

The Scientific Revolution – Document Packet #2

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In place of the multitude of precepts of which logic is composed, I believed I should find the four following rules quite sufficient, provided I should firmly and steadfastly resolve not to fail of observing them in a single instance.

The first rule was never to receive anything as a truth which I did not clearly know to be such; that is, to avoid haste and prejudice, and not to comprehend anything more in my judgments than that which should present itself so clearly and so distinctly to my mind that I should have no occasion to entertain a doubt of it.

The second rule was to divide every difficulty which I should examine into as many parts as possible, or as might be required for resolving it.

The third rule was to conduct my thoughts in an orderly manner, beginning with objects the most simple and the easiest to understand, in order to ascend as it were by steps as to the knowledge of the most composite, assuming some order to exist even in things which did not appear to be naturally connected.

The last rule was to make enumerations so complete, and reviews so comprehensive, that that I should be certain of omitting nothing.

Those long chains of reasoning, quite simple and easy, which geometers are wont to employ in the accomplishment of their most difficult demonstrations, led me to think that everything which might fall under the cognizance of the human mind might be connected together in a similar manner, and that, provided only one should take care not to receive anything as true which was not so, and if one were always careful to preserve the order necessary for deducing one truth from another, there would be none so remote at which he might not at last arrive, nor so concealed which he might not discover. And I had no great difficulty in finding those with which to make a beginning, for I knew already that these must be the simplest and easiest to apprehend; and considering that, among all those who had up to this time made discoveries in the sciences, it was the mathematicians alone who had been able to arrive at demonstrations—that is to say, at proofs certain and evident—I did not doubt that I should begin with the same truths which they investigated....

After this, and reflecting upon the fact that I doubted, and that in consequence my being was not quite perfect (for I saw clearly that to know was a greater perfection than to doubt), I [wondered where] I had learned to think of something more perfect than I; and I knew for certain that it must be from some nature which was in reality more perfect. [And I clearly recognized that] this idea . . . had been put in me by a nature truly more perfect than I, which had in itself all perfections of which I could have any idea; that is, to explain myself in one word, God. . . .

Finally, whether awake or asleep, we ought never to allow ourselves to be persuaded of the truth of anything unless on the evidence of our Reason. And, it must be noted that I say of our Reason, and not of our imagination or of our senses: thus, for example, although we very clearly see the sun, we ought not therefore to determine that it is only of the size which our sense of sight presents; and we may very distinctly imagine the head of a lion joined to the body of a goat, without being therefore shut up to the conclusion that a chimaera exists; for it is not a dictate of Reason that what we thus see or imagine is in reality existent; but it plainly tells us that all our ideas or notions contain in them some truth; for otherwise it could not be that God, who is wholly perfect and veracious, should have placed them in us.

SOURCE: Rene Descartes, *The Discourse on Method*, 1637.

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Lastly, some are weakly afraid lest a deeper search into nature should transgress the permitted limits of sober-mindedness, wrongfully wresting and transferring what is said in Holy Writ against those who pry into sacred mysteries to the hidden things of nature, which are barred by no prohibition. Others, with more subtlety, surmise and reflect that if the secondary causes are unknown, everything can be more readily referred to divine hand and rod--a point in which they think religion greatly concerned; which is, in fact, nothing else but to seek to gratify God with a lie. Others fear from past example that movements and changes in philosophy will end in assaults on religion; and others again appear apprehensive that in the investigation of nature something may be found to subvert, or at least shake, the authority of religion, especially with the unlearned.

But these two last fears seem to me to savor utterly of carnal wisdom; as if men in the recesses and secret thoughts of their hearts doubted and distrusted the strength of religion, and the empire of faith over the senses, and therefore feared that the investigation of truth in nature might be dangerous to them. But if the matter be truly considered, natural philosophy is, after the word of God, at once the surest medicine against superstition and the most approved nourishment for faith; and therefore she is rightly given to religion as her most faithful handmaid, since the one displays the will of God, the other his power.

SOURCE: Sir Francis Bacon, *The Advancement of Learning*, 1605.

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All these things being considered, it seems probable to me, that God in the Beginning formed Matter in solid, massy, hard, impenetrable, moveable Particles, of such Sizes and Figures, and with such other Properties, and in such Proportion to Space, as most conduced to the End for which he formed them; and that these primitive Particles, being Solids, are incomparably harder than any porous Bodies compounded of them; even so very hard, as never to wear or break in pieces; no ordinary Power being able to divide what God himself made one in the first Creation. . . .

To derive two or three general Principles of Motion from Phaenomena, and afterwards to tell us how the Properties and Actions of all corporeal Things follow from those manifest Principles, would be a very great step in Philosophy, though the Causes of those Principles were not yet discovered: And therefore, I scruple not to propose the Principles of Motion . . . and leave their Causes to be found out. Now by the help of these Principles, all material Things seem to have been composed of the hard and solid Particles above-mentioned, variously associated in the first Creation by the Counsel of an intelligent Agent. For it became him who created them to set them in order. And if he did so, it's unphilosophical to seek for any other Origin of the World, or to pretend that it might arise out of a Chaos by the mere Laws of Nature; though being once formed, it may continue by those Laws for many Ages. For while Comets move in very eccentric orbits in all manner of Positions, blind Fate could never make all the Planets move one and the same way in concentric orbits, some inconsiderable Irregularities excepted, which may have risen from the mutual Actions of Comets and Planets upon one another, and which will be apt to increase, till this System wants a Reformation. Such a wonderful Uniformity in the Planetary System must be allowed the Effect of Choice. And so must the Uniformity in the Bodies of Animals, they having generally a right and a left side shaped alike,

and on either side of their Bodies two Legs behind, and either two Arms, or two legs, or two Wings before upon their Shoulders, and between their Shoulders a Neck running down into a Backbone, and a Head upon it; and in the Head two Ears, two Eyes, a Nose, a Mouth, and a Tongue, alike situated . . .

and the Instinct of Brutes and Insects, can be the effect of nothing else than the Wisdom and Skill of a powerful ever-living Agent, who being in all Places, is more able by his Will to move the Bodies within his boundless uniform Sensorium, and thereby to form and reform the Parts of the Universe, than we are by our Will to move the Parts of our own Bodies. And yet we are not to consider the World as the Body of God, or the several Parts thereof, as the Parts of God. He is a uniform Being, void of Organs, Members or Parts, and they are his Creatures subordinate to him, and subservient to his Will. . . .

And since Space is divisible in infinitum, and Matter is not necessarily in all places, it may be also allowed that God is able to create Particles of Matter of several Sizes and Figures, and in several Proportions to Space, and perhaps of different Densities and Forces, and thereby to vary the Laws of Nature, and make Worlds of several sorts in several Parts of the Universe. At least, I see nothing of Contradiction in all this. As in Mathematics, so in Natural Philosophy, the Investigation of difficult Things by the Method of Analysis, ought ever to precede the Method of Composition. This Analysis consists in making Experiments and Observations, and in drawing general Conclusions from them by Induction, and admitting of no Objections against the Conclusions, but such as are taken from Experiments, or other certain Truths. For Hypotheses are not to be regarded in experimental Philosophy. And although the arguing from Experiments and Observations by Induction be no Demonstration of general Conclusions; yet it is the best way of arguing which the Nature of Things admits of. . . . By this way of Analysis, we may proceed from Compounds to Ingredients, and from Motions to the Forces producing them; and in general, from Effects to their Causes, and from particular Causes to more general ones, till the Argument end in the most general. This is the Method of Analysis: And the Synthesis consists in assuming the Causes discovered, and established as Principles, and by them explaining the Phaenomena proceeding from them, and proving the Explanations.

SOURCE: Sir Isaac Newton, "Principles of Analysis," from *Optics*, 1704.

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As this book alone declares the blood to course and revolve by a new route, very different from the ancient and beaten pathway trodden for so many ages, and illustrated by such a host of learned and distinguished men, I was greatly afraid lest I might be charged with presumption did I lay my work before the public at home, or send it beyond seas for impression, unless I had first proposed its subject to you, had confirmed its conclusions by ocular demonstrations in your presence, had replied to your doubts and objections, and secured the assent and support of our distinguished President. For I was most intimately persuaded, that if I could make good my proposition before you and our College, . . . I had less to fear from others. . . . For true philosophers, who are only eager for truth and knowledge, never regard themselves as already so thoroughly informed, but that they welcome further information from whomsoever and from whencesoever it may come; nor are they so narrow-minded as to imagine any of the arts or sciences transmitted to us by the ancients, in such a state of forwardness or completeness, that nothing is left for the ingenuity and industry of others. . . . Neither do they swear such fealty to their mistress Antiquity, that they openly, and in sight of all, deny and desert their friend Truth. . . .

My dear colleagues. . . I profess both to learn and to teach anatomy, not from books, but from dissections; not from the positions of philosophers, but from the fabric of nature. . . .

From these and other observations of the like kind, I am persuaded it will be found that the motion of the heart is as follows:

First of all, the auricle contracts, and in the course of its contraction throws the blood, (which it contains in ample quantity as the head of the veins, the store-house and cistern of the blood,) into the ventricle, which being filled, the heart raises itself straightway, makes all its fibers tense, contracts the ventricles, and performs a beat, by which beat it immediately sends the blood supplied to it by the auricle into the arteries; the right ventricle sending its charge into the lungs by the vessel which is called *vena arteriosi*, but which, in structure and function, and all things else, is an artery; the left ventricle sending its charge into the aorta, and through this by the arteries to the body at large. . . .

Thus far I have spoken of the passage of the blood from the veins into the arteries, and of the manner in which it is transmitted and distributed by the action of the heart. . . . But what remains to be said upon the quantity and source of the blood which thus passes, is of so novel and unheard-of character, that I not only fear injury to myself from the envy of a few, but I tremble lest I have mankind at large for my enemies. . . . Still, the die is cast, and my trust is in my love of truth, and the candor that inheres in cultivated minds. And

when I surveyed my mass of evidence, . . . I revolved in my mind, what might be the quantity of blood which was transmitted, in how short a time its passage might be effected, and the like; . . . I began to think whether there might not be *A MOTION, AS IT WERE, IN A CIRCLE*. Now this I afterwards found to be true; and I finally saw that the blood, forced by the action of the left ventricle into the arteries, was distributed to the body at large. . . impelled by the right ventricle. . . through the veins, and so round to the left ventricle in the manner already indicated. . . .

The heart, consequently, is the beginning of life; the sun of the microcosm, even as the sun in his turn might well be designated the heart of the world; for it is the heart by whose virtue and pulse the blood is moved, perfected, made apt to nourish, and is preserved from corruption and coagulation; it is the household divinity which, discharging its function, nourishes, cherishes, quickens the whole body, and is indeed the foundation of life, the source of all action.

SOURCE: William Harvey, *On the Circulation of the Blood*, 1628.