The Origin of forms and Qualities (according to the corpuscular philosophy) illustrated by (1) considerations and (2) experiments 1. The Theoretical Part

Robert Boyle

1666

[Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. Every four-point ellipsis . . . . indicates the omission of a brief passage that seems to present more difficulty than it is worth. Longer omissions are reported between brackets in normal-sized type.—This text is (1) 'the theoretical part' of Boyle's *Origin of Forms and Qualities*; the somewhat shorter (2) 'experimental part' is not presented here.—Some of the divisions and section-titles are Boyle's, but most have been added in this version.

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Glossary

affection: An affection of a thing is a state or property or quality or attribute of the thing. The word will be left unchanged throughout this work, because there seems to be no systematic replacement for it.

chemist: For Boyle's objection to the 'chemistry' of his time, see 'Can we hope for help. . . ' on page 9.

history: Boyle uses this word as we still use it in the phrase 'natural history'. In this sense, a 'history of. . . heat' (page 10) is an assemblage of observed facts about heat, organised or classified in some useful way.

modification: A thing's 'modifications' are its non-relational properties—whatever can be attributed to or predicated of the thing. What makes it the case that (for example) *This lump of brass is spherical*? Answer **(a)**: The brass somehow contains a thing-like item, its sphericalness. Answer **(b)**: The brass is laid out in space in a certain way. Boyle regularly uses 'modification' as a way of opting for **(b)**.

motion: In this version, 'motion' often replaces Boyle's 'local motion' = 'motion involving change of place'. For us, all motion is local motion; but there is a long tradition of using 'motion' (and its conventional equivalents in other languages) to mean 'change'; and 'local motion' served to narrow that. We don't need it.

phenomenon: Boyle regularly uses this word to mean 'particular event or state of affairs'.

philosophy: In Boyle's time 'philosophy' covered science as well as the discipline called 'philosophy' today. The word will be left untouched in this version, but Boyle's topic throughout is science, specifically physics, though issues that are 'philosophical' in our sense sometimes come into it.

physical: In Boyle's time, 'physical' had a broader meaning than it has today. It came from an ancient trilogy:

logic, physics, ethics,

having to do with

what must be, what is, what ought to be.

Roughly speaking, Boyle's 'physical' means 'having to do with what is really out there in the world'.

principle: In the early modern period 'principle' (like its kin in French and Latin) **sometimes** meant, as it does today, a proposition that has some privilege of basicness or certainty; but **more often** it meant something totally different: a source, a cause, a generating factor. (Hume's *Enquiry into the Principles of Morals* doesn't discuss any moral propositional principles; it's an enquiry into the *sources in human nature* of our moral beliefs and feelings.) Boyle uses 'principle' a lot in each of those senses: through pages 1–8 in our sense of it; but then on page 9 he speaks of the chemists' 'three principles', referring (old sense) to three *kinds of matter*—salt, sulphur and mercury—which the chemists credited with having special causal powers. Then in the same paragraph he speaks (our sense) of 'a system of theoretical principles of philosophy'.

school: The 'schools' to which Boyle frequently alludes were, roughly speaking, heavily Aristotelian philosophy departments; the cognate adjective is 'scholastic'.

second cause: For those with certain theological views, God is the first cause of everything that happens in the world; a 'second cause' is an ordinary down-to-earth cause such as heat causing butter to melt. It is a 'second' cause because God causes the butter to melt *through* bringing heat to bear on it.

Section 7: The origin of forms: preliminaries

The origin of forms, Pyrophilus, is thought to be the noblest question that arises in natural philosophy; and I think that it has been found to be one of the most difficult and challenging ones. One of the things that has invited me to look for some more satisfactory account than the schools usually give of this matter is my observation that the wisest men who have busied themselves in explaining forms according to the Aristotelian notions of them have either •openly admitted that they can't explain them or •unknowingly proved that they can't by giving such unsatisfactory explanations of them. [At the top of the page Boyle quotes (in Latin) different accounts of substantial forms by Scaliger, Aquinas and Sennert.]

When I am merely writing *notes*, you won't expect me to list—let alone to examine—all the opinions men have had concerning the origin and nature of forms. It's enough for my purpose if, having indicated what my ·mechanistic· hypothesis would have us think about this topic, I now briefly consider the general opinion of our modern Aristotelians concerning it. I say the *modern* Aristotelians because many of the ancient commentators on Aristotle (especially the Greek ones) seem to have understood his doctrine of forms very differently—and less absurdly—than his ·more recent· Latin followers, the schoolmen and others, have done. And I don't explicitly count Aristotle himself among the champions of substantial forms because although •in one or two places he seems openly enough to count forms among substances, he seems to me •over-all to have been undecided whether there are any such substances, or else to speak so ambiguously and obscurely about them that there's no knowing what his opinions of them were. I base this conclusion on **(1)** the fact that the examples Aristotle uses to illustrate the forms of natural things concern the shapes of artificial things (statues and the like), which everyone agrees are mere accidents, and **(2)** the fact that he makes little if any use of substantial forms to explain the phenomena of nature.

But the sum of the controversy between the schools and me is this:

- •When generation occurs, are the forms of natural things (always excepting human souls) educed out of the power of the matter? and
- •Are these forms true substantial entities, distinct from the other substantial principle [see Glossary] of natural bodies, namely matter?

The word 'educe' is one that the schoolmen use. [It is from Latin meaning 'draw out'.] I have three main reasons for answering 'No' to both these questions. **(1)** Matter and its accidents are all we need to explain as much of the phenomena of nature as we do understand or are likely to come to understand; so there is no *need* to include substantial forms among natural things. **(2)** I don't see what use this puzzling doctrine of substantial forms has in natural philosophy. The more frank of the Aristotelians generally admit that the true knowledge of forms is too difficult and abstruse to be within their reach; and that includes the acute Scaliger and the others who have been busiest investigating substantial forms. How likely is it that particular phenomena will be explained by a principle whose nature is admittedly unknown? You be the judge! I have already said a lot regarding those two points, and they will come up again a few times. What I want to stress now is my third point. **(3)** I can't conceive •how forms can be generated, as the Aristotelians say they are, or •how the things Aristotelians say about them are consistent with the

principles of true philosophy or even with other parts of the Aristotelians' doctrine.

How forms are 'educed' out of the power of the matter, according to the part of the doctrine of forms that the schools mainly agree on, is so inexplicable that I'm not surprised that able men have come up with many different hypotheses to make it intelligible. There have been so many of these lately that I can't appropriately list them all here, especially since I find them all to be very unsatisfactory—so much so that I have to think that the sharp-minded adherents of any one of them are driven to embrace it less by anything satisfying that they find in it than by the obvious drawbacks of all its rivals! Speaking for myself, I find so much reason in what each party says against the explanations of the rest that I think they all refute well, and none establish well.

As for the part of the doctrine that they mostly agree on: my present ·note-presenting· exercise forbids me to press many arguments against it. I shall stress only the argument that for me has the most force, namely that I don't find the doctrine to be comprehensible.

I know that the modern schoolmen at this point take refuge, as they usually do, in an obscure distinction: they tell us that matter's power in relation to forms is

- •partly 'eductive', as the agent can make the form out of the matter, and
- •partly 'receptive', as the matter can receive the form that has been so made.

But those who say this don't accept that when a body is generated its form already existed in its matter, or indeed anywhere else; and it's hard to conceive how one substance x can be 'educed' out of another substance y that has a totally distinct nature from x, unless before the 'eduction' x actually existed in y. And as for the 'receptive' power of the matter: all that does is to make the matter able to receive or lodge [= 'house', 'store', etc.] a form that is brought to be united with it. Well, granted that matter can harbour this new substance when it is produced, how can we make sense of the thesis that this ability of •the matter contributes something to the *production* of a new substance that is quite different in nature from •itself? Furthermore, it's obvious that the human body has a 'receptive' power in relation to the human soul; but ·the modern Aristotelians· admit that our soul is a substantial form that is *not* 'educed' out of the power of matter.

The 'eductive' power of matter might signify something if its sponsors **(a)** accepted that the form of a natural body is merely a more finely divided part of the matter (compare spirit of wine, which is a part of the wine though when it is isolated from the wine what remains is no longer wine but vinegar); or if they **(b)** joined me in saying that the form is merely a modification [See Glossary] of the matter; for then the 'receptivity' of a portion of matter would be merely its ability to be ordered in such a way as to constitute a body of kind K with its own special name. . . . But they won't go along route **(b)** because they don't want the form to consist merely of accidents. And they won't follow **(a)** either, because that would imply that matter is corruptible (which they deny) and that matter and form, rather than being two different substantial principles, are one and the same except for differences in how firm they are and how big their parts are. [The modern Aristotelians have fancy theories about how form can arise out of matter, Boyle remarks, but he declines to spend time on them:] Let the production of forms be as elegant and intricate as you like, if the work is done by a physical and finite agent it can't involve anything that clashes with the nature of things; so I am still left with my objection. According to the modern Aristotelians, what happens in generation is the production

of a form that is a substance that didn't previously exist anywhere outside the portion of matter of which it is the form. I say that in that case it must either **(i)** be produced by refining or fine-graining some parts of the matter into form, or else **(ii)** be produced out of nothing, i.e. created. . . . If they accept **(i)** then the form will indeed be a substance, but it won't be distinct from matter ·as the Aristotelians say it is·, because however much matter is refined it is still matter. . . . Furthermore, the Aristotelians say that the form is not made of any part of the matter; and indeed it's inconceivable that a physical agent should turn a material substance into an immaterial one, especially if they are right in holding that matter can't be either corrupted or generated. In fact they reject **(i)**, denying that the substantial form is made of anything material; so they must allow me to think that it is produced out of nothing, until they show me some other way in which a substance can come into existence. On this account, every natural body with its own special name—gold, marble, saltpetre, etc.—must be produced not barely by generation but partly by generation and partly by creation. And since everyone agrees that **no** natural agent can **produce the tiniest atom of matter**, it's strange that the Aristotelians should credit **every** physical agent with the power to **produce a form**, which they regard as not only a substance but a far nobler one than matter! In this they are attributing to the lowest created things the power of creating substances, which the ancient natural scientists thought too great to be ascribed to God himself, and which is indeed too great to be ascribed to anything other than him. This led some schoolmen and philosophers [see Glossary] to derive forms immediately from God; but this deserts Aristotle and the Aristotelian philosophy they want to maintain, and it would credit Omnipotence with performing many thousands of miracles every hour, so as to bring about in a *supernatural* way something that seems to be an utterly familiar event in the ordinary course of *nature*—I mean the generation of bodies with new names.

For those reasons the production of forms out of the power of matter is incomprehensible to me; and some of the things that the Aristotelians ascribe to their substantial forms are more than I can reconcile my reason to. They tell us outright •that these forms are substances, but also •that they depend on matter in coming into existence and in remaining in existence [Boyle gives these in technical Latin], so that they can't even exist outside the matter that supports them (which is why they are usually called 'material forms'). This makes them substances in name but mere accidents in truth;. . . .because the very notion of a substance is that of a self-subsisting entity, i.e. something that can exist without support from any other created being. A further point: there are only two sorts of substances, material and immaterial; a substantial form must be of one sort or the other; but the Aristotelians ascribe things to substantial forms that make them very unfit to belong to either. And finally: these imaginary 'material forms' are almost as harmful to the theory of corruption as to that of generation. If a form is a true substance really distinct from matter, it must (I repeat) be able to exist on its own, with no other substance to support it; and in line with this my present adversaries hold that the soul of man survives the body that it was the form of before death. Yet they insist that in corruption the form is quite abolished and utterly perishes, not being able to exist separated from the matter that it was united to; so that here again they treat as an accident something that they *call* a substance. . . .

Section 8: Examining metaphysical and logical arguments for substantial forms

I should now examine the arguments that the schools customarily use to establish their substantial forms. But ·I shall pass up most of them because· the nature and scope of my present work requires me to be brief; and anyway the arguments that are mentioned as the chief ones are (with one or two exceptions) metaphysical or logical rather than being based on the principles and phenomena of nature; they concern words rather than things. So I, who have neither the inclination nor the leisure to wrangle about words, will settle for presenting and very briefly answering a few arguments that are thought to be the most plausible.

1. The argument I shall take first is so uncouth in Latin that it is hard to put it into English. It is this:

(a) *Omne compositum substantiale requirit materiam & formam substantialem, ex quibus componatur.*

(b) *Omne corpus naturale est compositum substantiale*

(c) *ergo*. . . etc.

[**(a)** Every substantial composite requires matter and a substantial form, out of which it is composed.

(b) Every natural body is a substantial composite.

(c) therefore. . . etc.]

Some people claim plausibly enough that the conclusion doesn't follow; but for brevity's sake I choose to deny premise **(b)**, and challenge the proposers to prove it. I don't know of anything in nature that is composed of matter and a substance distinct from matter—except man, who alone is made up of an immaterial form and a human body. If the other side insist that in that case other bodies can't properly be said to be *composita substantialia*—·substantial composites·—I cheerfully give them permission to find some other name for other natural things.

2. Their next argument is that

> If there were no substantial forms, all bodies would be mere entities *per accidens* (as they put it), which is absurd.

[The Latin *per accidens* doesn't mean 'by accident', and isn't linked with the term 'accident' that we have met all through this work of Boyle's. Something is an entity *per accidens* if its status as a single thing depends on how we regard it, use it, talk about it, or whatever; for example a brick. The antonym of this is an entity that is *ordinatur ad unum per se* = 'is ordered to unity though itself' = 'is intrinsically unified' = 'has something about it, considered just in itself and apart from our interests and needs, that testifies to its unity'; for example an animal.]

Here is my answer to this. According to the notion that various learned men have of an entity *per accidens*—namely something that isn't *ordinatur ad unum*—those of us who don't admit substantial forms are not committed to saying that all natural bodies are entities *per accidens*; because in natural bodies the matter, shape, situation, and motion that work together to constitute the body are *ordinantur per se & intrinsece*—·ordered through themselves, ordered intrinsically·—to constitute one natural body. If this answer doesn't satisfy the other side, then I shall add that speaking for myself what I care about is what nature has made things to be in themselves, not what a logician or metaphysician will call them in his technical terminology; because I think it is much more appropriate to alter words to improve their fit with the nature of things than to assign a wrong nature to things to improve their fit with forms of words that were probably invented when the things themselves were not known or understood and perhaps not even thought of.

3. ·In the spirit of that last remark·, I shall confront one more argument of this sort, namely:

> If there were no substantial •forms, there couldn't be any substantial •definitions, and that is absurd.

Well, now: the Aristotelians themselves admit that bodies' forms are of themselves unknown; so it seems to me that all we get from this latest argument is this:

> If we don't admit *somethings* that don't exist in the nature of things, we can't build our definitions on them.

But if we did admit substantial forms, we still couldn't give substantial definitions of natural things unless we could define natural bodies by things that we don't know; for the wisest Aristotelians admit that we don't know substantial forms, and they don't claim to give the substantial definition of any natural composite except man. Perhaps our needs would be met if instead of •substantial definitions we had •essential definitions of things; I mean ones based on the essential differences of things that put them into some kind of natural bodies and distinguish them from all those of any other kind.

You can find these three arguments for substantial forms, Pyrophilus, as I have, scattered through the writings of the Aristotelians and schoolmen. Sometimes they are slightly modified; but I think that all of them that I have come across are adequately dealt with by the criticisms I have presented or at least by the grounds on which those criticisms are built. That is because those seemingly various arguments have this in common:

(1) they concern words rather than things, or
(2) they are based on precarious suppositions; or
(3) they claim to be 'absurd' something that. . . .doesn't seem to be in the least absurd.

Some of the modern defenders of substantial forms, perhaps fearing that arguments of the above sort won't have much force in the minds of natural scientists, have seen a need to add some more physical arguments. . . . I shall here briefly consider these now.

Section 9: Examining physical arguments for substantial forms

1. The argument that is most confidently insisted on comes from the spontaneous return of heated water to coldness. This outcome, the adversaries say, *must* be ascribed to the action of the substantial form, whose job it is to preserve the body in its natural state and to return it to •that state when the body leaves •it. This argument indeed might be plausible if we were sure that heated water would grow cold again (without its more agitated parts evaporating) if it were placed in some of the imaginary spaces beyond the world; but as things stand, I see no need to bring in a substantial form, because the facts can easily be explained without it. The water we heat is surrounded by our air, or by some vessel or other body contiguous to the air; and in our climate the air and the water are usually less agitated than the

fluids in our hands or other organs of touch; so we find the air and water to be cold. When water is exposed to a fire, that starts up a new agitation, more vigorous than that of the parts of our sense-organs. . . .; but when the water is removed from the fire, this acquired agitation must gradually be lost, either **(i)** by the evaporation of the fiery corpuscles that the epicureans imagine to find their way into heated water, or **(ii)** by the water's communicating the agitation of its parts to the contiguous air, or to the vessel that contains it, until it loses its surplus motion, or **(iii)** by the water's acquiring the freezing-cold atoms ·that some people believe in·; if there were such things, England would have plenty of them! [Notice that **(i)** and **(iii)** rest on things that Boyle doesn't accept. You'll see in a moment that he puts his money on **(ii)**.] In any of these three ways, the hot water can be brought back to its former temperature, with no help from a substantial form. Compare this with a ship floating slowly down a river, suddenly sped up by a gust of wind blowing the same way the stream runs: when the wind stop, the ship reverts to its former speed with no need for any 'internal principle'. Similarly with the cooling water: we don't need to bring in any 'internal principle', because the temperature of the surrounding air is sufficient to explain what happens. And if water is kept. . . .in the upper rooms of a house in hot weather, the water will throughout the summer be warmer than (according to the Aristotelians) its nature requires. [Boyle adds that in arctic places water remains as cold hard ice throughout the year, despite the supposed substantial form whose job is to keep it at its natural temperature. Such temperatures, he says impatiently, depend entirely on the temperature of the air.]

2. Another argument that has recently been much urged by some learned men goes like this:

> There is nothing in matter as such that favours one sort of accident over another; but somehow a thing of a given kind retains and preserves the accidents that constitute it; so there must be a substantial form that does this, because the matter itself has no greater appetite for some accidents than for others.

·ONE RESPONSE: WHAT IS A NATURAL STATE?·

One thing I could say in response to this is that I am not convinced of the view, usually assumed as undeniable by philosophers as well as ordinary people, that a body has a natural state that nature tries to keep it in and that it can't be taken out of except by being put into some preternatural [= 'unnatural'] state. I mean the view that *all* bodies have this; I am not denying here that some do. Given that the world has been constituted by the great Author of things, I regard natural phenomena as being caused by collisions between portions of matter; and I'm not so fully convinced that nature ever *aims* to keep a parcel clothed with one set of accidents rather than with some other.

I look on many bodies, especially fluid ones, as frequently changing their state according to whether they happen to be more or less agitated or otherwise affected by the sun and other considerable agents in nature. Think about air, water, and other fluids: if the temperature and rarefaction or condensation that they are in at the start of Spring here in London is picked on as their natural state, then they'll have very differing natural states in the tropics and polar regions; and here in London they'll be in varying unnatural states through most of the summer and all the winter. . . .

And the natural state of many more stable and constant bodies is, I take it, either •the most usual state or •the state they are in after a notable change in them has taken place. Consider a slender piece of silver: in most cases it will be flexible—it will retain any shape that you care to bend it into. Now let such a piece of silver be well hammered: that will turn it into a spring, which bounces back from any

deformation. •I classify the silver's flexibility as its natural state, because silver is usually found to be flexible, and our present piece of silver was so before it was hammered; but •the springiness it acquires by hammering is really no more unnatural to the silver than the flexibility was; and if both pieces of silver were left alone and shielded from outward violence, the flexible one would stay flexible (absent the violent motion of the hammer) and the springy one would stay springy (absent the violent agitation of an annealing fire).

·ANOTHER: NO NEED FOR THE SUBSTANTIAL FORM·

The accidents the argument speaks of are introduced into the matter by the agents or causes, whatever they may be, that produce in the matter an essential form (*not* a substantial form); I explained this earlier [page 23]. And once these accidents have been introduced into the matter, there's no need for a new substantial principle to keep them there. By the general law—i.e. the common course of nature—the matter that has the accidents must continue in the state they have put it into, until it is forcibly deprived of those accidents by some agent or other. For example: when the motion of tools under the guidance of the artificer has turned a piece of brass into a sphere, there's no need for a new substance to preserve that round shape; because the brass must keep that shape until it is destroyed by some agent—perhaps the sphere-maker himself—that can overcome the matter's resistance to having its shape changed.

[•An argument *ad hominem*—Latin meaning 'against the man'—is an argument to show not that doctrine P is false but that one's opponent is deprived of the right to believe P by other things he has said. •The Aristotelian 'elements' that Boyle will speak of here are air, earth, fire, and water. •Four 'first qualities' were supposed to characterise these elements, thus: earth dry/cold, air wet/hot, fire hot/dry, water cold/wet.]

I can back this up with an *ad hominem* argument against the Aristotelians. A considerable party among the Aristotelians maintain that the ·four· elements don't have substantial forms, their role being played by what the Aristotelians call the 'first qualities': for example that •fire has no other form than heat and dryness, and that •water has no other form than coldness and moistness. Now, these bodies are the vastest and the most important of our world. If

> **they** consist only of universal matter and those few accidents, and don't need any substantial form to keep them in their ·elemental· state, hanging on to those qualities for as long as the law of nature requires,

then why should someone who believes this deny that in **other bodies as well** qualities can be preserved and kept united to the matter they belong to without being tied down or held up by a substantial form? [Boyle inserts into that sentence a clause that he *may* think somewhat weakens his *ad hominem* argument: 'Although besides the four so-called "first" qualities the elements have various others—heavy/light, solid/fluid, opaque/transparent.' He then proceeds to strengthen his conclusion thus:] Given this:

> When there's no suitable destructive cause in the vicinity, a body's accidents will by the law of nature remain as they were,

it can't reasonably be denied that

> When there *is* a suitable destructive cause, a body will lose those of its accidents that are supposed to flow from its substantial form; and the form won't be able to do anything about it.

If you expose a lead bullet to a strong fire, it will quickly lose its shape, coldness, malleableness, colour (for it will appear of the colour of fire), flexibility, and some other qualities; and all this will be lost despite the imaginary substantial form.

According to Aristotelian principles, the substantial form must still be there in the bullet, but it won't be able to help it! Removing the lead from the fire usually restores to it most of its previous qualities. . . .but that may be due partly to its special texture and partly to the coldness of the surrounding air. . . . [Boyle adds that if the lead remains in a hot enough fire for long enough, it won't regain its former qualities; this being something he has discovered for himself.]

·Having argued that the work assigned to supposed substantial forms by their devotees often doesn't get done, I now contend that their assigned work often *is* done but not by them·! Pluck an orange from its tree: no-one will deny that the fruit (except perhaps for its seeds) is no longer animated by the 'vegetative soul', i.e. the substantial form, of the tree or the plant; yet we see that the same colour, odour, taste, shape, and consistency that are supposed to have flowed from the soul of the tree can continue in the orange even after the tree has been cut down and burned. And for all we know this will be true not just of the colour etc. but also other qualities, perhaps even some occult qualities such as the orange's medicinal powers. And we find that tamarinds, rhubarb, senna, and many other herbal remedies will retain their purgative and other medicinal properties for many years after they have been deprived of their former vegetative soul.

3. I also find people arguing like this:

> Why is whiteness separable from a wall but not from snow or milk? There's no answer to this unless we bring in substantial forms.

[Boyle prefaces his answer to this with an irrelevant replay of his view that essences are relative to kinds or to the names of kinds. One turn of phrase in this is worth quoting: you can alter the shape of the matter composing a brass sphere, he says, but when you do that 'the body perishes in the capacity of a sphere'. Now for his relevant answer:] If whiteness were inseparable from snow and milk, that wouldn't prove that there must be a substantial form to make it so. The firmness of the corpuscles that compose snow is as inseparable from it as the whiteness; but everyone knows that *that* is the work not of the water's substantial form but of the excess coldness of the air, which puts the water out of its supposedly natural state of fluidity and into a supposedly unnatural one of firmness and brittleness. Why does snow seldom lose its whiteness except when it loses its nature as snow? The reason seems to be that snow's component particles are so arranged that the same heat of the surrounding air that is fit to make it a transparent body is also fit to make it a fluid one, and when that happens we no longer call it 'snow' but 'water'. . . .

4. There's one remaining argument for substantial forms that tends (perhaps because it is physical) to be overlooked or not taken very seriously by opponents of substantial forms; but it deserves (just because it is physical!) to be discussed here. It is this:

> It seems that we must admit substantial forms in bodies, to enable us to derive from them •all the various changes that bodies undergo, •the various effects that bodies produce. . . .and •the keeping of each body's parts together as a single whole.

Answering this argument ·fully· requires many things I have already said in these notes and many others that I shall say later. Right now I shall merely indicate the ·three· main points on which the solution is based.

(i) Many large and small alterations in bodies seem clearly to come from their particular texture and the action of external agents on them; and it can't be shown that these events wouldn't happen if there were no substantial forms in the natural world. For example: when tallow [a kind of fat] is melted by fire, it loses its

coldness, firmness, and whiteness,
and acquires instead
heat, fluidity, and some transparency;
and when it is allowed to cool down it immediately exchanges the second trio of qualities for the first trio. But various of these changes are obviously effects partly of the fire and partly of the surrounding air—and not of I-know-not-what 'substantial form'. It is a familiar but remarkable fact that fire can produce a great variety of changes in bodies. . . .; in every such an event a body consisting of imperceptible parts moving vigorously and randomly brings about some change by those motions.

(ii) As I have often had occasion to declare at intervals through this treatise, various operations of a body can be derived from •the texture of the whole and •the mechanical affections of the particular corpuscles or other parts that compose it. When vitriol is made of iron with a corrosive liquor, that is a merely artificial body, made by applying the small parts of the saline solvent to the small parts of the metal; but *this* vitriol will do most, if not all, of the same things that natural vitriol dug out from the bowels of the earth will do. I don't see why the qualities of the natural vitriol must come from a substantial form, when the same qualities in the artificial vitriol clearly come from the joint operation of metallic and saline corpuscles. . . .

(iii) Lastly, regarding the confident and plausible claim that a substantial form is required to keep the parts of a body united so that it constitutes *one* body: I answer that the this cohesion could be produced by a structure of suitably shaped parts, and in some cases their juxtaposition, without the help of a substantial form. . . . A pear-tree grafted onto a hawthorn stock (or a plum grafted onto an apricot) will bear good fruit and grow up with the stock as though they together constituted only one tree and were animated by the same common form; whereas really both the stock and the grafted plant have separate forms, as can be seen in the differing leaves, fruits, and seeds that they bear. [Boyle adds further botanical details, some of them based on a misunderstanding of how the mistletoe relates to the plants of which it is the parasite. He also repeats the point that there are thoroughly artificial bodies (e.g. a lump of glass) whose unity is very strong although there can't be any substantial form involved in it.]

Moving towards a conclusion: I know that this is said on behalf of substantial forms:

> Because substantial forms are in natural bodies as the true principles [see Glossary] of their properties and therefore of their operations, anyone who leaves them out condemns his own natural philosophy to being very imperfect and defective.

Speaking for myself, this consideration inclines me against substantial forms rather than in favour of them. Suppose that there is in every natural body a substantial form from which all its properties and qualities immediately flow; then place this alongside the observed fact that most if not all of the actions of bodies on one another have as their immediate causes the bodies' qualities or accidents. The upshot is that many explicable natural phenomena could hardly be explained without help from substantial forms; and one would expect that many of the more abstruse phenomena wouldn't be explicable in any other way. But the *fact* is that almost all the reasonable explanations we have of difficult phenomena are ones that pay no attention to substantial forms. And the clear solutions (unknown by many run-of-the-mill philosophers) that we find for many phenomena in statics and other parts of mechanics—especially in hydrostatics and pneumatics—show clearly that many phenomena can be explained without employing a substantial form. And, on

the other hand, I don't recall Aristotle or any of his followers giving a solid and intelligible explanation of any one natural phenomenon with the help of substantial forms (Aristotle may not have even tried to do so). Don't be surprised that I say this: the greatest patrons of ·substantial·forms admit that their nature is unknown to us. . . . To explain any effect by a substantial form, they admit, must be to declare *ignotum per ignotius* or at least *per aeque ignotum* [= 'to explain the unknown through the more unknown, or at least through the equally unknown']. To explain a phenomenon is to derive it from something else in nature that we know better than we do the thing we are explaining; so how can the employing of incomprehensible (or at least uncomprehended) substantial forms help us to explain intelligibly this or that particular phenomenon? To say that such a given effect comes not from •this or that quality of the cause but from •its substantial form is to take an easy way to resolve all difficulties in general without properly resolving any one in particular!. . . .

Why does jet attract straws?

Why does rhubarb purge choler?

Why does snow, and not grass, dazzle the eyes?

To answer that effects like these are performed by the substantial forms of the respective bodies is at best to tell me only •what the agent is, not •how the effect is brought about. . . . So I don't think that natural philosophy will be harmed by ignoring the doctrine of substantial forms as a useless theory. It's not that we can now explain all the phenomena of nature without them; but we can't intelligibly explain anything with them.

So there it is, Pyrophilus: I have offered you some of the many things that make me disinclined to accept the received doctrine of substantial forms. If any more piercing enquirer persuades himself that he understands it thoroughly and can explain it clearly, I'll congratulate him on his splendid intellect and be ready to learn from him. But what the schools usually teach concerning the origin and attributes of substantial forms is something that I admit I can't yet understand; and since I am joined in this by some of the most eminent modern philosophers, though perhaps not for the same reasons, it doesn't *have* to be the case that the reason I can't understand this doctrine is that my understanding is defective, rather than that the thing itself is unconceivable. In purely philosophical [see Glossary] matters I don't like •accepting things that I don't understand, or •offering to explain things to other people in terms of something that appears to me to be itself inexplicable; so I hope I'll be excused if I leave substantial forms to those who think they understand them, and try instead to explain phenomena in terms of things that I do understand. . . .

Section 10: My own view about the origin of forms

Now for my doctrine regarding the origin of forms: it won't be hard to infer it from what I have been saying about qualities and forms together. According to me the form of a natural body is merely an essential modification of it [see Glossary and note on page 23]. . . ., i.e. a combination of size, shape, motion (or rest), situation and texture. . . .of the small parts that qualify the body as being of such-and-such a kind; and all these accidents can be produced in matter by motion, which is not part of the essence of matter. So it fits my hypothesis to say that

(1) the **first** and universal cause of forms, though not their immediate cause, is none other than God. He started matter moving, established the laws of motion among bodies, and also (I think) guided it in various cases at the beginning of things;

. . . and to say that

(2) among **second** causes [see Glossary] the grand cause of forms is motion, which by variously dividing, grouping, transposing, and so connecting the portions of matter, produces in them the accidents and qualities that qualify the body in question to belong to this or that determinate species of natural bodies. . . .

But in this last summary account of the origin of forms, I think I should make it clear to you that although •I agree with our Epicureans in thinking it probable that the world is made up of countless singly imperceptible corpuscles that have their own sizes and shapes, I disagree with Epicurus when he plainly denies that the world was made by any deity ('*any* deity', because he was a polytheist). And although I agree with the Cartesians in believing. . . .that matter originally got its motion not from itself but from God, I disagree with what seems to be his view about God's role after that. So far as I can tell from his writings and those of the most eminent Cartesians, he thought that once God had put matter into motion and established the laws of motion, there was no need for him to intervene any further, even for the production of plants or animals, which according to Descartes are mere engines. I flatly don't believe that either •the Cartesian laws of motion or •the Epicurean random coming together of atoms could bring mere matter into such an orderly and well-designed structure as this world is. So I think that the wise Author of nature didn't just set matter moving, but also—when he decided to make the world—regulated and guided the motions of the small portions of the universal matter in such a way as to get the greater systems of them into the order they were to continue in. And, more especially, he worked some portions of that matter into seminal rudiments or principles [see Glossary] and lodged them in convenient receptacles (wombs, as it were), and worked others into the bodies of plants and animals. A main part of his contrivance, I think, consisted in constructing some of the organs of plants and animals in such a way that. . . .some fluid parts of these living creatures would be fit to turn into fertile seeds, so that the animals and plants could propagate their ·respective· species. According to my view, therefore, there had to be at the outset an intelligent and wise agent. . . . Without the intervention of the world's architect. . . .I think it utterly improbable that brute and unguided matter in motion should ever come together into such admirable structures as the bodies of perfect animals. But given that the world has been constructed and the course of nature [here = 'the laws of nature'] established, the natural scientist doesn't need to

invoke the first cause for anything except the general and ordinary support and influence through which it preserves matter and motion from annihilation or coming to a halt. In explaining particular phenomena, the natural scientists considers only the size, shape, motion (or rest), texture, and the resulting qualities and attributes of the small particles of matter—except in some few cases where God or incorporeal agents intervene.

And thus in this great automaton the world (as in a watch or clock), the materials it consists of if left to themselves could never initially combine into such an intricate an engine; but once the skilful artist has made it and set it going, the phenomena it exhibits can be explained in terms of the number, size, proportion, shape, motion (or endeavour), rest, adjustment, and other mechanical affections [see Glossary] of the spring, wheels, posts, and other parts it is made up of. . . .

My duty to the author of nature obliged me to take this short detour. I now return to the main road.

I hope that the hypothesis I have offered regarding the origination of forms has been made probable by various details in what I have said, and will be both illustrated and confirmed by some of the experiments (especially the fifth and seventh of them) to be presented in the latter part of this present treatise [not offered on the website from which the present version came]. . . . But in addition to the support for my doctrine of forms that is supplied by my past notes and the experiments that are to come, I will present further confirmation right now by describing two sorts of experiments. . . . •In one of them, we see that bodies of very different natures can be put together like the parts of a watch to generate a new texture, and thus new qualities, the result being a new portion of matter whose structure gives it as much claim to have a substantial form attributed to it as any body has—all this being done without *bringing in* any substantial form. ·This line of thought will occupy section 11, i.e. will run until page 47·. And in the other •a natural body is broken up into new bodies with natures quite unlike its own; then these are broken up and their parts are re-assembled into something that is almost or exactly like the original body (like disassembling a clock and then re-assembling it).

Section 11: Experiments and thoughts about the production of forms

In my notes on the origin of qualities I said that it was very much by a kind of tacit agreement that men have distinguished the species of bodies, and that those distinctions are more arbitrary than we usually realize. I haven't yet found in Aristotle or any other writer any genuine and objective criterion for distinguishing species of bodies from one another. . . . I would say this: what men count as distinct species of bodies are mostly ones that *happen* to have had distinct names given to them; and the members of such a 'species' may be less alike than some other groups of bodies

that aren't regarded as forming a species because they aren't grouped under a species-name. I shan't attach any weight to the point about *names* ·as sources of people's sense that given groups of particulars do or don't constitute species·, but I do want to say this: I have found that in the absence of genuine markers of species it has been and still is **(1)** very uncertain whether various pairs of bodies belong to different species or the same species, and **(2)** very difficult to give an adequate reason why various bodies that are products of nature assisted by art shouldn't count as distinct kinds ·or species· of bodies, just as well as others that are generally reckoned to be so.

Are water and ice, for instance, distinct *kinds* of bodies? It is so far from obvious what the right answer to this is that some writers who claim to be very well versed in Aristotle's writings and opinions say that according to him water doesn't lose its own nature by being turned into ice; yet Galen is said to regard these two as distinct species of bodies. Aristotle's view is made plausible by the fact that ice can be turned back into water; Galen's is made plausible by the differing qualities of ice and water:

- •water is fluid, ice is solid and even brittle;
- •ice is commonly more or less opaque compared with water;
- •ice is lighter than water, since it floats on it.

. . . .I would like someone to tell me whether •grape juice, wine, spirit of wine, vinegar, tartar, and sour wine belong to distinct species. And what about •a hen's egg and the chick that hatches out of it? And •wood, ashes, soot? And similarly:

> the eggs of silkworms, which first become small caterpillars (or worms, as some think) when they are newly hatched, and then aurelias (silkworms in their cocoons), and then butterflies,

which I have observed with pleasure to be the successive output of the prolific seed of silkworms. And whatever answer is given to any of these questions—whether Yes or No—I suspect that the reason given for it will be one that doesn't hold in other cases that I might come up with. [Boyle adds a longish presentation of a comparable question about whether charcoal enters a new species when it is on fire, and reports a desperate handling of this by 'a very subtle modern schoolman' whom he does not name.]

Nor is it very easy to settle whether clouds, rain, hail and snow belong to different species from water and from each other. Writers on meteorology usually treat them as distinct. And if such slight differences as the ones there are between clouds, rain etc.. . . .are enough to make them different *kinds* of bodies, it will be hard to give a satisfactory reason why the same privilege shouldn't be granted to other bodies that differ in more ways or in more considerable ways. I presume, that •snow differs less from •rain than •paper does from •rags, or •glass made of wood-ashes does from •wood. And indeed men having by tacit consent agreed to look on

> paper,
> glass,
> soap,
> sugar,
> brass,
> ink,
> pewter,
> gunpowder

and I don't know how many others, to be distinct sorts of bodies, I don't see why they can't be thought to have as good a basis for these distinctions as the bases for other species-distinctions. ·You may say: 'There is a relevant difference, namely that· the bodies listed above are all artificial, made by men'; but that actually isn't relevant,

because decisions about whether x and y belong to the same species should depend on the present nature of x and y, not on how they came to have their natures. In many countries salt is made by boiling sea-water in cauldrons; and then there is true sea-salt such as is made in the Isle of Man without any human input, by the bare action of the sun on the pools of sea-water that happen to be left behind in hollow places after a high spring-tide. And silk worms hatched by the heat of human bodies, and chickens hatched (in Egypt) by the heat of ovens or dunghills, are just as truly silk-worms (or chickens) as the ones that are hatched by the sun (or by hens).

It may be objected that we must distinguish artificially made bodies from natural ones. I shan't pause here to examine how far that distinction should be allowed to go, because for present purposes it may suffice to say this: Whatever may be said about

(1) artificial bodies where a man uses instruments of his own providing to give shape and/or texture to the perceptible parts (not the imperceptible parts) of the matter he works on—as when a joiner makes a stool, a sculptor makes an image, or a turner makes a ball

may not be true of

(2) bodies the production of which involves humans in a different way—ones where the imperceptible portions of matter are altered by natural agents that do most of the work among themselves but only after being introduced in the right way by a human artificer.

So I don't know why all the productions of the fire made by chemists should be looked on as artificial bodies rather than natural ones; the fact that the chemist is using the fire—which is the grand agent in these changes—doesn't mean that the fire is anything but a *natural* agent. And some of the things that chemists produce using fire are also given to us by nature, using fire. For example, in Etna, Vesuvius and other volcanoes. . . .stones are sometimes turned into lime. . . .and sometimes into glass; metallic and mineral bodies are fused by the violence of the volcano into masses of very strange and compounded natures. [Boyle gives some details, and says he is relying partly on what tourists have told him and on samples they have brought home with them, 'some very good'. Then:] I have sometimes suspected, on reasonable grounds, that some of the minerals and other bodies that we find in the lower parts of the earth, and ·usually· think to have been formed and lodged there ever •since the beginning of things, have actually been *produced* there •more recently with the help of subterranean fires [and he decorates this with remarks about effects that we know long-lasting fire can produce. Then he consents to 'return to what I was saying about Etna and other volcanoes'.] These productions of the fire, being of nature's own making, can't be denied to be 'natural' bodies, so I don't see why similar productions organised by the chemist should be thought unworthy that name. The only difference is that one fire was

> lit in a hill by chance,

while the other was

> lit in a furnace by a man.

If flower of sulphur, lime, glass, and fused mixtures of metals and minerals are to be counted among natural bodies, it seems only reasonable on the same grounds to count flower of antimony, lime, glass, pewter, brass, and so on. . . .to be classified as 'natural' too. And then it will be obvious that to distinguish the species of natural bodies all we need are comings-together of accidents, with no need for any substantial form.

But because I don't need here to have recourse to controversial examples I will illustrate the mechanical production of forms by *vitriol*, because nature herself, without the help

of art, often produces vitriol (as I have elsewhere shown experimentally), and there's no reason why vitriol produced by easy chemical operations shouldn't be regarded as a body of the same nature and kind. [What follows are several pages of details about the production of different varieties of vitriol, speculations about what is going on in them, side-remarks about misuses of terminology, suggestions for further experiments, and so on—all this coming in a tumbling torrent from Boyle's incredibly well-stocked mind. This brings him to two conclusions.]

(1) Our man-made vitriol resembles natural vitriol in being

> green,
> easy to fuse,
> harsh-tasting,
> shaped in a special way,
> able to turn black with an infusion of galls,
> able to produce vomiting,

and so on. In addition, man-made and natural vitriol share with one another and with various other salts properties such as transparency, brittleness, solubility in water, etc.

(2) These qualities in ordinary ·natural· vitriol are believed to flow from the stuff's substantial form, and have as much weight as any qualities of other inanimate bodies in arguments for the existence of substantial forms; but in the vitriol described above, made with spirit of salt, those same qualities and properties were produced by combining the two ingredients of which the vitriol was made; and what happened was simply this:

> The steel being dissolved in the spirit, the saline particles of the spirit of salt and the metalline particles of the steel, each with its own particular shape, combined to make corpuscles of a mixed or compounded nature; and the assemblage of many of those corpuscles gave rise to a new body whose constitution enabled it to •affect our sense-organs and •work on other bodies in the way that ordinary ·natural· vitriol does.

In this course of events it doesn't seem that any substantial form is generated. [Boyle adds that this process of making vitriol doesn't even involve what the scholastics called an 'exquisite mixture', i.e. one from which the components can't be separately extracted. It is merely a matter of *putting together* corpuscles of two kinds—metalline and saline. He adds some experimental evidence that that's all that happens.]

Concerning the intricate shapes of crystals

[This is an 8-page subsection of thoughts and experimental reports relating to the shapes of 'salts', usually meaning 'crystals'. All that will be presented here are two short passages. One is the subsection's opening paragraph:]

The very precise and intricate shapes that vitriol and other salts take on when they crystallise have been used as arguments for the presence and plastic skill of substantial forms and other seminal powers; but I confess that I'm not as fully convinced of this as even the modern philosophers appear to be. Plato's excellent claim that 'God does geometry' may be applied to ·these crystals·, these exquisite productions of nature. God has thought fit to make bodily things in a much easier and more intelligible way than by the intervention of substantial forms; and there seems with crystals to be no need to bring in any sort of 'plastic power' (though I willingly admit that such powers are at work in plants); but the divine Architect's geometry should be acknowledged and admired. He chose to give the primary and imperceptible corpuscles of salts and metals such determinate, intricate, and exact

shapes that when they happen to be brought together they naturally produce bodies. . . .that are all very intricate and elaborate-seeming in their different ways. I have elsewhere said how little credence should be given to this:

> The bodies of animals can be reasonably supposed to have been produced by chance, i.e. without the guidance of an intelligent Author of things;

remembering that animal bodies consist of so many intricately formed and wonderfully adapted organic parts, whose structures are a thousand times more intricate than the structures of salts, and crystals, and other minerals. But I confess that I regard these shapes that we wonder at in crystals and in some kinds of stones. . . .as textures that are so simple and slight in comparison of the bodies of animals, and often in comparison of some one animal organ, that I think it can't be in the least inferred that because •the slight figurations ·of inorganic crystals· needn't be explained in terms of the plastic power of seeds, •the stupendous and incomparably more elaborate fabric and structure of animals themselves needn't be explained in that way either.

With this premised, I shall add that my conjecture about the shapes of crystals has seemed to me to be supported by the following considerations.

[Then Boyle presents experimental reports occupying most of the subsection, including, near the end, the following short passage:]

Thus, if these intricate shapes that are believed to be among the most admirable effects strongest proofs of substantial forms can be the results of texture, and if vitriol itself can be produced by human skill as well as by nature, what is wrong with thinking that in ordinary phenomena that are much less wonderful there is no need to bring in substantial forms?. . . .

Section 12: Experiments in the reproduction of forms

[Boyle's title for this section is 'Experimental attempts about the red-integration of bodies', i.e. the re-assembling of bodies that have been chemically taken apart. The title adopted here signifies that this section mirrors section 11. It's true that the topic here is the re-assembling not of •forms but of •bodies that are typical candidates for the role of form-possessor; but the short-hand adopted in the above title echoes Boyle's short-hand in his title for section 11, the real topic of which was the production not of •forms but of •bodies that are typical candidates for the role of form-possessor. Remember throughout this that **reproducing** a body is **putting it back together again**, not **making a copy of it**.]

You'll remember, Pyrophilus, that at the end of section 10 [page 43] I announced two arguments to confirm ·my account of· the origin of forms. One was based on facts about how a combination of accidents that deserves to count as a form can be produced; and I have been dealing with that ·in section 11·. Now I come to the second argument, which is drawn not from the initial production of a physical body but from its reproduction. Both arguments are valid; but if this second one could—despite the practical difficulties of running the experiment—be as clearly made out as the other

one was, I think you would like it better than the other. Why? Well, if we could reproduce a body that has been deprived of its substantial form, ·thus giving it back its substantial form if it ever had one·, I think you would regard it as *at least* highly probable what is commonly called 'the form' of a composite body,

> •which gives the body its being and name, and •from which all the body's qualities are supposed to flow (heaven knows how!)

is in some bodies merely a modification [see Glossary] of the matter the bodies consist of. ·Spelling that out a little, it would amount to the view that· the relevant portions of matter, by being related to one another thus and so, constitute a determinate kind of body with such and such properties; whereas if the same portions had been inter-related differently they would have constituted other bodies with very different natures from that of the composite body that they used to be parts of. . . .

It may be impossible to make a perfect re-assembly of a chemically analysed body, because some of the products of the analysis will either

> • escape at places where one vessel is joined to another (even if they are diligently closed), or if they are very finely divided will
> •fly away when the vessels are separated, or will
> •irrecoverably stick to the inside of the vessels.

But I think that a reproduction of a kind that we clearly *can* make can suffice to show what we intend it to show. Even in experiments ·where some of the products of analysis are lost· we find that when the form of a natural body is abolished, and the parts ·of the body· are violently scattered, they can be gathered together again in the same inter-relations as before, and just that—with no addition of anything else—enables those parts again to constitute a body of the same nature as the one that had been destroyed, though not quite of the same size. And indeed the experiment reported by our author [see bracketed passage just before the Preface on page 6] about the reproduction of saltpetre, is the best and most successful I have ever been able to make on bodies that needed strong heat to pull them apart; so I hope it will suffice to get you to think about this matter in the way the author aimed at in presenting it.

In his essay he points to some attempts to re-integrate bodies that he says •he intends to make; and now I shall now proceed to acquaint you with the outcomes of some of these that •I actually made. I can do this only on the basis of some lab-outcome notes that I find among my loose papers, ·and the outcomes are never perfect successes·, but I have two reasons for presenting this material to you. **(1)** Since our author's essay was published, these attempts have been represented (I fear by conjecture only) as very easy to do accurately enough, and I want to show you how hard they are. **(2)** Our author has reasons for his view that when reproductions of bodies can be done they are useful; and for his view that such attempts, even if they don't perfectly succeed, can increase the number of noble and active bodies and thereby enlarge the inventory of mankind's goods.

With all that in mind, I tried to dissipate and re-unite the parts of common *amber*. When chemists set about to distill something, they usually add to it. . . .some sand or brick or the like—I have sometimes used powdered glass—as a precaution against breaking their vessels. This of course gets in the way of measuring and using the products of the distillation. But I found, as I had expected to, that if the retort is not too full, and if the heat is applied slowly and cautiously, there's no need to add any other body ·to prevent breakage·. So: I put into a glass retort four or five ounces of amber, and gradually heated it until I saw the amber to

melt and bubble. (I mention this because some able men have lately questioned whether amber can be melted.) At the end of this process I separated the retort from the receiving vessel and found that the liquid that the heat had sent across from one vessel to the other—a mixture of oil, spirit and phlegm, and volatile salt—had nearly half the weight of the original amber. [phlegm = 'any watery odourless and tasteless substance obtained by distillation' (OED).] Then I broke the retort ·so as to get at the solid residue·, and I found there a cake of coal-black matter with an exquisitely polished upper surface. (I can hardly remember ever before seeing such a surface; despite its colour it was fit for use as a mirror as long as I kept it.) It was exceedingly brittle, and when I broke it the larger fragments had an excellent lustre. All those parts of the amber—·solid and liquid·—were put together into a glass vessel those top was then cemented shut; and this was placed in sand, to be acted on by a gentle heat. [The narrative continues with an account of how something went wrong; the upshots are described; and then Boyle presents three further pages of details of other experiments. He ends this section thus:]

But among all my experiments with the reproduction of bodies, the one that seemed to succeed best was made on turpentine. I took some ounces of very pure and good turpentine, put it into a glass retort, and subjected it to gentle heat until I had separated it into a good quantity of very clear liquid and a very dry and brittle solid residue. I then broke the retort, took the solid residue out and crushed it to powder. (Before being crushed it was exceedingly smooth, fairly transparent, and very red; but in its powdered state it appeared as pure yellow.) I carefully mixed this powder with the liquid that had been separated from it by distillation, which immediately dissolved part of it into a deep red balsam; but when I left it for longer in a large carefully sealed glass, that colour began to fade, though the rest of the powder was perfectly dissolved, and reunited so well with the more volatile parts of the original stuff that hardly anyone, judging by its smell, taste or consistency, would take it for other than good pure turpentine. (A tiny amount of the powder didn't dissolve; it was roughly proportional to the amount of liquid that had presumably been lost by evaporation and by the transfer from one vessel to another.)

[Up to here we have had The Theoretical Part of the work; what remains is The Historical Part, consisting of 10 pages of 'Observations' (informal empirical data) followed by 50 pages of 'Experiments' (ten of them). The Historical Part is not presented on the website from which the present version came.]