The New Organon: or True Directions Concerning the Interpretation of Nature

Francis Bacon

Copyright © Jonathan Bennett 2017. All rights reserved

[Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. Every four-point ellipsis . . . . indicates the omission of a brief passage that seems to present more difficulty than it is worth. Longer omissions are reported between brackets in normal-sized type.—'Organon' is the conventional title for the collection of logical works by Aristotle, a body of doctrine that Bacon aimed to replace. His title *Novum Organum* could mean 'The New Organon' or more modestly 'A New Organon'; the tone of the writing in this work points to the definite article.

First launched: January 2005

Contents

APHORISMS CONCERNING THE INTERPRETATION OF NATURE: BOOK 2: 1–25

1. What **human power** does and is intended for is this:

> For a given body, to create and give to it a new nature (or new natures)—·e.g. melting gold or cooking chicken or dissolving salt in water·.

What **human knowledge** does and is intended for is this:

> For a given nature, to discover its form, or true specific differentia. . . .

·i.e. the features that a thing *must* have if it is to qualify as belonging to this or that natural kind, e.g. the features of *gold* that differentiate it from *metal* in general·. [Bacon adds two even more obscure technical terms, semi-apologising for them; they don't occur again in this work. Then:] Subordinate to these primary works are two secondary and less important ones. Under the 'power' heading: turning concrete bodies into something different, so far as this is possible—·e.g. turning lead into gold, if this can be done·. Under the 'knowledge' heading:

(1) in every case of generation and motion, discovering the *hidden* process through which the end-state form results from the *manifest* efficient ·cause· and the *manifest* material; and

(ii) discovering the hidden microstructure of bodies that are not changing.

·An example of **(i)**: the wax around the wick of a lighted candle melts. Flame is the efficient cause, wax is the material, and meltedness is the end-state form. But 'flame' and 'wax' stand for items that are *manifest*, obvious, out there on the surface; we know that when you apply one to the other you get melting; but that isn't knowing what *hidden* process is involved—what is *really basically going on* at the sub-microscopic level when flame melts wax·.

·An example of **(ii)**: discovering what the sub-microscopic structure is of wax when it isn't melting·.

2. Human knowledge is in a poor state these days—*how* poor can be seen from things that are commonly said. ·Not that they are *all* wrong·.

> True knowledge is knowledge by causes.
>
> Causes are of four kinds: material, formal, efficient, and final.

[A coin's •material cause is the metal, its •formal cause is the property of being round-with-a-head-inscribed-on-it etc., its immediate •efficient cause is the stamping of a die on the metal, and its •final cause is its purpose, use in commerce.] So far, so good; but ·the concept of· *final cause* spoils the sciences rather than furthering them, except in contexts involving human action. The discovery of formal causes is despaired of. Efficient and material causes ·are real and solid and important, but they· are investigated and believed in ·only as they appear on things' surfaces·, without reference to the hidden process through which the end-state form comes about; and, taken in *that* way, they are slight and superficial, and contribute little or nothing to true and active science. Earlier in this work [1**51**] I noted as an error of the human mind the opinion that to understand what exists you have to look at forms. It's true that nature really contains only

> individual bodies, performing individual pure actions [see note on page 11] according to a fixed law;

but in science this *law* is what we inquire into, discover, and explain; it is at the root of our theorizing as well as of our practical applications. When I speak ·approvingly· of 'forms', what I'm talking about is this law. . . .; I use the word 'form' because it has become familiar.

3. If someone knows the cause of a nature such as whiteness or heat in *only some* subjects, his •knowledge is incomplete; and if he can produce a certain effect in *only some* of the substances that are capable of it, his •power is incomplete. Now efficient and material causes

- •are unstable causes, ·i.e. they can't be depended on to act in the same way in all cases·;
- •they are nothing but *vehicles* ·in which the operative hidden structures and causes are carried·;
- •they are causes that convey the ·end-state· form in *only some* cases.

If a man's knowledge is confined to *them*, he may arrive at new discoveries ·that hold generally about· some pre-selected class of fairly similar substances; but he doesn't get to the fixed, deeper boundaries of things—·'fixed' in contrast to the 'unstable' nature of manifest causes·. But someone who knows *forms* gets hold of the unity of nature in things that are ·superficially· most unalike, and this enables him to discover and bring to light really new things—things that no-one would ever have thought of, and that would never have come to light in the course of nature, or through deliberate experiments, or even by accident. So the discovery of forms leads to truth in theory-building and freedom in operation.

4. The roads to human power and to human knowledge lie extremely close together and are nearly the same. Still, because of the bad old habit of thinking in terms of abstractions, it is safer to get the sciences started and to carry them on from foundations that have to do with their *practical* part, and to let the practical part itself be a stamp of authenticity and also a limit-setter for the purely theoretical part. Well, then, let's think about a man who wants to confer some nature on a given body; he wants, for instance, to give a piece of silver the yellow colour that gold has or to make it heavier (subject to the laws of matter), or he wants to make an opaque stone transparent, or to make glass sticky, or to get something that isn't a plant to grow. Our question should be: what kind of rule or direction or guidance should he most wish for? And we should answer this in the simplest and plainest terms ·that we can find·. **(1)** He will undoubtedly want to be shown something that won't let him down or fail when it is put to the test. **(2)** He will want a rule that won't tie him down to this or that particular means and mode of operation. Otherwise he may be stuck: he doesn't have the prescribed means, others are available and would do the job, but the rule he is to follow doesn't allow them. **(3)** He will want to be shown a procedure that isn't as difficult as the thing he wants to do—·e.g. he won't want to be told 'To make that silver yellow like gold, you must make it yellow like gold'·; he'll want something more practicable than that.

A true and complete rule of operation, then, will have to be a proposition that is **(1)** certain, **(2)** not constricting and **(3)** practicable. And the same holds for the discovery of a true form. For the form of a nature is such that:

> given the form, the nature is sure to follow; so that the form is absent whenever the nature is absent. . . .

and is also such that

> if the form is taken away, the nature is sure to vanish; so that the form is present whenever the nature is present. . . .

[Bacon ties each 'so that. . . ' clause to the wrong proposition—a mere slip, here corrected, rather than a logical error.] Lastly,

> the true form derives the given nature from some essence that many other also things have and that is (as they say) *better known to nature* than the form ·we are discussing·.

[For 'better known by nature' see note in [1]**22**]. Here, then, is the procedure that I urge you to follow to get a true and perfect axiom of knowledge concerning a nature N_1: discover some other nature N_2 that is •convertible with N_1 and is •a special case of some more general nature N_3, falling under it as ·a true species falls· under a true and real genus. Now these two directions, the active ·rule of operation· and the contemplative ·rule of discovery·, are one and the same thing; what is most useful in operation is what is most true in knowledge.

5. There are two kinds of rule or axiom for the transformation of bodies. The first regards a body as a company or collection of simple natures. In gold, for example, the following properties meet:

•it is yellow in colour,
•it is heavy up to a certain weight,
•it is malleable and ductile up to a certain length,
•it doesn't vaporize or lose any of its substance through the action of fire,
•it turns into a liquid with a certain degree of fluidity;
•it is separated and dissolved by such-and-such means;

and so on for the other natures that come together in gold. This ·first· kind of axiom derives the thing from the forms of its simple natures. Someone who knows •the forms of yellowness, weight, ductility, fixity, fluidity, dissolving and so on, and •the methods for giving them to bodies, and •their intensities and varieties, will work to have them come together in some body which will thereby be transformed into gold. This kind of operation pertains to the primary kind of action; ·the fact that it involves many natures doesn't mean that it is a later, non-basic kind of event·. For the principle of generating many simple natures is the same as that of generating just one; except that the investigator is more tightly constrained if more than one nature is involved, because of the difficulty of bringing together so many natures that don't easily combine except in the well-trodden ordinary paths of nature. Anyway, ·despite that drawback· it must be said that this mode of operation that looks to simple natures in a compound body starts from what in nature is constant and eternal and universal, ·namely *natures*·, and opens broad roads to human power—ones that in the present state of things human thought can scarcely take in.

The second kind of axiom depends on the discovery of hidden processes. It doesn't start off from simple natures, but from compound bodies just as they are found in the ordinary course of nature. For example, one might be inquiring into the origins of gold or some other metal or stone—How does it start forming? What process takes it from its basic rudiments or elements right through to the completed mineral? Or, similarly, the question of how plants are generated—What process takes the plant from the first congealing of sap in the ground, or from seeds, right through to the formed plant. . . .? Similarly ·we might inquire into· the process of development in the generation of animals from the beginning right through to birth; and similarly with other bodies.

This investigation concerns not only the •generation of bodies but also other motions and operations of nature. For example, we can inquire into •nutrition, the whole continuous series of events leading from the swallowing of the food through to its complete assimilation. Or into •voluntary motion in animals, from the first impression on the imagination and the continuous efforts of the spirits through to the flexing and moving of limbs. Or into •what is involved in the motion of the tongue and lips and other organs right through to the uttering of articulate sounds. Each of these inquiries relates to natures that have been concretized, i.e. brought together into a single structure; they concern what may be called particular and special practices of nature, not its basic and universal laws that constitute *forms*. ·That drawback of this approach is balanced by an advantage that it has over the other·. It has to be admitted that this second approach seems to have less baggage and to lie nearer at hand and to give more ground for hope than the first approach, ·i.e. the one described first in this aphorism·.

The practical-experimental approach corresponding to this ·second· theoretical approach starts from ordinary familiar natural events and moves on from them to ones that are very like them or at least not too unlike. But ·the merits of the first approach mustn't be forgotten·. Any deep and radical operations on nature depend entirely on the primary axioms, ·which are the business of the first approach·. And then there are the matters where we have no power to *operate* but only to *know*, for example the heavenly bodies (for we can't operate on them, alter them, or turn them into something else). With *these* things, whether we are investigating the facts about what happens in the heavens or trying to understand why it happens, we have to depend on the primary and universal axioms concerning simple natures, such as the nature of spontaneous rotation, of attraction or magnetism, and of many others that apply to more things than just to the heavenly bodies. 'Does the earth rotate daily, or do the heavens revolve around it?' Don't think you have a hope of answering this before you have understood the nature of spontaneous rotation.

6. The hidden process of which I speak is utterly different from anything that would occur to men in the present state of the human mind. For what I understand by it is not

> the different stages—different •*steps*—that bodies can be •seen to go through in their development,

but rather

> a perfectly •continuous process which mostly •escapes the senses.

For instance: in all generation and transformation of bodies, we must inquire into

- •what is lost and escapes, what remains, what is added;
- •what is expanded, what is contracted;
- •what is united, what is separated;
- •what is continued, what is cut off;
- •what pushes, what blocks;
- •what predominates, what gives way;

and a variety of other particulars. And it's not just with the generation or transformation of bodies, but with all other alterations and motions we should inquire into

- •what goes before, what comes after;
- •what is quicker, what is slower;
- •what produces motion, what ·merely· guides it;

and so on. In the present state of the sciences (in which stupidity is interwoven with clumsiness) no-one knows or does anything about any of these matters. For seeing that every natural action takes place

Latin: *per minima*
possibly meaning: by means of the smallest particles
or it might mean: by smallest steps, i.e. continuously

or at least by ones that are too small to strike the senses, no-one can hope to govern or change nature unless he understands and observes such action in the right way.

7. Similarly, the investigation and discovery of the hidden •microstructure in bodies is something new, as new as the discovery of the hidden •process and of the •form. At this time we are merely lingering in nature's outer courts, and we aren't preparing a way into its inner chambers. Yet no-one can give a body a new nature, or successfully and appropriately turn it into a new ·kind of· body without first getting a competent knowledge of the body so to be altered or transformed. Without that, he will run into methods that are worthless or at best cumbersome and wrongly ordered and unsuitable to the nature of the body he is working on. So that is clearly another road that must be opened up and fortified.

It's true that some good useful work has been done on the anatomy of organized bodies such as men and animals; it seems to have been done subtly and to have been a good search of nature. [The phrase 'organized bodies' refers to *organisms*; but the adjective 'organized' emphasizes the idea of a body with different parts *of different kinds*, unlike such seemingly homogeneous bodies as lumps of lead.] But this kind of anatomizing lies within the visible range and is subject to the senses; also, it applies only to organized bodies. And it's obvious and easy compared with the true anatomizing of the hidden microstructure in bodies that are thought to be the same all through, ·i.e. homogeneous·; especially in things (and their parts) that have a specific character, such as iron and stone; and homogeneous parts of plants and animals, such as the root, the leaf, the flower, flesh, blood, bones and so on. But there has been *some* human industry even on this kind of thing; because this is just what men are aiming at when they break up homogeneous bodies by means of distillation and other kinds of analysis so as to reveal how the complex structure ·of the *seemingly* homogeneous compound· comes from combination of its various homogeneous parts. This is useful too, and is the kind of thing I am recommending; but in practice it often gives the wrong answer, because the procedures that are used—fire, heat, and so on—sometimes *create* new natures, which the scientist thinks existed in the compound before and were merely brought into the open by the separation procedure. Anyway, this is only a small part of the work of discovering the true microstructure of the compound body—a structure that is far more subtle and detailed ·than these processes could discover·. The operation of fire doesn't reveal and clarify this structure—it scrambles it.

So the way to separate and analyse bodies is not by fire but by reasoning and true induction, with experiments in a helping role; and by comparison with other bodies, and reduction to simple natures and their forms which meet and mix in the compound. In short, we must pass from Vulcan to Minerva—·from physical activities to intelligent mental ones·—if we want to bring to light the true •textures and •microstructures of bodies. It is on •these that depend all the hidden properties and powers of things, and all their so-called *specific* properties and powers. They are also the source of every effective alteration and transformation. For example, we must inquire what each body contains in the way of •spirit, and what of •tangible stuff; and regarding the spirit we should inquire into whether it is

- •plentiful (making the body swollen) or meagre and scarce;
- •fine or coarse,
- •more like air than like fire, or vice versa,
- •vigorous or sluggish,
- •weak or strong,
- •increasing or decreasing,
- •broken up or continuous,
- •agreeing or disagreeing with objects in the external environment,

and so on. Similarly, we must inquire into the tangible stuff (which is just as variable as spirit)—into its hairs, its fibres, its kinds of texture. Other things that fall within the scope of this inquiry are: •how the spirit is distributed through the bodily mass, with its pores, passages, veins and cells; and •the rudiments or first attempts at organic body [on this see page 95]. In these inquiries, and thus in all discoveries relating to hidden microstructure, the primary axioms cast a true and clear light which entirely dispels darkness and subtlety.

8. ·Three fears that you might have can be allayed·. **(1)** This won't lead us to the doctrine of *atoms*, which presupposes •that there is a vacuum and •that matter doesn't change—which are both false. All we shall be led to are *real particles*—which ·are not merely hypothesized but· have been discovered. **(2)** Don't be afraid that all this will be so subtle—·so complex and fine-grained in its detail·—that it will become unintelligible. On the contrary, the nearer our inquiry gets to simple natures the more straightforward and transparent everything will become. The whole affair will be a matter of getting

from the complicated to the simple,
from the incommensurable to the commensurable,
from the random to the calculable,
from the infinite and vague to the finite and certain,

like the case of the letters of the alphabet and the notes of music. Inquiries into nature have the best result when they begin with physics and end in mathematics. **(3)** Don't be afraid of large numbers or tiny fractions. In dealing with numbers it is as easy to write or think *a thousand* or *a thousandth* as to write or think *one*.

9. From the two kinds of axioms that I have spoken of [**5**] arises a sound division of philosophy and the sciences. The investigation of forms, which are. . . .eternal and immutable, constitutes **Metaphysics**; the investigation of efficient causes, of matter, of hidden processes and of hidden microstructures—all of which concern the common and ordinary course of nature, not its eternal and fundamental laws—constitutes **Physics**. Each of these has a subordinate *practical* branch: physics has **mechanics**; and metaphysics has what in a cleaned-up sense of the word I call **magic**, on account of its sweeping ways and its greater command over nature. 'Metaphysics' etc. are the most accurate labels for these categories, but I am understanding them in senses that agree with my views.

10. Having looked at *doctrines*, we must go on to *precepts*, dealing with them in the most direct way and not getting things the wrong way around. Guides for the interpretation of nature are of two fundamental kinds: **(1)** how to draw or fetch up axioms from experience; **(2)** how to get from axioms to new experiments. Precepts of kind **(1)** divide into three kinds of service: (i) catering to the senses, (ii) catering to the memory, and (iii) catering to the mind or reason. (i) First of all we must prepare an adequate and sound natural and experimental history, this being the basis for everything, for we are not to •imagine or •suppose but to •discover what nature makes or does. [Bacon doesn't return to (ii) memory.] (iii) But natural and experimental history is so various and diffuse that it confuses and scatters the intellect unless it is kept short and set out in a suitable order. So we must create tables and arrangements of instances that are done in such a way that the intellect can act on them. And even when this is done, the unaided and unguided intellect hasn't the competence to form axioms. Therefore in the third place we must use induction, true and legitimate induction, which is the very key of interpretation. But I must deal first with this ·induction·, though it comes last, and then I shall go back to the others. [In fact, all the rest of the work has to do with what Bacon calls 'induction'.]

11. The investigation of forms proceeds in this way: For a given nature, we must first turn our minds to all known instances that agree in having this nature (they'll differ greatly in other ways). This collection is to be made in the manner of a ·natural· history, with no rush to theorize about it and with no great amount of subtlety. If for example we are to investigate the form of heat, we need a **table of instances of heat**. This is my **First Table**:

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

2. The sun's rays reflected and condensed. . . .especially in burning glasses and mirrors.

3. Fiery meteors.

4. Lightning.

5. Eruptions of flame from the cavities of mountains.

6. All flame.

7. Burning solids.

8. Natural warm baths.

9. Hot or boiling liquids.

10. Hot vapours and fumes, and even air that becomes furiously hot if it is confined, as in reverbatory furnaces.

11. Weather that is clear and bright just because of the constitution of the air, without reference to the time of year.

12. Air that is confined and underground in some caverns, especially in winter.

13. All shaggy substances—wool, skins of animals, down of birds—have some warmth.

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

15. Sparks from flint and steel that are struck hard.

16. All bodies—stone, wood, cloth, etc.—when rubbed strongly (axles of wheels sometimes catch fire; and rubbing was how they kindled fire in the West Indies).

17. Green and moist plants jammed together, as roses or peas in baskets (hay in a damp haystack often catches fire).

18. Quicklime sprinkled with water.

19. Iron when first dissolved in *aqua fortis* [= nitric acid] in a test tube without being put near a fire (the same with tin, though not with the same intensity).

20. Animals, especially their insides (and *always* their insides), though we don't feel the heat in insects because they are so small.

21. Freshly dropped horse dung and other animal excrements.

22. Strong oil of sulphur and of vitriol has the effect of heat when it scorches linen.

23. Oil of marjoram and similar oils have the effect of heat in burning the bones of the teeth.

24. Strong alcohol acts as though it were hot: it makes egg-white congeal and turn white, as though it were cooked; it makes bread crusty, like toast.

25. Aromatic and hot herbs. . . .although not warm to the hand. . . .feel hot to the palate when they are chewed.

26. When strong vinegar or any acid is applied to parts of the body that don't have skin—the eye, the tongue, or on any part that has been damaged and lost some skin—it produces a pain like the pain heat produces.

27. Even keen and intense cold produces a kind of sensation of burning. . . .

28. Other instances.

I call this the Table of **Essence and Presence**.

12. Secondly, we must turn our minds to instances where the given nature is lacking, because—as I said above—the form should not only be present when the given nature is present but also be absent when the nature is absent. But a list of these would be endless! So the negatives should be linked with the affirmatives: we shall look into the absence of the given nature only in things that are most like ones where the nature is present and apparent. I call this, which is my **Second Table**, the Table of **Divergence** or of **Nearby Absence**. These are instances where the nature of heat is absent but which are in other ways close to ones where it is present. [Each tag of the form **#n** means that the topic is negative instances that are nearby to positive instance n.]

1. (**#1**) The rays of the moon and of stars and comets are not found to be hot to the touch; indeed the severest colds are experienced at the full moons. The larger fixed stars, however, when passed or approached by the sun, are thought to increase and intensify the heat of the sun. . . .

2. (**#2**) The rays of the sun in the so-called 'middle region' of the air don't give heat. (The usual explanation for this is pretty good: namely, that region is far enough away from the body of the sun that gives off the rays and from the earth that reflects them.) And this appears from the fact that on mountain-tops there is perpetual snow, unless they are very high: it has been observed that on the Peak of Tenerife and among the Andes of Peru the summits of the mountains are free from snow though there is snow a little way below the summits. Actually, the air at the very top is not found to be at all cold, but only thin and sharp—so much so that in the Andes it pricks and hurts the eyes by its excessive sharpness and also irritates the entrance to the stomach, producing vomiting. The ancients observed that on the summit of Olympus the air was so thin that those who climbed it had to carry sponges with them dipped in vinegar and water, and to apply them from time to time to the mouth and nose, because the air was too thin to support respiration. They also reported that on this summit the air was so serene, and so free from rain and snow and wind, that words written by the finger in the ashes of a sacrifice were still there, undisturbed, a year later. . . .

3. (**#2**) The reflection of the sun's rays in regions near the polar circles is found to be very weak and ineffective in producing heat: the Dutch who wintered in Nova Zembla and expected their ship to be freed by the beginning of July from the mass of ice that hemmed it in were disappointed in their hopes and forced to take to their row-boats. It seems, then, that the direct rays don't have much power, even down at sea level; and don't reflect much either, except when they are many of them combined. That is what happens when the sun moves high in the sky, for then the incident rays meet the earth at acuter angles, so that the lines of the rays are nearer each other; whereas when the sun ·is lower in the sky and so· shines very obliquely, the angles are very obtuse which means that the lines of rays are further from one another. Meanwhile, bear in mind that the sun may do many things, *including ones that involve the nature of heat*, that don't register on our sense of touch—things that *we* won't experience as detectable warmth but that have the effect of heat on some other bodies.

4. (**#2**) Try the following experiment. Take a glass made in the opposite manner to an ordinary burning glass, let the sun shine through it onto your hand, and observe whether it •lessens the heat of the sun as a burning glass •increases and intensifies it. It's quite clear what happens with *optical* rays ·shone through a glass·: according as the middle of the glass is thicker or thinner than the sides, the objects seen through it appear more spread or more contracted. Well, see whether the same holds for *heat*.

5. (**#2**) Try to find out whether by means of the strongest and best built burning glasses the rays of the *moon* can be caught and collected in such a way as to produce *some* warmth, however little. In case the warmth produced is too weak to be detected by the sense of touch, use one of those glasses that indicate the state of the atmosphere in respect to heat and cold: let the moon's rays fall through the ·extra-powerful· burning glass onto the top of a glass of

this kind, and then see whether the water sinks because of warmth. [The 'glasses' in question are thermometers; see item 38 on page 63 for Bacon's instructions on how to make and use one.]

6. (**#2**) Try a burning glass with a source of heat that doesn't emit rays or light—such as iron or stone that has been heated but not ignited, or boiling water, or the like. Observe whether the burning glass produces an increase of the heat as it does with the sun's rays.

7. (**#2**) Try a burning glass also with ordinary flame.

8. (**#3**) Comets (if we are to count these as meteors) aren't found to exert a constant and detectable effect in increasing the heat of the season, though they have been seen often to be followed by droughts. Moreover bright beams and pillars and openings in the heavens appear oftener in winter than in summertime, especially during the intensest cold but always accompanied by dry weather. (**#4**) Lightning-flashes and thunderclaps seldom occur in the winter, but rather at times of great heat. So-called 'falling stars' are commonly thought to consist of some thick and highly incandescent liquid rather than to be of any strong fiery nature. But this should be further looked into.

9. (**#4**) Certain flashes give light but don't burn; and these always come without thunder.

10. (**#5**) Discharges and eruptions of flame occur just as frequently in cold as in warm countries, e.g. in Iceland and Greenland. In cold countries, too, many of the trees—e.g. fir, pine and others—are more inflammable, more full of pitch and resin, than the trees in warm countries. This is an affirmative instance ·of heat·; I can't associate it with a ·nearby· negative instance because not enough careful work has been done on the locations and soil-conditions in which eruptions of this kind usually occur.

11. (**#6**) *All* flame, always, is more or less warm; there are no ·nearby· negative instances to be cited here. [Bacon then cites seven kinds of situation in which there are something like flames but little if any detected heat. He says, for example, that a sweaty horse when seen at night is faintly luminous. Then:]

12. (**#7**) *Every* body that is subjected to heat that turns it to a fiery red is itself hot, even if there are no flames; there are no ·nearby· negative instances to go with this affirmative. . . .

13. (**#8**) Not enough work has been done on the locations and soil-conditions in which warm baths usually arise; so no ·nearby· negative instance is cited.

14. (**#9**) To boiling liquids I attach the negative instance of *liquid in its own nature*. We don't find any tangible liquid that is warm in its own nature and remains so constantly; the warmth always comes from something outside the liquid and is possessed by the liquid only temporarily. The water in natural warm baths ·is not inherently warm; when it· is taken from its spring and put into a container, it cools down just like water that has been heated on a fire. The liquids whose power and way of acting makes them the hottest and that eventually *burn*—e.g. alcohol, chemical oil of spices, oil of vitriol and of sulphur, and the like—are at first cold to the touch; though oily substances are less cold to the touch than watery ones, oil being less cold than water, as silk ·is less cold· than linen. But this belongs to the Table of Degrees of Cold.

15. (**#10**) Similarly, to hot vapour I attach the negative instance of the nature of vapour itself as we experience it. For although the vapours given off by oily substances are easily flammable, they aren't found to be warm unless they have only recently been given off by a body that is warm.

16. (**#10**) Similarly, to hot air I attach the negative instance of the nature of air itself. For in our regions we don't find any air that is warm, unless it has either been confined or subjected to friction or obviously warmed by the

sun, fire, or some other warm substance.

17. (**#11**) I here attach the negative instance of weather that is *colder* than is suitable for the season of the year, which in our regions occurs during east and north winds; just as we have weather of the opposite kind with the south and west winds. . . .

18. (**#12**) Here I attach the negative instance of air confined in caverns *during the summer*. But *air in confinement* is something that needs to be looked into more carefully ·than has so far been done·. For one thing, it isn't certain what is the nature of air in itself in relation to heat and cold. It's clear that air gets warmth from the influence of the heavenly bodies, and cold perhaps from the exhalations of the earth and in the so-called 'middle region' of air from cold vapours and snow. So that we can't form an opinion about the nature of air by examining the open air that is all around us; but we might do better by examining it when confined. But the air will have to be confined in something that won't communicate warmth or cold to the air from itself, and won't easily let the outer atmosphere affect the confined air. So do an experiment using an earthenware jar wrapped in many layers of leather to protect it from the outer air; let the vessel remain tightly closed for three or four days; then open it and test the level of heat or cold either by touch or by a thermometer.

19. (**#13**) There's also a question as to whether the warmth in wool, skins, feathers and the like comes from •a faint degree of heat that they have because they came from animals, or from •some kind of fat or oil that has a nature like warmth; or simply (as I suggested in the preceding paragraph) from •the air's being confined and segregated. For all air that is cut off from the outer air seems to have some warmth. So: try an experiment with fibres made of linen, not of such animal products as wool, feathers or silk. It is also worth noting that when something is ground to a powder, the powder (which obviously has air enclosed in it) is less cold than the intact substance from which it was made; and in the same way I think that all froth (which contains air) is less cold than the liquid it comes from.

20. (**#14**) I don't attach any negative to this because everything around us, whether solid or gaseous, gets warm when put near fire. They differ in this way, though: some substances (such as air, oil and water) warm up more quickly than others (such as stone and metal). But this belongs to the Table of Degrees.

21. (**#15**) I don't attach any negative to this either, except that it should be noted that •sparks are produced from flint and iron and the like only when tiny particles are struck off from the substance of the stone or metal; that •you can't get sparks by whirling something through the air, as is commonly supposed; and that •the sparks themselves, owing to the weight of the body from which they are struck, tend downwards rather than upwards, and when they are extinguished they become a tangible sooty substance.

22. (**#16**) I don't think there is any negative to attach to this instance. For every solid body in our environment clearly becomes warmer when it is rubbed; so that the ancients thought (dreamed!) that the heavenly bodies' only way of gaining heat was by their rubbing against the air as they spun. On this subject we must look into whether bodies discharged from ·military· engines, such as cannon-balls, don't acquire some heat just from the blast, so as to be found somewhat warm when they fall. But moving air chills rather than warms, as appears from wind, bellows, and blowing with the lips close together. It isn't surprising that this sort of motion doesn't generate heat: it isn't rapid enough, and it involves a mass moving ·all together· rather than particles ·moving in relation to one another·.

23. (**#17**) This should be looked into more thoroughly. It seems that green and moist grass and plants have some heat hidden in them, but it is so slight that it isn't detectable by touch in any individual ·carrot or cabbage·. But then a lot of them are collected and shut up together, their gases aren't sent out into the atmosphere but can interact with one another, producing palpable heat and sometimes flame.

24. (**#18**) This too needs to looked into more thoroughly. For quicklime sprinkled with water seems to become hot either •by the concentration of heat that was previously scattered (as in the (23) case of confined plants) or •because the fiery gas is excited and roughed up by the water so that a struggle and conflict is stirred up between them. Which of these two is the real cause will appear more readily if oil is poured on ·the quicklime· instead of water; for oil will concentrate the enclosed gases just as well as water does, but it won't irritate it in the same way. We should also broaden the experiment •by employing the ashes and cinders of bodies other than quicklime, and dousing them with liquids other than water.

25. (**#19**) The negative that I attach to this instance is: other metals, ones that are softer and more fusible. When gold leaf is dissolved in *aqua regia* it gives no heat to the touch; nor does lead dissolved in nitric acid; nor again does *mercury* (as I remember), though *silver* does, and copper too (as I remember); tin still more obviously; and most of all iron and steel, which not only arouse a strong heat when they dissolve but also a vigorous bubbling. So it seems that the heat is produced by conflict: the *aqua fortis* penetrates the substance, digging into it and tearing it apart, and the substance resists. With substances that yield more easily hardly any heat is aroused.

26. (**#20**) I have no negative instances to attach to the heat of animals, except for insects (as I have remarked) because of their small size. Fish are found to have *less* heat than land animals do, but not a complete absence of heat. Plants have no heat that can be felt by touch, either in their sap or in their pith when freshly opened up. The heat in an animal varies from one part of it to another (there are different degrees of heat around the heart, in the brain, and on the skin) and also from one event to another—e.g. ·the animal's heat increases· when it engages in strenuous movements or has a fever.

27. (**#21**) It's hard to attach a negative to this instance. Indeed animal dung obviously has potential heat ·even· when no longer fresh; this can be seen from how it enriches the soil.

28. (**#22** and **#23**) Liquids, whether waters or oils, that are intensely caustic act as though they were hot when they break into bodies and, after a while, burn them; but they don't feel hot at first. But how they operate depends on what they are operating on. . . . Thus, *aqua regia* dissolves gold but not silver; nitric acid dissolves silver but not gold; neither dissolves glass, and so on with others.

29. (**#24**) Try alcohol on wood, and also on butter, wax and pitch; and observe whether it has enough heat to melt any of them. For **24** shows it exhibiting a power that resembles heat in making bread crusty. Also, find out what it can do in the way of liquefying substances. Experiment with a thermometer or calendar glass, hollow at the top; pour some well-distilled alcohol into the hollow; cover it so that the spirit keeps its heat better; and observe whether by its heat it makes the water go down. [A 'calendar glass' is a thermometer. See item 38 on page 63].

30. (**#25**) Spices and sharp-tasting herbs are hot to the palate and much hotter to the stomach. So we should see on what other substances they act as though they were hot. (Sailors report that when large quantities of spices are kept

shut up tightly for a long time and then suddenly opened, those who first disturb and take them out are at risk of fever and inflammation.) Something else that can be tested: whether such spices and herbs in a powdered form will dry bacon and meat hung over them, as smoke does.

31. (**#26**) Cold things such as vinegar and oil of vitriol are corrosive and penetrating, just as are hot things such as oil of marjoram and the like. Both alike cause pain in living things, and tear apart and consume things that are inanimate. There is no negative to attach to this ·positive· instance. A further point: whenever an animal feels pain it has a certain sensation of heat. [A warning about 'inanimate': it translates *non animatus*, which strictly means 'not breathing', and Bacon often uses it to cover plants as well as things that are 'inanimate' in our sense. This version will stay with 'inanimate' except in one place where 'non-animal' is required.]

32. (**#27**) In many contexts heat and cold have the same effect, though for different reasons. Boys find that after a while snow seems to burn their hands; cold preserves meat from going rotten just as fire does; and heat makes bodies shrink, which cold does also. But these and similar instances are better dealt with in the investigation of cold.

13. ·We have dealt with firstly (**11**) a Table of Essence and Presence, secondly (**12**) a Table of Divergence or of Nearby Absence. Now·, thirdly, we must turn our minds to instances in which the nature being investigated is found in different degrees, greater or lesser; either by comparing the amounts of it that a single thing has at different times or by comparing the amounts of it that different things have. The •form of a thing is the very •thing itself; the only difference between

the thing and the form

is just that between

the apparent and the real,

the external and the internal, or

the thing in reference to man and the thing in reference to the universe.

From this is rigorously follows that no •nature should be accepted as the true •form unless it—·i.e. the thing whose nature is in question·—always decreases when the nature decreases, and increases when the nature increases. So I call this—my **Third Table**—the Table of **Degrees** or the Table of **Comparison**.

Here is my Table of **Degrees** or of **Comparison,** in relation to **Heat**. I start with substances that contain no degree of heat that can be felt by touch but seem to have a certain potential heat—a disposition and readiness to be hot. Then I shall move on to substances that are actually hot—hot to the touch—and to their intensities and degrees.

1. We don't encounter any solid, tangible things that just *are hot* in their own natures. No stone, metal, sulphur, fossil, wood, water or animal carcass is found to be hot. The water in ·naturally· hot baths seems to be heated by external causes—either by flames or subterraneous hot material such as is thrown up from Etna and many other mountains, or by bodies colliding as when iron or tin is ground to powder and heat is caused. Thus, there is no heat detectable by touch in non-living substances; though they differ in how cold they are—wood isn't as cold as metal. But that belongs to the Table of Degrees of Coldness.

2. However, many inanimate substances—such as sulphur, naphtha and oil extracted from rocks—have a lot of potential heat and are strongly disposed to burst into flame.

3. ·Some· substances that have been hot continue to have some of their former heat lurking in them. Examples of this are horse dung retaining the heat of the horse, also lime (and perhaps also ashes and soot) retaining the heat of the fire. . . .

4. As for the vegetable kingdom: no plant or part of a plant (such as sap or pith) is warm to the human touch. But as I have already remarked, green plants become warm when they are shut up; and some plants are warm and others cold, this being detectable by the *internal touch* ·as I call it· of the palate or stomach, and even to touch by external parts of the body ·such as the hands·. It takes a little time for this to develop; we see it at work in poultices and ointments.

5. We don't find anything warm to the touch in the parts of animals that have died, or in parts that they have excreted. Not even horse dung retains its heat unless it is enclosed and buried. Yet all dung seems to have potential heat, as is seen in how it enriches the fields. Similarly, the carcasses of animals have some such hidden potential heat. A result of this is that in cemeteries where burials take place daily the earth collects a certain hidden heat which consumes a newly buried body much faster than pure earth would. . . .

6. Substances that enrich the soil, such as dung of all kinds, chalk, sea sand, salt and the like, have some disposition to become hot.

7. When anything rots, there are the beginnings of slight heat, but not enough to be detectable by touch. Even the substances which when they putrefy break up into little animals (meat, cheese, etc.) don't feel warm to the touch; nor does rotten wood, which shines in the dark, feel warm to the touch. In rotting substances, though, heat sometimes announces itself by strong nasty smells.

8. The lowest degree of heat among things that feel warm to the touch seems to be the heat of animals, which varies over quite a wide range. At the bottom of the scale, as in insects, the heat is hardly perceptible to the touch; and the highest scarcely equals the heat the sun gives off in the hottest countries and seasons, and isn't too great to be tolerated by the hand. But it is said of Constantius, and of some others who had a very dry constitution and bodily condition, that in acute fevers they became so hot as to burn slightly any hand that touched them.

9. Animals increase in heat by motion and exercise, wine and eating, sex, burning fevers, and pain.

10. When attacked by intermittent fevers, animals are at first seized with cold and shivering, but soon after they become exceedingly hot; and in burning and pestilential fevers they are very hot right from the start.

11. We should investigate the different degrees of heat in different ·broad kinds of· animals, such as fish, quadrupeds, snakes, birds; and also according to their ·narrower· species, such as lion, vulture, man. ·This would be, among other things, a check on popular beliefs·. For fish are generally thought to be the coldest internally, and birds—especially doves, hawks and sparrows—to be very hot.

12. We should also investigate the different degrees of heat in the different parts of the same animal. For milk, blood, semen and ova are found to be only mildly warm—cooler than the outer flesh of the animal when it is moving or agitated—but no-one has yet investigated what the temperature is in the brain, stomach, heart, etc.

13. In winter and cold weather all animals are cold externally, but internally they are thought to be even warmer ·than at other times·.

14. Even in the hottest countries and at the hottest times of the year and day, the heavenly bodies don't give off enough heat to kindle a flame in the driest wood or straw or even cloth, except when the heat is increased by burning glasses. But it can raise steam from moist matter.

15. Astronomers have a traditional belief that some stars are hotter than others. Of the planets, Mars is regarded as the hottest after the sun; then comes Jupiter, and then Venus. The moon is said to be cold and Saturn the coldest of

all. Of fixed stars, Sirius is said to be the hottest, then Cor Leonis (or Regulus), then the Dog-star, and so on.

16. The sun gives off more heat the nearer it comes to the perpendicular [= 'to being straight overhead']; and this is probably true of the other planets also, within their own ranges of temperature. Jupiter, for instance, feels warmer when it is under Cancer or Leo than when it is under Capricorn or Aquarius.

17. The sun and the other planets can be expected to give more heat when they are closest to the earth than when they are furthest away. If it should happen that in some region the sun is at its closest and also near the perpendicular, it would have to give off more heat *there* than in a region where it is also at its closest but is shining more obliquely. So there should be a study of ·the heat-effects of· the planets in different regions according to how high or low in the sky they are.

18. The sun and other planets are thought to give more heat when nearer to the larger fixed stars. When the sun is in ·the constellation· Leo it is nearer to ·the stars· Cor Leonis, Cauda Leonis, Spica Virginis, Sirius and the Dog-star than when it is in ·the constellation· Cancer, though in the latter position it is nearer to the perpendicular ·and thus has one factor making for less heat and another making for more·. And we have to think that the parts of the sky that are furnished with the most stars, especially big ones, give off the greatest heat, though it isn't all perceptible to the touch.

19. Summing up: the heat given off by the heavenly bodies is increased in three ways—•by perpendicularity, •by nearness to the earth, and •by the company of stars.

20. The heat of animals, and the heat that reaches us from the heavenly bodies, are *much* less than

•the heat of a flame (even a gentle one) ,
•the heat from a burning body, and
•the heat of liquids and the air itself when strongly highly heated by fire.

For the flame of alcohol, even when scattered and not concentrated, is still enough to set paper, straw, or linen on fire. The heat of animals will never do that, nor will the sun without a burning-glass.

21. The heat of flames and burning bodies comes in many different intensities; but they haven't been carefully studied, so I can only skim across the surface of this topic. It seems that the flame of alcohol is the gentlest of all (unless perhaps the will-o'-the-wisp or the flames or sparks from the sweat of animals are even gentler). Next, I think, comes the flame from vegetable matter that is light and porous, such as straw, reeds, and dried leaves—and the flame from hairs or feathers is pretty much the same. Next perhaps comes flame from wood, especially wood containing little resin or tar. ·There is a distinction to be made within the class of flames from that kind of wood·: the flame from small bits of wood such as are commonly tied up in bundles is milder than the flame from trunks and roots of trees. Anyone can see this in the fact that a fire fuelled by bundles of twigs and tree-branches is useless in a furnace for smelting iron. After this, I think, comes flame from oil, tallow, wax and similar fatty and oily substances that aren't very caustic or corrosive. But the strongest heat comes from tar and resin, and even more from sulphur, camphor, naphtha, rock oil, and salts (after the crude matter is discharged), and from their compounds such as gunpowder, Greek fire (commonly called 'wildfire') and its variants, whose heat is so stubborn that it's hard to extinguish with water.

22. I think that the flame resulting from some imperfect metals is very strong and piercing; but all these things need to be looked into further.

23. The flame of powerful lightning seems to be stronger

than any of those others, for it has been known to melt wrought iron into drops, which *they* can't do.

24. In burning bodies too there are different degrees of heat, but these haven't been carefully investigated either. The weakest heat of all, I think, is what comes from the sort of burning linen wick that we use to start fires with, and from the fuses that are used in firing cannons. After this comes burning charcoal made from wood or coal. . . . [In what follows, a single Latin word is rendered sometimes as 'red-hot' and sometimes as 'burning', according to the context.] But I think that red-hot metals—iron, copper etc.—are the hottest of all hot substances. But this needs to be looked into.

25. Some red-hot bodies are found to be much hotter than some flames. Red-hot iron, for instance, is much hotter and more destructive than flame of alcohol.

26. Of substances that aren't burning but only heated by fire, such as boiling water and air confined in reverbatory furnaces, some are found to be hotter than many flames and burning substances.

27. Motion increases heat, as you can see in bellows and by blowing ·hard into your hand·; so that the way to get a quiet fire to melt one of the harder metals is to take a bellows to it.

28. Try the following experiment with a burning-glass (I am describing it from memory). **(1)** Place a burning-glass nine inches away from a combustible body. **(2)** Place the burning-glass at half that distance from the object and then slowly move it back to a distance of nine inches. You will find that the glass doesn't burn or consume as much of the object in case **(1)** as it does in case **(2)**. Yet the cone and the focus of the rays are the same in each; it's the motion that makes the heat more effective.

29. [Omitted. What Bacon wrote doesn't make physical sense.]

30. Things don't burst into flames unless the flames have some empty space in which to move and play; except for the explosive flame of gunpowder and the like, where the fire's fury is increased by its being compressed and imprisoned.

31. An anvil gets very hot under the hammer; so if an anvil were made of a thin plate and were hit with many strong blows from a hammer I would expect it to it become red-hot. This should be tried.

32. If a burning substance is porous, so that the fire in it has room to move, the fire is immediately extinguished if its motion is checked by strong compression. For example, you can immediately extinguish the burning wick of a candle or lamp by snuffing it out with an extinguisher, or burning charcoal or coal by grinding it down with your foot.

33. The closer something is to a hot body the more heat it gets from it; and this applies to light as well—the nearer an object is to a light-source the more visible it becomes.

34. Combining different heats increases the ·over-all· heat unless the combining is done by mixing the hot substances together. For a large fire and a small fire in the same house give more heat than either alone, but warm water poured into boiling water cools it.

35. The longer a hot body is applied to something else, the more heat it gives it; because heat is perpetually being transferred and mixed in with the heat that is already there, so that amount of heat transferred increases through time. A fire doesn't warm a room as well in half an hour as it does if continued through a whole hour. Not so with light: a lamp or candle gives no more light after it has been long lighted than it did at first.

36. Irritation by surrounding cold increases heat, as you can see in fires during a sharp frost. I think this is not so much because the cold confines and contracts the heat. . . .as because it irritates it. ·Another example of such

irritation—one that doesn't concern heat—occurs· when air is forcefully compressed or a stick is forcefully bent; it doesn't merely rebound back to its initial position but goes further than that. A careful experiment is needed here: put a stick or some such thing into a flame, and see whether it isn't burned more quickly at the edge of the flame than at its centre.

37. Things differ greatly in how susceptible to heat they are. Note first of all how even the bodies that are least susceptible of heat are warmed a little by faint heat. Even a piece of metal warms up a little if held for a while in your hand. So readily and universally is heat transmitted and aroused—without the warmed body changing its appearance.

38. Of all the substances we know, the one that gets and gives heat most readily is air. You can see this in calendar glasses [= 'thermometers'], which are made thus.

- •Take a glass flask with a rounded belly and a narrow elongated neck;
- •attach along its neck a strip of paper marked with as many degrees as you choose;
- •use a flame to warm the flask's belly; then
- •turn the flask upside down and lower it—mouth down and belly up—into another glass vessel containing water. Let the mouth of the inserted flask touch the bottom of the receiving vessel, with the flask's neck resting lightly on the mouth of the receiving vessel. (It may help if you apply a little wax to the mouth of the receiving vessel, but not so as to create a seal. We are going to be dealing with very light and delicate movements, and we don't want them to be blocked because air can't pass through.

·There is your equipment; and now here is the experiment·. The air in the flask was expanded by the heat of the flame; and now it will contract as the flask cools down, so that eventually the flask will contain the same amount of air as before but in a smaller space than that of the entire flask. The remaining space in the flask will be filled with water from the receiving vessel. You'll see that the colder the day is the more the air contracts and thus the more water is drawn up into the flask; and the markings on the flask's neck will let you measure these changes. Air is much more finely sensitive to heat and cold than we are with our sense of touch; a ray of sunshine, or the heat of your breath, not to mention the heat of your hand placed on the top of the glass, will lower the level of the water by a perceptible amount. Yet I think that animal spirits are even more sensitive to heat and cold, or would be if they weren't deadened by the mass of the body.

39. Next to air, the bodies that seem to me most sensitive to heat are ones that have recently been compressed by cold, such as snow and ice; for it takes only a very gentle heat to start them melting. Next, perhaps, comes mercury. Then fatty substances such as oil, butter, etc.; then wood; then water; and lastly stones and metals, which are slow to heat, especially internally. These ·slow-to-heat substances·, however, once they are hot, remain so for a long time; so much so that when an intensely hot brick, stone or piece of iron is plunged into a basin of water it remains too hot to touch for nearly a quarter of an hour.

40. The less mass a body has the more quickly it grows warm from being near a hot body; which shows that all heat in our experience is in some way opposed to tangible matter.

41. To the human sense of touch, heat is a variable and relative thing; tepid water feels hot to a hand that was cold, and cold to a hand that was hot.

14. From the above tables you can see how impoverished my ·natural· history is. I have ·frequently· offered, in place of proven history and solid instances, mere traditions and hearsay. I have always noted the doubtful credibility and authority of these, ·but that doesn't alter the fact that they represent *gaps* in my natural history, which is why· I have often had to resort to saying things like 'Try an experiment' and 'We should inquire'.

15. The job of these three tables is—in the terminology I have chosen—to *present instances to the intellect*. After the presentation has been made, induction itself must get to work. After looking at each and every instance we have to find a nature which

- •is always present when the given nature (in our present case: heat) is present,
- •is always absent when the given nature is absent,
- •always increases or decreases with the given nature, and
- •is a special case of a more general nature

(I mentioned this last requirement in **4** [on page 49]). If the mind tries to do this •affirmatively from the outset (which it always does when left to itself), the result will be fancies and guesses and ill-defined notions and axioms that have to be adjusted daily. (Unless like the schoolmen we choose to fight in defence of error; and in that case how well an axiom fares will depend ·not on how much truth it contains but· on the ability and strength of its defender.) It is for God (who designed and gave the forms), and perhaps also for angels and higher intelligences, to have an immediate •affirmative knowledge of forms straight away. This is certainly more than man can do. We have to proceed at first through •negatives, and finally to come to •affirmatives after we have made all the required exclusions.

16. [Bacon will now be likening scientific procedure to a kind of chemical analysis, in which various components of a complex liquid are distilled off by heat, leaving the residue in which we are interested.] So we have to subject the nature ·in which we are interested· to a complete dismantling and analysis, not by fire but by the mind, which is a kind of divine fire. The first task of true induction (as regards the discovery of forms) is to reject or exclude natures that

- •are not found in some instance where the given nature is present, or
- •are found in some instance from which the given nature is absent, or
- •are found to increase in some instance when the given nature decreases, or
- •are found to decrease when the given nature increases.

After these rejections and exclusions have been properly made, and all volatile opinions have been boiled off as vapour, there will remain at the bottom of the flask (so to speak) an affirmative form that is solid, true and well defined. It doesn't take long to *say* this, but the process of *doing* it is lengthy and complex. Perhaps I'll manage not to overlook anything that can help in the task.

17. I have to warn you—and I can't say this too often!—that

> When you see me giving so much importance to *forms*, do *not* think I am talking about the 'forms' that you have been used to thinking about.

·Treating my forms as your 'forms' in the present context would be wrong in two ways·. **(1)** I'm not talking here about composite forms, the ones in which various simple natures are brought together in the way the universe brings them together—the likes of the forms of *lion*, *eagle*, *rose*, *gold*, and so on. It will be time to treat of these when we come to *hidden* processes and *hidden* microstructures, and the discovery of them in so-called *substances* or composite natures.

(2) In speaking of ·forms or· simple natures, I'm not talking about *abstract* forms and ideas which show up unclearly in matter if indeed they show up in it at all. When I speak of 'forms' I mean simply the objective real-world laws of pure action [see not on page 11] that govern and constitute any simple nature—e.g. heat, light, weight—in every kind of matter and in anything else that is susceptible to them. Thus the 'form of heat' or the 'form of light' is the same thing as the *law* of heat or the *law* of light; and I shan't ever use abstractions through which I step back from things themselves and their operations. [In the next sentence, 'rarity' is cognate with 'rare' in the sense of 'thin, attenuated, not *dense*'.] So when I say (for instance) in the investigation of the form of heat

- 'reject rarity ·from the list of simple natures that constitute heat·', or
- 'rarity does not belong to the form of heat',

·I may seem to be talking about an abstract property *rarity*, but what I am saying can just as well be said without any noun purporting to refer to any such abstraction. For· those statements are tantamount to

- 'It is possible for us to make a dense body hot', or
- 'It is possible for us keep or remove heat from a rare body',

·where 'rarity' and 'denseness' give way to 'rare' and 'dense'·.

You may think that my forms also are somewhat abstract, as they mix and combine things that are very different from one another. ·This complaint might come from your noticing that·

- the heat of heavenly bodies seems to be very unlike the heat of fire,
- the relatively durable redness of a rose (say) is very unlike the ·transient shimmering· redness that appears in a rainbow, an opal, or a diamond, and
- the different kinds of death—by drowning, burning, stabbing, stroke, starvation—are very unalike;

yet they share the nature of heat, redness and death respectively. If you *do* have that thought, this shows that your mind is captive to •habit, to •things taken as a whole ·and not subject to analysis or bit-by-bit examination·, and to •men's opinions. For it is quite certain that these things, however unalike they may be, agree in the form or law that governs heat, redness and death (respectively); and human power can't possibly be freed from the common course of nature, and expanded and raised to new powers and new ways of operating, except by discovering of forms of this kind. This •union of nature is the most important thing I have to talk about; but when I have finished with it I shall take up, in the proper place, the •divisions and veins of nature, both the ordinary ·superficial· ones and also the ones that are more internal and true. ·By the 'union of nature' I mean the coming together of disparate things under a single form. By the 'division and veins of nature' I mean the complexities in which disparate structures and functions come together in a single thing·.

18. I should now provide an example of the exclusion or rejection of natures that are shown by the Tables of Presentation not to belong to the form of heat. All that is needed for the rejection of any nature ·from the form we are investigating· is a single ·contrary· instance from one of the tables; for what I have said makes it obvious that any conjecture ·of the type 'Nature N belongs to form F'· is knocked out by a single contrary instance. But I shall sometimes cite two or three such instances—for clarity's sake and to provide practice in using the tables.

An example of exclusion or rejection of natures from the form of heat:

(1) reject: elemental nature **because of** the rays of the sun
(2) reject: heavenly nature **because of** ordinary fire, and especially underground fires, which are the most completely cut off from the rays of heavenly bodies
(3) reject: how fine-grained a body's structure is **because of** the fact that all kinds of bodies (minerals, vegetables, skin of animals, water, oil, air, and so on) become warm simply by being close to a fire or other hot body
(4) reject: being attached to or mixed with another body that is hot **because of** the fact that red-hot iron and other metals give heat to other bodies without losing any of their own weight or substance
(5) reject: light and brightness **because of** boiling water and ·hot· air, and also metals and other solids that become hot but not enough to burn or glow
(6) reject: light and brightness **because of** the rays of the moon and other heavenly bodies (except the sun)
(7) reject: light and brightness **because of** the fact that red-hot iron has more heat and less brightness than the flame of alcohol
(8) reject: rarity **because of** very hot gold and other metals that have the greatest density
(9) reject: rarity **because of** air, which remains rare however cold it becomes
(10) reject: change in a body's size or shape **because of** red-hot iron, which doesn't become larger or change its shape
(11) reject: change in a body's size or shape **because of** the fact that in thermometers, and the like, air expands without becoming noticeably warmer
(12) reject: destructive nature, or the forceful addition of any new nature **because of** the ease with which all bodies are heated without any destruction or noticeable alteration
(13) reject: expanding or contracting motion of the body as a whole **because of** the agreement and conformity of similar effects displayed by both heat and cold
(14) reject: the *basic* natures of things (as distinct from properties they have through antecedent causes) **because of** the creation of heat by rubbing things together
There are other natures beside these; I'm not offering complete tables, but merely examples.

Not a single one of the 'reject:' natures belongs to the form of heat. In all our dealings with heat we can set those aside.

19. The process of exclusion is the foundation of true induction; but the induction isn't completed until it arrives at something affirmative. Of course the excluding part ·of our work· is itself nothing like complete, and it can't be so at the beginning. For exclusion is, obviously, the *rejection of simple natures*; so how can we do it accurately when we still don't have sound and true notions of simple natures? Some of the notions that I have mentioned (such as the notions of *elemental nature*, *heavenly nature* and *rarity*) are vague and ill defined. I'm well aware of, and keep in mind, how great a work I am engaged in (namely making the human intellect a match for things and for nature); so I am not satisfied with what I have said up to here. I now go further, and devise and supply more powerful aids for the intellect—aids that I shall now present. In the interpretation of nature the mind should be thoroughly prepared and shaped up, so that it will at each stage settle for the degree of certainty that is appropriate there, while remembering (especially at the beginning) that the answer to 'What is *this* that we have before us?' depends to a great extent on what will come of it later on.

20. Truth emerges more quickly from error than from confusion, ·which implies that it can be worthwhile to aim for clarity even at the risk of going wrong·. So I think it will be useful, after making and weighing up three tables of first presentation (such as I have exhibited), to give the intellect permission to try for an interpretation of nature of the affirmative kind on the strength of the instances given in the tables and also of any others that may turn up elsewhere. I call this kind of attempt •'permission for the intellect' or •'sketch of an interpretation' or—·the label I shall actually use in this work·—•the 'first harvest'.

A first harvest of the form of heat

Something that is perfectly clear from what I have said earlier should be borne in mind here, namely that the •form of a thing is present in each and every instance of the thing; otherwise it wouldn't be its •form; from which it follows that there can't be any counter-instances ·where the thing is present and the form isn't·. Still, the form is much more conspicuous and obvious in •some instances than in others, namely in •those where the nature of the form is less restrained and obstructed and limited by other natures. Instances of •this kind I call 'luminous' or (·most of the time·) 'revealing' instances. So now let us proceed to the first harvest concerning the form of heat.

> In each and every case of heat the cause of the nature of which heat is a special case appears to be **motion**. This shows most conspicuously in flames, which are on the move all the time, and in boiling or simmering liquids, which are also constantly in motion. It is also shown when motion stirs heat up or increases it—as happens with bellows and with wind (Third Table 29) and with other kinds of motion (28 and 31). It is also shown when fire and heat are extinguished by any strong compression, which checks and stops the motion (see 30 and 32). It is shown also by the fact that all bodies are destroyed or at any rate significantly changed by any fire or strong heat, which makes it quite clear that heat causes a tumult and agitation and lively motion in the internal parts of a body, which gradually moves it towards dissolution.

In certain cases heat generates motion and in certain cases motion generates heat, but *that* isn't what I am saying when I say that motion is like a genus in relation to heat ·as one of its species·. What I mean is that heat itself *is* nothing but motion of a certain specific kind; I'll tell you soon what special features of a case of motion make it qualify as a case of heat. Before coming to that, though I shall present three cautions that may be needed to avoid unclarity about some of the terms I shall be using.

·First caution: My topic is *heat*, not *heat-as-we-feel-it*·. Heat as we feel it is a relative thing—relative to humans, not to the world; and it is rightly regarded as merely the effect of heat on the animal spirits. Moreover, in itself it is variable, since a single body induces a perception of cold as well as of heat, depending on the condition of the senses. This is clear from the item 41 in the Third Table [page 63].

·Second caution: My topic is *heat*, not *the passing on of heat*·. Don't confuse the *form* of heat with the *passing on* of heat from body to body, for *heat* is not the same as *heating*. Heat is produced by the motion of rubbing something that at first has no heat; and that's enough to show that the transmission of heat is no part of the form of *heat*. And even when something is heated by another hot thing's coming close to it, that doesn't come from the form of heat; rather, it depends entirely on a higher and more general nature, namely the nature of *assimilation* or *self-multiplication*, a subject that needs to be investigated separately. [See page 114.]

·Third caution: My topic is *heat*, not *fire*·. Our notion of fire is a layman's one, and is useless ·for scientific purposes·. What it counts as 'fire' is the combination of heat and brightness in a body, as in ordinary flame and bodies that are red hot. [Red-heat is treated as a kind of 'burning' in item 24 on page 62.]

Having guarded against verbal misunderstandings, I now at last come to the true specific differences which qualify a case of •motion (·genus·) to count as a case of •heat (·species·).

The **first** difference then is this. Heat is an *expansive* motion in which a body tries expand to a greater size than it had before. We see this most clearly in flame, where the smoke or thick vapour obviously expands into flame.

It also appears in any boiling liquid, which can be seen to swell, rise and bubble, and goes on expanding itself until it turns into a body that is far bigger than the liquid itself, namely into steam, smoke, or air.

It appears also in all wood and ·other· flammable things, where there is sometimes sweating and always evaporation.

It is shown also in the melting of metals. Because they are highly compact, metals don't easily expand and dilate; but their *spirit* expands, and wants to expand further; so it forces and agitates the lumpier parts into a liquid state. If the metal becomes hotter still, it dissolves and turns much of itself into a volatile substance.

It appears also in iron or rocks: they don't liquefy or run together, but they become soft. Similarly with wooden sticks, which become flexible when slightly heated in hot ashes.

But this kind of motion is best seen in air, which a little heat causes to expand—see Third Table 38 [page 63].

It shows up also in the contrary nature, namely *cold*. For cold contracts all bodies—makes them shrink—so that in a hard frost nails fall out of walls, bronze vessels crack, and heated glass when exposed to cold cracks and breaks. Similarly, a little cooling makes air contract, as in 38. But I'll say more about this when I deal properly with cold.

It's no wonder that heat and cold should exhibit many actions in common (for which see the Second Table 32 [at page 59]). This first specific difference ·helping to denarcate the species *heat* within the genus *motion*· concerns a feature of heat that is diametrically opposite to a feature of *cold*, because whereas heat expands cold contracts; but the third and fourth differences (still to come) belong to the natures both of heat and of cold.

The **second** difference is a special case of the first, namely: Heat is a motion in which the hot body •expands while it •rises. This is a case of mixed motion, of which there are many—e.g. an arrow or javelin •rotates while it •flies forward. Similarly the motion of heat is an expansion as well as a movement upwards.

This difference appears when you put a poker into a fire. If you put it in upright and hold it by the top, it soon burns your hand; if you put it in at the side or from below, it takes longer to burn your hand.

It can also be seen in fractional distillation, which men use for ·extracting essences from· delicate flowers that soon lose their scent. It has been found in practice that one should place the fire not below ·the distilling retort· but above it, so as to burn less. For all heat, not only flame, tends upward.

This should be tried out on the opposite nature, cold, to learn whether cold contracts a body downward as heat expands it upward. Here's how to do it. Take two iron rods or glass tubes of exactly the same dimensions, warm them a little and place a sponge steeped in cold water or snow at the bottom of the one, and a similar one at the top of the other. I think that the end of the rod that has snow at the top will cool sooner than the end of the rod with snow at the bottom—the opposite of what happens with heat.

The **third** specific difference is this: heat is a motion that isn't expansive uniformly through the whole ·hot· body, but only through its smaller particles; and this expansion ·in any one particle· is at the same time checked, repelled, and beaten back ·by the expansions of other particles·, so that there's a back-and-forth motion within the body, which is irritated by all the quivering, straining and struggling that goes on; and from that comes the *fury* of fire and heat.

This ·specific· difference is most apparent in flames and in boiling liquids, where there are continual little rises and falls across their surface.

It also shows up in bodies that are so compact that when heated or ignited they don't swell or expand in bulk—e.g. in red-hot iron, in which the heat is very sharp.

And it is apparent in hearth fires, which burn brightest in the coldest weather.

It also shows in the fact that when the air in a calendar glass [see item 38 on page 63] expands without obstacles or counter-pressures, and thus expands at the same rate throughout, there is no perceptible heat. Also when an enclosed body of ·compressed· air escapes, no great heat is observed; that is because although the air bursts out with the greatest force, its only expansive motion is a motion of *the whole*, with no back-and-forth motions in *the particles*. . . .

It is also shown in this, that all burning acts on minute pores in the body in question, so that burning digs into the body, penetrating and pricking and stinging it like the points of countless needles. . . .

And this third specific difference is shared with the nature of *cold*. For in cold the contractive motion is checked by a tendency to expand, just as in heat the expansive motion is checked by a tendency to contract. Thus, whether the particles of a body work inward or outward, the mode of action is the same though the degree of strength may be very different; because on the surface of the earth we don't have anything that is intensely cold. [See item (3) on page 121.]

The **fourth** specific difference is a special case of the third. It is that the motion of pricking and penetrating must be fairly fast, not sluggish, and must go by particles—very small ones but a bit bigger than the smallest.

This difference is apparent when you compare the effects of •fire with the effects of •time or age. Age or time makes things wither, consumes and undermines them, reduces them to ashes, just as much as fire does, though it acts on even smaller particles than fire acts on; because that motion is very slow and acts on very tiny particles, there is no detectable heat.

It is also shown by comparing the dissolution ·in acids· of iron and gold. Gold is dissolved without any heat being stirred up, whereas iron, when it is dissolved about as quickly as gold, starts up a violent heat. This is because the solvent for gold enters the gold gently and works at a level of very small particles, so that the particles of the gold give way easily; whereas the solvent for iron enters the iron roughly and forcibly, and the particles of the iron are more stubborn.

It is also apparent in some gangrenes and cases of rotting flesh, which don't arouse much heat or pain because the rotting process operates at the level of such tiny particles.

I offer this as the •first harvest—or •sketch of an interpretation—concerning the form of heat, made by way of •permission to the intellect [these three labels are introduced in **20** on page 67.].

The form or true definition of heat can be derived from this first harvest. (I'm talking about heat considered absolutely, not heat relative to the senses.) Here it is, briefly:

> •Heat is an expansive motion that is resisted, and that fights its way through the smaller particles ·of the hot body·.

Special case of this expansion:

> •While expanding in all directions ·the hot body· has

a tendency to rise.

Special case of the struggle through the particles:

•It is not very slow; rather it is fast and has some force.

This tells us how in practice to create heat. Here is the story:

In some natural body, arouse a motion to expand; and repress this motion and turn it back on itself so that the expansion doesn't proceed evenly, but partly succeeds and is partly held back.

If you do that you will undoubtedly generate heat. It makes no difference whether

- •the body is made of earthly elements or contains heavenly substances,
- •is luminous or opaque,
- •is rare or dense,
- •is spatially expanded or still of its original size,
- •tends towards dissolution or keeps its original condition,
- •is animal, vegetable, or mineral (water, oil or air),

or any other substance that is capable of the motion described. Sensible heat is the same, but considered with reference to the senses. Let us now proceed to further aids. [That last remark refers to the 'aids' that were promised in **19** on page 66; the first such 'aid' has been **20**. A reminder about 'the tables of first presentation':

- •the first table, of essence and presence, starts on page 54;
- •the second table, of divergence or nearby absence, starts on page 55
- •the third table, of degrees or of comparison, starts on page 59;
- •'the table of exclusion or rejection' starts on page 65;
- •'the first harvest' starts on page 67.

This reminder may be useful as a guide to Bacon's next remark.]

21. So much for the tables of •first presentation and of •rejection or exclusion, and the •first harvest based on them. Now we have to proceed to the other aids to the intellect in the interpretation of nature and in true and perfect induction. I'll present them in terms of heat and cold whenever tables are appropriate; but when only a few examples are needed I'll take them from all over the place, so as to give my doctrine as much scope as possible without creating confusion.

[We are about to meet the phrase 'privileged instances'. The Latin *praerogativa instantarum* strictly means 'privilege of instances', but Bacon always handles it as though it stood for a kind of instance, not a kind of privilege. The use of 'privilege' to translate *praerogativa* is due to Silverthorne, who relates it to the *centuria praerogativa* in ancient republican Rome—the aristocrats' privilege of voting first and thus having the best chance to influence the votes of others.] My topics will be, in this order:

1. privileged instances
2. supports for induction
3. the correcting of induction
4. adapting the investigation to the nature of the subject
5. which natures should be investigated first, and which later
6. the limits of investigation, or a synopsis of all natures in the universe
7. practical consequences
8. preparations for investigation
9. the ascending and descending scale of axioms.

[There are twenty-seven classes of privileged instances, some with a number of sub-classes. Bacon's discussion of them runs to the end of the work. The other eight topics were to have been dealt with in later instalments of the Great Fresh Start, which he never wrote.]

22. Class 1 of privileged instances: **solitary instances**. Those are ones in which the nature we are investigating

appears in things that have *nothing else* in common with other things that have that nature,

or ones in which the nature we are investigating does not appear in things that have *everything else* in common with other things that do have that nature.

·I put these first · because it is clear that they save us from detours, leading quickly and securely to *exclusions*, so that a few solitary instances are as good as many.

Suppose for example that we are investigating the nature of colour: in that context prisms, crystals, dew-drops and the like, which make colours in themselves and project them outside themselves onto a wall, are solitary instances. For they have nothing else in common with the colours inherent in flowers, coloured stones, metals, woods, etc.—i.e. nothing but colour. From which we can easily draw the conclusion that colour is merely a modification of the light that the object takes in. With prisms, crystals etc. the light is modified by the different angles at which the light strikes the body; with flowers, coloured stones etc. it is modified by various textures and microstructures of the body. These instances are •resemblance-solitary.

In that same investigation of light: the distinct veins of white and black in a piece or marble, and the variegation of colour in flowers of the same species, are solitary instances. The black and white streaks in marble have almost everything in common except their colour, and so do the streaks of pink and white in a carnation. From this we can easily infer that colour doesn't have much to do with the intrinsic nature—·the microscopic fine texture·—of a body, but only on the quasi-mechanical arrangement of its larger parts. These instances are •difference-solitary. . . .

23. Class 2 of privileged instances: **shifting instances**. Those are ones where the nature under study is •shifting towards being produced when it didn't previously exist, or •shifting towards non-existence when it existed before. Shifting instances, whichever kind of shift they involve, are always twofold, or rather it is one instance in which the movement is continued until it reaches the opposite state. [At this point some material is removed, and will be reinserted as a paragraph between *asterisks* below; it is easier to understand there than it would be here.]

Here is an example of a shifting instance. Suppose we are investigating *whiteness*: shifting instances in which the shift is towards production or existence ·of whiteness· are

unbroken glass shifting to powdered glass

ordinary water shifting to water shaken up to make foam.

Plain glass and water are transparent, not white, whereas pounded glass and foaming water are white, not transparent. So we have to ask what happened to the glass or water in this shift. Obviously, the form of whiteness is brought in by the pounding of the glass and the shaking of the water; but we find that nothing has occurred except the breaking up of the glass and water into small parts, and the introduction of air. So we have this result:

Two bodies, air and water (or: air and glass) which are more or less transparent come to exhibit whiteness as soon as they are broken up into small bits ·and the bits are mixed·, this whiteness being brought about by the unequal refraction of the rays of light.

This is a big step towards discovering the form of whiteness.

*Such instances don't just lead quickly and securely to exclusions, but also narrow down the search for the affirmation or the form itself ['exclusion' and 'affirmation' are introduced in **15** on page 64]. For the form of a thing must be something that is introduced by a shift, or removed and wiped out by a shift in the other direction. Of course every exclusion supports some affirmation, but the support is more direct when the exclusion comes from one case rather than from a number of cases. And my discussion has made it clear that the form that comes to light in a single instance leads the way to the discovery of it in all the rest. And the simpler the shift, the more value we should attach to the instance. And another thing: shifting instances are of great value in the practical part ·of scientific inquiry·: a shifting instance exhibits •the form ·under investigation· linked with •the cause of its existing (or the cause of its not existing); that provides great clarity in one instance and an easy transition to others. But shifting instances create a certain danger against which I should warn you: they may lead us to link the form too closely to its efficient cause, and so encourage a false view of the form, drawn from a view of the efficient cause. The efficient cause is always understood to be merely the vehicle for or bearer of the form. It is not hard to avoid this danger in a properly conducted exclusion.*

I should give an example of this danger. A mind that is led astray by efficient causes of this sort will too easily conclude that •air is always required for the form of whiteness, or that •whiteness is generated only by transparent bodies—both of which are entirely false, and refuted by numerous exclusions. What *will* be found (setting air and the like aside) is this:

all the particles that affect vision are equal	transparent
unequal and simply textured	white
unequal with complex regular texture	any but black
unequal and complex in an irregular way	black

So now we have before us an instance with a shift to the •production of the nature under study, namely whiteness. For an instance that shifts to the •destruction of the same nature of whiteness, consider breaking up foam or melting snow. In each case, what you then have is *water*, not broken into little particles and not mixed with air, and this sheds whiteness and puts on transparency.

It's important to note that shifting instances include not only those in which the nature under study shifts toward production or toward destruction, but also those in which the nature shifts towards increasing or decreasing. It's because these also contribute to revealing the form, as can be clearly seen from the definition of *form* that I have given ·in **17**·, and the Table of Degrees [starting on page 59]. Paper that is white when dry become less white and nearer to being transparent when it is wetted—i.e. when air is excluded and water introduced. The explanation of what is happening here is analogous to the explanation of the first shifting instances.

24. Class 3 of privileged instances: **revealing instances**, which I have already mentioned in the first harvest concerning heat [page 72], and which I also call 'luminous' and 'freed and predominant'. They are the instances in which the nature under study is revealed

> naked and standing on its own feet, and also
> at its height and in full strength,

not muffled by any impediments. This is either because •there aren't any impediments in this instance or because •there are some but the nature we are studying is present in such strength that it holds them down and pushes them around. ·Here is the background *setting* for these revealing instances·:

> Every body is capable of having many forms or natures linked together; they can crush, depress, break and bind one another so that the individual forms are obscured. But we find that in some subjects the nature under investigation stands out from the others, either because there are no obstacles or because its vigorous strength makes it prominent.

Instances of this kind reveal the form with special clarity.

But we should be careful in our handling of ·what seem to be· revealing instances, not rushing to conclusions. When something reveals a form very conspicuously and seems to force it on the notice of our intellect, we should view it with suspicion and should avail ourselves of a strict and careful exclusion ·of other potentially relevant features, rather than abruptly brushing them aside in our enthusiasm for the conspicuous nature that has attracted our attention·.

Suppose, for example, that we are investigating the nature of heat. As I said earlier [in item 38 on page 63], the motion of expansion is the main element in the form of heat, and a revealing instance of *that* is a •thermometer. Although •flame obviously exhibits expansion, it doesn't show expansion as an ongoing process, because a flame can be so quickly snuffed out. Nor does •boiling water provide a good display of expansion in its own body ·*as water*· because it so easily turns into vapour or air. As for red-hot iron and its like: they are so far from exhibiting expansion as an ongoing process that their expansion is almost imperceptible; that's because their spirit is being crushed and broken by the coarse and compact particles, which curb and subdue the expansion. But a thermometer clearly displays expansion in air, revealing it as conspicuous, progressive, and enduring rather than transitory.

To take another example: suppose the nature inquired into is *weight*. A revealing instance of weight is mercury. It is heavier than anything else except gold, which is only slightly heavier; and mercury does a better job of indicating the form of weight than gold does, because gold is solid and compact—features that seem to come from its *density*—whereas mercury is liquid and full of spirit despite being much heavier than the diamond and other bodies that are thought to be the most solid. This reveals that the form of heaviness or weight depends simply on the *quantity* of matter and not on how *compact* the body is.

25. Class 4 of privileged instances: **concealed instances**, which I also ·though not again in this work· call 'instances of the twilight'. They are pretty nearly the exact opposites of revealing instances. They exhibit the nature under investigation at its lowest strength, as though it were in its cradle, newly born, making its first attempts but buried under and subdued by a contrary nature. Still, such instances are very helpful in the discovery of forms; because just as

revealing instances lead easily to •specific differences,

so also

concealed instances are the best guides to •genera,

i.e. to the common natures of which the natures under investigation are merely special cases. ·That is to say, revealing instances help us to move down the classificatory table, concealed instances help us to move up·.

Suppose for example that the nature under investigation is •solidity or a thing's holding its shape, the opposite of which is •fluidity. Concealed instances of this are ones that exhibit some low level of shape-holding *in a fluid*—for example a bubble of water, which has a sort of shaped *skin* made of water. Similarly with trickling water: if the water keeps coming, the drops lengthen themselves out into a thin thread so as to keep the stream unbroken; and if there isn't enough water for that, the water falls in round drops, that being the shape that best preserves the water from breaking up ·into still smaller portions·. But the instant the thread of water stops and the drops begin, the water jumps back upwards so as to avoid breaking. And in metals, which when melted form thick fluids, the molten drops often jump back up and stay there. . . . The same kind of thing can be seen in the children's game when they take water, thicken it a little with soap, and blow it through a hollow reed: this combines the water with air so as to make a cluster of bubbles that is firm enough to be thrown some distance without breaking up. But foam and snow provide the best examples of this phenomenon. They become almost solid enough to be cut with a knife, although they are made out of two fluids—air and water. All of this pretty clearly indicates •that 'solid' and 'liquid' are ·not useful terms in the present context, because they are· layman's notions which relate ·not to the scientific facts about a thing but only to how it strikes· our senses. It also indicates •that in fact all bodies have a tendency to avoid being broken up, a tendency that is weak in homogeneous bodies (which is what fluids are), and stronger in bodies made up of different kinds of materials (·the ones the layman calls 'solid'·). That is because a body is bound together when heterogeneous matter is introduced to it, whereas the insertion of homogeneous matter dissolves the body and makes it fall apart.

Here are three more examples. **(1)** Suppose that the nature we are investigating is the *attraction* or *coming together* of bodies. The best revealing instance of the form of this is the magnet. There is also the *non-attracting* nature—the contrary of the attracting one—and this can even be found in the same substance. Thus iron doesn't attract iron, lead doesn't attract lead, or wood wood, or water water. [In what follows, an 'armed' magnet is one equipped with an 'armature' in the sense of 'a piece of soft iron placed in contact with the poles of the magnet, which preserves and increases the magnetic power; or any arrangement which produces the same result' (OED). Another such arrangement is an 'armature' in *our* sense of the word—coils of wire conducting electricity—but that wasn't discovered as a means of magnetism until two centuries later.] Now a concealed instance ·of attraction· is provided by •a magnet armed with iron, or rather by •the iron in an armed magnet. Its nature is such that

> an armed magnet does not attract iron *from a distance* more powerfully than an unarmed magnet does,

whereas

> when the iron in an armed magnet *touches* some other iron, the magnet supports a far greater weight of iron than a simple unarmed magnet would.

This is because of the similarity of substances, iron on iron—an effect that was latent in the iron ·all along·, but was completely *concealed* before the magnet was brought into play. So it is clear that the form of coming-together is something that is lively and strong in the magnet, feeble and latent in iron. **(2)** It has been noticed that small wooden arrows with no iron points, shot from large guns into the sides of ships or into other wooden targets, penetrate more deeply than they would if they were tipped with iron. This is because of the similarity of substances, wood on wood, although this property had previously been latent in the wood—·only latent, and thus concealed·. **(3)** Similarly, whole bodies of air (water) don't obviously attract other bodies of air (water), but the likelihood of a bubble's bursting is increased when it is touched by another bubble. This is because of water's ·usually concealed· inclination to join with water, and air's to join with air. Such concealed instances (which are very useful, as I have said) show up most conspicuously in small portions of bodies. The reason for that is that larger masses follow more general forms, as I'll explain in due course.

APHORISMS CONCERNING THE INTERPRETATION OF NATURE: BOOK 2: 26–43

26. Class 5 of privileged instances: **constitutive instances**, which I also like to call 'bundled' instances. They are ones that constitute a single *species* of the nature we are investigating; they are a sort of minor form, ·not the major form of the nature as a whole·. Genuine ·non-lesser· forms are always convertible with the natures we are studying:

·where you have F you have N, and vice versa, ·

whereas with a lesser form LF,

where you have LF you have N, but *not* vice versa.

Genuine forms lie deep and are hard to find; so the nature of the case and the weakness of our intellects dictate that we shouldn't neglect—indeed that we should carefully attend to—particular forms that bundle up certain groups of instances (though not all) into some common notion. For anything that pulls a nature together, even partially, opens the way to the discovery of forms. So instances that are useful in this way are not negligible—they have a certain privilege.

But we must be very careful here to avoid a certain great danger. It is that our minds, having discovered many of these particular forms and on the basis of them established partitions or divisions of the nature we are investigating, will settle for *that* and assume that the nature in question is multiple and divided the whole way down, scoffing at any ·attempt at· further unification of the nature and rejecting it as pointless subtlety and verging on mere abstraction. This would stop us from preparing to make the legitimate discovery of the major form. [The next long paragraph starts 'For example'. What it offers are six examples of constitutive instances, not examples of the need for the warning Bacon has just given. The warning, as applied to these six, would say: 'Don't think that these six "minor forms" of aid-to-memory are the whole story, and that there is no "major form", no unitary process of aiding-memory of which these six are only special cases.' Bacon presumably believed this, but you'll see that he doesn't say it or anything like it in this next paragraph.]

Suppose for example that the nature we are investigating is *memory*, or *triggers and helps for the memory*. **1** A constitutive ·or bundled· instance of this ·has three components·: **(a)** *Order* or *arrangement*, which clearly aids the memory. ·An example might be: being helped to remember what we did on a certain date by remembering that first we did A, then we did B, and so on *in order* through our day·. **(b)** 'Places' in artificial memory [= 'memory helped by artifice']. These may be either (a) places in the literal sense of the word—a door, a corner, a window or the like—or (b) 'places' in some ordered list of familiar and well-known persons, animals, plants, words, letters, or whatever; though some of these work better than others. Such •artificial 'places' help the memory wonderfully, and raise it far above its •natural powers. **(c)** Verse is learned and remembered more easily than prose. This bundled trio of instances—order, artificial 'places', and verse—constitutes one species of aid to the memory, a species that could rightly be called *limiting the unlimited*. When you try to recall something without having in advance any notion of what you are looking for, you are looking and working and rushing about in a seemingly unlimited space. But if you have a definite notion of it in advance, that immediately sets some limits, leaving your memory with much less space to rummage through. And in ·each of· the three instances I have described, the notion-in-advance is clear and definite. In the first, the item sought for must be something that fits with the order;

in the second it must be

an image that has some relation or conformity to those specified 'places';

and in the third, it must be

words that fall into verse.

In each case, the unlimited is curtailed. **2** Other instances yield a second species—the one that most artificial aids to memory rely on. It is that anything that puts an intellectual conception in touch with the senses assists the memory. **3** Other instances provide this species: memory is helped by anything that makes an impression on our feelings—by inspiring fear, admiration, shame or delight. **4** From other instances we get: things are more likely to stick in the memory if they were chiefly imprinted when one's mind was clear, and hadn't just emerged from a cluttered state and wasn't about to go into such a state; that's why one is less likely to remember things learned in childhood, things thought of before going to sleep, things experienced for the first time. **5** Other instances will give us this species: memory is aided by there being a large variety of details ·in the material to be searched·—a variety of 'handles' for the memory to latch onto, such as breaking up a text into sections or reading or reciting aloud. **6** Lastly, other instances yield this species: things that are waited for and that attract one's attention will stay in the memory for longer than will things that just slip by. For example, you won't learn a passage as well by •reading it ·straight through· twenty times as you will by •reading it only ten times and trying each time to recite it from memory and looking at the text only when your memory fails. So there seem to be six minor forms of aid-to-memory, namely:

•limiting the unlimited,
•associating concepts with things that are sensorily perceptible,
•impression made on the mind in a state of strong feeling,
•impression made on a clear mind,
•a large variety of points to take hold of,
•expectation beforehand.

[Bacon next presents another example of a constitutive instance—one that is relevant to an inquiry into the nature of the sense of *taste*. It concludes: 'The sense of taste is a sort of compound of an internal *smell* and a delicate power of *touch*—but this is not the place to go into that.' Then:]

For another example, suppose the nature we are investigating is *passing on* [Latin *communicatio*] *a quality without passing on any substance*. The instance of light will give or constitute one species of passing-on, heat and the magnet another. ·They are different species, because· the passing on of light is virtually instantaneous, and stops the instant the original ·source of· light is removed. But when heat or magnetic power is transmitted to a body—or, rather, aroused in a body—it stays there for a considerable time after its source is removed.

Summing up: constitutive instances are *very* privileged, because they contribute greatly to making definitions (especially particular definitions) and to ·establishing· divisions or partitions of natures. Plato said a good thing about these two tasks: 'He who knows well how to define and to divide should be regarded as a god.'

27. Class 6 of privileged instances: **matching instances** or instances of **analogy**, which I also ·though not again in this work· call 'parallells' and 'physical resemblances'. They are the ones that bring out resemblances and linkages between things—not between •minor forms (as constitutive instances do) but between •the things themselves. They are like the first, the lowest, steps toward the unity of a nature. They don't yield any axiom immediately from the beginning, but simply point out and mark a certain agreement between bodies. [On 'agreement', see note on page 87.] They aren't much use for the discovery of forms, but they are very useful in revealing the structure of the parts of a whole, and taking apart its members; and from this they often lead us by the hand, as it were, to sublime and noble axioms, especially to ones concerning •the structure of the world rather than •simple forms and natures.

These are instances of matching:

> •an eye and •a mirror,
> •the construction of the ear and •places that return an echo.

From these matches. . . .it is easy to gather and form this axiom:

> The •organs of the senses are similar in nature to •bodies that produce reflections to the senses.

On this hint the understanding easily rises to this higher and nobler axiom:

> •Bodies endowed with sense agree and harmonize ·with things in their environment·, and so do •inanimate bodies without sense. The only difference is that in the former but not the latter an *animal spirit* is added to a body that is fit to make use of it.

It follows from this that animals would have ·many more senses than they do·—even as many •senses as inanimate bodies have •ways of responding to their environments—if an animal body had ·more· perforations allowing the animal spirit to pass freely into an appropriately structured part of the body, as into a healthy sense-organ. Inanimate bodies with no animal spirit have as many •ways of moving as animals have •senses—indeed many *more*; because how many senses an animal has is limited by its small number of sense-organs. A vivid example of this concerns *pain*. There are many kinds and varieties of pain in animals (the pain of burning, of intense cold, of pricking, squeezing, stretching and the like), but all of these, considered as kinds of motion, also occur in inanimate substances. Think of what happens in wood or stone that is burned or frozen or drilled or cut or bent or stretched, and so on, though the senses don't come into this because of the lack of animal spirit ·and of sense-organs acted on by animal spirit·.

•The roots of plants and •their branches are matching instances, for every plant swells and pushes out its parts into the environment, •downward as well as •upward. It may seem odd to call this a case of *matching*, ·but it really is one, because· the only difference between roots and branches is that the root is buried in the ground while the branches are exposed to the air and sun. For if you take a tender, living •branch of a tree and bend it down and stick it into the earth, it won't itself interact with the ground but it will soon put out not a branch but a •root. . . .

•Tree resins and most •rock gems are instances of matching. Both of these are simply juices that have been filtered ·and hardened· after being extruded in one case from trees and in the other from rocks. What makes each of them so clear and beautiful is the fine and delicate filtering they have been through. ·Another example of the aesthetic power of filtering·: the reason why animal fur is not as lovely and brightly coloured as the plumage of many birds is that juices don't filter so finely through skin as through quills.

Another instance of matching: •the scrotum in males and the •womb in females. In land animals the physical difference between the sexes seems come down to the difference between •external and •internal. The greater force of heat in the male forces the genitals outward, while in the female the heat is too weak to do this, so her genitals stay inside.

The ·four· •fins of fish and the •feet of quadrupeds and •the feet and wings of birds, are instances of matching; and Aristotle has added ·a further matching quartet, namely· the •four undulations in the motions of serpents. From this it seems that. . . .the motions of living creatures are generally brought about by a quartet of limbs or of bends.

The •teeth of land animals and the •beaks of birds are instances of matching; from which it is obvious that in all completed animals some hard substance moves towards the mouth.

And there is a similarity—don't dismiss this as absurd!—between a man and an upside-down plant. In ·a man and indeed in· animals generally, the root of the nerves and faculties is the head, while the part with seeds is at the bottom (I'm setting aside the legs and arms). In a plant, the root (which matches the animal head) is regularly located at the bottom while the seeds are at the top; ·so if you turn the plant upside down you get a *match*·.

A final point: I couldn't over-emphasize the need for men to change their focus when they are investigating and collecting natural history. Until now they have worked hard on observing the variety of things, and setting out in detail the **differences** that mark off the various species of animals, plants, and fossils—though most of these differences are •nature playing around rather than •differences that have serious significance for the sciences. Such things are fun to know about, and sometimes they are practically useful; but for getting insight into nature they are nearly or wholly useless. What we should be doing is to investigate and observe the **resemblances** and analogies of things, taken as wholes and also in their parts. These ·resemblances· are what unify nature, and get us started on achieving sciences.

[Then a paragraph warning against frivolous, fanciful, fictional 'resemblances', in favour of 'real and substantial resemblances' that are 'grounded in nature'. Then:]

Don't ignore the *matches* provided by large-scale aspects of how our world is configured. Take, for example, •Africa and •the region of Peru with the coastline stretching to the Straits of Magellan; these two regions have similar isthmuses and similar promontories, and that won't have come about by accident.

And ·the *match* between· the •old world and the •new world, both of which are very wide towards the north and narrow and pointed towards the south.

A remarkable matching instance is provided by •the intense cold existing in the so-called 'middle region' of the air and •the fierce fires that are often seen to burst out from beneath the ground. These two things ·have in common that they· are ultimates and extremes: the extreme of the nature of •cold toward the edge of the sky, and of the nature of •heat toward the bowels of the earth; ·each of these· coming about through. . . .a nature's rejection of the contrary nature.

A final point: don't neglect the matches that there are amongst the axioms of the sciences. [He cites a rhetorical device and a matching musical one; and an axiom of arithmetic and a matching rule about syllogisms. Then:] In short, it will be *very* useful in *many* cases if as many people as possible put their minds to work hunting down physical matches and similarities.

28. Class 7 of privileged instances: **unique instances**, which I also call 'irregular' instances. . . . These consist in bodies that seem to be out of line, almost cut off from the order of nature, having very little in common with other things of the same kind. Where matching instances are like *one another*, unique instances are only like *themselves*.

Unique instances are useful in the way that concealed instances are [see the start of **25** at page 73]. They are useful because they lead us to •pull out ·for separate inspection· the nature ·that makes the thing unique· and to •relate it to other natures, the aim being to discover •genera, common natures, that can then be divided up on the basis of genuine •specific differences. We shouldn't stop investigating until the properties and qualities we find in things that might be seen as *natural wonders* have been analysed and brought under some •form, some •definite law. In that way, every irregularity or singularity can be found to depend on some common form, and the only 'natural *wonder*' won't be in the species itself but in

Latin: *differentiis accuratis et gradu et concursu raro*

literal meaning: the exact differences and degrees and the unusual combination

actually meaning: ??

whereas *now* the thoughts of men don't get beyond calling such things 'secrets' and 'monstrosities' of nature, as though they had no causes and were exceptions to general rules.

Examples of unique instances are

the sun and moon—among stars
the magnet—among stones
mercury—among metals
the elephant—among quadrupeds
sexual sensations—among kinds of touch
scents that hunting dogs pick up—among kinds of smell.

Also, grammarians regard the letter S as unique because of how easily it combines with ·other· consonants, sometimes with two or even three, which no other letter does. Unique instances should be prized because they sharpen and quicken investigation and refresh intellects that have been made stale by habit and the common course of things.

29. Class 8 of privileged instances: **deviant instances**, that is, errors of nature, random and freakish things or events, in which nature turns aside and goes off her usual course. •Errors of nature differ from •unique instances in this: the latter are prodigies of •species, the former of •individuals. But they are alike in what they are useful for, namely •as a corrective for the effects on the intellect of the ordinary run of events, and •to reveal common forms. For we must approach deviant instances in the same way as unique instances: we must keep working at them until we discover the cause of the deviation. . . . If you know nature's ·regular· ways you'll more easily observe the deviations; and conversely if you know the deviations you'll more accurately describe nature's ·regular· ways.

Deviant instances differ from singular instances in being much more usable in practical and experimental work. It would be very hard to •produce a new species, but much easier to •vary a known species and from that to produce many rare and unusual results. It is easy to move from natural wonders to artificial wonders; for once we have detected a natural deviation and found out why it occurred, it won't be hard to create as many deviations from that nature as we wish, leading it •by artificial means to the point ·of deviation· which it had reached •by accident. And not only to that one point, but also to others, for errors in one area point the way to errors and deflections elsewhere. I needn't give examples of deviant instances, because there are so many of them. We should make a collection or particular natural history of all the weird and wonderful things to which nature gives birth—of every natural item that is new or rare or out of the ordinary. Our standards ·for admission into our catalogue of natural wonders· must be of the very highest, so that our results will be believed. We should be especially sceptical about wonders that depend in any way on religion, like the ones that Livy recounts, and also about ones that we find in writers on natural magic or alchemy and other fable-loving men of that sort. We should accept ·into our natural history· only things drawn from serious and credible history and trustworthy reports.

30. Class 9 of privileged instances: **borderline instances**, which I also ·though not again in this work· call 'instances of sharing'. They exhibit species of bodies that seem to be made up out of two species, or elements that lie between one species and another. These instances could properly be classified as *unique* instances, since in the whole scheme of things they are rare and out of the ordinary. But they are important enough to deserve a class of their own, for

- •they are excellent indicators of the composition and structure of things,
- •they suggest causes for *how many* and *what* ordinary species the world contains, and
- •they lead the intellect from what *is* to what *can be*.

Examples of these ·borderline instances· are:

- •moss, which is between putrescence and a plant,
- •some comets, between stars and blazing meteors,
- •flying fish, between birds and fish,
- •bats, between birds and quadrupeds,
- •the ape, ·between man and beast·

—the ape of which Ennius wrote 'the ape, repulsive creature, how like us!'. Also mongrel animals that mix two different species, and the like.

31. Class 10 of privileged instances: **instances of** ·human· **power**. . . .which I also call 'instances of man's ingenuity' or 'of his physical skill'. These are the noblest, most perfect—as it were the *ultimate*—products of each ·human· art. [As noted on page 1, 'art' in this work refers to any human activity that involves techniques and requires skills. In the present section Bacon is evidently thinking mainly of practical 'arts' such as engineering, weaving, glass-blowing etc., though his mention of 'liberal arts' may be a gesture towards painting, music, poetry etc.] Our main object ·in science· is to make nature serve *our* needs and wants; and it's suitable to that end that we should list the works that are already in man's power (like listing the provinces that have already been subdued and occupied ·before embarking on new conquests·), especially the clearest and most perfect of them; because they are a good starting-point for the journey. . .

Bacon wrote: . . . *ad nova et hactenus non inventa.*

It could mean: . . . towards new things (·techniques or devices·) that haven't yet been invented.

Or it could mean: . . . towards new things (·scientific results·) that haven't yet been discovered.

For if you think hard about these ·most perfect works·, and push on from them with energetic zeal, it surely won't be long before you •develop and extend them or •deflect them to something new in their neighbourhood or •apply them to an even nobler use.

But that's not all. Rare and extraordinary works of •nature stimulate the intellect to investigate and discover *forms* capacious enough to include them, and—·this being my present point·—excellent and wonderful works of •art do the same thing. Indeed they do it even more ·than natural wonders do·, because with an •artificial wonder it is usually pretty clear how it was discovered and how it works, whereas for •natural wonders this is usually quite obscure.

But we must be *very* careful not to let wonderful works of art hold the mind down, tether it to the ground, so to speak. The danger is this:

> There's a risk that these works of art—which seem to be the high points of human activity—will capture and bewitch the intellect so that it can't make any further progress, because it will think that nothing of this sort can be done except in the way that *those* were done—perhaps improved by a little more work and more careful preparation.

The truth of the matter is quite different! It is quite certain •that the ways and means so far discovered for constructing things and carrying out processes are mostly very poor affairs, and •that all major power depends on—flows from the springs of—forms, and so far *no forms have been discovered*.

I gave examples of this earlier [[1]**109**]; someone who gave his life to thinking hard about the war engines and battering-rams of the ancients wouldn't light on the discovery of cannon acting by means of gunpowder. And if he studied and thought about the manufacture of wool and cotton, he would never be led to discover the nature of the silkworm or silk.

All the most outstanding discoveries—think about it!—have been brought to light not by •small elaborations and developments of ·already-established· arts, but entirely by •chance. Now, chance takes *ages* to achieve anything; but the only way of moving faster than that is through the discovery of forms.

I needn't give examples of instances of power—there are so many of them. What *does* need to be done is this: seek out and thoroughly inspect all the mechanical arts, and all the liberal arts too (so far as they deal with works), and on that basis make a collection—a detailed history—of each art's most accomplished and perfect works, including their modes of production or operation.

But I don't restrict this project to works that set us wondering, the acknowledged masterpieces and mysteries of an art. ·Those are *not* what we should be mainly concerned with·, because ·our wonder at something is not a good indicator of its being scientifically significant·. Wonder is the child of rarity! Rare things make us wonder even if they are of quite ordinary kinds. Whereas things that really *do* call for wonder because of how they differ in kind from other species, if they are in common use in our environment, are hardly noticed.

Unique products of •arts should be attended to, just as should the unique products of •nature, which I have already discussed, ·and let us remember not to confuse 'unique' with 'unfamiliar'·. Although the sun, the moon, the magnet and so on are extremely familiar things, I count them as unique instances of nature; and we should have the same attitude to unique instances of the arts.

For example, one unique instance of art is *paper*, which is a very ordinary ·and familiar· thing. But, now, think about how most artificial materials are made. Some are textiles, woven from threads—silk, wool, linen or the like—at right angles. Others are made of dried liquids—brick, earthenware, glass, enamel, porcelain, and so on. When these are well compacted, they shine; otherwise they are hard but not shiny; and they are all brittle—they don't hold together ·when dropped onto a hard surface, for instance·. In contrast with all this, *paper* does hold together; you can cut or tear it (·which you can't do with glass etc,·); so that it imitates and almost rivals the skin or membrane of an animal, the leaf of a plant, and other such products of nature. It isn't brittle as glass is, or woven from threads as textiles are. Just like natural materials, it has *fibres* but not distinct *threads*. You'll have trouble finding any other artificial material like paper—it is in fact altogether unique. The best artificial things are •the ones that imitate nature most closely and •·the ones that don't imitate nature *at all*·—the ones that stand up to nature and turn it on its head.

Don't treat juggling and conjuring tricks as negligible instances of man's ingenuity or of his physical skill. The uses to which they are put are trivial and frivolous, but there may be something to be learned from them.

Lastly, we shouldn't leave out superstition and magic (in the ordinary sense of that word). Such things lie buried deep beneath a mass of lies and fables, but they should be looked into a little to see whether some hidden natural operation is at work in them—as in spells,

Latin: *fortificatione imaginationis,*
literal meaning: strengthening of the imagination,
actual meaning: ?

agreement between things at a distance, transmission of impressions from mind to mind as well as from body to body, and the like.

32. Classes 1 through 5 of privileged instances shouldn't be collected •until a relevant nature is being investigated, and the same holds true for most of classes 11 through 27, which are still to come. But what I have said makes it obvious that the collecting of instances in classes 6 through 10—namely

matching instances
unique instances
deviant instances
borderline instances
instances of ·human· power

—should be begun •right away, as a sort of particular history. Instances of those kinds can ·help to· organize the materials that the intellect takes in, correcting the poor job that is made of this by the intellect itself, which is absolutely bound to be affected, infected, and eventually perverted and distorted by the constant assaults of everyday impressions.

So these instances should be used as a preliminary to correcting and cleansing the intellect. ·They *can* do this· because anything that draws the intellect away from the things it is used to smoothes and levels its surface for the reception of the clear dry light of true ideas.

Such instances also clear and pave the road leading to practical applications, as I'll say in the proper place, when I come to deal with the move ·from the theoretical· to the practical. [He doesn't reach this in the present work.]

33. Class 11 of privileged instances: **instances of friendship** and of **enmity**, which I also call 'instances of fixed propositions'. ·Let N be the nature we are inquiring into. Then· instances in class 11 are the ones that exhibit a body or concrete substance which *always* brings N with it (as though N were a friend) or *never* does so (as though N were an enemy). [Bacon says this more colourfully, but the content is the same.] From instances of this kind we form sure universal propositions, either affirmative (·friend·) or negative (·enemy·), in which the subject is a concrete body and the predicate is the nature N. Particular propositions are wholly *un*fixed. I mean propositions in which the nature in question is found to be fleeting and movable with respect to any concrete body—sometimes •had or acquired by the body and sometimes •lacked or lost by it. That is why particular propositions have no special privilege—except in the case of *shifting* which I have already discussed [in **23** on page 71]. Still, even these particular propositions are useful when considered alongside universal propositions, as I shall show in the proper place. [He seems not to do so in this work.] For a proposition to count as 'universal' I don't require that it make a flawless and absolute affirmation or negation. There may be exceptions to it, but they must be rare and unique.

What instances of friendship are useful for is *narrowing down* the search for the form we are investigating. An instance of shifting tells us that the form of the nature we are investigating must be

> something that the *shifting* event either passes along or wipes out;

this ·lays a constraint on the nature in question, and in that sense· narrows down the search for it. Well, in a similar way, an instance of friendship (or of enmity) tells us that the form of the nature we are investigating must be

> something that enters as an ingredient into the make-up of that concrete body (or that refuses to enter it).

Thus, someone who knows what the constitution or microstructure is of such a body is well on the way to discovering the form of the nature in question.

Suppose for example that we are inquiring into the nature of *heat*. An instance of friendship is flame. For in water, air, stone, metal and most other substances heat is variable—it comes and goes—whereas *all* flame is hot, so that heat is *always* there when things come together to compose flame. But no instance of enmity towards heat is found in our world. We have no sensory evidence about the bowels of the earth, but of all the bodies that we *do* know there is not a single one that isn't susceptible of heat.

Or suppose we are inquiring into the nature of *solidity*. An instance of enmity towards solidity is *air*. Metal can be liquid or solid, so can glass; and water can be solid, namely when it is frozen; but it is impossible that air should ever lose its flowingness and become solid.

Regarding such instances of fixed propositions two cautions should be given—they bear on our present concern. **(1)** Where ·for a given nature· there is *no* universal affirmative or negative, that fact should be carefully noted as a definite negative result. That's what I did in the case of heat, for which nature offers no universal negatives so far as we can tell from our experience. Similarly, if we were investigating the nature of eternalness or incorruptibility—·i.e. investigating what would make something resistant to *ever* going wrong or falling apart·—there are no universal affirmatives to be found in our experience. For eternalness or incorruptibility can't be predicated of any of the bodies lying on the surface of the earth; ·and that—returning now to my warning—is a definite fact that we would have to take note of in such an inquiry·. **(2)** As well as universal propositions, affirmative or negative, concerning any concrete body, we should take note of concrete substances that come nearest to being negative ·or positive· instances of the nature we are inquiring into. If the nature is heat, the gentlest and least burning flames (·which are hot, but barely hot·); if it is incorruptibility, gold (·which isn't outright incorruptible, but comes close·). Such instances point to the line nature draws between being and non-being, ·e.g. between being and not being hot, or between being and not being corruptible·. They help to lay down the limits of the forms, preventing them from slithering and wandering beyond the conditions of matter.

34. Class 12 of privileged instances: **terminal instances**. . . . These ·instances of *extremes*· are instructive not only when attached to fixed propositions but also by themselves and in their own nature. For they clearly indicate

- •nature's real divisions,
- •the real measures of things,
- •how far a given nature can act or be acted on, and
- •the shift from one nature into another.

Examples: gold (·a terminal instance of· weight), iron (hardness), the whale (animal size), the dog (sense of smell), gunpowder explosion (speed of expansion), etc. And we should take note of extremes at the bottom of the scale as well as at the top—e.g. alcohol (·a terminal instance of·

weight), silk (softness), skin-grubs (animal size) etc.

35. Class 13 of privileged instances: **instances of alliance or union**. These are the ones that mix and unite natures that are ·generally· thought to be heterogeneous and are marked and set down as such in the accepted classifications.

Instances of alliance show that operations and effects attributed to some one nature as special to *it* may belong also to other ·supposedly· different natures, and that this supposed difference isn't genuine—it doesn't get down to the essences of the things, but consists only in different special cases of a common nature. So they are extremely useful in raising the intellect from •·specific· differences to •genera, and in getting rid of phantoms and false images of things that come before us, *masked*, in concrete substances.

Suppose for example that we are investigating the nature of heat. We are offered, as something very official and authentic, a three-part classification of kinds of heat:

> the heat of heavenly bodies,
> the heat of animals, and
> the heat of fire.

And we are told that these heats are distinct and heterogeneous in their actual essence and species—that is to say, in their specific nature. This is held to be especially true of the heat of fire as against the other two, because the heat of heavenly bodies and of animals •creates and nourishes, while the heat of fire •spoils and destroys. Well, then, here is a quite ordinary experience that provides an instance of alliance ·between the heat of heavenly bodies and the heat of fire·:

> A vine-branch is brought into a house where a fire is constantly kept burning, and the grapes on it ripen a whole month sooner than they would have out of doors. Thus, the ripening of fruit that is still on the tree, which would seem to be work for the sun, can be done by fire.

This makes it easy for the intellect to *rise*, •rejecting the notion of essential heterogeneity, •accepting that the heat of the sun shares a common nature with the heat of fire, and •investigating the real differences between them that cause them to work so differently ·in so many cases·.

There will turn out to be four of these differences. **(1)** The heat of the sun is far gentler and softer than the heat of fire. **(2)** The heat of the sun, especially as it reaches us through the air, is much more humid than the heat of fire. **(3)** The main difference: the heat of the sun is exceedingly inconstant, now approaching and increasing, now receding and diminishing. That's what contributes to the generation of bodies. For Aristotle was right when he said that the principal cause of births and deaths on the surface of our planet is the oblique course of the sun through the zodiac, which produces enormous variations—day and night, summer and winter—in how much heat the sun gives. But the man went straight on to twist and distort his good discovery. Laying down the law to nature in his typical manner, he dogmatically says that births are caused by the sun's coming closer, and deaths by its retreating; whereas really *each* plays a role in births *and* deaths, both of which are partly caused by *inconstancy* in the heat from the sun. . . . **(4)** Another very important difference between the heat of the sun and the heat of fire: the sun operates by gentle action through long periods of time, whereas fire, egged on by man's impatience, does its work much more quickly. [He goes on to say that a carefully managed *slow* and *irregular* fire would be enough like the sun in its effects to cure us of the notion that fires and heavenly bodies produce radically different kinds of heat. And he offers further instances of alliance in which fires do the work of the sun in reviving half-frozen butterflies, hatching eggs, and curing apoplexy. Then:] [In the next paragraph, 'rotate' doesn't cover a thing's rotating on its axis; the topic is moving around a closed loop, not necessarily a circular one.]

Or suppose we are investigating the nature of motion and rest. There seems to be wide acceptance of the three-part division according to which bodies

rotate,
move in a straight line, or
don't move.

This is supposed to have deep philosophical roots, because a body must either

move without a terminus,
move towards a terminus, or
stay still at a terminus,

·the idea being that those three exhaust the possibilities·. It seems that the heavenly bodies are the ones that perpetually •rotate; that the globe of the earth is •stationary, and that other bodies move •straight up or •straight down, depending on whether they are light or heavy. The theory is that so-called 'light' or 'heavy' bodies are ones that are displaced from the region where they naturally belong, and that their up or down movements take them ·towards their proper regions, i.e.· towards masses or accumulations of bodies that are *like* them—light bodies upward towards the circuit of heaven, heavy ones downward towards the earth.

That's all very fine, but we have an instance of alliance in one of the lower comets that is far below the heaven and yet rotates. (Aristotle's fiction of a comet being tied to or following some one star has long been exploded, not only because it is such an unlikely theory but also because we *see* that the comets wander irregularly through various parts of the sky.)

Another instance of alliance on this subject is the motion of air. In the tropical regions, where the circles of rotation are larger, the air seems to *revolve* from east to west.

[He goes on to say that a full understanding of tides might reveal that 'rotatory motion is not limited to heavenly bodies, but is shared also by air *and water*'. Then:]

Even the upward movement of light objects is subject to variations ·that aren't recognized in the official three-part story·. A bubble of water can serve here as an instance of alliance. Air under water rises quickly to the surface; it isn't raised by any •effort or struggle of its own, but by being •*pushed* upwards. . . .by the descending water. When the air reaches the surface of the water ·it forms a bubble, that is· it is stopped from rising higher, by the water's slight resistance to parting from it; so its own tendency to rise must be very slight.

Or suppose we are investigating the nature of weight. The accepted view is that

- •dense and solid bodies move toward the centre of the earth, while
- •rare and light bodies move toward the circuit of the sky,

and that in each case the body in question is moving towards *its proper place*. Now, despite what they teach in the universities, it is just silly and childish to suppose that *place* can *do* anything. Some philosophers have said that if a hole were bored right through the earth, heavy bodies would fall to its centre and then stop. This ·implies that mere place—the centre of the earth—has some causal power; and it· is just babble. The only things that can act on bodies are bodies. A place is a mathematical point, a sort of *nothing*; what a wonderfully powerful *nothing* it would be that could act on bodies and attract them to itself! Actually, a body's tendency to rise or fall depends either on its microstructure or on its sympathy or agreement with some other body. If we can find any dense body that doesn't move towards the ground, that puts an end to this distinction—·i.e. this treatment of dense-down and light-up as the basic story about weight. *Can* we find such a body·? Well, if Gilbert is right that the earth's magnetic power extends out beyond the surface of the earth so far and no further, there will be heavy bodies that it doesn't attract—and thus that don't fall downwards—because they are outside its sphere of influence. If we could find just one such body, that would give us an instance of alliance on the subject of weight. But we don't yet have any clear and uncontroversial example of this. The nearest we have to come to one, it seems, is with the waterspouts [Latin *cataractae coeli* = 'waterfalls of the sky'] that are often seen in the Atlantic Ocean. A waterspout suddenly discharges so much water, and with such force, that it seems that the water had gathered in that place ·in the sky· and to have •stayed hanging there until it was *thrown* down by some forceful cause—rather than to have •fallen by the natural motion of its weight. So we may conjecture that a dense and compact mass at a great distance from the earth would hang there like the earth itself until some cause pushed it down. But I am not confident about this. Note in passing that sometimes, as here, I can't produce clearly correct instances and have instead to fall back on suppositions for my examples. This shows how poor we are in natural history,

Or suppose we are investigating the nature of *intellectual activity*. The distinction between •human reason and •animal resourcefulness seems to be a perfectly correct one. Yet sometimes animals act in ways that seem to reflect logical thinking on their part. For example the old story of a crow which, half dead from thirst, saw some water in the hollow trunk of a tree, found the opening too narrow to get through, and proceeded to drop in pebbles until the water rose high enough for it to drink. This became proverbial.

[And one last example, an alliance challenging the supposedly deep division between light and colour.]

36. Class 14 of privileged instances: **signpost instances**, borrowing the term from the signposts that are set up at road-junctions indicating where the various roads go. I also call them 'decisive instances' [and he gives them three other names that don't occur again in this work]. I explain them thus. Sometimes when investigating a nature N the intellect is so balanced as to be unsure which of two or more natures it should take to be the cause of N (this happens because very often many natures occur close together). What a signpost instance does is to show that •one of the ·candidate· natures is linked with N firmly and unbreakably while •the other is linked with N only sometimes, erratically. That settles it: the former nature is accepted as the cause of N, while the latter is rejected. Such instances are very illuminating and have great authority; sometimes they provide the finishing touch that *completes* a process of interpretation. It sometimes happens that within a set of instances what we already know about one of them turns out to be a signpost instance, but most signpost instances are new, and have been deliberately looked for and uncovered only by hard clear-thinking work.

For example, suppose we are investigating the nature of the ebb and flow of the sea—which ebbs and then comes up again twice a day, taking six hours each time with slight variations in that corresponding to the motion of the moon. Here now is a road-junction.

This motion ·of the sea· *has to* be caused in one of these two ways:

(1) It is caused by the backward and forward motion of the waters; compare water sloshing back and forth in a basin, going up on one side as it goes down on the other.

(2) It is caused by the up and down motion of the waters; compare the rise and fall of boiling water.

Which of these two causes should be assigned as causing the ebb and flow of the sea? If we adopt **(1)**, we'll have to accept that when there is a high tide on one coast there must be at the same time a low tide on the other coast. So that is what we investigate. Now careful observers have found that high tides on the Florida coast occur at the same time as *high* tides on the coasts of Spain and Africa, and low tides also occur at the same time on the two sides of the ocean. This seems decisively to rule out hypothesis **(1)** in favour of **(2)**, but on a closer look it turns out not to. For it can happen that a body of water is moving the same way and yet rises on the opposite shores of the same channel at the same time; all that is needed for this is that the water is being pushed along from some *other* direction. That's what happens when the level of a river rises because of water flowing in from the sea; the flow is in *one* direction, but the level rises on *both* banks. Perhaps something like that is happening with the tides. Perhaps a great mass of water from the Indian Ocean pushes into the basin of the Atlantic, thereby producing high tides on both sides at once. So we have to investigate whether there is anywhere for the water to be retreating and going down at the same time, ·because according to hypothesis **(1)** there can only be high tides somewhere if at the same time there are low tides *somewhere*·. Well, we have the Pacific Ocean, which is big enough for the purpose—it is actually bigger than the Atlantic.

Now at last we have reached a ·possible· signpost instance in this matter. If we find for certain that when there is a high tide on the coasts of Florida and Spain in the Atlantic there is also a *high* tide on the coasts of Peru and of China in the Pacific, then on the authority of this decisive instance we *would* have to reject the hypothesis **(1)** that the ebb and flow of the sea occurs by a forward motion; for there is nowhere for the forward-moving water to *come from*. (The easiest way to settle this would be to ask the inhabitants of Panama and Lima, where the Atlantic and Pacific are separated by a small isthmus, whether the high and low tides occur on the opposite sides of the isthmus at the same time, or whether instead a high tide on one coast is matched by a low tide on the other.) Now the outcome of this inquiry seems to settle the issue between **(1)** and **(2)**—*if we assume that the earth is immovable*. If the earth revolves ·on its axis·, however, it may be that the waters of the ocean are sometimes forced up into a pile which then collapses, letting the waters down again, all this being a result of differences (in speed or force) between the movement of the earth and the movement of the waters. This should be investigated separately. This hypothesis ·provides an alternative to the thesis that high tides on some coasts must coincide with low tides *on some other coasts*, but it· doesn't disturb the thesis that when the sea goes up somewhere it must go down *somewhere else*.

Now, suppose we have done what is needed to refute hypothesis **(1)** and have therefore accepted the hypothesis **(2)** that the tides come from the sea's rising and sinking. The inquiry into how that could happen is faced with a three-way fork in the road. (a) A large amount of water flows from the interior of the earth into the oceans, and then back again. (b) The amount of water in the oceans stays the same, but it changes in how dense it is, so that it can take up more space (high tide) or less (low tide). (c) The amount of water stays the same, and so does the amount of space it occupies, but portions of it are raised by some magnetic force attracting them from above and then by agreement letting them fall back again.

[Here 'agreement' translates the Latin *consensus*. Bacon quite often speaks of *consensus* between inanimate bodies, and he explains it on page 125 thus: 'Agreement ·between two things· is just a symmetry between the forms and microstructures of one and those of the other.' *Consensus* can also mean 'joint action', and it seems clear that Bacon at least sometimes thinks of it in causal terms. At the end of **31** he includes 'agreement between distant objects' in a short list of things that *may* have something real behind them but that 'lie buried deep beneath a mass of lies and fables'; and his topic there seems to be *action* at a distance. If in our present example 'agreement' is meant causally, he is representing this magnetic attraction as involving causal input both from the magnet in the sky and from the water below. In this version of the work, *consensus* will be translated by 'agreement' throughout.]

Allow me to set aside (a) and (b), and look only into the question of whether (c) there is any such raising by agreement or magnetic force. First point: the waters lying in the bed of the sea can't all be raised at once, because there is nothing to take their place; so even if the waters did have such a tendency to rise, it would be blocked from having any effect by the way things hang together—uneducated people would say that it would be blocked 'so as not to create a vacuum'. So we are left with the thesis that the waters are raised in one place and therefore are lowered in another ·so as to flow in and take the place of the water that is raised·. And the thesis will have to be that since the magnetic force can't act on the whole ·body of the ocean's water· it must act with the greatest intensity on the middle, lifting the water in the middle while the rest falls away from the sides.

At last we come to a signpost instance on this subject. If we find that

> at low tide the surface of the water is more arched and round, with the waters rising in the middle of the sea and falling away at the edges, i.e. at the coasts, and at high tides the surface of the sea is flatter as the waters return to their former position,

then on the authority of this decisive instance we can accept the ·theory about· the raising of the waters by magnetic force; otherwise it must be utterly rejected. It wouldn't be hard to find out whether this is so, using sounding lines to discover whether at the times of ·coastal· low tides it really is deeper in the middle of the sea than it is at the times of high tides. Notice, incidentally, that if this *is* how things stand, then contrary to the common opinion the water rises in low tides and falls in high tides!

Or suppose we are investigating the nature of the spontaneous motion of rotation, and in particular the question regarding the daily motion in which it looks to us as though the sun and stars rise and set: Is it •a real rotation by the heavenly bodies, or •an apparent motion by them and a real motion of the earth? We would have a signpost instance for this topic if we found that:

- •There is some east-to-west movement (perhaps very faint) in the ocean, and
- •a similar motion is found to occur in the air and to be slightly faster (·we should look for this· especially in the tropics, where the larger circumference would make the movement easier to detect), and
- •the same motion, but now very lively and strong, is found in the lower comets, and
- •it is found in the planets, conforming to the pattern that the further a planet is from the earth the faster it moves, with bodies in the starry regions moving the fastest of all.

In that case we should accept that the daily motion really does occur in the heavens, and that it the earth doesn't take part in it. Why? Because it will be clear that •the east-to-west movement occurs throughout the cosmos, by the agreement of the universe, and that •it is fastest in the highest parts of the heavens and gradually becomes slower until eventually it stops, is extinguished, when it meets the unmoving part of the universe—namely the earth.

[Bacon's next two difficult paragraphs describe another supposed signpost instance for settling a different question about motion in astronomy. Then:]

Or suppose we are investigating the nature of weight or heaviness. Here the road branches into two:

> Heavy things either •tend of their own nature towards the centre of the earth because of their own microstructure or •are attracted by the bodily mass of the earth as an agglomeration of bodies of the same kind, being carried towards it by agreement.

If the latter of these is right, it follows that •the closer heavy things come to the earth the more powerfully they move towards it, and that the further away they are the more weakly and slowly they move (as is the case with magnetic attraction); and that •this ·attraction· is confined with certain limits, so that if something is so far away that the earth's power ·of attraction· couldn't act on it, it won't fall to earth but will rather remain suspended—like the earth itself! Here is something that would be a signpost instance ·at this junction·. Take a clock that is powered by leaden weights, and another powered by an iron spring. Ensure that neither goes faster than the other (check this carefully). Then place the weight-driven clock on the top of a very high steeple, keeping the other at ground level, and check whether the clock on the steeple goes more slowly than it did because of the lessened power of its weights. Then repeat the experiment in the bottom of a very deep mine, checking on whether the clock in the mine now goes faster than it did because of the increased power of its weights. If the weights are found to have less power on the steeple than at ground level, and more in the mine, this confirms that attraction by the mass of the earth is the cause of weight.

Suppose we are investigating the nature of the polarity of an iron needle that has been touched by a magnet. This leads to a two-way fork in the road: it must be the case that either

- •the touch of the magnet itself gives the iron a north-south polarity, or
- •the magnet merely activates the iron, preparing it to receive its motion from the presence of the earth.

Gilbert thinks the latter is right, and has worked hard to prove it. All his observations, collected with such alert intelligence, come down to two things. **(1)** An iron nail that has lain for a long time along a north-south line, untouched by a magnet, acquires north-south polarity. The idea is that the earth itself •activates the iron in the way the touch of a magnet would have done, and then •conforms the iron (now in its activated state) to itself, ·i.e. to the earth·, and makes it turn ·like a compass-needle·. It takes a long time to do this, Gilbert maintains, because of how far away the nail is ·from the part of the earth that activates and polarizes it·; according to him the surface or outer crust of the earth has no magnetic power. **(2)** If red-hot iron is allowed to cool while lying along a north-south line, it also acquires polarity without the touch of a magnet ·and without lying there for a very long time·. The idea here is that the particles of the iron are stirred into motion by the heat and then, while they are calming down as the iron cools, they are more than usually susceptible—more *sensitive*, as it were—to the ·magnetic· power emanating from the earth; so that that power is able to activate the iron. These are good observations, but they don't quite prove what Gilbert says they do.

Here is something that would be a signpost instance on this question: Take a magnetic globe [Latin *terrella* = 'little earth'] and mark its poles; then orient the globe so that the line between *its* poles is the earth's east-west and not its north-south line, ·the latter being of course the line between the big earth's poles·. Then place an untouched iron needle on top of the globe, ·lying in the earth's north-south line·, and let it stay there for about a week. While it is there, the needle will swing away from the earth's north-south line and align itself with the line between the poles of the globe, ·the little earth·; there is no doubt about this. So there is the needle, lying on the globe and pointing east-west. Now take the needle right away from the globe, and put it on a pivot ·that will let it rotate, as did the surface of the globe·. •If it then, suddenly or gradually, aligns itself north-south, then ·that settles it·: its polarity is caused by the earth. •If on the other hand the needle aligns itself east-west as it did on the globe, or loses its polarity altogether, that casts doubt on the thesis that the earth causes the polarity, and further investigations are needed.

[Then two paragraphs about possible signpost instances for the question 'What is the moon made of—is it light and airy or solid and dense?' Then:]

Or suppose we are investigating the nature of the motion of projectiles (javelins, arrows, balls, etc.) through the air. The ·Aristotelian· schoolmen have—of course!—dealt with this very carelessly. [Re this next bit, see page 17.] They have thought it enough

- •to label it 'violent motion' as distinct from what they call 'natural motion' ·such as the motion of a falling body·, and
- •to account for the start of such motion in a collision by the axiom that two bodies can't be in the same place ·at the same time· because matter is impenetrable.

That explanation ·tells us that when body x bumps into body y it doesn't melt into it·, but the schoolmen don't concern themselves with what happens *after* the moment of collision. The two-way fork in the road on this question goes as follows. Either

- •this motion occurs because the air carrying the moving body collects behind it, as a stream does in the case of a boat. . . .or
- •it occurs because the parts of the body don't stand up to the collision but rather push forward in succession to get away from it.

The former view is adopted by. . . .nearly everyone who has looked into this kind of motion with any care, and there is no doubt that the air has *something* to do with it; but countless experiments show that the other account is certainly the true one. Here is just one of them, a signpost instance on this subject: Take a thin iron plate or a stiff piece of iron wire,. . . . bend it into a curve between your finger and thumb, ·and then remove your thumb·; the iron will spring away. Obviously this motion can't be attributed to air gathering behind the body, because the source of motion is in the middle of the piece of iron not at its end.

[Then two paragraphs about the explosion of gunpowder: is this just a case of the general phenomenon of *hot things expanding* or is there more to it? Bacon thinks there is more to it, and cites a couple of signpost instances that he says point that way. Then:]

Or suppose we are investigating the transitory nature of flame, its capacity for being quickly snuffed out. It seems that here in our world there is nothing fixed and stable about flame; it is generated at every moment and then instantly extinguished. When we see something going on burning for a long time, what we see throughout that time is not •the very same individual flame, but rather •a series of new flames generated one after another. That it's not the same individual flame all through is easily seen from the fact that the flame instantly dies when its fuel, its nourishment, is taken away. Here is a two-road fork in this investigation: the short-lived nature ·of flame· comes either from •the stopping of the cause that first started it (as with the short-livedness of light, sounds, and the so-called 'violent' motion ·of projectiles·) or from •the flame's being intrinsically able to continue in our world but being destroyed by the so-called 'violence' it meets with from contrary natures that surround it. ·Briefly, this is a choice between •'The flame is *allowed* to go out' and •'The flame is *made* to go out'·. Here is a possible signpost instance on this road. [Bacon's account of the signpost instance that is supposed to favour the second of the two hypotheses, is hard to make understandable without breaking away from his wordings. The gist of it is this: Flames are pyramids; the broader a flame is at its base, the higher it leaps. Flames at the centre of the pyramid are surrounded by other flames, and thus aren't under attack from •anything else that works against flame; but flames around the edge are constantly under attack from •the surrounding air, which is why the column of flame gets thinner the higher it goes. Three other details should be reported. **(1)** The flame going up the centre of the pyramid is numerically the same flame throughout, not a succession of short-lived flames. (This seems not to be an essential feature of the signpost instance.) **(2)** Air is receptive to smoke, just as it pushes against flame. That is why smoke forms an *inverted* pyramid. **(3)** One upshot of all this is the untenability of the idea that flame is just burning air.]

[Then Bacon offers a second more precise signpost instance. Then:]

That is enough about signpost instances. I have spent so long on them so that men may gradually get into the habit of judging natures by signpost instances and illuminating experiments, rather than by probable reasoning.

37. Class 15 of privileged instances: **instances of separation**, which indicate the separation of natures that commonly occur ·together·. Because they concern the separation of one nature from another *nature* they are different from the instances ·of enmity· that I presented along with the instances of friendship [in **33**, page 82], in that the latter concern the separation of a nature from some *concrete thing* that ordinarily has it. They differ from signpost instances because they don't *settle* anything, but merely point out the separability of one nature from another. What they are good for is to detect false forms and to blow away flimsy theories suggested by what lies on the surface. You could say that they add leaden weights to the intellect [see [1]**104**].

Suppose for example that we are investigating the four natures that Telesio regards as always going together, namely

> heat, brightness, rareness, mobility or readiness for motion.

[Here as elsewhere 'rare' means thin, finely divided, like a fluid or a gas.]

We find many instances of separation amongst these. For air is rare and mobile, but not hot or bright; the moon is bright without heat; boiling water is hot without light; the motion of a compass needle is quick and agile though the needle is cold, dense, and opaque; and there are many more of this kind.

Or suppose we are investigating corporeal nature and natural action. It *seems* that natural action isn't found anywhere except in some body; but here too we may be able to find some instance of separation—for example, magnetic action by which iron is drawn to the magnet and heavy bodies are drawn to the globe of the earth, and there may also be other operations that are performed at a distance ·and are therefore not wholly *in* any body·. For action at a distance

> takes some period of time (it doesn't happen in an instant), and operates across some stretch of space. . . .

So there must be some moment M and some location L such that the power or action passes through L at M, and is at that moment suspended *between* the two bodies that are causing the motion. So the question we have to face is this: Is the following the case?

> •The ·two· bodies that are the terminals of the motion organise or modify other bodies that are between them, so that the force passes from one terminal body to the other through a series of actual contacts ·and doesn't involve *action* that isn't in any body·;

Or is the situation rather the following?

> •There are no ·relevant· intermediate bodies; all we have are the ·terminal· bodies, the force or power or action, and the space, ·in which case there is *action* that isn't in any body·.

In rays of light, sounds, heat and certain other things that act at a distance, it's probable that intermediate bodies are organized and altered, especially because they don't work unless there is a suitable medium to carry the force. But magnetic or attractive force works with any kind of medium; there is no medium that blocks or lessens it. And

> if •the power or action has nothing to do with any intermediate body, it follows that •there is a natural force or action existing at some time and *in some place* without being *in any body* (since it isn't in the terminal bodies or in any intermediate body).

So magnetic action may be an instance of separation between corporeal nature and natural action. [The remainder of this paragraph alters the order of Bacon's text but not its content.] And there is an **important corollary**, which I now expound. Consider these two propositions:

> **(1)** Only bodies can *transmit* natural action.
> **(2)** Only bodies can *generate* natural action.

They both look to be true, ·and one would think they stand or fall together·. But now we have found evidence that

> natural power and action can be generated by a body and then operate at some time in some place entirely without any body,

which falsifies proposition **(1)**. And when you deny **(1)** you aren't far from denying **(2)**, which amounts to allowing that

> there are entities and substances—·things that can act·—that are neither made of matter nor *in* matter.

It is remarkable that this case for **the existence of incorporeal substances** comes merely from human empirical science.

38. Now we come to five types of instances that I lump together as 'torchlight instances'. They are instances that help the senses. All interpretation of nature starts with the senses, and leads by a straight, regular, and secure road from •perceptions of the senses to •perceptions of the intellect, which are true notions and axioms. So, inevitably, the fuller and more accurate the representations or offerings of the senses are, the more easily and well everything will go.

Of these five ·classes of· torchlight instances, •the first strengthen, enlarge, and correct the immediate actions of the senses; •the second bring within reach of our senses things that we ·initially· don't sense; •the third indicate ·the whole extent of· continuous processes of which we usually observe only the beginning, the ending, or episodes along the way; •the fourth provide a substitute for the senses when they utterly fail; the •fifth attract the attention of the senses, making them *attend*, and at the same time set bounds to the subtlety of things. I shall now take these up one at a time. [Regarding the second of those: Bacon wrote *deducunt non-sensibile ad sensibile*, which literally means something like 'they lead non-sensible things to being sensible'. When the language of 'bring(ing) within reach' occurs in the next few pages, it will always be a translation of something using the verb *deduco* or the related noun *deductio*.]

39. Class 16 of privileged instances: **door-opening instances**, this being my name for instances that help the immediate actions of the senses. It's clear that eyesight is the most informative of the senses, and is therefore the one that it's especially important to find help for. There seem to be three kinds of aid to eyesight—ones that enable us **(1)** to see things that we now don't see, **(2)** to see things at a great distance, **(3)** to see them more exactly and distinctly. [When Bacon writes about (1) glasses that greatly increase the apparent size of small objects and (2) glasses that bring us into a closer relation with the stars, he is referring of course to (1) the *microscope* and (2) the *telescope*, and those words—which didn't become standard English for another few decades—will for convenience be used in this version.]

(1) The first kind are microscopes—invented not long ago—which greatly increase the apparent size of small objects, thus revealing their hidden, invisible little details and their hidden microstructures and processes. Microscopes enable us to see the exact shape and bodily details of a flea, a fly, a worm, and amazing colours and motions that we had never before seen. It is said that a straight line drawn with a pen or pencil is seen through a microscope to be quite crooked, because neither the motion of the hand (even when aided by a ruler) nor the impression of the ink or pigment is really smooth, though the unevenness is on such a small scale that it can't be detected without such glasses. Some people say that

> microscopes •do honour to the works of nature but •discredit artifacts.

But the truth of the matter is just that

> microscopes •are illuminating about things that have very fine microstructures and •not about things that don't;

and natural things are of the former kind and artifacts of the latter. (·To believe that a *glass* can detect the difference between what's natural and what's artificial· is an instance of something that usually comes into play when a new and wonderful discovery is made—namely *superstition*!) Thus, microscopes are good only for tiny things; if Democritus had seen one he'd have jumped for joy, thinking that a way had been found for seeing atoms, which he had declared to be altogether invisible. However, just because they do their work only when applied to tiny things—and not even for *them* when they are parts of larger bodies—microscopes aren't actually much use. If they could be applied also to larger bodies, or to small parts of larger bodies, so that the texture of a linen cloth could be seen as a net and we could discern the hidden micro-features of gems, liquids, urine, blood, wounds and many other things, that undoubtedly *could* lead to great benefits. (Incidentally, in dealing with this first kind of door-opening instance, I haven't mentioned spectacles—·the sort that people wear·—because they serve only to alleviate defective vision, and aren't ways of getting new information.)

(2) The second kind are telescopes, those other glasses discovered through the memorable efforts of Galileo—glasses that let us develop and maintain a closer relation with the heavenly bodies, as though we could row or sail over to them. Telescopes show us that the Milky Way is a group or cluster of entirely separate and distinct small stars—something that the ancients could only *suspect*. They seem also to show that the spaces of the so-called planetary orbits do have some stars in them, so that the heavens begin to be starry—though with stars too small to be seen without a telescope—before we come to the 'starry heavens'! The telescope lets us see the little stars wheeling as in a dance round the planet Jupiter (from which we may conjecture that there are several centres of motion among the stars). It lets us see and locate the different light and dark parts of the moon, of

which we can make a kind of map of the moon. It lets us see spots on the sun, and other such things. These are all splendid discoveries, insofar as we can safely credit such demonstrations. I am in fact very suspicious of them, because their empirical results stop at these few things; they haven't led to discoveries concerning many other things that are equally worthy of investigation.

(3) Of the third kind are rods for measuring parts of the earth, astrolabes ·for measuring the heights of stars·, and the like. These don't •enlarge the sense of sight, but •correct it and •point it in the right direction.

If there are instances that aid the other senses in their immediate individual actions, but don't add anything to the information already possessed, they aren't relevant to my present concerns, which is why I haven't mentioned them.

40. Class 17 of privileged instances: **summoning instances**, borrowing the name from the civil-law courts, which

> •summon things to appear •that haven't appeared before. . . .

·Analogously·, these instances

> •bring within reach of our senses things •that we ·initially· don't sense.

An object may escape the senses because

(1) it is too far away, or
(2) there are bodies between us and the object, or
(3) the object isn't fit to make an impression on the senses, or
(4) there isn't enough of the object to affect the senses, or
(5) there isn't time for the object to affect the senses, or
(6) the sense-organs can't tolerate the impression of the object, or
(7) the sense is already taken up by another object and has no room for motions caused by this one.

These mainly concern sight, and secondarily touch; for those are the senses that give a wide range of information about •objects in general; the other three senses give hardly any information except immediate information about •objects that are special to each sense.

(1) When an object can't be perceived because it is too far away, the only way to bring it within reach of the ·relevant· sense is to connect it with (or replace it by) some other object that *can* strike the sense from a greater distance—as in spreading news by beacons, bells, and the like.

(2) When the inside x of an object y is concealed from the senses by the part of y that surrounds x, and y can't easily be opened up, x can be brought within reach of the senses by parts of y that lie on its surface or come to its surface from the inside. That is how the condition of the ·whole· human body is known from the state of the pulse, the urine, etc.

(3, 4) The next two kinds of bringing-within-reach apply to ever so many things, and in our investigations of things they should be looked for everywhere. Here are some examples, ·which will occupy the next three pages·.

Air and spirit and other things that are also rare and subtle throughout obviously can't be seen or felt by touch. In investigating bodies like these, it is utterly necessary to resort to devices for bringing within reach. Suppose we are investigating *the spirit enclosed in tangible bodies*, wanting to discover what its nature is and how it acts. Everything tangible in our environment contains an invisible and intangible spirit which it envelops and clothes. This is the source of three powerful and wonderful effects that spirit brings about in a tangible body. If the spirit in a tangible substance is (a) discharged,

> it shrinks the body and dries it up;

if it is (b) ·completely· kept in,

it softens the body and makes it melt;

if it is (c) partly discharged and partly kept in,

it shapes the body, gives it limbs, absorbs, digests, excretes, organizes, and so on.

And all these processes are brought within reach of the senses through their conspicuous effects. ·In the next three paragraphs I shall describe the processes in more detail·.

(a) In every tangible inanimate body the enclosed spirit first •multiplies and then feeds on the tangible parts that are readiest and nearest at hand for that purpose, digests and dissolves them and turns them into spirit; and then they—the spirit that was originally there, and the extra spirit that has been made from tangible parts of the body—•escape together. ·The two parts of this total process are brought within reach of the senses in different ways·. •The multiplication of the spirit and its dissolving of tangible material are brought within reach of the senses by *loss of weight*. Whenever something dries up, there is some decrease in its quantity. I'm not talking about the quantity of spirit that was previously there (because that's irrelevant, as spirit doesn't weigh anything). I'm talking about the tangible material that the body loses because it is turned into spirit. •The discharge or release of the spirit is brought within reach of the senses in the rusting of metals and other similar kinds of going-bad (but don't follow this line of thought out to bodies that start to qualify as *living*, for they involve (c) the third kind of process). What happens in compact bodies is that the spirit finds no pores or passages through which to escape, so it has to *force* its way out, driving tangible parts of the body before it so that they leave the body—as rust or whatever—when the spirit does. The discharge of spirit leaves the tangible body drier than it was, and more condensed; and these changes are brought within reach of the senses by the increased hardness of the body but much more by its splitting, shrinking, wrinkling and folding in on itself. . . .

(b) Contrasting with that: when the spirit is kept in while being expanded and stirred up by heat or something like it (as happens to very dense and hard bodies), then the body becomes soft, like red-hot iron; or it becomes ·even softer, so that it is · able to flow, like a ·white-hot· metal; or it becomes liquid, as do gums, wax etc. So we can easily reconcile the opposite effects of heat, which hardens some things and melts others. When it hardens:

the spirit is discharged, and the hardening is the action of the tangible parts that are left behind;

and when it softens ·or melts·:

the spirit is stirred up and detained, and the melting is caused by the action of the heat and spirit.

[The next two sentences considerably expand something that Bacon clearly intends but says with drastic brevity.] In the melting case, the tangible parts and the spirit are both actively at work in the melting. In the hardening case, the tangible parts do all the work, and the discharge of the spirit figures only as the *occasion* for this—not a partial cause but merely a trigger that releases the cause.

(c) But when the spirit is neither wholly kept in nor wholly discharged, but only tries things out within its boundaries and comes across tangible parts that are obedient and ready to follow, so that they do follow wherever it leads, what that leads to is the forming of an organic body, the development of organs, and all the other life-processes in plants and in animals. What brings these processes within reach of the senses is mainly careful observation of the first beginnings of life—the elements or first attempts at life—in little animals that are generated from putrefaction—ants' eggs, worms, flies, frogs after rain, and so on. For life to start, ·two more things are required·. •There must be gentle heat [*lenitas* *caloris*], so that the spirit isn't rushed into breaking out from the body. And •the body must be flexible [*lentor corporis*], so that the spirit isn't prevented by the stiffness of the parts from folding and moulding them like wax.

Again, there are many bringing-within-reach instances that set before our eyes that most remarkable and far-reaching trichotomy of spirits:

- •isolated spirit [or perhaps: 'spirit cut short']—the spirit of all inanimate substances,
- •simply branching spirit—the spirit of plants,
- •spirit that is both branching and cellular—the spirit of animals.

[There are no further mentions of this trichotomy or any of its members.]

It's obvious that the more fine-grained textures and microstructures of things (even when the body as a whole is visible or tangible) are not perceptible either by sight or by touch. So we get our information about these also through their being *brought* within reach of our senses. Now, the deepest and most basic difference between microstructures depends on how much or how little matter there is in a given stretch of space. All other microstructures, which have to do with the spatial relations amongst the qualitatively different parts of a body, are secondary to this one.

Suppose, then, that we are investigating ·this most fundamental topic·, the nature of the expansion or contraction of matter in bodies, i.e. ·what it is that settles· for each body how much matter it contains in how much space. ·In exploring this, we shall be guided by three important propositions, of which the first is really two in one·. Nothing is truer in nature than the twin propositions:

> •Nothing comes from nothing. •Nothing is reduced to nothing.

This is to say that any given portion of matter—or the sum total of all matter—remains unchanged, not getting larger or smaller. It is equally true that

> •How much matter a given region contains varies according to what kind of body it is contained in.

For example, a given region would contain more matter when completely filled with water than it would when completely filled with air. So that to assert that a given volume of water can be *changed into* an equal volume of air is tantamount to saying that something can be reduced to nothing; and conversely to say that a given volume of air can be *changed into* an equal volume of water is tantamount to saying that something can come from nothing; ·though of course a given volume of water (air) can be *replaced by* an equal volume of air (water)·. The notion of the *denseness* or *rareness* of matter—so widely accepted and so variously understood!—should properly be based on ·this difference in· how much matter there is in this or that region. We should also work with a third proposition which is also quite certain:

> •There are ways of making exact—or nearly exact—numerical comparisons between the amount of matter in one body and the amount in another.

So there is nothing wrong with saying ·for instance· that the amount of matter in a cubic foot of gold is the same as the amount in twenty-one cubic feet of alcohol.

Now, amounts and proportions of matter are brought within reach of the senses by means of *weight*, because •weight corresponds to •amount of matter. (In the thing's tangible parts, that is. A thing's weight doesn't let you calculate how much spirit it contains, because adding spirit to a thing makes it lighter, not heavier.) I have drawn up a pretty accurate table on this subject, in which I have recorded the weight-per-volume of each of the metals, the principal stones, woods, liquids, oils, and most other bodies, natural as well as artificial. This has all sorts of uses, theoretical and practical; and much of what it reveals is quite contrary to expectation. One significant upshot of it is this: Setting aside bodies that are spongy and hollow and chiefly filled with air, and attending only to compact bodies, we can say that all the ones that much concern us lie within the range 1-21, that is, the most dense of them is 21 times as dense as the least dense.

I have also thought it worthwhile to try to find out the ratio of intangible bodies to tangible ones. Here is the experimental set-up that I used. I took a glass bottle that could hold about an ounce (keeping it small so that less heat would be needed to produce evaporation). I filled it with alcohol almost to the brim (selecting alcohol because. . . .it is the least dense—contains the least matter in a given volume—of all tangible bodies except ones that contain pores and hollows). Then I took careful note of the weight of the spirit and bottle together. Next I took a bladder with about a quart capacity, squeezed it flat, getting out as much of the air as possible; having previously rubbed grease into it, to block any pores it might have. I tightly tied the mouth of the bladder over the opening of the bottle. . . . Then I put the bottle above a pan of hot coals. Before long a steam or breath of the alcohol, expanded and made gaseous by the heat, inflated the bladder so that it bellied out in all directions like a sail ·with the wind in it·. Then I immediately took the glass off the fire and put it on a carpet so that it wouldn't be cracked by the cold ·of a bare floor·, and punctured the bladder ·to let the gas escape·, so that none of the gas would liquefy upon cooling, ·run back into the bottle·, and so spoil the measurement. I then removed the bladder ·from the bottle· and weighed ·the bottle and· the alcohol that remained, calculating how much had been converted into gaseous form. That of course enabled me also to calculate what *volume* that portion of the liquid had had in the bottle. Then comparing that volume with the volume of the inflated bladder, I calculated the ratio, which showed clearly that the material's change from liquid to gas multiplied its volume by a hundred.

[Then a brief repeat of what Bacon said earlier [item 38 on page 63] about thermometers, this time stating it in terms of bringing very small differences of temperature within reach of the senses. Then:]

Suppose we are investigating the nature of the *mixtures* of bodies—what they contain of water, oil, spirit, ash, salt, and the like; or (to take a particular case) what milk contains of butter, curd, whey and so on. For •tangible elements, ·the proportions of· these mixtures are brought within reach of the senses by skillfully contrived separations. The nature of the •spirit in them, though not immediately perceived, is discovered by the different motions and efforts of the tangible bodies in the very act and process of their separation, and also by how corrosive or acidic they are, and by the various colours, smells, and tastes that the bodies have after separation. This is a part of the task at which men have worked hard with their distillations and controlled separations, but with not much better success than in their usual kinds of experiments: groping around, moving in the dark, putting in more effort than intelligence, and (worst of all) not trying to imitate ·the gentle ways of· nature but instead using high heat and unduly strong forces which destroy all the delicate microstructures that are the main source of the hidden powers and agreements of things. [Bacon then repeats a warning given in on page 52 about testing a substance by means that alter it. Then:]

Quite generally, all our refined ways of testing bodies, whether natural or artificial—to distinguish pure from adulterated, better from worse—belong *here*; for what they do is to bring within reach of our senses things that we ·initially· don't sense. So they should be sought and collected from all quarters with diligent care. [The ensuing '(5)' relates to the list on page 94.]

(5) The fifth way in which objects escape the senses is this:

> Obviously the action of the senses occurs as motion, and motion occurs in time. So if a body moves vastly slower or vastly quicker than the movements involved in the ·relevant· action of the senses, the body isn't perceived at all.

For example, the motion of a clock-hand, the motion of a speeding bullet. Motion that is too slow to be perceived is easily and usually brought within reach of the senses by considering long stretches of it. Motion that is too quick hasn't yet been competently measured, but sometimes the investigation of nature requires that this be done.

(6) In the sixth kind, where the sense doesn't represent the object properly because the object is too powerful for it, the object can be brought within the sense's scope by •increasing the distance between it and the object, or •dulling the object's effect by interposing something that will weaken but won't annihilate the ·effect of the· object; or •accepting the less powerful impression of a *reflection* of the object—like seeing the sun reflected in a basin of water.

(7) The seventh kind of case where an object isn't sensed, namely where the ·relevant· sense is so occupied with some other object that it has no room to let this one make itself felt, is pretty much confined to the sense of smell and has little to do with the matter in hand.

That's all I have to say about procedures for bringing things that we ·initially· don't sense within reach of our senses.

Sometimes a thing is brought within reach of the ·relevant· sense not of a man but of some other animal in which this sense is keener than it is in man. For example: bringing certain smells to the sense of a dog; bringing light to the sense of a cat, an owl, and other such animals that see in the dark. (This second example concerns the light that is latent in air that isn't lit up from outside itself. Telesius has rightly observed that there *is* in the air itself a kind of original light, though it's faint and weak not much use to the eyes of men or most animals. His reason is that some animals see in the dark, and he thinks they are ones whose sense of sight is able to pick up this light; for it is hardly credible that they see without any light at all or that they see by a light that comes from within them.)

It's important to take in that my topic has been *deficiencies* of the senses and their remedies. The *errors* of the senses should be dealt with in investigations of sense and the objects of sense. Except for the *great* error of the senses, namely that they draw the lines of nature on the pattern of man and not of the universe [see [1]**41** on page 8]; and this can be corrected only by reason and universal philosophy, ·not by empirical scientific investigations·.

41. Class 18 of privileged instances: **instances of the road**, which I also ·though not again in this work· call 'travelling instances' and 'jointed instances'. They call attention to the processes of nature *while they are going on*. These instances are ·remedies for· failures to •attend rather than failures to •perceive. Men are surprisingly careless in these matters, ·especially the processes in which organic bodies come into being·. They study nature on and off, attending when the bodies are finished and completed but not while nature is at work on them. But if you wanted to see and think about the techniques and procedures of a craftsman, you wouldn't settle for merely seeing his raw materials and his finished products; you would want to be there while he was *working towards* completing the product. Well, it's like that with ·the investigation of· nature. For example, if we are investigating the life-processes of plants, we must begin from the time when the seed is sown. (That's not hard to do: you just take up and carefully examine a few seeds each day after the first.) We should note how and when the seed begins to swell and to fill up with spirit; then how it begins to burst and put out shoots, at the same time raising itself a little unless the soil is too resistant; then how it puts out its shoots, some downwards for the roots and some upwards for the stems, sometimes also creeping sideways if it can find easier soil in that direction; and a good many other things of that sort ·should be done·. In the same way we should examine the hatching of eggs, where we can easily observe the whole process of coming alive and getting organized , what parts come from the yolk and what from the white of the egg, and so on. Similarly with the ·tiny· animals that come into being from putrefaction. (It would be inhuman to investigate complete ·large· animals in this way, cutting the foetus out of the womb; though miscarriages and animals killed in hunting offer some opportunities.). . . .

The same thing should be tried with inanimate things, as I myself have done in investigating the expansion of liquids by fire [item (a) on page 95]. For water expands in one way, wine in another, vinegar in a third. . . . It would easy to show this by putting them in a clear glass vessel and boiling them over a slow fire. But I'm only touching on these matters briefly here; I plan to treat of them more fully and exactly when I come to the discovery of the hidden processes of things. Please understand that all I am doing here is to give examples—I'm not dealing with the things themselves.

42. Class 19 of privileged instances: **instances of supplement or substitution**, also called 'instances of last resort'. When the senses don't provide us with any proper instances, we get information by resorting to these ·members of class 19·. There are two ways of making a substitution. (a) •By degrees: Here is an example. We don't know of any medium that entirely blocks a magnet's effect on iron; the effect isn't stopped by interposing gold, silver, stone, glass, wood, cloth or other fibres, air, flame etc. But if we're careful we may be able to show that some medium blocks *more* of the magnet's power than any other—this being a difference of degree. . . . Again, we haven't found any ·kind of· body that isn't warmed by being brought near a fire; but air heats up *faster* than stone. That's substitution by degrees.

(b) •By analogy: Though certainly useful, this is less sure ·than substitution by degrees·, so it should be used with discretion. It's what we use when something that isn't directly perceptible is brought within reach of the senses not through

> ·observation of· the perceptible activities of the body that isn't perceptible in itself,

but rather through

> observation of some related body that *is* perceptible.

[Bacon then gives an example, which is extremely hard to follow. The present version keeps all its content, and adds nothing; but it does re-arrange the materials considerably.] For example, suppose we are inquiring into a mixture of spirits (which are invisible bodies)—specifically into the mixture of •air and •flames. The related bodies that will give us our instance of substitution are •water and •oil, which seem to be related to air and flames respectively by being *fuel* for them. (Flames grow when they are above fumes from oil, and air grows when it is above water vapour.) Our senses won't show us the mixture of air and flame, so let us look instead at the mixture of water and oil—something that our senses will let us do. Now our senses tell us this:

> Oil and water •don't mix well when they are merely

shaken up together, but they •mix fully and smoothly when they are ingredients of plants, blood, and the parts of animals.

So something similar *may* be the case with the mixture of flame and air in spirits, namely:

•When flame and air are simply mixed, they don't stay mixed; but •when they're mixed in the spirits of plants and animals they do mix ·in a more durable way.·

·That is our substitution instance. It gets some independent confirmation from the fact that· all living spirit takes both watery and fatty substances as its fuel.

Or suppose that what we are investigating is not more or less perfect mixtures of spirits but simply how ·different kinds of· spirits intermingle. •Are they ·all· easy to mix so that they incorporate one another? •Or is it rather the case that *some* winds and vapours and other spirits don't mix with ordinary air, but remain suspended and floating in it in blobs and drops that and are smashed by the air rather than welcomed and incorporated? With ordinary air and other spirits we can't answer this by consulting our senses because these spirits are too subtle—·too finely divided·—for our senses to be able to register them. Still, we may get some idea of what happens in those cases by looking at analogous cases involving ·pairs of liquids or· liquids ·and air· which come together but don't incorporate one another:

- •mercury ·and just about anything·,
- •oil and water,
- •air and water (note how air breaks up and rises in little bubbles when dispersed in water),
- •·air and· the thicker kinds of smoke, and lastly
- •air with dust suspended in it.

This is not a bad way of looking at the matter ·of combinations of spirits·, provided that we first check carefully into whether there *can* be such a heterogeneity—·such an unevenness of mixing·—in spirits as well as in ·some· liquids ·in relation to other liquids or to air·. If there can be, then there is nothing wrong with substituting these images by analogy ·for the spirit-to-spirit combinations that are our real topic·.

But with regard to these instances of supplement, although I said that information can be derived from them as a last resort in the absence of proper instances, please understand that they are also of great use even when proper instances are available, because they can confirm what we learn from the proper instances. I'll discuss them more fully when I come in due course—·though not in the present work·—to speak of the Supports of Induction.

43. Class 20 of privileged instances: **dissecting instances**, so-called because they dissect nature. They could be called 'Democritean instances' ·in honour of Democritus, whose metaphysic dissected nature right down to its smallest elements, the atoms·. I also call them—·though not again in this work·—*nudging* instances, because they nudge the intellect to make it aware of nature's wonderful and exquisite fineness of grain, stirring it up to pay attention, to observe, to investigate. Here are some examples:

- •a little drop of ink can make so many letters or lines;
- •a piece of silver gilded only on the outside can be drawn out to such a length of gilt wire;
- •a tiny worm such as we find in the skin has spirit and a complex structure;
- •a little saffron colours a whole barrel of water;
- •a little civet or spice fills a much larger volume of air with its aroma;
- •a little fumigating powder creates such a cloud of smoke;
- •fine-grained differences of sounds such as are involved

in spoken words carry in every direction through the air and even (in weakened form) through the holes and pores of wood and water, and are moreover echoed back—all this being done so clearly and quickly;

- light and colour pass so quickly and at such distances through solid bodies of glass and water, or are refracted by them or reflected back from them, all this with such an exquisite variety of images;
- the magnet acts through bodies of all sorts, even the most dense.

Even more wonderful is the fact that in all these events, passing as they do through a non-interfering medium such as air, the action of one thing doesn't much interfere with the action of another. That is to say that the spaces of the air carry so many images of visible things, so many impressions of voices speaking, so many different colours, as well as heat and cold and magnetic influences—doing all this, I repeat, at the same time and without getting in one anothers' way, as though each kind of influence had its own private paths that the others couldn't get into.

[A paragraph saying that this non-interference applies only between influences of different kinds. A strong light can drown a weak one, a cannon's noise can obliterate the sound of a voice, etc. Bacon says he will discuss all this when he gets to the supports of induction—which he doesn't get to in this work.]

APHORISMS CONCERNING THE INTERPRETATION OF NATURE: BOOK 2: 44–52

44. So much for instances that help the senses. These are useful mainly for the informative part ·of my topic·, because information starts from the senses. But the end-point of the whole project consists in *works*: start with information, end with works. So I now come to instances that are chiefly useful for the applied part. There are **seven** kinds of these *practical instances*, as I call them, and they fall into •two groups, corresponding to the •two ways in which things can go wrong in the practical part ·of the scientific endeavour·. An application may •fail, or it may •be too much trouble to carry out. When it simply fails (especially if the ·relevant· natures have been carefully investigated), that is because the forces and actions of bodies haven't been properly discovered and measured. For the forces and actions of bodies to be properly described and measured, we have to answer questions of these forms:

How far away are they?
How long did it last?
How much of the stuff was there?
What power did it have?

Unless we have carefully accurate answers to these questions we won't get anywhere with our practical applications, however pretty our science is as a purely theoretical affair. To the **four** instances that correspond to these I give the general name 'mathematical instances' and 'instances of measurement'.

When an application is too laborious, that will be because

there is a clutter of useless stuff
too much equipment is needed, or
the scale on which something has to be done is too great.

So we should value instances that either point our applications towards things that most closely concern mankind, or keep down the amount of equipment, or enable things to be done on a smaller scale. To the **three** instances that bear on these three matters I give the general name 'propitious' and 'benevolent instances'.

I'll now discuss these **seven** instances one by one; and that will bring me to the end of my treatment of privileged or leading instances.

45. Class 21 of privileged instances: **instances of the measuring-stick**, which I also call 'instances of range' or 'no-further instances'. The distances across which the powers and motions of things act and take effect are not •indefinite or •matters of chance; rather, they are •definite and •fixed. It's of great practical value to observe and note these distances in relation to any natures that we are investigating; that will help us to avoid downright errors, and will also give our applications wider scope and greater power. For we *can* sometimes increase powers and in a way reduce distances, as for example by the use of telescopes.

Most powers act and take effect only by out-in-the-open contact, as in collisions, where one body makes another move only by coming into contact with it. Also medical remedies that are applied externally, like ointments or plasters, don't do any good unless they touch the ·patient's· body. And we don't taste or touch anything without coming into contact with it.

Some other powers act at a distance, though a very small one. These haven't been much attended to; there are many more of them than you might think. Some examples involve humdrum objects: amber or jet attracts straws; a bubble will burst another bubble when they come close; certain laxatives draw down bodily fluids; and so on. The magnetic power by which a magnet comes together with a piece of iron or with another magnet iron operates within a fixed, narrow sphere of action. But if there is any magnetic power coming from the earth (just below the surface, it seems) and affecting the polarity of an iron needle, it must be operating at a considerable distance.

Again, if there is magnetic force operating by agreement [see long note on page 87] between the globe of the earth and heavy bodies, or between the globe of the moon and the waters of the ocean (as seems highly likely judging by the twice-monthly cycle of high and low tides), or between the starry heaven and the planets whereby the planets are drawn up to their highest points, all these must operate at very great distances. Some cases have been found in which materials—the naphtha at Babylon is said to be one—catch fire from a great distance. Heat also travels great distances, as does cold: the inhabitants of Canada feel the cold that is given off far away by the icebergs that break loose and float through the Atlantic toward their shores. . . . Lastly, light and sound operate at vast distances.

Whether they are great or small, all the distances at which these powers act are definite and known to nature [see note in [1]**22** on page 6]. So ·in each case· there is a kind of *no further* which depends either on

how much matter there is in the ·interacting· bodies,
how strong or weak their powers are, or
how much the forces are helped or hindered by the intervening medium

—and all of these should be noted and brought into the calculation. We should also measure so-called 'violent' motions [see page 17]—movements of missiles, guns, wheels, etc.—because clearly these also have their fixed limits.

Over against motions and powers that operate •by contact and not at a distance, there are ones that operate •at a distance and not by contact, and others that operate •weakly at a short distance and more powerfully at a longer one. Vision, for example, requires a distance across a medium; it doesn't work well by contact. . . . Still, it is clear that one doesn't have a clear view of large bodies unless they are at. . . .a certain distance ·from the eye·. And old people see objects better when they are a little way off than when they are very close. With missiles, too, it is certain that the impact is not as powerful at a very short distance as it is a little further off. These are some of the things that we should take account of. . . .

Another kind of spatial measurement of motion shouldn't be ignored. It has to do not with linear motions ·in which something goes from one place to another· but rather with the motion that is involved when a body expands or contracts. Among our measurements of motions of this kind we must include inquiries into how much compression or extension bodies naturally allow, and at what point they begin to resist, until at last they will take it *no further*. When an inflated bladder is compressed, for example, it allows some compression of the air, but if it is compressed far enough it eventually can't take it any longer, and bursts.

I tested this more precisely with a subtle experiment. I took a small metal bell, light and thin like a salt-cellar, and lowered it into a basin of water in such a way that it carried the air contained down with it. I had previously put a small globe at the bottom of the basin, and when I lowered the bell I put it over the globe—·*over*, not *onto*; the entire globe was inside the inner space of the bell·. It turned out that if the globe was small enough in proportion to the cavity of the bell, the air retreated into a smaller space, and was simply compressed rather than being squeezed out. But if the globe, ·though still small enough to go wholly inside the cavity·, was too large for the air to give way freely, then the air wouldn't submit to the greater pressure, and instead tilted the bell and rose to the surface in bubbles.

And here is an experiment I did to find out to what extent air could be *de*compressed. I took a glass egg with a small hole at one end, and drew air out of it by strong suction, ·of course leaving some of the air still in there, expanded to fill the whole interior space of the egg·. Then I immediately blocked the hole with my finger, immersed the egg in water, and then took away my finger. The air, having been decompressed by the suction and expanded beyond its natural volume, and now trying to pull itself in again (so that if the egg hadn't been under water it would have drawn in air with a hissing sound), now pulled in enough water for the air to recover its previous volume.

It is certain that less dense bodies (such as air) can be considerably compressed, as I have said, but that tangible bodies (such as water) are much harder to compress and can't be compressed as much. To find out how much compression they allow, I conducted the following experiment.

I had a hollow globe made out of lead, with a capacity of about one quart and with sides thick enough to stand a considerable force. Having made a hole in it, I filled it with water and then closed the hole with molten lead, so that the globe became quite solid. I then flattened the globe by beating two opposite sides of it with a heavy hammer; this forced the water to shrink into less space, because a sphere is the most capacious of shapes. When the hammering had no more effect in making the water shrink, I used a vise ·to flatten the globe further·, until the water couldn't take any more pressure and leaked through the solid lead like a fine dew. I then calculated how much space had been lost by the compression, and concluded that this was the extent of compression which the water had allowed, but only when put under great force.

Bodies that are denser, dry, or more compact—such as wood, stones and metals—are much harder to compress; any contraction they undergo under pressure is scarcely perceptible. They free themselves by breaking, by moving away, or by other tactics, as we can see in the bending of wood or metal, in the unwinding of springs that drive clocks, in projectiles, in hammering, and in countless other motions. All these things with their measures should be noted and tested in the investigation of nature—either exactly, or by estimate, or by comparison, as opportunity arises.

46. Class 22 of privileged instances: **running instances**. . . . These measure nature by periods of time, as the instances of the measuring-stick measure it by spatial distances. Every natural motion or action is performed in time, some quicker, some slower, but all across periods that are certain and known to nature. Even events that seem to be performed instantly—in the blink of an eye, as we say—are found to last for more or less time.

·Let us start by looking at some processes and their various speeds, starting with some protracted ones and gradually moving to ones that go faster·. The revolutions of heavenly bodies take known periods of time, as does the cycle of the ocean's high and low tides. The movement of heavy things ·falling· to the earth and of light things floating up towards the region of the heavens happens in definite periods which vary according to the body that is moving and the medium through which it is moving. The sailing of ships, the movements of animals, the onward thrust of missiles—these too take periods of time that can be calculated in rough and ready terms. As for heat, we see boys in wintertime bathe their hands in flame without being burned. ·And flow of liquids·: jugglers nimbly and smoothly upend jars of wine or water and then turn them right way up again, not spilling the liquid. And so on. The compression, expansion and eruption of bodies occur at different rates depending on the kind of body and kind of motion, but all of them take *some* time. When several cannons go off at once, they may be heard thirty miles away, but they will be heard *earlier* by people who are close by. The action of eyesight, though extremely rapid, does take some time to occur; this is shown by things that move too fast to be seen. For example, when a bullet is fired from a gun it goes too quickly for an impression of it to reach the eye, ·and that shows that it *takes time* for eyesight to work·.

Facts like these have at times prompted me to suspect (though this is *strange*) that

> the face of a serene and starlit sky is seen not exactly when it really exists but a little later,

which involves suspecting that

> so far as our sight of heavenly bodies is concerned, there is ·a difference between· real time and seen time, like the distinction between real place and seen place that astronomers take account of when they correct for parallax.

This suspicion came from its seeming incredible to me that the images or rays of heavenly bodies could reach our eyes across such an immense space *instantaneously*, rather than taking a perceptible length of time to reach us. But the suspicion that there is an appreciable interval between real time and seen time vanished entirely when I came to think of •how *enormously* much brighter the stars are than they appear to us to be (because of how far away they are); and of •the fact that merely white bodies on earth are seen *instantly* across ·large· distances—sixty miles or more, ·two days' journey for a man·. There is no doubt that the light of the heavenly bodies is *many* times more vigorous in its radiation not only than merely white things but also than the light of every flame known to us here on earth. ·And if radiation x is vastly •more vigorous than radiation y, it can hardly be the case that x is •slower than y!· Also, the immense velocity of the body itself [presumably meaning: the sun or any star] that we see in its daily motion (a velocity so amazing that some serious thinkers prefer to believe that it's only the earth that moves) makes it easier to believe in this wonderfully fast emission of rays. But what carried most weight with me was the thought that if any perceptible interval of time passed between the reality and the sighting, the images would often be intercepted and confused by disturbances that occurred in the medium during that interval—clouds arising and the like. That completes what I have to say about simple ·non-comparative· measurements of time.

Much more important than those, however, are comparisons amongst the times taken by various motions and actions; for this information is extremely useful and relates to very many things. ·Here are some comparisons that we know about·. •It seems that light travels faster than sound: we see the flash of a gun before we hear the bang, although the bullet must strike the air ·thus causing the bang· before the flame behind it can get out ·thus causing the flash·. •Visual images are taken up by sight faster than they are discarded. Examples of this:

> •When a violin string is plucked with a finger, it looks like two or three strings, because ·as it moves· new images are received before the old one is discarded;
> •spinning rings look like globes;
> •a lighted torch carried swiftly at night seems to have a tail.

(Galileo built his theory of the tides on the basis of the unequal speeds of motions. He held that the earth revolved too fast for the oceans to keep up, so that the water heaps up and then falls down, as we see it do in a basin of water moved quickly. But in building this theory he took for granted something that can't be taken for granted, namely that the earth moves. Also, he wasn't well informed about the six-hourly movement of the ocean.)

A genuine example of my double topic—•the comparative measures of motions and •the enormous *usefulness* of the comparative measurement of motions—is the following. When gunpowder is used in subterranean mines, a tiny amount of the powder upsets vast masses of earth, buildings, and so on, throwing them into the air. What causes this is that the expanding motion of the gunpowder (the impelling force) is many times faster than the only motion that could provide any resistance, namely the motion from the weight of the earth, buildings etc.; so that the first motion is all over before the countermotion gets started, which means that at first there is no resistance. That is also why it is that to get a projectile to carry a long way you need to give it not a •strong launching but a •sharp quick one. And why can the small quantity of animal spirit in animals, especially in such huge creatures as whales and elephants, steer and control such a vast bodily mass? It is because the spirit moves very quickly and the bodily mass moves slowly in exerting its resistance. . . .

Lastly, we should note the *before* and *after* aspects of every natural action. [He gives examples involving the extracting of medicines or aromas—first this one, then that—from various substances.]

47. Class 23 of privileged instances: **instances of quantity**. . . . These are instances that measure powers in terms of the quantity of the bodies ·that have them·, showing •what quantity of the body generates •how much of the power. First, there are some powers that are possessed only by world-sized quantities ·of matter·, that is, quantities that agree with the structure and fabric of the world as a whole. For the earth stands fast; its parts fall. The ebb and flow of waters occurs in the oceans but not in rivers (except from the sea flowing in to them). Then there are particular powers nearly all of which act according to whether it is a large or a small body that has them. •Large quantities of water go stale and bad slowly, small ones quickly. •Wine and beer mature and become fit to drink much more quickly in small containers than in casks. . . . •In its effect on the human body, a bath is one thing, a light sprinkling another. •·Unlike heavy dews and outright rain·, *light* dews in the air never fall, but are dissipated and incorporated into the air. (If you breathe on a precious stone you'll see that little bit of moisture instantly dissolved, like a cloud scattered by the wind.) •A whole magnet draws more iron than a piece of it does. And then there are powers that are *greater* when *small* quantities ·of matter· are involved—for example, a sharp point pierces more quickly than a blunt one does, a pointed diamond engraves on glass, etc.

But we shouldn't linger on these indefinite ·relations between quantity of stuff and amount of power·. We should investigate *how much* the power of a body varies with its quantity. ·Don't think that there is no need to *investigate* this because it is obvious how power is proportioned to quantity·. It would be natural to think that the relationship is one of equality, so that a one-ounce piece of lead will fall to the ground twice as quickly as a two-ounce piece. But the fact is that it won't! And the power-to-quantity proportions are different for different kinds of power. To get these measures, therefore, we must go to the things themselves—·to empirical experiments·—and not rely on likelihood or conjecture. . . .

48. Class 24 of privileged instances: **instances of strife**, which I also call 'instances of predominance'. These indicate relative strengths and weaknesses of powers—which of them is stronger and prevails, which is weaker and gives way. ·This is a more complex matter than you might think, because· the motions and efforts of bodies can be compounded, decomposed, and remixed, just as the bodies themselves can. If I am to •identify and explain instances of strife and predominance, doing this clearly, I need first to •compare the strengths of various kinds of power; and to do *that* I must first •say what the main kinds of motion or active power *are*. ·There are nineteen of them, and they will occupy my next ten pages·.

(1) I take first *the motion of antitypy*. [In the standard sense of this word—it is pronounced an-*tit*-apee—a thing has 'antitypy' if it occupies a region of space in such a way that while *it* is there no other body can be there. Bacon understands it differently, though at the end of this paragraph he points to the standard meaning.] This is in every single portion of matter, so that it absolutely refuses to be annihilated. Thus, no fire or weight or pressure or force or passage of time can reduce any portion of matter, however small, to nothing. A portion of matter will always •be something, and •be somewhere. When it is under stress it may escape by changing its form or moving to somewhere else; but if it can't do either, it will stay *as* it is ·and *where* it is·; it will never be brought to the point of being nothing or being nowhere. The Schoolmen (who usually name and define things by effects and negative consequences rather than by inner causes) call the motion of antitypy 'the motion to prevent penetration of dimensions' or express it through the axiom *Two bodies can't be in one place ·at the same time·*. I needn't give examples of this motion, because it is inherent in every body.

(2) In the second place I take *motion of bonding*, by which a body doesn't allow itself to be separated at any point from contact with another body—as though they enjoyed being bonded and in contact. The Schoolmen call this 'the motion to prevent a vacuum', as when water is drawn up by suction or in a pump, when flesh is pulled up by cupping glasses, when water stays in a pot that has a hole at the bottom unless the mouth of the jar is opened to let in air, and countless things of that sort.

(3) Thirdly, what I call *motion of liberty*, by which a body tries to free itself from unnatural •pushes or •pulls and to restore itself to the shape suitable to its nature. We have countless examples of this too. I'll start with ones that involve getting free from •pushes: the motion of water around a swimming fish, of air around a flying bird, of water around the oars of rowers, of air in wind-gusts, of springs in clocks. We have a neat example in the motion of compressed air in children's popguns. [He tells the reader how to make a popgun. Then:] As for bodies getting free from •pulls: this motion displays itself in the air that remains in a glass egg after suction; in strings, leather and cloth, which regain their shape after the pulling stops (unless the pull has gone too far for that), and in similar phenomena. The Schoolmen call this 'motion in accordance with the form of the element', but this was ignorance on their part; the motion in question belongs not only to fire, air, and water (·traditionally classified as 'elements'·), but to every kind of solid substance—wood, iron, lead, cloth, parchment, etc. An individual body composed of one of these has its own characteristic shape which can't easily be much altered.

[In this next paragraph, mentions of 'being squeezed down to nothing' are translations of some uses of 'penetration of dimensions'. That is not *at all* what the phrase has standardly meant; its standard meaning, like that of 'antitypy', concerns a body's not sharing its space with any other body. But it is clear that in this present context Bacon does, bizarrely, use ‘penetration of dimensions’ to mean a body’s being squeezed down to nothing; and the present version makes that explicit, in the interests of clarity.] Just because there is so much of this motion of liberty and because it is so obvious, it would be as well to be very clear about exactly *what* motion it is. Some people carelessly confuse **(3)** this motion with **(1,2)** its two predecessors. Specifically,

- •they confuse **(3)** getting free from pushes with the motion of **(1)** •antitypy, the idea being that when bodies are pushed they **(3)** push back so that **(1)** nothing will be squeezed down to nothing; and
- •they confuse **(3)** getting free from •pulls with the motion of **(2)** •bonding, the idea being that when bodies are pulled they **(3)** pull back so that **(2)** there won’t be a vacuum.

·Both these lines of thought are quite wrong·. If air under pressure were to contract itself to the density of water, or wood to the density of stone, that wouldn’t require it to be squeezed down to nothing; these bodies could let themselves be compressed far more drastically than they ever are in fact, without any risk of contracting to *nothing*; ·so it can’t be right to explain their resistance to pressure as required to avoid being squeezed down to nothing·. Similarly, if water were to expand to the rareness of air, or stone to the rareness of wood, that wouldn’t require there to be a vacuum; these bodies could let themselves be expanded far more than they ever are in fact, without any risk of a vacuum; ·so it can’t be right to explain their resistance to pulling as required to avoid vacuum·. In short:

> •Condensation and •rarefaction don’t involve •squeezing down to nothing or •vacuum, except at their extreme limits; and the motions I am talking about—·ones that actually occur·—are nowhere near these limits. They are merely the tendencies that bodies have to keep their own shapes. . . .unless they are altered gently and through agreement.

·So much for a couple of things that the motion of liberty *is not*·. A more important point, with a lot riding on it, concerns something that the motion of liberty *is*. Think about so-called ‘violent’ motion [see page 17], which I call ‘mechanical’ motion, and that Democritus (who in his exposition of his ‘primary motions’ doesn’t rise to the level of mediocrity!) called motion of the *blow*. I now say that this—·e.g. the motion of a ball when it is kicked·—is simply the motion of liberty, that is, of getting free from compression and loosening up again. When you kick a ball, the ball as a whole won’t start to move until your kick compresses parts of it more than is natural for them. *Then* those parts will push against adjacent parts, and so on through all the parts—and eventually the entire ball is moved. (Essentially the same story holds for the ball’s subsequent movement through the air.). . . .

That’s all I want to say about this kind of motion.

(4) Fourthly there is the kind of motion that I call *matter motion*. [When talking about this kind of motion, but nowhere else in the work, Bacon uses the Greek word for ‘matter’, not the Latin one.] It is a kind of opposite of the motion of liberty that I have just been discussing. In the motion of liberty the body in question hates and avoids taking on a new shape or size, and tries its hardest to get back to its original state. By contrast, in this matter motion a body wants a new size or shape, and works towards it freely and promptly, and sometimes with most vigorous effort, as in the case of gunpowder. The chief instruments of this motion—perhaps the most powerful ones, and certainly the commonest—are heat and cold. For example, when air is expanded by ‘pulling’, as by suction in glass eggs, it struggles to •·contract and thereby· restore itself ·to its pre-suction size·. But if air is heated, it wants to •expand and to take on a new size and shape, and it readily

acquires that and passes over into a so-called 'new form'. And after achieving a certain degree of expansion it doesn't want to return, unless invited to do so by an application of cold, and what that brings about is not really a *return* but rather a renewed transformation. Similarly, when water is made to contract by pressure, it resists and wants to return to its previous state, i.e. it wants to become larger. But if is it then subjected to intense and continued cold, it spontaneously and freely changes itself to the density of ice; and if the cold continues for a long time without a break (as happens in deep caves), it turns into crystal or some such, and never returns ·to its previous liquid state·.

(5) In fifth place I take the *motion of ·cohesion· or inter-connection*. I don't mean the simple basic holding-together of a pair of bodies (that's the motion of bonding), but the holding-together or cohesion of a single body just in itself. It is quite certain that all bodies resist a breaking up of their continuity—some more than others, but *all* to some extent. In hard bodies such as steel and glass the resistance to breaking up is exceedingly strong. And in liquids, where the power of cohesion seems to be absent or at any rate very weak, we never find it to be *entirely* absent though in liquids it is present in very low degree. It shows itself in a multitude of empirical events: bubbles, the roundness of drops, thin little trickles of water, stickiness of glutinous bodies, and the like. But this force ·for holding together· is most evident when you try to break up very small fragments. When something is being ground in a mortar, after a certain stage the pestle stops having any effect. Water doesn't penetrate into minute chinks; even air itself, finely broken up as it is, gets through the pores of fairly solid vessels only when given a long time to do so. ·Whereas the water and the air would rapidly and easily pass through if there were no limit to how finely they could easily be divided·.

(6) Sixthly, there is what I call *motion for gain* or motion *of need*. It is what comes into play when a body is placed among other bodies that are quite unlike it and almost hostile to it, and it finds an opportunity to get away from these and to connect up with bodies that are more like itself. Even if these others have no great agreement with it, the body in question embraces them, chooses them as preferable, and seems to view this connection as a *gain* (hence the label), and as though it *needed* such bodies. For example, gold or any other metal in leaf form doesn't like the surrounding air, and if it comes across any thick tangible body (finger, paper, what you will) it instantly sticks to it and isn't easy to peel off. So too paper, cloth, and the like aren't comfortable with the air that is lodged in their pores, and gladly soak up water or other moisture and drive out the air. If you dip a sugar-lump or a sponge half-way into water or wine, it will gradually draw the liquid upward.

This gives us excellent rule for opening up and dissolving bodies. Set aside corrosives and acids that have their own ways of opening up bodies. Then: Suppose that a body x is forcibly united with another body y, ·and that you want to drive them apart·. Find some suitable body z that is more friendly and agreeable to x than y is; and x will immediately open up, loosen itself, and take in z while rejecting y. This motion for gain can exist and act without immediate contact. For the electric operation of which Gilbert and his followers have stirred up such fables is nothing but the result of activating a body by gentle friction so that it doesn't tolerate the air and prefers whatever other tangible body it can find nearby.

(7) In seventh place is what I call *the motion of major aggregation*, by which bodies are carried towards masses that are like themselves—heavy bodies to the globe of the earth, light ones to the sphere of the heavens. The School-

men called this ‘natural motion’, for the trivial reason that •they couldn’t see any external cause for it, from which they inferred that it was a built-in aspect of things’ nature, or perhaps just because •it never stops. *Of course* it never stops! the heavens and the earth are always there, whereas the causes and origins of most other motions are sometimes absent and sometimes present. So the Schoolmen regarded this motion as in-built and perpetual, and all others as ·not in-built but· caused from outside, because it starts up the moment the others leave off. In fact, though, this motion is fairly weak and dull; except in very large bodies, this motion gives way to all other motions as long as they are in operation. And though this motion has filled men’s thoughts to the almost total exclusion of all others, they know very little about it and are involved in many errors about to it.

(8) Eighthly, there is the motion of ‘minor aggregation’. In this kind of motion

> •the homogeneous *parts* of a body separate themselves from the heterogeneous parts and combine together;

and also

> •*whole* bodies that are alike in substance embrace and cherish each other, sometimes having come together through attraction across a considerable distance.

An example of this is provided by milk that has stood awhile, when the cream rises to the top; and by wine in which the dregs sink to the bottom. What causes these events is not the mere motion of heaviness (dregs to the bottom) or lightness (cream to the top), but rather the desire of the homogeneous parts to come together and coalesce into one.

This motion differs from (6) the motion of *need* in two ways. (a) In the motion of need the main stimulus comes from a malignant and contrary nature, whereas in *this* motion the parts unite (provided they aren’t blocked or tied down) through friendship; they don’t have to be escaping from some other thing whose nature is troublesome to them. (b) This motion produces a union that is closer and more *chosen* (as it were) ·than the union produced by the motion of need·. In the motion of need, bodies that don’t have much to do with one another will come together ·loosely· just to avoid some body that is hostile to them; whereas in this ·motion of minor aggregation· substances are drawn together ·tightly· into a kind of unity by the tie of close relationship. This motion is present in all compound bodies, and would easily show up in each one if it weren’t for the fact that other appetites and necessities in the bodies tie it down and constrain it, thus interfering with ·the forming of· the union. [Recall that Bacon introduced this long section on page 106 with remarks about ‘powers’, then ‘motions and efforts’ (it could be ‘motions and forces’), then ‘the main kinds of motion or active power’. From there on he has said it all in terms of ‘motion’, not ‘power’, but his basic topic is *powers*. What he means in the sentence starting ‘This motion is present’ is not that certain movements secretly occur, but that a certain power is secretly present.]

When this motion is tied down, that usually happens in one of three ways: through •the sluggishness of bodies, through •the constraint of a dominant body, or through •external motions. ·These are large topics, and I shall give them a paragraph each·.

Sluggishness: It is certain that tangible bodies have in varying degrees a kind of laziness, a dislike of moving, so that unless they are stimulated they prefer remaining in their present state (whatever it is) to changing for the better. There are three ways for this sluggishness to be thrown off: by •heat, or by •the dominant power of some related body, or by •a lively and powerful motion. **Heat:** It is because of this role of heat that it was defined by Aristotelians as *what separates heterogeneous things and brings together* *homogeneous things*. Gilbert rightly mocked this definition, saying that it is on a par with defining *man* as *something that sows wheat and plants vines*—the point being that each is a definition in terms of a few of the effects ·of the item whose name is being defined·. But the ·Aristotelian· definition has a worse fault, namely that the effects that it picks on (such as they are)

aren't special to heat,

because cold produces the same effects, as I shall show later; and also they

don't come directly from heat as such.

What directly causes the effects in question is the desire of homogeneous parts to come together, and heat takes an indirect hand in this by help the body to shake off the sluggishness that had been getting in the way of the desire. **The power of a related body:** There's a fine example of this in any armed magnet [explained in note on page 74], the power of which enables a piece of iron to throw off its sluggishness, thus activating its power of holding onto ·other pieces of· iron ·to which it is attracted·because their substance is similar to its own. **Help from motion:** This is shown in wooden arrows that have wooden points. When such an arrow is shot into wood, its point penetrates more deeply than it would have if it had been tipped with iron, because of the wood-to-wood the similarity of substance; and what gets the arrow to throw off its sluggishness and act in this way is its fast motion through the air. I mentioned these two experiments in the section on concealed instances [**25** on page 73].

Constraint of a dominant body: This kind of hindering of the motion of minor aggregation can be seen in the way blood and urine are broken up by cold. As long as blood or urine is filled with an active spirit that dominates the whole thing and controls and keeps in check all its parts of whatever kind, the homogeneous parts are restrained from coalescing. But when that spirit has evaporated, or been choked by cold, then the parts are freed from restraint and coalesce in accordance with their natural desire. That's why any body containing a sharp, strong spirit (salt or the like) doesn't separate out ·into different kinds of matter·, and instead stays whole—because of the permanent, durable restraint of a dominant and commanding spirit.

External motion: The clearest example of external motion hindering the motion of minor aggregation is the shaking of bodies that prevents them from going rotten. All putrefaction is based on the coalescing of parts of the same kind, which gradually leads to the undoing of the so-called 'prior form' and the creation of a new one. If the preceding coalescing of parts of the same kind isn't impeded, it is a simple process of the separating out of parts, ·with nothing rotten about it·. But if it encounters various obstacles, *then* putrefactions start up, and they are the beginnings of a new generation, ·i.e. the creation of a new form·. Now, this motion of ·separating out and re·-uniting is a delicate and sensitive affair, which needs to be free from disturbances from the outside. If the body in question is subjected to frequent agitation caused by some external motion, then the motion is disturbed, and stops. ·So there are three ways things could go, depending on what happens to the motion of minor aggregation: (a) It happens without interference, resulting in simple distillation or separating out of the parts. (b) It is somewhat obstructed, resulting in putrefaction. (c) It is subjected to great agitation, resulting in the body's remaining in its present condition, not divided into kinds and not rotten·. We see countless examples of (c): water that flows, or that is often stirred, doesn't go bad; winds keep off pestilence in the air; corn that is turned over and shaken up in the granary remains unspoiled; in short, anything that is disturbed from the outside will be slower to rot inwardly.

I should mention the coming-together of the parts of bodies that is the chief cause of hardening and desiccation. [Bacon seems here to use *desiccatio* to mean something like 'the condition of being *visibly obviously* dried out'.] When the spirit (or moisture turned into spirit) has evaporated from some porous body such as wood, parchment or the like, then the denser parts contract and combine with greater force, and that leads to hardening and desiccation. What is going on here, I think, is not a motion of bonding [see (2) on page 107] or the fear of a vacuum, but rather this motion of friendship and union.

What about coming together from a distance? That happens rarely, but more often than is generally recognized. Examples of it:

- •when one bubble dissolves another,
- •when medicines draw out bodily fluids because their substance is similar,
- •when the string in one lute makes a string in another lute give off the same sound,

and so on. This motion is very active in the spirits of animals, though nobody ·else· has noticed this. It is conspicuous in magnets and magnetized iron. **(**Since the topic of magnets has come up, I should make clear some distinctions amongst their motions. Magnets have four powers—four kinds of thing they do—that should be kept apart, though men in general, in wonder and bewilderment ·about the magnet in general·, have confused them. They are:

- •the attraction of magnet to magnet, of iron to magnet, of magnetized iron to iron;
- •the magnet's north-south polarity, and at the same time its deviation from that;
- •its penetration through gold, glass, stone, everything;
- •its communication of its power from ·lode·stone to iron, and from iron to iron, with no intervening substance.

My present topic is the first of these powers, the magnet's power to combine.**)** Remarkable also is the coming-together motion between mercury and gold: gold attracts mercury, even when made up into ointments; men who work amidst mercury fumes usually hold a piece of gold in their mouths to collect the fumes that would otherwise invade their skulls and bones—and in this process the gold quite soon turns white. And that's all I have to say about the motion of minor aggregation.

(9) The ninth ·kind of· motion is *magnetic motion*. Although in a general way it belongs to the species *motion of minor aggregation*, when it operates across great distances and on large masses it deserves to be investigated separately—especially if it doesn't start with contact as do most cases of motion of aggregation, or lead to contact as do *all* [? = 'all other'] cases of motion of aggregation, but simply raises bodies or makes them swell, and nothing more. When the moon •raises the waters, or makes moist things swell; when the starry heaven •draws planets to their high-points; when the sun •holds Venus and Mercury so that they never get further from it than a certain distance; these motions don't seem like good cases of either major or minor aggregation, but rather to involve a sort of intermediate and incomplete aggregation, and therefore to deserve to have a species to themselves.

(10) The tenth ·kind of· motion is *motion of avoidance*. In this bodies are driven by antipathy to flee from hostile bodies and drive them away—to withdraw from them and refuse to mingle with them. (So it's the opposite of the motion of minor aggregation.) In some cases this motion may seem to be an incidental result of some motion of

minor aggregation: homogeneous things can't meet without dislodging and pushing away heterogeneous things, ·and that could look like motion of minor aggregation·. But we should recognize the motion of avoidance as belonging to a species all of its own, because in many cases we can see that the drive to avoid is more dominant than the drive to combine.

This motion is remarkably conspicuous in animals' excretions and in ·other· objects that are offensive to some of the senses, especially smell and taste. The sense of smell rejects a fetid odour so ·strenuously· that it brings about, through agreement, a motion of expulsion in the mouth of the stomach [i.e. it makes one throw up]; a bitter nasty taste is so ·strongly· rejected by the palate or the throat that it brings about, through agreement, a shaking of the head and a shudder. But this motion ·of avoidance· occurs elsewhere as well. It is observed in certain forms of reaction; the coldness of the middle region of the air seems to be ·a result of· the exclusion of the nature of cold from the region of the heavenly bodies; just as the great heat and fire that is found in subterranean places appear to be ·results of· the exclusion of the nature of heat from the deeper parts of the earth's interior. For heat and cold, in small quantities, wipe one another out. But when they occur in large masses, like opposing armies, the outcome of the conflict is that each displaces and ejects the other. It's said that cinnamon and other perfumes retain their scent longer when placed near to latrines and ·other· foul-smelling places, because they refuse to come out and mingle with the nasty odours. Liquid mercury would unite into a single undivided mass if left to itself, but it is certainly kept from doing so by saliva, hog's lard, turpentine and the like, owing to the its parts' lack of agreement with such bodies. When any of these substances is scattered, the mercury withdraws, its avoidance of these intervening bodies being more powerful than its desire to unite with other parts like itself. They call this 'mortifying' the mercury. Why doesn't oil mix with water? Not because their weights are different, but because of the poor agreement between them. You can see ·that weight isn't the reason, from· the fact that alcohol, though even further from the weight of water than oil is, mixes well with water. . . .

(11) In the eleventh place is the *motion of assimilation* or of self-multiplication or of simple generation. In that last phrase I'm not talking about the generation of •whole ·organically structured· bodies such as plants and animals, but of •bodies that ·don't have organic structure and instead· are of uniform texture. With this sort of motion, that is, such uniform bodies convert others that are kin to them, or at least well disposed to them and well prepared, into their own substance and nature. Thus flame over vapours and oily substances multiplies itself and generates new flame; air over water and watery substances multiplies itself and generates new air; vegetable and animal spirit over the more delicate parts of watery and of oily substances in food multiplies itself and generates new spirit; the solid parts of plants and animals—leaf, flower, flesh, bone and so on—generate new substance out of the juices of their food. Don't be taken in by the wild talk of Paracelsus who holds that •nutrition consists purely of separation; that •eye, nose, brain and liver lie hidden in bread and meat, and that •root, leaf, and flower lie hidden in the moisture of the ground. A human sculptor, he points out, brings leaf, flower, eye, nose, hand, foot etc. out of the raw stone by separating out and rejecting what he doesn't want in it; and he likens this to •Archaeus, the inner craftsman, who he says makes the various organs and parts of our body by selecting some parts of our food and rejecting the rest. (I suppose he was drunk from his own distillations ·when he wrote this·!) Leaving this nonsense aside, it's

certain that the individual parts of plants and animals—parts that are themselves organically structured as well as parts that aren't—do at first take in somewhat selectively the juices of their food. . . .and then assimilate them and turn them into their own nature. ·What distinguishes this from the fantasy of Paracelsus is the *assimilation* part of the story. I don't say that the form or nature of the nose, eyes, fingers etc. are latent in the food, but merely that the food contains material that the nose, eyes, fingers etc. can take over and remould into its own form·. This assimilation or simple generation doesn't occur only in living bodies; inanimate bodies also share in it, as I said regarding flame and air. Moreover, the non-living spirit contained in every tangible animated thing is constantly at work to digest the denser parts and turn them into spirit which will afterwards be discharged; from which arises weight-loss and desiccation, as I said earlier [page 112]. Assimilation includes a kind of *accretion* which no-one thinks is a case of nourishment; as when •clay between stones thickens and turns into a stony material, or •the scaly substance on the teeth turns into a substance as hard as the teeth themselves, and so on. [In the clay example: 'thickens' translates the Latin *concrescit*. Look up 'concretion' in any encyclopaedia.] For I hold that *all* bodies have a desire for •assimilation as well as for •uniting with substances that are like them; but the •former power is held in check, as is the •latter, though not by the same means. These means should be thoroughly investigated, as also should the ways of escape from them—·i.e. the ways of enabling the assimilation process to be freed to continue·—because this is relevant to the reinvigoration of old age.

And a final point: It is worth noting that in the nine other motions I have discussed—·setting aside (1) the motion of antitypy, as an absolutely special case·—bodies seem to desire only the •preservation of their nature, but in this eleventh they desire its •propagation.

(12) The twelfth motion is the *motion of arousal*. It seems to be of the same kind as *assimilation*, and I sometimes call by that name. Each of these motions is

- •diffusive ·rather than narrowly focussed·,
- •communicative,
- •transitive ·i.e. something's affecting something *else*·,
- •multiplicative, ·i.e. something's generating *more* of itself·,

and they have pretty much the same effect, though differing in •how, and •on what, they bring it about. **How**: The motion of assimilation proceeds as though with power and authority: it *orders* y the assimilated body to change into x the body that is assimilating it—it *forces* it to do so. But the motion of arousal proceeds as though it were cunningly and stealthily wheedling y the body that is being acted on, *inviting* it to acquire the nature of x the body that is acting on it, and getting it to *want* to. **On what**: What the motion of assimilation multiplies and transforms are •bodies and substances, for example ·bringing it about that there is· more flame, more air, more spirit, more flesh. But what the motion of arousal multiplies and transfers are only •powers—·leading to· more heat, more magnetic power, more putrefying.

This motion is especially conspicuous in heat and cold. When a hot body x makes another body y become hot, it doesn't do this by spreading its own heat through y; rather, it arouses the parts of y to engage in the kind of motion that is the form of heat (I have dealt with this in the first harvest concerning the nature of heat [**20** at page 67]). That's why it takes much longer to arouse heat in stone or metal than in air: stone and metal are unfit and unready for that motion. So it's likely that there are deep in the bowels of the earth materials that altogether refuse to be heated because their great density deprives them of the spirit with which ·the response to· this motion of arousal generally begins. Similarly, a magnet doesn't lose any of its own power when it gets a piece of iron to have a new layout of *its* parts and a motion to match. Similarly

- •leaven arouses and invites a successive and continued motion in dough,
- •yeast arouses and invites it in beer,
- •rennet arouses and invites it in cheese, and
- •certain poisons arouse and invite it in the human body,

not so much by the force of the arousing body as by readiness and easy compliance of the body that is aroused.

(13) Thirteenth is the *motion of pushing*. The subtlest of the diffusive motions, it belongs to the genus of the motion of assimilation; but I have thought fit to assign it to a species of its own, because of a striking difference between it and the motions of arousal and of assimilation. The simple motion of •assimilation actually transforms the bodies themselves, so that if you remove the original source of the motion that makes no difference to what follows. The later states of a fire in a grate are not affected by whatever external cause it was that first started the fire. . . . Similarly with the motion of •arousal: it continues in full force—·or, more accurately, the motion that it brings about in the aroused body continues in full force·—for a very long time after the first mover has been withdrawn. Examples are a heated body when the primary heat has been removed; magnetized iron when the magnet has been put away; bread dough when the leaven has been taken out. But the motion of •pushing, though diffusive and transitive [i.e. involves something's afffecting something *else*], seems to remain dependent on the first mover; so that if *it* is taken away or stops operating, the motion *immediately* fails and comes to an end. So the motion of pushing must have its effect instantly, or anyway in a very brief space of time. . . . It shows up in three things: (a) rays of light, (b) the communication of magnetic power, (c) the making of sounds by percussion. **(a)** By removing light you immediately make colours and its other images disappear. **(b)** Take away the magnet and the iron immediately drops. We can't take away the moon from ·influencing· the ocean, or the earth from ·influencing· falling heavy bodies, so we can't do experiments on those, but the same kind of thing is going on ·in them as when a magnet holds up a piece of iron·. **(c)** If you stop drumming, and thus stop the vibration of the drum, the sound soon dies away. . . . If you strike a bell, the sound seems to continue for a while, and that might make us think that during the whole that time the ·original· sound is floating and hanging in the air. But it isn't. What we hear then is not the very same sound that we first heard, but a repetition of it. . . . If the bell is held firmly so that it can't vibrate, the sound immediately stops. . . .

(14) In the fourteenth place I put the *motion of configuration or position*. This occurs when a body seems to want not to •combine with other bodies, or to •separate from them, but to •have some specific position or relative to them or to enter into some specific pattern with them. This little-known motion hasn't been well investigated. In some cases, indeed, it looks as though it couldn't have a cause. Why do the heavens revolve from east to west rather than from west to east? Why is the axis on which they pivot near the Bear constellation rather than near Orion or some other part of heaven? The questions seem almost crazy, because ·it *seems* that· these phenomena should simply be accepted on the basis of experience and classified as brute facts ·with no explanation·. But I don't think that's right. No doubt some things in nature *are* basic and uncausable, but it doesn't seem to me that this motion ·of configuration or position· is

one of them. I think that it comes from a certain harmony and agreement of the universe that hasn't yet come under observation. ·Don't think you can evade the questions by denying that the heavens revolve at all·. Take it as given that *the earth* revolves. It must still revolve on an axis, and we can ask: Why is the axis where it is rather than somewhere else? Again the polarity, direction, and deviation of the magnet can be explained in terms of this motion. . . .

(15) The fifteenth motion is the *motion of passage*. . . . It is because of this that the powers of bodies are more or less impeded or promoted by the media they are in, depending on the nature of the body, of the active powers, and of the medium. For one medium suits light, another sound, another heat and cold, another magnetic powers, and so on.

(16) The sixteenth motion is what I call the *royal motion* or the *political motion*. Through this, the predominant and commanding parts in any body

> curb, tame, subdue, and regulate the other parts, and compel them to unite, separate, stand still, move, and arrange themselves, not in accordance with their own desires but so as to favour the well-being of the commanding part;

so that the ruling parts of the body exercise a sort of government over the subject parts. This motion is especially conspicuous in animal spirit which, as long as it is in full strength, modifies all the motions of the other parts ·of the animal's body·. It is also found in lower degree in other bodies. As I said [on page 111], blood and urine don't decompose until the spirit that mixes their parts and keeps them together is discharged or stifled. In most bodies the spirits are in charge because they move so fast and so penetratingly, but the royal motion isn't entirely confined to them. In denser bodies that aren't filled with a strong and lively spirit (such as mercury and vitriol have), the thicker parts are the masters, so that there's little hope of transforming such bodies unless we can devise some method of shaking off this bridle and yoke.

A possible misunderstanding should be headed off. My whole purpose in listing and classifying motions is to help us investigate which of them dominates which others in instances of *strife*—·remember that all this started at page 107 under the heading 'instances of strife or of predominance'·. You might think that I have muddied the waters by talking as though just *one* of the nineteen listed kinds of motion concerns the dominance of some •motions by others, but I haven't. This royal motion that I have been describing has to do with domination not over •motions or powers but over •parts of bodies.

(17) I take as the seventeenth motion the *spontaneous motion of rotation*, by which bodies that delight in motion and are well placed for it •enjoy their own nature, •follow themselves and not some other body, and, so to speak, •hug themselves to themselves. For bodies seem either to

> move without any terminus, or
> remain entirely at rest, or
> move in a way that brings them to a terminus

—the terminus being either •rotation or •rest, depending on the nature of the body. Those that are well placed and delight in motion move perpetually in a circle. (Those that are well placed and hate motion, stay entirely still. Those that are not well placed move in a straight line—the shortest path—to be in the company of bodies of their own nature.) ·Any case of· this motion of rotation in marked off by nine features:

1. the centre around which the body moves,
2. its axis of rotation,
3. its distance from the centre,
4. its velocity,
5. the course of its motion, whether from east to west or

from west to east,

6. its deviation from a perfect circle by spiral lines more or less distant from the centre,
7. its deviation from a perfect circle by spiral lines more or less distant from the axis,
8. the greater or lesser distance of these spirals from each other,
9. the variation of the poles themselves, if they are movable.

But movements *of* the poles are not part of the motion-of-rotation story unless the poles move around in a circle. For centuries the motion of rotation has been widely thought to belong exclusively to the heavenly bodies, though this has been seriously questioned by some of the ancients and by some moderns who say that the earth moves ·and the heavens don't·. But on the basis that the earth doesn't rotate, a different and more reasonable question arises (unless it's now beyond question), namely: is rotatory motion confined to the heavenly bodies, or does it come down from them and get communicated to the atmosphere and the oceans? (Not the rotations of missiles—darts, arrows, musket balls etc.—because they involve the motion of liberty [(3) on page 107].)

(18) The eighteenth motion is the *motion of trepidation*. I haven't much faith in the astronomers' version of this. But we come across it when we search seriously and thoroughly for the drives of natural bodies, and it seems to rate being counted as a species by itself. It is like the motion of something that is in perpetual captivity. It occurs when a body is in a position that is not quite right for its nature but isn't downright bad either, so that it is forever trembling and stirring restlessly, not content as it is but also not daring to break out. This kind of motion is found in the hearts and pulses of animals; and it must occur in all bodies that are caught between good states and bad in such a way that when they are shaken up they try to free themselves, suffer defeat, then try again—and again and again, for ever.

(19) The nineteenth and last motion is one that I'll call *the motion of repose* or the motion of hatred of moving. It barely answers to the label 'motion', yet it clearly *is* one. [See the note on 'motion' on page 110.] It is by this motion that the earth stands still in its mass while parts of it well away from the centre move towards the centre—not to an imaginary centre but to union ·with the stuff that is there. The motion of repose is at work here because although things on the world's periphery move towards its centre, the mass at or near the centre doesn't move out the meet the things from the periphery·. This is also the appetite by which very dense bodies reject motion. Indeed, their only appetite is their desire not to move. In many ways they can be enticed and challenged to move, but they do their best to maintain their own nature. When forced to move, they still seem always to act so as to resume their state of rest and not move any more. While they are doing *that*, indeed, they show up as busily agile, struggling quickly and persistently as though weary and impatient of all delay. We can see •here only a partial representation of this, because •in our part of the universe. . . .all tangible things are not only *not* utterly dense but even have some spirit mixed in with them.

So there you have it: I have presented the most widespread species or simple elements of motions, appetites, and active powers. And in setting them out I have sketched a significant portion of natural science. I don't deny that other species may be added, or that my classification may be reformed so as to get closer to carving up reality at its joints, or reduced to a smaller number. But I don't see what I am offering as an abstract classification, like saying that

> bodies desire *either* the preservation *or* the growth *or* the reproduction *or* the enjoyment of their nature;

or that

> the motions of things tend to the preservation and the good *either* of the whole (antitypy and bonding) *or* of great wholes (major aggregation, rotation and hatred of moving), *or* of particular forms (the others).

These assertions are true, but unless their content and structure correspond to the true lines ·in nature· they are merely useless bits of theory. ·The status of each of them depends on the status of its 'either x or y or z or w' element. If that is just a rag-bag of different items with no one important property common to all of them, then the assertion is a relatively idle bit of abstract theorizing. The assertion will be better than that—will be a real addition to science—if its 'either x or y or z or w' element does correspond to some single natural kind, united by some one property·.

In the meantime, these—·by which I mean the items in my nineteen-part classification of motions·—will suffice and be useful in weighing dominances of powers and tracking down instances of strife, which is my present topic. For some of the motions I have presented are quite invincible; some are stronger than others, fettering, curbing, controlling them; some extend further ·in space· than others; some last longer than others or go faster than they do; some cherish, strengthen, enlarge, and accelerate others.

The motion of antitypy [see page 107] is altogether invincible—an immovable object ·so to speak·. Whether the motion of bonding [page 107] is also invincible I am still not sure, because I can't say for sure whether there is a vacuum (whether all together ·as empty space· *or* mixed in with matter). But I am sure of this: the reason that Leucippus and Democritus gave for introducing vacuum is wrong. They held that there must be vacuum because without it a body couldn't fold, and fill sometimes larger and sometimes smaller spaces. But clearly a material coil *can* fold and unfold itself in space, within certain limits, without vacuum coming into it. . . .

The other motions sometimes rule and sometimes are ruled, depending on their vigour, quantity, speed and force of projection, and also on what helps or hindrances they encounter. Here are five examples.

•An armed magnet will hold and suspend iron of sixty times its own weight; that's how greatly [page 110] the motion of minor aggregation (·the pull of the magnet·) prevails over [page 109] the motion of major aggregation (·the pull of the earth·). But with a still greater weight it—·i.e. the magnet's force·—is overcome. •A lever of given strength will raise a given weight; to that point [page 107] the motion of liberty prevails over that of major aggregation. But with a greater weight it—·i.e. the lever with that amount of force applied to it·—is overcome. •Leather stretches to a certain extent without breaking; that's how far [page 109] the motion of cohesion prevails over the motion of ·escape from· tension [see (3) on page 107]. But if the tension is increased the leather breaks and the motion of cohesion is overcome. •Water runs out through a crack of a certain size; that's how far the motion of major aggregation prevails over the motion of cohesion. But with a narrower crack, it—·i..e. the motion of major aggregation·—gives way and the motion of cohesion prevails. •If you charge a gun with a bullet and simple sulphur, and apply fire, the bullet won't be discharged, because in this case the motion of major aggregation overcomes the matter motion. But if you put gunpowder in, [page 108] the matter motion in the sulphur prevails, helped by the matter motion and [page 112] the motion of avoidance in the nitre. And so on with the other motions.

So instances of strife, which concern the dominance of powers and indicate the various ratios between dominating and giving way, should be sought with keen and careful diligence everywhere.

We should also look carefully into *how* and *why* these motions give way. ·Under the 'how' question I include this, stated as for a single kind of motion·: 'When it gives way, does it altogether *stop*, or does it continue the struggle until it is overpowered?' No terrestrial body is ever really motionless—as a whole or in its parts—though sometimes they appear to be. This *apparent* rest is caused either by

- •equilibrium, as in scales that stand still if the weights are equal, or by
- •absolute dominance of ·one· motion ·by another·, as in watering pots with ·tiny· holes in them, where the water stays still and is kept from falling by the dominance of the motion of bonding.

But, I repeat, when a motion succumbs, we should note how much resistance it puts up when doing so. Compare: a man pinned to the ground and tied hand and foot; he may struggle hard, putting up enormous resistance although it isn't enough to get him free. But if the answer to our question 'Is the motion that yields to one that dominates it outright annihilated, or does it continue to put up a resistance that we can't see?' is hidden from us when motions •conflict, perhaps it will become apparent to us when they •co-operate. For example, try this experiment with a gun: Find out how far it will carry a bullet horizontally. . . .; then try it again to see how much power the bullet has, after going that same distance, (a) when it is fired ·with an· upward ·tilt· (with no help being given to the motion of the blow and (b) when it is fired ·with a· downward ·tilt· (where the motion of the blow is helped by the motion of gravity). [The 'motion of the blow' is the impetus from the explosion of the gunpowder.]. . . .

49. Class 25 of privileged instances: **suggestive instances**, the ones that suggest or point to benefits for man. Mere power and mere knowledge *expand* human nature, but they don't ·necessarily· *do it any good*. So from the whole store of things we must gather those that do the most good for ·human· life. A better place to deal with this is when I come to discuss practical applications. Moreover, in the actual work of interpretation in each particular subject, I always provide a place for the human chart, or chart of things to wish for. For science requires not only asking good questions but also wishing good wishes.

50. Class 26 of privileged instances: **multi-purpose instances**. These are ones that are relevant to various topics and come up quite often, thus sparing us a lot of work and fresh proofs. The right place to discuss the instruments and contrivances themselves will be when I come to deal with practical applications and experimental methods. Those that are already known and in use will be described in the particular histories of the different arts [reminder: in this work, 'art' refers to any human activity that involves techniques and requires skills]. In the meantime I'll add some general remarks about them simply as examples of multi-purposiveness.

Apart from simply assembling and disassembling things made of natural bodies, man works on natural bodies in seven main ways—

1. by keeping out obstructive and disturbing items,
2. by compressing, stretching, shaking, and the like,
3. by heat and cold,
4. by letting time pass while the body is kept in a suitable place,
5. by checking and controlling motion,
6. by ·exploiting· special cases of agreement ·between things·,
7. by appropriately alternating or otherwise stringing together some or all the above six.

·I shall discuss these in turn, taking seven pages to do so·.

(1) We are ·often· considerably disturbed by ordinary air that is all around us and pressing in. (As we are also by the rays of the heavenly bodies, ·but I shan't say much about them·). So anything that serves to exclude air can fairly be counted as multipurpose. For example [slightly simplifying what Bacon wrote]: when we have put something inside a vessel for some practical purpose, we can keep out the air by having a vessel whose sides are very thick and dense, and blocking its opening with the stuff that the alchemists call 'clever clay'. Also very useful is a liquid sealant, as when they pour oil on wine or herb juices—it spreads over the surface like a lid and protects the stuff from the air. Powders are good too. They have air mixed in with them, but they keep off the force of the open air, as we see when grapes and other fruits are preserved in sand and flour. It is also good to coat things with wax, honey, pitch, and such sticky substances, to make an even better job of sealing them in and keeping off the air and ·rays from· heavenly bodies. I have sometimes tried the experiment of placing a vessel or some other body in mercury, which is by far the densest of all the substances that can be poured. Caves and underground cavities are very useful for preventing exposure to the sun and keeping off the ravages of the open air; they are used for that purpose as granaries in northern Germany. Sinking bodies in deep water has the same effect. I remember hearing this: someone put some wineskins full of wine into a deep well to cool; through accident or neglect they were left there for many years, and then taken out; and the wine hadn't gone flat or stale, and indeed tasted much finer, apparently because its parts were more thoroughly mixed ·during all those years in the well·. And if some project requires that bodies be submerged in deep water—river or sea—while surrounded only by air, having no contact with the water and not being shut up in sealed vessels, there is a very useful device for doing that. It is a vessel that has sometimes been used for working under water on sunken ships; it lets divers stay under water for a long time, intermittently taking breaths. Here it is:

> A hollow metal bell is evenly lowered into the water with its mouth remaining parallel to the surface of the water. It takes all the air it contains down to the bottom. It stands there (like a tripod) on three feet that are little shorter than a man is tall; so that when the diver can't hold his breath any longer he can put his head into the hollow of the bell, breath in, and then go on with his work.

(I have also heard of a machine has been invented—a little ship or boat—that can carry men under water for some distance.) Under the bell device that I have described it would be easy to suspend bodies of any sort—that's what makes it relevant to my present topic.

I have talked about the sealing off of bodies so as to keep air from getting *in*; it can also be useful to keep the spirit of the body that we are working on from getting *out*. For someone who is experimenting on natural bodies has to be certain of his total quantities—i.e. that nothing evaporates or leaks out. For profound alterations occur in bodies when nature prevents annihilation while human skill prevents loss or evaporation of any part. [Bacon reports the common opinion that when spirits of bodies are hot enough they can't be held by any container, however dense. This would be bad news for scientists, he says, if it were true—but it isn't. He sketches and criticises reasons that have been given for this false opinion. Then:]

(2) With regard to the second item on my list of seven kinds of operation on bodies—·namely compressing, stretching, shaking, etc.·—it should be especially noted that forceful

means such as *compression* are enormously powerful in their effects on movement, e.g. of machines and projectiles, even going so far as to *destroy* •organic bodies and •any powers that consist only in motion. Compression destroys all life and all flame and fire, ignition, and damages or disables every kind of machine. It also destroys powers that consist in the arrangement of crudely dissimilar parts. Colours, for example: a bruised flower doesn't have the same colour that it had when intact. . . . Also tastes: an unripe pear tastes significantly less sweet than one that has been squeezed and softened. But •such forceful methods aren't much use for producing the more notable transformations and alterations of bodies of uniform structure, because •they don't give bodies a new stable consistency but only a temporary one that is always trying to free itself and get back to where it was. Still, it would be a good idea to look more carefully into the question of whether a body of very uniform structure (such as air, water or oil) can by some application of force be made permanently denser or rarer, in a way changing its nature. This should be tried first by ·applying the force in question and then· just waiting for a while. I could have done this (if only I had thought of it!) when I was condensing water by hammering and flattening its spherical container until the water burst out [page 104]. I ought to have left the flattened sphere alone for a few days, and *then* drained the water from it, and noted whether it immediately had the same volume that it had before condensation. If it •didn't do so, either immediately or at any rate pretty soon, the condensation would have shown itself to be stable; if it •did, that would have shown that a restoration had taken place and ·thus· that the compression had been short-lived. [He makes the same point about his air-in-glass-egg experiment, page 104. Then:] In cases like these, it is likely that the state brought about by forceful means *is* stable. Anyway, it would be worthwhile to look into this experimentally; since in bodies that are less internally uniform ·than water, oil, and air·, changes brought about by forceful means and then left alone for a while *do* turn out to be stable. For example, a stick that stays bent for some time under pressure doesn't straighten out ·the moment the pressure stops·. Don't think 'That's because during that interval the wood loses some of its quantity'; because the same thing happens when a strip of steel is kept bent by pressure (for a longer period of time), and *steel* doesn't waste away! I said that we should *first* see what the sheer passage of time would do. If that doesn't produce a stable new state, we should try ·applying force and then· using aids and agreements to keep the new state stable. For it would be a considerable thing if we could use forceful means ·together perhaps with other aids· to impose fixed and stable ·new· natures on bodies. Such a technique would enable us to turn air into water by condensation, and produce many other such effects—because the application of *force* is what man does best!

(3) The third on my list of seven ways of operating on bodies is *heat and cold*—the great instrument of the operations of nature and of art. In this matter human power is plainly lopsided. We have the heat of fire which is infinitely more intense than the heat of the sun as it reaches us, and than the heat of animals. But the only cold we can get is from winter storms, underground caves, or packing things in snow and ice. *How* cold is that? Well, it about *as cold* as the heat of the sun at noon in the tropics, increased by bouncing off mountains and walls, is *hot*. ·That's not extreme·. For a short time animals can endure that much cold or that much heat. This heat is nothing compared with that of a burning furnace, and this cold is nothing compared with the cold that matches the heat of a furnace in intensity. That's why here among us things drift towards rarefaction

and desiccation and exhaustion, and hardly anything moves towards condensation and thickening, except ·when this is brought about· by mixtures and artificial methods. So instances of cold should be collected most carefully. We can find them, it seems, when bodies are

exposed on towers in sharp frosts,
put in underground caves,
packed in snow and ice in pits dug for the purpose,
lowered into wells,
buried in mercury and metals, or
plunged into liquids that turn wood into stone.

The last of these is said to be what the Chinese do when making porcelain. Masses of material made for this purpose are left underground for forty or fifty years, we are told. . . . We should also investigate all natural condensations brought about by cold, so that when we know their causes we can build them into techniques of our own. . . .

As well as things that are cold to the touch there are others that ·don't feel cold but· have the power of cold, and also condense. They seem to act only on the bodies of animals, hardly at all on anything else. Many medicines and plasters turn out to be like this. Some of them—such as astringent medicines and thickening medicines—condense flesh and tangible parts. Others—most notably the soporifics—condense spirits. There are two different ways in which soporific medicines induce sleep. (a) One is by •calming the spirits down. Examples are violets, dried rose leaves, lettuce, and other such blessed and blessing medicines: through their kindly and gently cooling vapours they invite the spirits to unite and put an end to their fierce and anxious motion. . . . (b) The other is by •putting the spirits to flight. Opiates and their like do this, utterly driving out the spirits by their malignant and hostile nature. When an opiate is applied externally, the spirits immediately flee from that part and don't easily flow back to it. When an opiate is swallowed, its vapours rise into the head, and the spirits contained in the ventricles of the brain flee in all directions. These retreating spirits can't escape, so they come together and are condensed. Sometimes •this uniting-and-getting-denser totally smothers and extinguishes the spirits; but in other cases—when the opiate is taken in a moderate dose—•it strengthens the spirits, makes them sturdier, and quells their useless and inflammatory motions. In this way an opiate can contribute to curing diseases and prolonging life. . . .

Because nature supplies cold so sparingly, we must do what the apothecaries do. When there's some medicinal ingredient that they can't get, they use a substitute instead—e.g. using aloes in place of balsam, cassia in place of cinnamon. We should follow suit, looking around carefully to see if there are any 'substitutes' for cold, i.e. any way of making bodies denser other than the standard way, namely cooling them. So far, only four such ways have been found.

(1) The first is simple compression. This may be a help ·in some processes· but it can't have much effect on permanent density because bodies spring back. **(2)** The second involves the contraction of the larger parts of a body after the tiny parts have left. That is what happens when a metal object is repeatedly made red hot by fire and then doused in cold water .**(3)** The third involves the coming together of the most solid of the homogeneous parts in a body, parts that had previously been dispersed and mixed with the less solid parts. . . . **(4)** The fourth involves agreement, when condensation is achieved by applying stuff that has a hidden power to do this. These agreements don't show up much, which is not surprising: we can't expect much success in an inquiry into agreement until we have discovered more about forms and microstructures.

There is no doubting that for animal bodies there are many remedies—internal as well as external—that condense as though by agreement, as I have just said. But this doesn't happen much with non-animal bodies. [Bacon then reports two stories of condensation activities in trees and bushes, and regretfully dismisses them as fables. He mentions also moisture found on oak-leaves, and explains why it is also not an example of his present topic. Then:]

As for heat: we have plenty of that, and great power over it; but some extremely important aspects of it haven't yet been empirically investigated—whatever the alchemists may say when hawking their wares! The doings of intense heat have been looked for and observed, but those of gentler heat, which come closest to nature's own ways, haven't been explored and therefore remain hidden. ·This is unfortunate, because there is more to be learned from gentle than from fierce heat·. Heat from the furnaces that are in favour nowadays

- •excites the spirits of bodies, e.g. nitric acid and other chemical oils;
- •hardens the tangible parts and sometimes fixes them while the volatile parts are discharged;
- •separates the homogeneous parts;
- •incorporates heterogeneous bodies in a coarse way, and coarsely mixes them up together; and above all,
- •smashes and confuses the microstructures of composite bodies.

The operations of a gentler heat ought to have been tried and explored. That way, subtler microstructures and more orderly configurations might be created and brought to light, following nature's example and imitating the works of the sun—as I sketchily indicated in the aphorism on instances of alliance [**35** at page 84]. Nature performs its operations on *much* smaller portions ·of matter· at a time, and by arrangements that are much more delicate and varied than anything we can produce by fire, used the way we use it now. We would see a real increase in man's power of man if we used heat and artificial forces to do something of the same basic kind as what nature does but ·with three differences·: perfected in power, varied in quantity, and, I may add, accelerated in time. [He gives examples of slow natural processes and fast artificial ones. Then:] Returning now to my present topic: every kind of heat, and its effects, should be diligently collected from every source and investigated: the heat

- •of heavenly bodies through rays that are direct, reflected, refracted, and concentrated in burning-glasses and mirrors;
- •of lightning, flame, and coal fire;
- •of fire from different materials;
- •of open fires and closed fires;
- •of fire modified by the different designs of furnaces;
- •of fire excited by blowing, and of fire that is quiescent and not excited;
- •of distant fire and fire close by;
- •of fire passing through various media.

·In addition to the heats of kinds of fire, there should be a study of· •moist heats, such as that of a Mary's bath, dung, external and internal animal warmth, and hay stored in a closed place; and •dry heats, such as the warmth of ashes, lime and warm sand. In short, heats of *all* kinds with their degrees. [A Mary's bath is a bowl of custard baked while sitting in a pan of water.]

But above all we must try to investigate *changes* of heat—specifically changes that are •gradual, •orderly and •periodic, and taking account of the relevant facts about distances and durations. We need to find out what happens *in* these events and what results *from* them. ·I emphasize •those three adjectives·, because nothing great can be expected from heat that is fierce ·or heat-changes that are· sudden, or irregular. The kind of orderly change ·that I want investigated· is truly the daughter of heaven and mother of generation. This is obvious even in plants. In the wombs of animals there are heat-changes caused by movement, sleep, eating, and the passion of the pregnant female. Lastly, in the wombs of the earth itself, I mean the wombs in which metals and fossils are formed, such changes also occur and have power. . . . That is all I have to say about the operations and effects of heat. Now is not the time to examine them thoroughly, when we haven't investigated and brought to light the forms of things and the microstructures of bodies. It will time for us to seek, apply, and adapt our instruments when we have solid knowledge of the exemplars—·i.e. the natural things and structures on which our instruments will be modelled·.

(4) The fourth way of dealing with natural bodies is to ·stand back and· let time pass. *Just waiting* is nature's way too; it is nature's table-waiter, store-keeper, in a way its dispenser of stores. I call it 'just waiting' when a body is left to itself for a considerable time, protected throughout from all external force. When there stops being any motion caused from the outside, that's when the internal motions ·of the body in question· show themselves and run their full course. The works of •time are far subtler than those of •fire.

- •Wine can't be clarified by fire as it can be by time.
- •Ashes produced by fire aren't as fine as the dust that substances are turned into by time.
- •When fire abruptly incorporates some bodies into others and mixes them, the results are much inferior to the incorporations and mixtures produced by time.
- •The complex and various microstructures that time aims for by just waiting—for example those involved in putrefaction—are destroyed by any fierce heat.

It is relevant to point out that when bodies are closely confined, their motions have something of violence in them. For such imprisonment impedes the spontaneous motions of the body. So for distilling purposes an open vessel is best; for mixtures a more or less closed one; and for putrefactions a vessel that is open enough to let in air. Anyway, instances showing what happens with the passage of time, and what results from that, should be carefully collected from all quarters.

(5) The regulation of motion (which is the fifth way of treating bodies) is very useful. I call it 'regulation of motion' when one body blocks, repels, allows or steers the spontaneous motion of another body. It is mostly done through the choice of shape and orientation of containers. For condensing vapours in a still, an upright cone is best. For draining off the dregs in refining sugar, an inverted cone is best. Sometimes what is needed is a winding shape that narrows and widens alternately. That is what *straining* requires: body x lets through one element in body y and holds back another. Straining, and other regulation of motion, isn't always done from outside. It can also be done by a body within a body, as when stones are dropped into water to collect the slime; and when syrups are clarified with egg-white—the coarser parts stick to it and can then be removed. . . .

(6) Operations by agreements or aversions (which is the sixth way) often lie deeply hidden. ·You might think that we have plenty of access to them, because of what is known about· so-called occult and specific properties, and sympathies and antipathies. ·But *they* are not what I am talking about: they· are to a great extent philosophy gone bad. We can't have much hope of discovering ·relational facts about· the agreements between things before we have learned ·the non-relational facts· about the forms and microstructures ·of individual things·. For agreement ·between two things· is

just a symmetry between the forms and microstructures of one and those of the other.

But the broader and more general agreements between things are not so obscure, so I'll start with them. The principle division between agreements is this:

(1) Sometime one body agrees with another in microstructure, while differing greatly from it in respect of how much matter it contains, i.e. its density or rarity.

(2) Sometimes one body agrees with another in respect of its density or rarity, while differing greatly from it in microstructure.

·Here first is an example of **(1)**·. . . . In mercury and sulphur we can see two of the most widespread general agreements in nature:

- •sulphur agrees with •oil and fatty vapour, •flame, and perhaps •the material that stars are made of;
- •mercury agrees with •water and watery vapours, •air, and perhaps •the pure ether between the stars.

·The members of each of· these two quartets. . . .differ enormously in how much matter they contain and how dense they are, but there is much evidence that they agree very well in microstructure. ·Now an example of **(2)**·. Various metals agree with one another very well in quantity of matter and density (especially as compared with plants), but their microstructures differ in many ways. Similarly, the microstructures of plants and animals vary in countless ways, but they don't differ much in their quantity of matter or density.

The next most general agreement is that between the principal ·kinds of· bodies and. . . .their support systems and their food. So we should investigate:

- •in what climates, in what sort of ground, and at what depth each kind of metal is generated;
- •whether gems come into being *in* rocks or *between* layers of them;
- •in what soil each kind of tree and shrub and herb grows best and prospers;
- •what kinds of plant-food—dung of some sort? chalk? sea-sand? ashes? and so on—do the most good; and which of them works best in which kind of soil.

Something else that depends heavily on agreement is the ·biological· process involved in the grafting of trees and plants, and the facts about what plants prosper best on what stocks. Until now grafting has been done only with fruit trees; it would be an agreeable experiment to try also grafting forest trees, so as to get more leaves and nuts and also more shade. Similarly, we should note what each kind of animal eats, and what it doesn't eat. . . . We should also note the different materials of putrefaction from which tiny animals are generated.

The agreements between principal bodies and their subordinates (for that's how I see the ones I have just listed) are sufficiently obvious. So are the agreements between the senses and their objects; and because these have been well observed and keenly explored, they may throw much light on other, hidden agreements.

The inner agreements and aversions, or friendships and enmities, of bodies ·haven't fared well in human hands. They· have been (a) said to exist where they don't, or (b) mixed with fables, or (c) ignored and thus not well known. (·Note the terminology that I used for this matter·. As for the ·time-honoured· terms 'sympathy' and 'antipathy'—I'm sick of then because they are so much tied to superstitions and stupidities.) **(a)** 'The vine and the cabbage are at odds with one another, because they don't thrive when planted next to one another'—wrong! The real reason is obvious: both of these plants are full of sap, and make fierce demands on the soil, so that they compete for nourishment. 'Corn has agreement and friendship towards the cornflower and the wild poppy, because these ·three· plants hardly ever come up except in cultivated fields.' Wrong! The truth is that there is discord between corn and those other two, because the poppy and cornflower are germinated and grow from some juice in the soil that the corn didn't want and so left behind, so that sowing corn prepares the ground for growing poppy and cornflower. There have been very many such false ascriptions. **(b)** As for fables, they should be utterly exterminated. **(c)** A small but established set of agreements have been solidly established by experiment—the magnet and iron, gold and mercury, and the like. Some other significant ones have been found in chemical experiments on metals. But the biggest group of discovered agreements (it's still small!) have to do with certain medicines whose so-called 'occult' and specific properties have a relationship ·that could be one of agreement· with limbs, or humours, or diseases, or sometimes with individual natures. And let's not overlook the agreements between the moon's motions and changes and the states of bodies here below—results gathered from careful experiments in agriculture, navigation, medicine, and other sciences, which we can honestly accept. As for universal instances of more hidden agreements: the fewer of them there are, the more earnestly we should inquire after them, making use of faithful and honest traditions and narrations, and doing this not in shallow willingness to believe anything, but rather in a frame of mind in which we are almost sceptical and are nervous at the prospect of believing something! We shouldn't neglect—indeed we should carefully follow up —a kind of agreement between bodies which, though it is a natural phenomenon, is useful to us in many ways. I mean the coming together or uniting of bodies—whether easy or difficult, whether by •composition or by •simple juxtaposition. [This last phrase foreshadows our distinction between •chemical compounds and •physical mixtures.] Some ·pairs of kinds of· bodies freely and easily mix with and incorporate one another; others do this only awkwardly and with difficulty. Thus powders mix best with water, ashes and lime with oils, and so on. And we should collect not only instances of bodies' propensity for or aversion from mixing, but also ·the properties of the resultant mixture·: what sort of mixture is it? how are the parts distributed and arranged? in the completed mixture which ·set of parts· is dominant?

(7) All that remains is the seventh of the listed ways of operating on bodies, namely by alternating uses of the other six. It wouldn't be appropriate to offer examples of this before we dig deeper into each of the six separately. Such an alternating chain of operations, aiming at something in particular, is a very useful thing but a hard one to devise. ·Not many of them *are* devised, because· men are utterly impatient of the theory of this as well as of the practice, though in any big project this is the thread that can lead us through the labyrinth. That's all I have to say about examples of multi-purposiveness.

51. Finally, class 27 of privileged instances: **magical instances**. That is my name for instances where the material or efficient cause is slight or small in comparison with the effect. An event of this kind, even if it is of a common sort, seems at first like a miracle—and sometimes it goes on seeming so even after careful thought. Nature hasn't given us a generous supply of these; but we'll see what emerges when nature's folds have been shaken out and we have made discoveries of forms and processes and microstructures. As at present advised, I conjecture that these magical effects come about in three ways: **(1)** By self-multiplication; as in fire, in so-called 'specific' poisons, and also in motions that increase in power as they pass from wheel to wheel [he is talking about *gears*]. **(2)** By exciting or inviting some other body, as in the magnet, which excites countless needles without losing any of its power, or in yeast and the like. **(3)** By a motion's *getting in first*, as in the case I mentioned of gunpowder, cannons and mines [page 106]. ·To understand· **(1)** and **(2)** we need a knowledge of agreements, for **(3)** a knowledge of the measurement of motions. I have at present no reliable evidence indicating whether there is any way for us to •change bodies through ·their smallest parts·, their so-called 'minima', or to •change the subtler microstructures of matter (which has to happen in every sort of transformation of bodies). If we did find a way of doing this, we would be able artificially to do *quickly* things that nature does in very round-about ways. . . .

52. That completes what I have to say about privileged instances. Do bear in mind that in this Organon of mine the topic is logic, not philosophy [here = 'not philosophy or science']. But it shouldn't surprise you that observations and experiments of nature are scattered throughout the work. They are there as illustrations, and as samples of the art I teach. My logic aims to instruct and train the intellect in how to dissect nature truly, and to discover the powers and operations of bodies, with their laws laid down in matter, so as to achieve a science that emerges not merely from the nature of •the mind but also from the nature of •things. Contrast this with vulgar logic! It aims to enable the mind to put out slender tendrils to clutch at abstractions.

What I have said shows that there are twenty-seven ·kinds of· privileged instances:

1. solitary instances (aphorism **22**, starting on page 70)
2. shifting instances (**23**, page 71)
3. revealing instances (**24**, page 72)
4. concealed instances (**25**, page 73)
5. constitutive instances (**26**, page 75)
6. matching instances (**27**, page 76)
7. unique instances (**28**, page 78)
8. deviant instances (**29**, page 79)
9. borderline instances (**30**, page 80)
10. instances of ·human· power (**31**, page 106)
11. instances of friendship and of enmity (**33**, page 82)
12. terminal instances (**34**, page 83)
13. instances of alliance (**35**, page 84)
14. signpost instances (**36**, page 86)
15. instances of separation (**37**, page 91)
16. door-opening instances (**39**, page 93)
17. summoning instances (**40**, page 94)
18. instances of the road (**41**, page 98)
19. instances of supplement (**42**, page 99)
20 dissecting instances (**43**, page 100)
21. instances of the measuring-stick (**45**, page 102)
22. running instances (**46**, page 104)
23. instances of quantity (**47**, page 106)
24. instances of strife (**48**, page 107)
25. suggestive instances (**49**, page 119)
26. multi-purpose instances (**50**, page 119)
27. magical instances (**51**, page 126)

What makes any one of these instances ·privileged, i.e.· better than run-of-the-mill instances, has to do with either •the information aspect of our project or •the practical aspect or •both. As regards information: the privileged instances assist either the *senses*, as do (16–20) the five torchlight instances [see **38** on page 92], or the *intellect*,

- •by hastening the exclusion of the form, as (1) solitary instances do, or
- •by narrowing and sharpening the affirmative ·account of· a form, as do (2) shifting and (3) revealing instances, and instances of (11) friendship and (12)

terminal instances, or
- •by raising the intellect and leading it to general and common natures, either
  - •immediately, as do (4) concealed and (7) unique instances, and (13) instances of alliance, or
  - •at one remove, as do (5) constitutive instances, or
  - •very indirectly, as do (6) matching instances, or;
- •curing the intellect of its ·bad· habits, as do (8) deviant instances, or
- •by leading it to the great form or fabric of the world, as do (9) borderline instances, or
- •by warning it against false forms and causes, as do (14) signpost instances and (15) instances of separation.

As for the practical aspect of our project: the privileged instances either •point out or •measure or •facilitate practice. •They point it out by showing where we should begin so as not to go again over old ground, as do (10) instances of ·human· power; or showing what we should try for if we become able to do it, as do (25) suggestive instances. •The four mathematical instances (21–4) measure practice. •The (26) multi-purpose and (27) magical instances facilitate it. [In this paragraph, each of the twenty-seven instances is mentioned exactly once.]

Of these twenty-seven kinds of instance there are some that we should start collecting right away, not waiting for specific investigation of natures. (I've already said this about some of them.) The kinds in question are: (6–11) matching, unique, deviant and borderline instances, and instances of ·human· power, and (16) door-opening and (25–7) suggestive, multipurpose and magical instances. ·These need to be embarked on right away· because they either help and cure the intellect and the senses, or provide general instructions for practice. The remainder needn't be inquired into until we come to draw up tables of presentation [see **15**, page 64] for the work of the interpreter of some particular nature. For the instances that are marked off as 'privileged' are like a *soul* amid the common instances of presentation; and, as I said at the outset ·concerning solitary instances· [**22** on page 70], a few of them will do the work of many; so in making up our tables we must vigorously investigate them—·i.e. our chosen privileged instances·—and include them in the tables. . . .

But now I must proceed to the supports for induction and corrections of it, and then to concrete things, and hidden processes and hidden microstructures, and then to the other tasks set out in aphorism **21** [on page 70]. My aim is to act like an honest and faithful guardian: when men's intellect has broken free and come of age, I shall put men's fortunes into their own hands. This is bound to lead to an improvement in the human condition and an increase in power over nature. In the Fall ·as recorded in the book of Genesis·, man underwent a •loss of innocence *and* a •weakening of his power over creation. Both of these losses can be to some extent made good, even in this life—the •former by religion and faith, the •latter by arts and sciences. For the curse ·that God laid on Adam and Eve· [Genesis 3:14–19] didn't make the creation a complete outlaw for ever. The part of it that said 'In the sweat of thy face shalt thou eat bread' means that by various labours (*not* by disputations or empty magical ceremonies!) man will in due course and to some extent compel the created world to provide him with bread, i.e. to serve the purposes of human life.