Occam's Razor

Occam's, or Ockham's razor is a principle attributed to the 14th century logician and Franciscan friar, William of Occam. Ockham was the village in the English county of Surrey where he was born.

The principle states that "Entities should not be multiplied unnecessarily." Sometimes it is quoted in one of its original Latin forms to give it an air of authenticity.

> "Pluralitas non est ponenda sine neccesitate"
> "Frustra fit per plura quod potest fieri per pauciora"
> "Entia non sunt multiplicanda praeter necessitatem"

In fact, only the first two of these forms appear in his surviving works and the third was written by a later scholar. William used the principle to justify many conclusions including the statement that "God's existence can not be deduced by reason alone." That one didn't make him very popular with the Pope.

Many scientists have adopted or reinvented Occam's Razor as in Leibniz' "identity of observables" and Isaac Newton stated the rule: "We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances."

The most useful statement of the principle for scientists is,

"when you have two competing theories which make exactly the same predictions, the one that is simpler is the better."

In physics we use the razor to cut away metaphysical concepts. The canonical example is Einstein's theory of special relativity compared with Lorentz's theory that ruler's contract and clocks slow down when in motion through the Ether. Einstein's equations for transforming space-time are the same as Lorentz's equations for transforming rulers and clocks, but Einstein and Poincaré recognised that the Ether could not be detected according to the equations of Lorentz and Maxwell. By Occam's razor it had to be eliminated.

The principle has also been used to justify uncertainty in quantum mechanics. Heisenberg deduced his uncertainty principle from the quantum nature of light and the effect of measurement.

Stephen Hawking explains in A Brief History of Time:
"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."

But uncertainty and the non-existence of the ether can not be deduced from Occam's Razor alone. It can separate two theories which make the same predictions but does not rule out other theories which might make a different prediction. Empirical evidence is also required and Occam himself argued for empiricism, not against it.

Ernst Mach advocated a version of Occam's razor which he called the Principle of Economy, stating that "Scientists must use the simplest means of arriving at their results and exclude everything not perceived by the senses." Taken to its logical conclusion this philosophy becomes positivism; the belief 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. Mach and his followers claimed that molecules were metaphysical because they were too small to detect directly. This was despite the success the molecular theory had in explaining chemical reactions and thermo-dynamics. It is ironic that while applying the principle of economy to throw out the concept of the ether and an absolute rest frame, Einstein published almost simult-aneously a paper on Brownian motion which confirmed the reality of molecules and thus dealt a blow against the use of positivism. The moral of this story is that Occam's razor should not be wielded blindly. 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."

Occam's razor is often cited in stronger forms than Occam intended, as in the following statements...

"If you have two theories which both explain the observed facts then you should use the simplest until more evidence comes along"

"The simplest explanation for some phenomenon is more likely to be accurate than more complicated explanations."

"If you have two equally likely solutions to a problem, pick the simplest."

"The explanation requiring the fewest assumptions is most likely to be correct."

... or in the only form which takes its own advice...
"Keep things simple!"

Notice how the principle has strengthened in these forms which should be more correctly called the law of parsimony, or the rule of simplicity. To begin with we used Occam's razor to separate theories which would predict the same result for all

experiments. Now we are trying to choose between theories which make different predictions. This is not what Occam intended. Should we not test those predictions instead? Obviously we should eventually, but suppose we are at an early stage and are not yet ready to do the experiments. We are just looking for guidance in developing a theory.

This principle goes back at least as far as Aristotle who wrote "Nature operates in the shortest way possible." Aristotle went too far in believing that experiment and observation were unnecessary. The principle of simplicity works as a heuristic rule-of-thumb but some people quote it as if it is an axiom of physics. It is not. It can work well in philosophy or particle physics, but less often so in cosmology or psychology, where things usually turn out to be more complicated than you ever expected. Perhaps a quote from Shakespeare would be more appropriate than Occam's razor: "There are more things in heaven and earth, Horatio, Than are dreamt of in your philosophy.".

Simplicity is subjective and the universe does not always have the same ideas about simplicity as we do. Successful theorists often speak of symmetry and beauty as well as simplicity. in 1939 Paul Dirac wrote,

"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"

The law of parsimony is no substitute for insight, logic and the scientific method. It should never be relied upon to make or defend a conclusion. As arbiters of correctness only logical consistency and empirical evidence are absolute. Dirac was very successful with his method. He constructed the relativistic field equation for the electron and used it to predict the positron. But he was not suggesting that physics should be based on mathematical beauty alone. He fully appreciated the need for experimental verification.

The final word falls to Einstein, himself a master of the quotable one liner. He warned,

"Everything should be made as simple as possible, but not simpler."

References:

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