

Isaac Newton

Principia mathematica

*Isaac Newton (1646-1723) was a mathematics professor at Cambridge University. His work **Principia mathematica** (1687) is generally regarded as the most important work of the Scientific Revolution*

Rules of Reasoning in Philosophy

Rule I. We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.

To this purpose the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes.

Rule II. Therefore to the same natural effects we must, as far as possible, assign the same causes.

As to respiration in a man and in a beast, the descent of stones [meteorites] in *Europe* and in *America*, the light of our culinary fire and of the sun, the reflection of light in the earth, and in the planets.

Rule III. The qualities of bodies, which admit neither [intensification] nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.

For since the qualities of bodies are only known to us by experiments, we are to hold for universal all such as universally agree with experiments; and such as are not liable to, diminution can never be quite taken away. We are certainly not to relinquish the evidence of experiments for the sake of dreams and vain fictions of our own devising; nor are we to recede from the analogy of Nature, which [is] . . . simple, and always consonant to itself. We no other way know the extension of bodies than by our senses, nor do these reach it in all bodies, but because we perceive extension in all that are sensible, therefore, we ascribe it universally to all others also. That abundance of bodies are hard, we learn by experience, and because the hardness of the whole arises from the hardness of the parts, we, therefore, justly infer the hardness of the undivided particles not only of the bodies we feel but of all others. That all bodies are impenetrable, we gather not from reason, but from sensation. The bodies which we handle we find impenetrable, and thence, conclude impenetrability to be an universal property of all bodies whatsoever. That all bodies are moveable, and endowed with certain powers (which we call . . . [*inertia*]) of persevering in their motion, or in their rest, we only infer from the like

properties observed in the bodies which we have seen. The extension, hardness, impenetrability, mobility, of the whole, result from the extension, hardness, impenetrability, mobility, . . . of the parts; and thence we conclude the least particles of all bodies to be also all extended, and hard and impenetrable, and moveable, . . . And this is the foundation of all philosophy. . .

Lastly, if it universally appears, by experiments and astronomical observations, that all bodies about the earth gravitate towards the earth, and that in proportion to the quantity of matter which they severally contain, that the moon likewise, according to the quantity or its matter, gravitates towards the earth, that, on the other hand, our sea gravitates towards the moon, and all the planets mutually one towards another, and the comets in like manner towards the sun, we must, in consequence of this rule, universally allow that all bodies whatsoever are endowed with a principle of mutual gravitation. . .

Rule IV. In experimental philosophy we are to look upon propositions collected by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, 'till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions,
This rule we must follow, that the argument of induction may not be evaded by hypotheses.

Gravity

Hitherto, we have explained the phenomena of the heavens and of our sea by the power of gravity, but have not yet assigned the cause of this power. This is certain, that it must proceed from a cause that penetrates to the very centres of the sun and planets, without suffering the least diminution of its force, that operates not according to the quantity of the surfaces of the particles upon which it acts (as mechanical causes used to do) but according to the quantity of the solid matter which they contain, and propagates its virtue on all sides to immense distances, decreasing always in the duplicate portion of the distances. . .

Hitherto I have not been able to discover the cause of those properties of gravity from the phenomena, and I frame no hypothesis; for whatever is not deduced from the phenomena is to be called an hypothesis; and hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterward rendered general by deduction. Thus it was the impenetrability, the mobility, and the impulsive forces of bodies, and the laws of motion and of gravitation were discovered. And to us it is enough that gravity does really exist, and acts according to the laws which we have explained, and abundantly serves to account for all the motions of the celestial bodies, and of our sea.

God and the Universe

This most beautiful system of the sun, planets, and comets could only proceed from the counsel and dominion of an intelligent and powerful Being. And if the fixed stars are the centers of other like systems, these, being formed by the like wise counsel, must be all subject to the dominion of One, especially since the light of the fixed stars is of the same

nature with the light of the sun and from every system light passes into all the other systems; and lest the systems of the fixed stars should, by their gravity, fall on each other mutually, he hath placed those systems at immense distances from one another. This Being governs all things not as the soul of the world, but as Lord over all; and on account of his dominion he is wont to be called "Lord God" . . . or "Universal Ruler." . . . It is the dominion of a spiritual being which constitutes a God. . . And from his true dominion it follows that the true God is a living, intelligent and powerful Being. . . he governs all things, and knows all things that are or can be done. . . He endures forever, and is everywhere present; and by existing always and everywhere, he constitutes duration and space. . . In him are all things contained and moved; yet neither affects the other: God suffers nothing from the motion of bodies; bodies find no resistance from the omnipresence of God. . . As a blind man has no idea of colors so we have no idea of the manner by which the all-wise God preserves and understands all things. He is utterly void of all body and bodily figure, and can therefore neither be seen, nor heard, nor touched; nor ought to be worshipped under the representation of any corporeal thing. We have ideas of his attributes, but what the real substance of any thing is we know not.... Much less, then, have we any idea of the substance of God. We know him only by his most wise and excellent contrivances of things. . . We reverence and adore him as his servants, and a god without dominion, providence, and final causes, is nothing else but Fate and Nature. Blind metaphysical necessity, which is certainly the same always and everywhere, could produce no variety of things. All that diversity of natural things which we find suited to different times and places could arise from nothing but the ideas and will of a Being necessarily existing. . . And thus much concerning God, to discourse of whom from the appearances of things does certainly belong to Natural Philosophy.

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