**Roger Cotes’ Preface to Isaac Newton’s *Mathematical Principles of Natural Philosophy*, 1729**

Introduction: Widely considered to be the greatest physicist in history (along, perhaps, with Albert Einstein), Sir Isaac Newton published his *Philosophiæ Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy) in 1687. (Natural philosophy was the term for science in that era.)

*Viewed retrospectively, no work was more seminal in the development of modern physics and astronomy. Its conclusion that the force retaining the planets in their orbits is one in kind with terrestrial gravity ended forever the view dating back at least to Aristotle that the celestial realm calls for one science and the sub-lunar, or earthly, realm another. Just as the Preface to its first edition had proposed, the ultimate success of Newton's theory of gravity made the identification of the fundamental forces of nature and their characterization in laws the primary pursuit of physics. The success of the theory led as well to a new conception of exact science under which every systematic discrepancy between observation and theory, no matter how small, is taken as telling us something important about the world. Even more fundamentally, it established the idea that all natural phenomena can only be properly understood in mathematical terms.*

*Though considered now to be the foundation of the modern study of physics, the ideas in Newton’s* Principia *were much disputed in his time, since he undermined existing ideas of the universe. Roughly four decades after the Principia came out, English mathematician Roger Cotes’ was tasked with putting out a second edition, for two reasons: 1) to include newer work by Newton not included in the first edition, and 2) to bring the book to a wider scientific community, as the first edition was only published in a few copies. Cotes’ edition was published just two years after Newton’s death in 1727.*

Roger Cotes’ Preface to Isaac Newton’s *Mathematical Principles of Natural Philosophy* (excerpts)

THOSE who have treated of natural philosophy, may be nearly reduced to three classes. Of these some have been attributed to the several species of things, specific and occult qualities; on which, in a manner unknown, they make the operations of the several bodies to depend. The sum of the doctrine of the Schools derived from *Aristotle*…is herein contained. They affirm that the several effects of the bodies arise from the particular natures of those bodies arise from the particular natures of those bodies. But whence it is that bodies derive those natures they don't tell us; and therefore they tell us nothing. And being entirely employed in giving names to things, and not in searching into things themselves, we may say that they have invented a philosophical way of speaking, but not that they have made known to us true philosophy.

Others therefore by laying aside that useless heap of words, thought to employ their pains to better purpose. These supposed all matter homogeneous, and that the variety of forms which is seen in bodies arises from some very plain and simple affections of the component particles. And by going on from simple things to those which are more compounded they certainly proceed right; if they attribute no other properties to those primary affections of the particles than Nature has done. But when they take a liberty of imagining at pleasure unknown figures and magnitudes, and uncertain situations and motion of the parts; and moreover of supposing occult fluids, freely pervading the pores of bodies, endued with an all-performing subtilty, and agitated, with occult motions; they now run out into dreams and chimera's, and neglect the true constitution of things; which certainly is not to be expected from fallacious conjectures, when we can scarce reach it by the most certain observations. Those who fetch from by hypotheses the foundation on which they build their speculations, may form indeed an ingenious romance, but a romance it will still be.

There is left then the third class, which process experimental philosophy. These indeed derive the causes of all things from the most simple principles possible; but then they assume nothing as a principle, that is not proved by phænomena. They frame no hypotheses, nor receive them into philosophy otherwise than as questions whose truth may be disputed. They proceed therefore in a two-fold method, synthetical and analytical. From some select phænomena they deduce by analysis the forces of nature, and the more simple laws of forces; and from thence by synthesis shew the constitution of the rest. This is that incomparably best way of philosophizing, which our renowned author most justly embraced before the rest; and thought alone worthy to be cultivated and adorned by his excellent labors. Of this he has given us a most illustrious example by the explication of the System of the World, most happily deduced from the Theory of Gravity. That the virtue of gravity was found in all bodies, others suspected, or imagined before him; but he was the only and the first philosopher that could demonstrate it from appearances, and make it a solid foundation to the most noble speculations.

I know indeed that some persons and those of great name, too much prepossessed with certain prejudices, are unwilling to assent to this new principle, and are ready to prefer uncertain notions to certain. It is not my intention to detract from the reputation of these eminent men; I shall only lay before the reader such considerations as will enable him to pass an equitable sentence in this dispute.

Therefore that we may begin our reasoning from what is most simple and nearest to us; let us consider a little what is the nature of gravity with us on Earth, that we may proceed the more safely when we come to consider it in the heavenly bodies, that lie at so vast a distance from us. It is now agreed by all philosophers that all circumterrestrial bodies gravitate towards the Earth. That no bodies really light are to be found, is now confirmed by manifold experience. That which is relative levity, is not true levity, but apparent only; and arises from the preponderating gravity of the contiguous bodies.

Moreover, as all bodies gravitate towards the Earth, so does the Earth again towards bodies. That the action of gravity is mutual, and equal on both sides, is thus proved. Let the mass of the Earth be distinguished into any two parts whatever, either equal, or any how unequal; now if the weights of the parts towards each other were not mutually equal, the lesser weight would give way to the greater, and the two parts joined together would move on ad infinitum in a right line towards that part to which the greater weight tends; altogether against experience. Therefore we must say that the weights of the parts are constituted in equilibrio; that is, that the action of gravity is mutual and equal on both sides…

Questions:

In the first two paragraphs, Coates criticizes the approaches of other natural philosophers (scientists) in explaining natural phenomena. What about their approaches does he find objectionable?

He then speaks approvingly of a third approach. What is that approach?

Why is Coates so critical of mere words to describe natural phenomena? What does he cite as a better means to explain how natural phenomena, such as gravity, function?