

*from* THE MATHEMATICAL PRINCIPLES  
OF NATURAL PHILOSOPHY (1687)

*Isaac Newton (1642–1727) was an eccentric and remote individual who was as interested in mysticism and the occult as he was in modern science. His The Mathematical Principles of Natural Philosophy, in which he sets forth the theory of universal gravitation, is among the most original and path-breaking works in the history of science. The importance of the book is that Newton is able to explain the movement of bodies in both heaven and earth on the basis of a universal set of laws, three involving their motion and one their attraction towards each other. Yet if Newton's mechanics was path-breaking, it is also a culmination of over two hundred years of scientific exploration, building on the labors of scientists such as Nicolaus Copernicus, Tycho Brahe, Johannes Kepler, and Galileo. Similarly, Newton's description of the scientific method builds on the work of thinkers such as Francis Bacon, while offering an extension of these ideas as well.*

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THE 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 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 intension nor remission of degrees, and which are found to belong to all bodies within 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 wont to be 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 a universal property of all bodies whatsoever. That all bodies are moveable, and endowed with certain powers (which we called the forces of inertia) or 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, and force of inertia of the whole, result from the extension, hardness, impenetrability, mobility, and forces of inertia of the parts: and thence we conclude that the least particles of all bodies to be also all extended, and hard, and impenetrable, and moveable, and endowed with their proper forces of inertia. And this is the foundation of all philosophy. Moreover, that the divided but contiguous particles of bodies may be separated from one another, is a matter of observation: and, in the particles that remain undivided, our minds are able to distinguish yet lesser parts, as is mathematically demonstrated. But whether the parts so distinguished, and not yet divided, may, by the powers of nature, be actually divided and separated from one another, we cannot certainly determine. Yet had we the proof of but one experiment, that any undivided particle, in breaking a hard and solid body, suffered a division, we might by virtue of this rule, conclude, that the undivided as well as the divided particles, may be divided and actually separated into infinity.

Lastly, if it universally appears, by experiments and astronomical observations, that all bodies about the earth, gravitate toward the earth; and that in proportion to the quantity of matter which they severally contain; that the moon likewise, according to the quantity of its matter, gravitates toward the earth; that on the other hand our sea gravitates toward the moon; and all the planets mutually one toward 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. For the argument from the appearances concludes with more force for the universal gravitation of all bodies, than for the impenetrability, of which among those in the celestial regions, we have no experiments, nor any manner of observation. Not that I affirm gravity to be essential to all bodies. By their inherent force I mean nothing but their force of inertia. This is immutable. Their gravity is diminished as they recede from the earth.

*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.