b12 Occam’s razor <Occam is the Latinized spelling of Ockham; “principle of least amazement” in natural science; *epi-* meaning: *upon, in addition to*, or *above.*>

> 167:22:28 [David] Scott: And so we thought we’d try it here for you. The feather happens to be, appropriately, a falcon feather for our Falcon. And I’ll drop the two of them here and, hopefully, they’ll hit the ground at the same time. (Pause)
> [Dave is holding the feather and hammer between the thumb and forefinger of his left and right hands, respectively, and has his elbows up and out the side. He releases the hammer and feather simultaneously and pulls his hands out of the way. The hammer and feather fall side by side and hit the ground at virtually the same time.]
> 167:22:43 Scott: How about that! *Mr. Galileo was correct!*
> 167:22:45 [Joseph] Allen: How about that! (Applause in Houston)
> [*Apollo 15 transcript* by Eric M. Jones, ©1996 omits the above phrase in italics][1]

Given several explanations for the same phenomena, a principle of parsimony (economy, or Ocham’s razor) is to choose the simplest. For example, 14th-century French physicist Nicole d’Oresme, and Galileo later, defended the Copernican “pleasing to the mind”[2] heliocentric planetary hypothesis (first impiously suggested in the 3rd century BCE by the Greek philosopher Aristarchus and for which Cleanthes, head of the Stoics, sort to have him indicted) as being simpler than Ptolemy’s earlier (and wrong) geocentric hypothesis of planets on epicycles on deferents to equants to account for cyclic motions in their overall eastward travel. However, even simpler (and wrong) is Tycho Brahe’s hypothesis (later enhanced by Galileo’s telescopic observation of moons orbiting Jupiter) of a stationary (as neither rotational nor orbital velocity is felt and no stellar parallax was seen) Earth with Moon and Sun in orbit about it, and the other planets in Sun-centered orbits (***Figure b12.1***).

Given an explanation for something, an application of Occam’s razor (***Footnote b12.1***) is to see if a component can be excised without altering conclusions derivable from it and its useful applications. The component has no “substance” if it can be. Victor J. Steger in 1998 used Occam’s razor to excise David Bohm’s addition in the 1950s of quantum potential to equations to account for quantum effects. Bohm’s theory[3] gives no new empirical predictions and yet to be justified, superluminal (faster than light) connections, for which no test has yet been devised, must be assumed.

A prior phrasing of Occam’s razor, attributed to Aristotle by William Lane Craig in *Reasonable Faith*, 1994, is: “One ought not to try to prove the obvious via the less obvious.”[4] Aristotle, called by Dante “The master of those who knew,” hopefully did not make that fatuous remark. What survives of his thoughts are some of his lecture notes and of his popular works we know some through the interpretive writings of Theophrastus his disciple and successor. Whatever of his makes contemporary sense may be our reading of it ignorant of his true thoughts. His poetic statement: “Now the sun, moving as it does, sets up processes of change and becoming and decay, and by its agency the finest and sweetest water is every day carried up and is dissolved into vapor and rises to the upper region, where it is condensed again by the cold and so returns to the ground,” must be weighed against his thought that earthquakes are caused by underground winds presaged perhaps by the stomach distress that carried him off at age 62. What is forthcoming is that nothing, which was obvious to Aristotle, survives as obvious in science today. This is because the explanation of all is *more* complex than Aristotle (384-322 BCE) could imagine. But glimpsed—as his often aporetic method was to *raise* difficulties that, because they would not go away, should be considered for solution.[5] His empiricism was to organize knowledge by comparing, fastidiously, like to like. Surprises were there when, during his sojourn in Lesbos, he found that of fish, dolphins are (warm) “blooded”(mammals). His “genera” of living things became numerous “characterized according to their ways of living, their actions, their habits and their bodily parts” and clear cut enough: “blooded or bloodless, two- or four-footed, hairy or feathered, outer shelled or not, ...”, for him to be regarded as the founder of biological taxonomy (and also, embryology, ecology, ...) but his goal to corroborate a notion of a single gradient of organization, *scala naturae*, revealed by animal’s degrees of perfection was a metaphysical hypothesis that muddled thought for millennia. Notably, Aristotle held in contempt “lowly” vermin and insects that he merely assumed (for he included snakes among the lowly for their lack of legs) did not have differentiated organs found in "higher" animals. Did he ever bother to look when he wrote that "women have fewer teeth than men."

Most of what is now accepted knowledge in science, beyond weights and measures, is non-intuitive and must be discovered using the scientific method. Science is the principle that metaphysics, which in its classical comprehension is the postulate of transcendence, of that which forever lies beyond pragmatic and logically demonstrable proceedings, is ignorance. Not simple, or self evident, is an understanding of DNA, and inevitable, given the world, chromosomal mutation which allows for the simpler assumption that humans and apes are homologous and not analogous which would need a more complicated special explanation for each. A ball rolling on the floor, in spite of its momentum, comes to rest because of friction. The phenomenon of momentum, which, it is true, awaits a rational explanation, and the effect of friction must be invoked to better what thereby becomes Aristotle's misperception that "The natural state of motion is rest."[6] As for weights and measures, Aristotle postulated that objects of different weights (a feather and a stone) by their nature fall at different speeds. Galileo noted no sorting by weight of different sized hailstones, and so he rightly doubted. Using his normal (i.e. about 60 beats a minute) pulse, Galileo counted the time it took for balls he rolled down planes (gently inclined to make their fall slow enough) to reach marked distances. Their speed, he found, doubles for each additional equal distance of fall and that the acceleration of the heavier is slightly faster than lighter.[7] That latter would not be so, he posited, in a vacuum and in a situation free of the effect of friction. Scott of Apollo 15 did demonstrate this on Moon, with a nod to Galileo, on television, by dropping, side by side, a feather and hammer. As for Galileo's famous Pisa experiment, Dava Sobel in *Galileo's Daughter*, 1999, informs:[8]

> Galileo never recorded the date or details of the actual demonstration himself but recounted the story in his old age to a young disciple, who included it in a posthumous biographical sketch. However dramatically Galileo may have executed the event, he did not succeed in swaying popular opinion down at the base of the Leaning Tower. The larger ball, being less susceptible to the effects of what Galileo recognized as air resistance, fell faster, to the great relief of the Pisan philosophy department. The fact that it fell only fractionally faster gave Galileo scant advantage.
>
> "Aristotle says that a hundred-pound ball falling from a height of a hundred braccia [arm lengths] hits the ground before a one-pound ball has fallen one braccio. I say they arrive at the same time," Galileo resummarized the dispute in its aftermath. "you find, on making the test, that the larger ball beats the smaller one by two inches. Now, behind those two inches you want to hide Aristotle's ninety-nine braccia and, speaking only of my tiny error, remain silent about his enormous mistake."

The mantra *entia non sunt multiplicanda prater necessitate* (entities should not be multiplied unnecessarily) that tells the contribution to philosophy by William of Occam (born 1285 at Ochham, Surrey, England, died 1349),[9] has application to theories spun by mathematicians and physicists. For the exact sciences, when competing theories explain the same phenomenon, the least complicated is preferred. Albert Einstein (1879-1955), considering space-time mechanics with the tool of Hermann Minkowski's (1864-1909) mathematics,[10] as proffered by its author ca. 1907, softened this to: "Everything should be made as simple as possible, but not simpler."[11] So, Occam's razor in the exact physical sciences has applications. To ascertain, say, the workings, by variational analytical methods, of natural mechanical systems, as these tend to settle into the groove of least work.

In Paul Dirac's mind when he scrawled on a Moscow blackboard in 1955: "Physical laws should have mathematical beauty" could be that messy ones are forgettable.[12] In that sense, the minimalist form of the most famous laws of physics celebrate Occam's razor and sing to the thought in: "When old age shall this generation waste, / Thou shalt remain, in midst of other woe / Than ours, a friend to man, to whom thou say'st, / 'Beauty is truth, truth beauty, —that is all / Ye know on earth, and all ye need to know.' (in *Ode to a Grecian Urn* by John Keats (1795-1821), 1884)". In *It Must Be Beautiful: Great Equations of Modern Science*,[13] edited by Graham Farmelo, 2002, is a collection of essays that further that claim. "A comprehensible and insightful model beats an exact description any day," writes Ian Stewart. But in that book, Steven Weinberg's reflective afterword: "How great equations survive," is that all of the equations are actually wrong.[14] Thus while simplicity surely did allow Newton to reason to the solution of a two body problem (as say, Mars orbits Sun in an ellipse), the described system does not exist in the solar system nor anywhere in the real universe. We receive hydraulics: "a science of variable constants," and hydrodynamics: "the mathematics of dry water."[15]

It is a trap to assume that Occam's razor has much application to the understanding of natural systems that are historical in nature. That is, when the product to be explained is the compromised result of numerous contingencies or when the description of it is grossly incomplete. Indeed, Occam's razor is a proven hindrance to progress in natural sciences such as geology and biology. Closed minds on subjects are all too soon encouraged: The simplest understanding of the ocean basins was that they are downwarped continental crust (sial). Libraries of works start with this premise or reach it as a conclusion. The facts, now in, are that the ocean floors are otherwise. The presumed fixity of the continents is a simpler concept than wandering continents, as that requires a mechanism for their movement. However, continents, do wander. Given the problem of how a four footed herbivore grown tall at the shoulder can reach for food, the simplest evolutionary solution would be an elongation of the neck. Who then would look for an elephant?

For the natural sciences, Occam's razor can be recast as "the principle of least amazement." And there, rather than to expect simplicity, look to find a Rube Goldberg contraption.[16] ❑

Footnote b12.1 Dr. Roald Hoffman, a Nobel laureate in chemistry, helped track down the earliest reference to a razor in connection with our severely censured nominalist's parsimony pitch. He steered me to a July 1918 article in *Mind*, a philosophy journal, by W. M. Thornburn, in which that logician cited a footnote in a 1746 work of the French philosopher Étienne Bonnot de Condillac. In what Thornburn called 'a flash of Gallic wit,' de Condillac characterized Ockham's principle as the *Rasoir des Nominaux,* 'the razor of the Nominalists.' Almost a century later, in the 1836 lectures by Sir William Hamilton on metaphysics and logic, the man and the metaphor met: 'We are, therefore, entitled to apply *Occam's razor* to this theory of causality.' —William Safire.[17]

Figure b12.1 [18] **Schematic representations of six major schemes of the universe**

> If every apparent movement gets saved [is forecast], as warranted by the hypotheses, why should anyone find it surprising that it is from such complicated motions that the movements of the heavenly bodies result? —Ptolemy.[19]

Geocentric *Ptolemaic* and *Platonic* systems with circular orbits centered on Earth of Sun, Moon, and the other "wanderers" (planets). Epicycles (not shown) were later postulated to explain observed sometimes retrograde motions of planets. Of this awkwardness to preserve geocentricity, Alfonso X (The Wise) King of Castile (AD 1221-1284) said: "If the Deity had asked my advice, these things would have been better arranged!" or, according to another source, had cried out upon viewing a contraption that modeled the movements: "If I had been consulted at the creation, I could have done the thing better than that!" [20]

> Truly indeed does the sun ... govern his family of planets as they circle about him. ... Thus we discover in this orderly arrangement the marvelous symmetry of the universe and a firm harmonious connection between the motion and the size of the spheres such as can be discerned by no other means. —Copernicus.[21]

Heliocentric *Copernican* (1543) system with Moon revolving around Earth, and Earth and all the other planets revolving around Sun. Parallax accounts for the retrograde motions as observed from Earth of the other planets.

Geocentric *Egyptian, Tychonic* (1588), and *Ricciolian semi-Tychonic* (1651) systems with Sun, Moon, and a sphere of stars revolving around Earth and one or more planets revolving around Sun.