

# The New Organon

## or: True Directions Concerning the Interpretation of Nature

Francis Bacon

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[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. Any 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.

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## 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:

(i) 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 [151] 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 unlike, 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 <sup>1</sup>**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 be 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 it 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 subterranean 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 reverberatory 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 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 unlike;

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 unlike 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 of 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.