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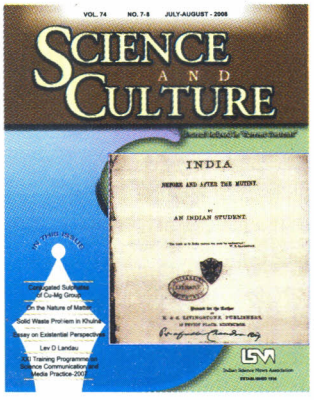
EDITORIAL

OCKHAM'S RAZOR



When the driver of my car dropped me at one of the business buildings of Park Street the other day, I cautioned him that exiting from the building would require a special skill of manoeuvring. He gave me a glance dismissing my concern. When he came back home after some work at Ballygunje post office, we noted a visible bruise at the side of the car. When asked, he explained that possibly a car grazed by when he had parked near the post office. He was not quite sure because at that time he was drinking water from a tubewell across the road where the car was parked. I rejected his explanation simply because it contained too many assumptions - a car came from the opposite direction and dashed my car exactly when he was drinking water – this was too far fetched. Instead, I stuck to the simpler theory that it happened during his backing out from the Park Street building. He finally admitted that it indeed happened at that building. This is exactly what Ockham's razor is all about, whereby we discard (sometimes unknowingly) hypotheses with too many assumptions and accept the simplest one which is more often than not is the correct answer.

It is not known who first connected the word razor with this principle but it was apparently to signify the act of shaving off unnecessary assumptions to select the simplest explanation.

Ockham's razor was named after William Ockham (also written as Occam) who was born in about 1285 in a place called Ockham near Surrey in England. Okham's razor is a principle which as expressed in Latin says '*entia non sunt multiplicanda praeter necessitatem*' and translated in English means 'entities should not be multiplied beyond necessity'. Although the same principle '*Frustra fit per plura quod potest fieri per pauciora*' or "It is pointless to do with more what can be done with fewer" was known to Aristotelians, it is only through the writings of Ockham that this principle became popular among philosophers. It is also described as the law of parsimony or the rule of simplicity. It is not known who first connected the word razor with this principle (the expression "Ockham's Razor" first appeared in print in 1852 in the writings of Sir William Hamilton), but it was apparently to signify the act of shaving off unnecessary assumptions to select the simplest explanation. The principle may have originated from the observation that nature loves symmetry as well as simplicity, and a simpler theory about nature appealed to the aesthetic sense of our earliest philosophers (Aristotle wrote "Nature operates in the shortest way possible"). In the world of physics, we are well familiar with the principles of least action and least path. Other things being equal, we prefer to accept the simpler explanation.

Rigorous application of Ockham's razor in science to consider the simplest solution as the correct one may not always be true. Ockham's razor is a heuristic principle, not a law or theory in the classical sense of being a model that explains physical observations. Instead of interpreting it to mean that the simplest explanation is always true, we ought to use it on methodological grounds. For instance, the application of Ockham's razor acts as a good guideline

to start with— sometimes it helps to get to the heart of the problem quickly. One example of success using Ockham's razor was the discovery of anti-particle by Paul Dirac. While dealing with the quantum mechanical equations of an electron, Dirac predicted a new type of particle with exactly the same basic properties of electrons except being positively charged. This solution was puzzling because there was nothing of that known of in nature. But the solutions were so simple, symmetrical and elegant that Dirac was convinced that the solution was real. The existence of the positively charged equivalent of an electron, now known as positron, was observed by Carl Anderson in later years. Dirac was an avid lover of simplicity and symmetry (beauty), and has expressed his sentiments on the subject very clearly through the following statement "The research worker, in his effort to express the fundamental laws of Nature in mathematical form should strive mainly for mathematical beauty. It often happens that the requirements of simplicity and beauty are the same, but where they clash the latter must take precedence." However unlike Aristotle (who believed that observation and experiment are unnecessary), Dirac believed in scientific observations and experimental verification. Ockham himself was not against scientific evidence either.

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The success of predicting the positron using the law of parsimony (simplicity) does not suggest that physics should be based on elegant theory or mathematical beauty alone. It is not uncommon that the simplest solution satisfying many of the properties of a given phenomenon finally turned out to be untrue. One such example is our early understanding of heat. Until the discovery that heat and energy were equivalent, heat was believed to be a kind of fluid (named 'caloric') which flowed from a hot object to a cold object. This ostensibly explained many observed facts such as the expansion of matter when heated (it was argued that it requires more space to allow more fluid volume to be accommodated). Interestingly, the argument of 'caloric' was so convincing that Lavoisier listed it as an element in his table of elements first published. However, this simple caloric theory was laid to rest by Count Rumford's mechanical theory of heat and the modern discipline of thermodynamics.

In physics, Ockham's razor is used to shave off metaphysical concepts, as we find in the development of Einstein's theory of special relativity. It is known that Einstein's equations for transforming space-time are the same as Lorentz's theory that postulated that a ruler (metre scale) contracts and a clock slows down when in motion through ether. By using very simple reasoning (Ockham's razor), the kind of extraordinary simplicity that belong to genius, and by drawing on Michelson-Morley's inconclusive attempts to detect ether, Einstein argued that, as in the mutual interaction of a magnet and a conductor, it is only relative motion that matters. He commented "Examples of that sort, together with the unsuccessful attempts to discover any motion of the earth relatively to the 'light medium' suggest that the phenomenon of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest."

Ernst Mach proposed a version of Ockham's razor known as the Principle of Economy which states that "Scientists must use the simplest means of arriving at their results and exclude everything not perceived by senses." This is the philosophy of positivism, which essentially means that there is no difference between something that exists but is not observable, and something that doesn't exist at all. Mach influenced Einstein when he argued that space and time are not absolute, but he also applied positivism to molecules. In spite of the success of molecular theory in explaining thermodynamics and chemical reactions, Mach and his followers believed that molecules are metaphysical since they cannot be observed. It is interesting that Einstein, on the one hand, used the principle of economy to eliminate the concept of ether and establish that space and time are not absolute, while on the other, in publishing a paper on Brownian motion (which confirmed the reality of molecules) around the same time, shunned the razor for logic and observation. This teaches us that Ockham's razor should not be used blindly to shave off metaphysics. As Einstein put it in his *Autobiographical notes,* "This is an interesting example of the fact that even scholars of audacious spirit and fine instinct can be obstructed in the interpretation of facts by philosophical prejudices."

In connection with the discovery of the double-helix structure of DNA by Watson and Crick in the early 1950s, Watson wrote in his book *The Double Helix* that the path to the discovery was favoured by the belief that 'the truth, once found, would be simple as well as pretty'. There is

no doubt that the structure they discovered was pretty and was based on a simple picture of fitting the parts of the molecule in space. However, in order to understand how two DNA chains are linked to form a double helix, the simple picture did not work. Each chain is lined with chemical structures called bases and labeled as *A*, *G*, *T* and *C*. Watson favoured the simple idea that *A*s on one chain linked preferentially with *A*s on the other chain, and *G*s with *G*s, and so on and so forth. He was so convinced of the correctness of this prediction that he wrote "only for brief moments did the fear shoot through me that an idea this good could be wrong". However, finally he found the correct model was that *A*s on one chain only link with *T*s on the other chain and *G*s with *C*s. We now know in the last fifty years after its discovery, that the structure is much more complex than that was originally proposed. Nonetheless the law of parsimony helped make a good start to obtain further details of the functioning of DNA.

Stephen Hawking in his book *'A Brief History of Time'* mentions Ockham's razor in connection with the discovery of Heisenberg's uncertainty principle, which signalled the end of Laplace's deterministic world. He wrote, "We could still imagine that there is a set of laws that determines events completely for some supernatural being, who could observe the present state of the universe without disturbing it. However, such models of the universe are not of much interest to us mortals. It seems better to employ the principle known as Occam's razor and cut out all the features of the theory which cannot be observed."

On a lighter note, Ockham's razor can also be used to arrive at the correct conclusion in many situations in real life. For example, one of the most common dilemmas an investor faces in judging the risk factor of an investment. Is an investment in a diversified equity fund is more likely to gain in a short period (say five years) than a sectorial fund? By applying the law of parsimony, it is easy to realize that getting returns in a particular sector requires an ad-hoc assumption that the particular sector is going to gain over the next five years, while getting gains from a diversified fund needs the simpler assumption that at least some sectors will do well for the next five years. (Do not take this as an advice at this time of market and political volatility). Variants of Ockham's razor have permeated to other aspects of life, ranging from politics (the KISS principle, or "Keep it Simple, Stupid") to medicine (a maxim in medical schools is "When you hear hoofbeats, think horses not zebras"). I leave it to the reader to apply Ockham's razor in other practical situations and verify how it works.

In conclusion, it should be remembered that the law of parsimony is not a substitute for logic or other scientific methods. It should not be accepted blindly as truth to arrive at or defend a conclusion. The law of parsimony can be taken as a rule-of-thumb to start with, but not as true as an axiom in physics. In order to ascertain the correctness of a hypothesis, logical consistency and observed or empirical evidence need to be taken into account. As Einstein remarked "Everything should be made as simple as possible, but not simpler." ❐

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