May 09
1. "Science is built of facts the way a house is built of bricks: but an accumulation of facts is no more science than a pile of bricks is a house" (Henri Poincaré). Discuss in relation to science and at least one other area of knowledge.
Franz Ronay, American International School, Vienna

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<u>Question 1:</u> "Science is built of facts the way a house is built of bricks: but an accumulation of facts is no more science than a pile of bricks is a house" (Henri Poincare) Discuss in relation to science and at least one other area of knowledge.

Poincare's statement may well sum up the consensus about the teleology of science in modern times. Not only in the natural sciences, but also in human sciences and ethics, researchers and developers attempt to fit an underlying structure of theory to the facts gathered in each field. This goal speaks much about the unuttered belief of scientists that the observable universe is coherently structured, and that even the most complicated of its phenomena can be explained using general statements. If this belief is justified, as it seems to be in almost every branch of natural and human sciences, Poincare's quote correctly captures the meaning of science. However, there are several obstacles that limit the universality of the statement. First of all, historic examples show that often science cannot develop without intentionally neglecting the general theory initially. Secondly, the statement fails to address the issue that the unifying models sought for by science are human creations, and not necessarily part of the reality they describe. And thirdly, as the physicist Werner Heisenberg put it, "although we (scientists) expect that the universe is governed by simple and consistent laws, we cannot justify this expectation with more than our hope and empiric experience" [i]. In other words, the logic generally used to justify Poincare's view of science is inductive, so there is no way of being sure it may not be contradicted by future counterexamples.

The natural sciences represent a natural setting to evaluate Poincare's statement. Their historic origin in the empiric formulas of the engineers, astronomers and blacksmiths of the first civilizations – I will consider ancient Egypt as an example – casts doubt on the assertion that science must always strive for general structures within the scope of its evidence.

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Consider the following dichotomy: An Egyptian blacksmith may have known which metals were feasible materials for weaponry, engineers may have known that a triangle with sides of the ratio 3:4:5 formed a right angle, and astronomers may have known the polar star always points north, without trying to extrapolate from their knowledge to overarching principles. On the other hand, Egyptian priests came up with unifying models that described stellar motion, but explained it with the movement of gods across the sky, and did not calculate the actual trajectories. If we took Poincare's definition too literally, the latter example would qualify as science more than the prior even though is more speculative, and much less useful in application. The solution to this apparent weakness in the statement is twofold: First, one has to differentiate between theoretical and applied science, and secondly, one has to emphasize, as Poincare did, the importance of empiric evidence in science. Seen in this way, neither of the previous examples qualifies as science at all. While the empiric recipes of the blacksmiths and geometers in the first instance weren't speculative enough, the theories of the priests in the second were *too* speculative (and not intended as science).

A very important preliminary requirement for modern natural science is probably a belief that was fully developed only much later. Although the so-called Enlightenment couldn't prevent the violent wars on European territory from the seventeenth century onward, it provided fertile ground for the sentiment that ancient Greek philosophers had uttered, but which had lapsed into obscurity during the Middle Ages - the sentiment that all natural phenomenons can be explained using reason and perception alone (Empiricism). This belief, paired with the technical advancements of the time, inspired Enlightenment scientists to develop *consistent* systems attempting to unify their observations and give them *predictive power*. Mathematics seemed to be the most apt means to attain this goal, and applying it to the natural sciences universally was an important step forward. Astronomy went from being a pseudo-science to a fully-fledged natural science with the introduction of mathematics. By comparing their hypothetical calculations with their actual measurements, early modern period astronomers now had a tool to pinpoint the flaws and shortcomings of their theories. Another remarkable trend that follows logically from Poincare's statement is the move from *isolated*, very specific branches of science, to more general subjects that began in this age. Newton's mathematical explanation of gravity for instance can be said to transformed astronomy (the study of stellar and planetary movement) into a branch of classical mechanics (the study of motion in general[ii]). However, this move to general theory has seldom occurred without empiric knowledge of the specific areas being developed first. Arguably the fact-gathering necessary to achieve the latter should be divorced from previous theoretical conclusions as to maintain independence from bias, at least initially.

In the course of the evolution of natural science, this counterclaim to Poincare's statement is illustrated time and again. To continue on a previous example, consider the debate about the expanding universe going on in Astronomy and Astrophysics during the first half of the twentieth century. Theoretical scientists had assumed a "Steady-State Universe" previously, a static, unchanging model. Their outspoken bias in its favor made it much more difficult to find the dynamic model accepted today. For instance, Einstein was so worried about solutions of his relativistic equations that allowed expansionary motion that he introduced an arbitrary figure called the *cosmological constant* to exclude them[iii]. This is an example of the dangerous confusion between "construct and reality" that is an inherent danger of any scientific theory. Eventually empirical evidence, though unordered, and originally unrelated to the overarching theory, settled the discussion. The red-shifts in the light of faraway stars observed by the Hubble telescope allowed astronomers to conclude that galaxies were indeed moving away from each other, and that the universe is expanding[iv]. Interestingly, this solution to the scientific problem seems contradictory to Poincare's definition, as it relied on unordered facts outside the accepted structure.

The realization that empirical facts must confirm a theory consistently in order for it to count as valid is also important in the human sciences. However, possibly due to the even greater bias that human beings bear towards their own affairs, it was made comparatively late. It seems that human sciences such as psychology and economics were flawed by wishful thinking for most of their history. If one sees seventeenth century documents such as "An Essay on Humane Understanding" by John Locke or "Leviathan" by Thomas Hobbes, both of which speculate about human nature, as first psychological publications, then one may identify the main shortcoming of the science in its early days. In accordance with the statement at the head of this essay, philosophers like Locke and Hobbes tried to come up with unifying theories of human behavior. Due to the difficulty of gathering quantitative evidence in this context, their theories were dogmatic constructs extrapolated from the few known facts. The human mind has since been described in a variety of absolutes: As "lacking innate ideas"[v] (Locke), "distorted by self-interest"[vi] (Hobbes), and "controlled by sinful nature"[vii] (New Testament, Romans 8:6-8). It seems that psychology throughout ancient times, the Middle Ages and the Enlightenment suffered from the confusion between model and subject previously observed among natural sciences.

It is unsure when human sciences gained predictive power and made the step toward quantitative methods seen as the hallmark of science today. (Natural scientists argue that some branches, such as psychology, still haven't attained this status fully!) Presumably economics, the social science dealing with the production, distribution and consumption of goods and services, was the first among the human sciences to be able to derive principles that could make accurate predictions about human behavior and evaluate them numerically. The origins of modern economics can be seen in the painstaking effort of eighteenth/nineteenth century statisticians as Sir Robert Giffen and Thomas Malthus to order their gathered data about prices and money transfer – interestingly the best-documented form of numeric evidence about human behavior at the time. Given the right circumstances, economics yields statistically correct statements and explanations concerning market affairs. However, the occasionally simplistic assumptions (most famously the assertion that human beings attempt to maximize their personal utility), which are fraught with exceptions in the real world, beg the question whether it is not too speculative after all, or truly “based on facts like a house is built of bricks”, as Poincare put it. Perhaps the human sciences should be pursued in a different way than natural sciences: instead of trying to describe complex structure of human society by simplistic axioms, they may have to restrict themselves to more and more specific branches to maintain their validity.

It is interesting that Poincare’s statement about science applies just as much to studying sciences in school as it does to science itself. Although in Physics and Chemistry classes it is often necessary to memorize specific constants and formulae before solving problems, it is much more important to grasp the underlying concepts as systematically as possible. The search for superimposed principles applies outside of the sciences as well: be it to the mastery of grammar required in studying a language, or the attempt to find rules applicable to any case when studying ethics. It is telling of the human belief in the universality of reason – one that seems justified so far.

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