it before each of those has been inquired into somewhat more deeply. The series or chain of such alternation, as it can be adapted to particular effects, is both very difficult to know and very powerful in practice. Yet men are gripped and possessed by the greatest impatience with such inquiry and such practice alike, although it is like the thread through the labyrinth where greater works are concerned. Let this suffice as an example of the Polychrest.

MAGICAL INSTANCES AND THE END

Small causes produce great effects; Bacon sums up the prerogative instances and man's recovery of power over nature.

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2.51 Inter *praerogativas instantiarum*, ponemus loco vicesimo septimo atque ultimo *Instantias Magicas*. Hoc nomine illas appellamus, in quibus materia aut efficiens tenuis aut parva est, pro magnitudine operis et effectus qui sequitur; adeo ut etiamsi fuerint vulgares, tamen sint

Among the *prerogative instances* we will put in the twenty-seventh and last place *Magical Instances*. By this name we call those in which the matter or the efficient cause is slight or small compared with the size of the work and effect that follows. Even

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instar miraculi; aliae primo intuitu, aliae etiam attentius contemplanti. Has vero natura ex sese subministrat parce; quid vero factura sit sinu excusso, et post inventionem formarum, et processuum, et schematismorum, futuris temporibus apparebit.

At ista effecta magica (quantum adhuc conjicimus) fiunt tribus modis: aut per multiplicationem sui, ut in igne, et venenis, quae vocant specifica; necnon in motibus, qui transeunt et fortificantur de rota in rotam: aut per excitationem sive invitationem in altero, ut in magnete, qui excit acus innumeras, virtute nullatenus deperdita aut diminuta; aut in fermento, et hujusmodi: aut per anteversionem motus, ut dictum est de pulvere pyrio, et bombardis, et cuniculis: quorum priores duo modi indagationem consensuum requirunt; tertius, mensurae motuum. Utrum vero sit aliquis modus mutandi corpora per minima (ut vocant), et transponendi subtiliores materiae schematismos (id quod ad omnimodas corporum transformationes pertinet, ut ars brevi tempore illud facere possit, quod natura per multas ambages molitur), de eo nulla hactenus nobis constant indicia.

Quemadmodum autem in solidis et veris aspiramus ad ultima et summa; ita vana et tumida perpetuo odimus, et quantum in nobis est profligamus.

2.52 Atque de Dignitatibus sive *Praerogativis Instantiarum* haec dicta sint. Illud vero monendum, nos in hoc nostro *Organo* tractare logicam, non philosophiam. Sed cum logica nostra doceat intellectum et erudiat ad hoc, ut non tenuibus mentis quasi claviculis rerum abstracta captet et prenset (ut logica vulgaris), sed naturam revera persecet, et corporum virtutes et actus eorumque leges in materia determinatas inveniat; ita ut non solum ex natura mentis, sed ex natura rerum quoque haec scientia emanet: mirum non est, si ubique naturalibus contemplationibus et experimentis, ad exempla artis nostrae, conspersa fuerit et illustrata.

Sunt autem (ut ex iis quae dicta sunt patet) *Praerogativae Instantiarum* numero 27; nominibus: *Instantiae Solitariae: Instantiae Migrantes: Instantiae Ostensivae: Instantiae Clandestinae: Instantiae Constitutivae: Instantiae Conformes:*

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when they are common, they are like a miracle, some at first sight, others even to one who contemplates them more attentively. Nature of herself supplies these sparingly. But what she will do once her lap has been shaken out, and after the discovery of forms, processes and configurations, will appear in times to come.

These magical effects, so far as we can yet conjecture, come about in three ways. The first is by self-multiplication, as in fire and in the poisons called specific, and also in motions that pass from wheel to wheel and grow stronger as they go. The second is by excitation or invitation in another body, as in the magnet, which excites countless needles without any loss or diminution of its power, or in ferment and the like. The third is by the forestalling of motion, as we said of gunpowder, cannon and mines. The first two ways require the tracking down of affinities; the third, the measurement of motions. Is there any way of changing bodies through their smallest parts (*per minima*, as they say), and of transposing the subtler configurations of matter? This concerns every kind of transformation of bodies, so that art might do in a short time what nature accomplishes by many windings. Of this we have as yet no signs.

But just as in solid and true matters we aspire to the ultimate and the highest, so we constantly hate what is empty and inflated, and drive it away as far as lies in us.

So much for the Dignities or *Prerogatives of Instances*. It should be pointed out, however, that in this *Instrument* of ours we are treating of logic, not philosophy. Ordinary logic catches and grasps at abstractions with the slender tendrils, so to speak, of the mind. Our logic, by contrast, teaches and trains the understanding truly to dissect nature, and to discover the powers and actions of bodies and their laws as determined in matter. This science therefore flows not only from the nature of the mind but also from the nature of things. So it is no wonder that it has been everywhere sprinkled and illustrated with observations of nature and experiments, as examples of our art.

The *Prerogative Instances*, as is clear from what has been said, are twenty-seven in number. Their names are: *Solitary Instances; Migrating Instances; Striking Instances; Clandestine Instances; Constitutive*

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Instantiae Monodicae: Instantiae Deviantes: Instantiae Limitaneae: Instantiae Potestatis: Instantiae Comitatus et Hostiles: Instantiae Subjunctivae: Instantiae Foederis: Instantiae Crucis: Instantiae Divortii: Instantiae Januae: Instantiae Citantes: Instantiae Viae: Instantiae Supplementi: Instantiae Persecantes: Instantiae Virgae: Instantiae Curriculi: Doses Naturae: Instantiae Luctae: Instantiae Innuentes: Instantiae Polychrestae: Instantiae Magicae. Usus autem harum *instantiarum*, in quo instantias vulgares excellunt, versatur in genere aut circa partem informativam; aut circa operativam; aut circa utramque. Atque quoad informativam, juvant illae aut sensum, aut intellectum.

Sensum, ut quinque *Instantiae Lampadis*: intellectum, aut accelerando exclusivam formae, ut *Solitariae*; aut angustiando et propius indicando affirmativam formae, ut *Migrantes, Ostensivae, Comitatus,* cum *Subjunctivis*; aut erigendo intellectum, et ducendo ad genera et naturas communes; idque aut immediate, ut *Clandestinae, Monodicae, Foederis*; aut gradu proximo, ut *Constitutivae*; aut gradu infimo, ut *Conformes*; aut rectificando intellectum a consuetis, ut *Deviantes*; aut ducendo ad Formam Magnam, sive Fabricam Universi, ut *Limitaneae*; aut cavendo de formis et causis falsis, ut *Crucis* et *Divortii*. Quod vero ad Operativam attinet; illae practicam aut designant, aut mensurant, aut sublevant. Designant aut ostendendo a quibus incipiendum, ne actum agamus, ut *Instantiae Potestatis*; aut ad quid aspirandum, si detur facultas, ut *Innuentes*: mensurant quatuor illae *Mathematicae*: sublevant *Polychrestae* et *Magicae*.

Rursus ex istis *instantiis* 27, nonnullarum (ut superius diximus de aliquibus) facienda est collectio jam ab initio, nec expectanda particularis inquisitio naturarum. Cujus generis sunt *instantiae conformes, monodicae, deviantes, limitaneae, potestatis, januae, innuentes, polychrestae, magicae.* Hae enim aut auxiliantur et medentur intellectui et sensui, aut instruunt praxin in genere. Reliquae tum demum conquirendae sunt, cum conficiemus *tabulas comparentiae* ad opus interpretis circa aliquam naturam

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Instances; Conformable Instances; Singular Instances; Deviating Instances; Bordering Instances; Instances of Power; Instances of Companionship and Hostile Instances; Subjunctive Instances; Instances of Alliance; Crucial Instances; Instances of Divorce; Instances of the Door; Summoning Instances; Instances of the Road; Supplementary Instances; Dissecting Instances; Instances of the Rod; Instances of the Course; Doses of Nature; Instances of Struggle; Intimating Instances; Polychrest Instances; Magical Instances. The use of these *instances*, in which they surpass ordinary instances, concerns in general either the informative part, or the operative part, or both. As regards the informative part, they help either the senses or the understanding.

They help the senses, like the five *Instances of the Lamp*. They help the understanding in several ways. They speed up the exclusion in the search for the form, like the *Solitary* instances. They narrow down and point more closely to the affirmative of the form, like the *Migrating, Striking* and *Companionship* instances, together with the *Subjunctive*. They raise the understanding and lead it to genera and common natures: either directly, like the *Clandestine, Singular* and *Alliance* instances; or at the next step, like the *Constitutive*; or at the lowest step, like the *Conformable*. They correct the understanding from what is habitual, like the *Deviating*. They lead it to the Great Form, or the Structure of the Universe, like the *Bordering*. They guard against false forms and causes, like the *Crucial* instances and those *of Divorce*. As for the operative part, they either point out, or measure, or ease practice. They point it out either by showing where to begin, so that we do not redo what is already done, like *Instances of Power*; or by showing what to aim at, if the means are available, like *Intimating* instances. The four *Mathematical* instances measure it; the *Polychrest* and *Magical* instances ease it.

Again, of these twenty-seven *instances*, some must be collected right from the start, as we said above of certain ones, without waiting for the particular inquiry into natures. Of this kind are the *conformable, singular, deviating* and *bordering* instances, those *of power* and *of the door*, and the *intimating, polychrest* and *magical* instances. For these either aid and heal the understanding and the senses, or instruct practice in general. The rest are to be

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particularem. Sunt enim *instantiae praerogativis istis* insignitae et donatae animae instar, inter vulgares instantias comparentiae; et ut ab initio diximus, paucae illarum sunt vice multarum; quocirca cum *tabulas* conficimus, illae omni studio sunt investigandae, et in *tabulas* referendae. Erit etiam earum mentio necessaria in iis quae sequuntur. Praeponendus itaque erat earum tractatus.

Nunc vero ad *adminicula* et *rectificationes Inductionis*, et deinceps ad *concreta*, et *latentes processus,* et *latentes schematismos*, et reliqua quae Aphorismo 21. ordine proposuimus, pergendum; ut tandem (tanquam curatores probi et fideles) tradamus hominibus fortunas suas, emancipato intellectu, et facto tanquam majore: unde necesse est sequi emendationem status hominis, et ampliationem potestatis ejus super naturam. Homo enim per lapsum et de statu innocentiae decidit, et de regno in creaturas. Utraque autem res etiam in hac vita nonnulla ex parte reparari potest; prior per religionem et fidem, posterior per artes et scientias. Neque enim per maledictionem facta est creatura prorsus et ad extremum rebellis.

Sed in virtute illius diplomatis, *In sudore vultus comedes panem tuum,* per labores varios (non per disputationes certe, aut per otiosas ceremonias magicas), tandem et aliqua ex parte ad panem homini praebendum, id est, ad usus vitae humanae subigitur.

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sought out only when we draw up *tables of presentation* for the interpreter's work on some particular nature. Instances marked out and endowed with these *prerogatives* are like a soul among the ordinary instances of presentation. As we said at the beginning, a few of them stand in place of many. So when we draw up the *tables*, they must be searched out with all zeal and entered in the *tables*. We shall also need to mention them in what follows. That is why they had to be treated first.

Now we must proceed to the *aids* and *rectifications of induction*, and then to *concrete bodies*, *latent processes*, *latent configurations*, and the rest that we set out in order in Aphorism 21. So at last, like honest and faithful guardians, we may hand over to men their fortunes, with the understanding emancipated and, as it were, come of age. From this there must follow an improvement of man's estate and an enlargement of his power over nature. For by the Fall man lost both his state of innocence and his dominion over the creatures. Both, however, can be repaired to some extent even in this life: the first by religion and faith, the second by the arts and sciences. For the curse did not make creation wholly and utterly rebellious.[47]

By virtue of that charter, *In the sweat of your face you shall eat bread*, creation is at last, and in some measure, subdued by various labors—certainly not by disputations or idle magical ceremonies—to provide man with bread, that is, to serve the uses of human life.[48]

47 Bacon listed these further topics in 2.21, but the *New Organon* ends here; he never wrote them.
48 Genesis 3:19, God's sentence on Adam after the Fall.