The New Organon

FRANCIS BACON
1561–1626

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Novum Organum

Translated from the Latin with AI (Claude) and edited



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The New Organon · Francis Bacon (1561–1626)

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CONTENTS

Introduction vii

Preface 1

Two kinds of learning 4

Book I 7

Two ways to truth 9

Anticipation and interpretation 11

The four idols 13

Idols of the Tribe 15

Idols of the Cave 18

Idols of the Marketplace 20

Idols of the Theater 22

Faulty material of speculation 26

Bad demonstrations 30

Signs that philosophy is sick 32

Causes of error 38

A road never built 41

Antiquity, authority and admiration 43

Superstition and the schools 49

Grounds for hope 52

A better foundation 56

Discoveries by chance 61

Objections answered 65

The excellence of the end 76

Book II 81

A rule for practice 83

Latent process and configuration 84

Metaphysics and physics 89

Table of essence and presence 90

Table of absence in proximity 92

Table of degrees 101
Induction by exclusion 109
The first vintage 114
Prerogative instances 120
Resemblances and oddities 130
Companions and alliances 140
Crucial instances 147
Instances of the Lamp 160
Practical instances 174
The kinds of motion 184
Instances of many uses 204
Magical instances and the end 218

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.

Pref. 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. 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]

Our method is hard to carry out but easy to state. It is this. We establish degrees of certainty. We 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

1 *Akatalēpsia* was the Greek Skeptics' term, used especially by the later Platonic Academy, for the view that nothing can be known with certainty.
2 Idols: false images or phantoms (Greek *eidōla*). By "dialectic" Bacon means the logic of the schools, above all Aristotelian syllogistic.

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 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? 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.

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? —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 under-

standing 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.

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

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]

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.

1.1 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 are aberrations, not abstracted and drawn out from things in the proper ways.

1.17 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 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.

1.19 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 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 experi-

ence. These evils, moreover, have been increased by dialectic, for the sake of the pomp of disputations.

1.21 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 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 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 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 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.

1.26 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 *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 Indeed, *anticipations* are far more powerful than *interpretations* at winning assent. They are 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 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 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 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 "Renewal" (*instauratio*) is Bacon's word for his larger project, the *Instauratio Magna* (Great Renewal), of which this work is the second part.

1.32 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 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 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 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. 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 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 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.

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

THE FOUR IDOLS

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

1.38 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 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 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]

1.41 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 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

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.

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 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 Lastly, there are *idols* that have migrated into people's minds from the various dogmas of philosophies, 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

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.

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.

1.45 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 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 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 van-

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.

ities 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.

1.47 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.

1.48 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 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

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

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.

1.49 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.

1.50 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 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] For the senses by themselves are weak and prone to error. Instru-

8 Bacon's "spirits" are fine, invisible substances which he believed were enclosed in all tangible bodies and drove their changes.

ments 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 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 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.

1.53 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 People become devoted to particular sciences and speculations. They may believe themselves their 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 cor-

9 Democritus of Abdera (5th century BC), with his teacher Leucippus, held that everything consists of atoms moving in the void.

rupt 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 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 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 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).

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 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.

1.59 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. Yet in natural and material things even definitions cannot cure this evil, since definitions themselves consist of words, and words beget words. So we 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.

1.60 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

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

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 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.

1.61 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.

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 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. 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*.

1.63 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 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] 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

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.

other treatises deal frequently with experiments.[13] 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 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 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.

1.65 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.

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.

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] 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.

1.66 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

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

universal nature of things. 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. 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 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 vacuum 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.

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 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.

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]

The school of Plato, on the other hand, introduced *acatalepsia*. At first it did so as a kind of joke and 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] But, as we said at the beginning and maintain throughout, the human senses and understanding, weak as they

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

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.

are, are not to be stripped of their authority. They are to be given help.

1.68 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.

1.69 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 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

17 An allusion to Matthew 18:3.

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.

1.70 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 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] 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.

1.71 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 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, Theo-

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.

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

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.

1.72 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. 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 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 discovered or drawn

out of philosophy and knowledge of causes.[23] 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.

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 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

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).

life: rough at first, then serviceable, then refined, and always improving.

1.75 Another sign must be taken as well, if indeed it deserves the name of sign. It is rather testimony, and 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.

1.76 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 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 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. 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 com-

mon notions, as was said above. 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 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.

1.78 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.

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

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.

intervening times they wore the sciences down with their many treatises rather than adding to their weight. 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 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 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

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

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.

1.80 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 become merely a passage or bridge to other things.

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. 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 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. 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 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.

1.82 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 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.

1.83 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.

1.84 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.

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.

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.

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.

1.85 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 intellectual 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 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.

1.86 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

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

seek nothing further in matters that are handed down as perfect and long since complete in every part.

1.87 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 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]

1.88 Far greater harm has been done to the sciences by faintheartedness, and by the smallness and slightness of the tasks

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

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. 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 delighted 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.

1.89 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]

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.

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.

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

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).

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.

1.90 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

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.

prisons; and anyone who disagrees with them is at once attacked as a troublemaker and a seeker after novelty. 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 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.

1.92 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.

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

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

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. 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 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 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]

1.97 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

34 Proclus (AD 412–485), Neoplatonist philosopher and head of the Platonic school at Athens.

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.

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.

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]

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.

1.98 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 number, 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

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.

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.

1.99 Again, in the very abundance of mechanical experiments there is found a great scarcity of those that do most to help and inform the understanding. The mechanic, not in the least con-

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

cerned 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.

1.100 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.

1.101 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]

1.102 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 understanding. 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 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 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)

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

are notional and abstract, and have nothing solid in them. 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.

1.105 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.

1.106 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 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 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.

1.108 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. 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 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.

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 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.

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 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. 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.

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

1.111 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 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 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 experience, can best be divided up and then combined. 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 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.

1.115 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.

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.

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 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.

1.116 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

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.

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

1.117 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.

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.

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 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 principles. 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.

1.119 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, 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 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] But enough and more

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

than enough of this, since this kind of fastidiousness is plainly childish and squeamish.

1.121 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.

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 indeed 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]

1.122 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.

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. 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

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.
42 Plutarch tells this story of Philip II of Macedon; Cassius Dio tells it of the emperor Hadrian.

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]

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

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. 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 So we may say of ourselves what someone once said in jest, especially since it cuts so neatly to the heart of the matter:

43 Atlantis is the legendary island described by Plato in the *Timaeus* and *Critias*.

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 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 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.

1.125 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 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.

1.126 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.

1.127 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 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. 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 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] 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.

1.129 It remains for us to say a few words about the excellence of the end. Had this been said earlier, it 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

44 Bacon's *The Advancement of Learning* (1605), later expanded in Latin as *De Augmentis Scientiarum* (1623).

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]

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

45 Lucretius, *On the Nature of Things* 6.1–3.

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 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,

46 Proverbs 25:2.

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.

1.130 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.

2.1 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 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

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.

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. For in nature nothing really exists except individual bodies, performing pure individual acts according to law. Yet in the sciences it is that very 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 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. 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.

2.4 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.

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.

2.5 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. 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.

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

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.

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. 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 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 certain 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.

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

2.8 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 calcul-

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

able, 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.

2.9 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 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 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.

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.

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.

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.

2.11 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.

Instances agreeing in the nature of heat.

1. The rays of the sun, especially in summer and at noon.

2. The rays of the sun reflected and concentrated, as between mountains or off walls, and most of all in burning glasses.

3. Fiery meteors.

4. Lightning that burns.

5. Eruptions of flame from mountain hollows, etc.

6. All flame.

7. Solids that are on fire.

8. Natural hot springs.

9. Liquids that are boiling or heated.

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. Certain spells of clear weather, owing to the very constitution of the air, regardless of the season.

12. Air shut up underground in some caves, especially in winter.

13. All shaggy things, such as wool, animal skins and plumage, have some warmth.

14. All bodies, whether solid or liquid, dense or rare (as air itself is), when brought near fire for a time.

15. Sparks struck from flint and steel by a strong blow.

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. 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. Quicklime sprinkled with water.

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. 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.

21. Horse dung, and fresh animal excrement of that kind.

22. Strong oil of sulfur and oil of vitriol do the work of heat in scorching linen.[3]

23. Oil of origanum and the like does the work of heat in burning the bone of the teeth.

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. 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. 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. Even sharp and intense cold produces a sensation of burning: "the North Wind's piercing cold scorches."[4]

28. Others.

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.

2.12 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.

So *negatives* must be attached to the *affirmatives*, and absences examined only in those subjects 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

3 Both are old names for sulfuric acid.

4 Virgil, *Georgics* 1.93.

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.

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]

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

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.

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 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 watery 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.

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.

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, insofar 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 liv-

ing 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.

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 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.

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

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 instance. 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.

2.13 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, 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 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.

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 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

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

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 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 con-

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

tinuous 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 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 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 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. 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. 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 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.

2.15 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. 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 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 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.

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.

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 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.

2.18 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.

1. Because of the sun's rays, *reject* elemental nature.

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. 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. 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. 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. Because of the rays of the moon and the other stars (except the sun), *reject* light and brightness too.

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. Because of gold and other red-hot metals, which are of very dense body as a whole, *reject* rarity.

9. Because of air, which is generally found to be cold and yet remains rare, *reject* rarity too.

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. 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. Because all bodies warm easily without any destruction or notable alteration, *reject* destructive nature, or the violent infusion of some new nature.

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. 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.

There are other natures as well; for we are not making complete tables, only examples.

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 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. 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.

2.20 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

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

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 understood 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.

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.

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: although 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 a struggle, and the parts of the iron are more stubborn.

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.

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*.

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.*

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. 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.

2.21 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 setting 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]

2.22 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

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.

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 Instances*. 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.

2.23 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 dir-

ectly 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.

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 gener-

ated 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 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.

2.24 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 predomin-

ates. 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 compact, 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.

2.25 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. 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 het-

erogeneous 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 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.

2.26 Among the prerogative instances we shall put *Constitutive Instances* in fifth place; we also call them *Bundled Instances*. These

13 An "armed" magnet is a lodestone fitted with iron caps, which greatly increases the weight it can lift.

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 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

14 The classical "art of memory" fixes things to be remembered on images placed in an imagined sequence of places (*loci*).

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 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 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.

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]

15 A paraphrase of Plato, *Phaedrus* 266b, where Socrates says he follows such a man "as if in the footsteps of a god."

RESEMBLANCES AND ODDITIES

Conformable, singular, deviating and bordering instances, and the masterworks of human art, prepare the understanding.

2.27 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.

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 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 exudations 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 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*

16 Aristotle, *On the Progression of Animals* 708a, observes that snakes move by four flexions, as other animals move on four points of support.

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 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.

2.28 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.

2.29 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]

2.30 Among the *prerogative instances* we shall put *Bordering Instances* in ninth place; we also call them *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

17 Livy's history regularly records the portents reported in each year.

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]

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

"the ape, that ugliest of beasts, how like us!"[19]

and the two-formed offspring of animals, mixed from different species; and the like.

2.31 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] 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.

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. 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

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.

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 achievements, 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.

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.

2.32 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.

2.33 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 companion. 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 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.

2.34 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.

2.35 Among the *prerogative instances* we shall place thirteenth *Instances of Alliance* or *of Union*. These are instances that mix and join together natures 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 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 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

21 Girolamo Fracastoro (c. 1478–1553), Italian physician, poet and natural philosopher.

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. 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 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.

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

22 Sudden torrential downpours or waterspouts; the phrase echoes the "windows (cataracts) of heaven" of the Flood in Genesis 7:11.

rose high enough for it to drink. The story afterwards became proverbial.[23]

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.

2.36 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 assigned. *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 some-

23 The story is told in Aesop's fable of the crow and the pitcher and in Pliny's *Natural History*.

24 Latin *crux*, "cross," here a signpost at a crossroads; Bacon's term is the source of the English phrase "crucial experiment."

times 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, 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

25 José de Acosta (1540–1600), Spanish Jesuit, author of the *Natural and Moral History of the Indies* (1590).

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 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

26 The South Sea is the Pacific Ocean.

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 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 world. These are the two things that gave birth to

this motion for us. 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.

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. 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.

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.

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

27 Gilbert's "little earth": a sphere of lodestone used as a model of the earth's magnetism.

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 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 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 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.)

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.

2.37 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 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. 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.

2.38 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.

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 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.

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 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

28 Bacon means the compound microscope, developed in the Netherlands in the early seventeenth century.

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 itself, 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.

2.40 Among the *prerogative instances* we will put in seventeenth place *Summoning Instances,* taking the word from the law courts,

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.

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 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 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.

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 given 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 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

30 Bacon writes “water” here, though the vial holds spirit of wine.

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. 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, 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.

2.41 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 forward. Something similar must be done with nature. 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. 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.

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.

2.42 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 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*.

2.43 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 is roused and awakened to proper attention, observation, and inquiry. 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; 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.

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.

2.44 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.

2.45 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 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 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 measures 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 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.

2.46 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 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 itself, 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,

31 Galileo set out this tidal theory in a treatise of 1616 and developed it in his *Dialogue* (1632).

which does the 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.

2.47 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 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.

2.48 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. 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*. There is no point in giving examples of this motion, for it is present in every body.

2. Let the Second Motion be what we call the Motion of *Connection*, by which bodies do not allow themselves to be separ-

ated 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 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 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. 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 (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

32 Gilbert coined the Latin term *electricus* in *De Magnete* (1600).

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 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 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, 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. 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.

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.

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. 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 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 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. 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

33 Paracelsus (1493–1541), Swiss physician and alchemist; his *Archeus* was an inner vital principle directing the processes of each body.
34 So Bacon counts; in his list this is in fact the eleventh motion.

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 its parts and a conforming motion, while losing nothing of its own power. 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. 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. 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] 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

35 In myth Saturn (Cronus) swallowed his children as soon as they were born; Jupiter's offspring survived.

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 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* exer-

cised 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* 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]

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

36 Bacon has in mind ancient Pythagoreans such as Philolaus and, among the moderns, Copernicus and William Gilbert.

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 perhaps 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.

37 In astronomy "trepidation" was a supposed slow back-and-forth oscillation of the equinoxes, assumed in medieval theory.

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.

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 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.

2.49 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.

2.50 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 described 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

38 "Polychrest" is from Greek *polychrēstos*, "useful for many things," a term used by apothecaries.

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 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 under-

39 Lute was a clay or paste used by chemists to seal vessels airtight.

water 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 paper 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

40 Probably the submarine of the Dutch inventor Cornelis Drebbel, demonstrated on the Thames around 1620.

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 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

41 Described at 2.45, where water sealed in a hollow lead sphere was hammered and pressed until it sweated through the metal.

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 packing 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 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 sublimated 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 crudely incorporated and mixed. But above all, the structures of com-

42 *Ros solis*, "dew of the sun," is the sundew, whose leaves bear glistening sticky drops.

pound bodies and their subtler configurations are destroyed and confounded.[43] 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] 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.

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

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.

times. For such 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.

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 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

45 The Paracelsian chemists held that all bodies are composed of three principles: salt, sulfur and mercury.

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 which small animals are generated should also be noted.[46]

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.

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. 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,

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.

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 experiments in agriculture, navigation and medicine, or elsewhere. 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. 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. 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.

2.51 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 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.

2.52 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 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 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

47 Bacon listed these further topics in 2.21, but the *New Organon* ends here; he never wrote them.

not by disputations or idle magical ceremonies—to provide man with bread, that is, to serve the uses of human life.[48]

48 Genesis 3:19, God's sentence on Adam after the Fall.