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Prescribed Title 2: "Facts are needed to establish theories but theories are needed to make sense of facts." Discuss this statement with reference to two areas of knowledge.

The scientific, technological and cultural advancement of humanity depends largely on the cumulative nature of shared knowledge; that is, by building upon existing pieces of knowledge, we are able to make new discoveries. This cyclical process of using knowledge to develop knowledge is demonstrated by facts and theories. Theories are general systems of thought that explain observations through causative relationships, and facts are claims that are true. Facts, in the form of evidence, are used as bases when coming up with accurate theories that describe the real world, and these theories then provide us with frameworks and models that can be used to test, understand and interpret other facts. The two most relevant areas of knowledge for this topic are the natural sciences, as they heavily involve the usage of theories to explain facts and the universe, and the human sciences, as they use theories or "models" to understand human behavior and actions. Both of these areas of knowledge involve reason, sense perception and intuition in the development and utilization of theories.

In the natural sciences, scientists systematically establish theories using facts, and attempt to use those theories to interpret other facts. For example, repeated experimentation with electrically charged objects yielded the fundamental fact that like charges repel. This was recognized using sense perception, by seeing that the objects moved away from each other. This fact was later used as a basis for developing the Valence Shell Electron Pair Repulsion (VSEPR) theory taught in IB Chemistry, which is used to predict the shapes of molecules and hence describe their behavior. The underlying principle behind the theory is that electrons will be positioned such that the repulsion between them is minimized (Bylikin 107). Reasoning was used to apply the principle of electrostatic repulsion to the electrons around molecules, and intuition to predict what geometries and shapes the molecules will take. VSEPR theory can be

used to interpret other facts. For example, the shapes of molecules which are predicted by VSEPR theory, along with the concept of electronegativity, help explain the polar characteristics seen in many molecules. This polar behavior is also responsible for strong intermolecular forces (dipole-dipole attraction) that significantly affect variables such as the boiling point, vapor pressure, and solubility in water. Hence, by utilizing VSEPR theory, we are able to understand polar behavior and many related phenomena. The theory is based upon facts, and helps interpret facts, thus confirming the title. However, this conclusion has certain implications regarding reliability. VSEPR theory is based on an empirical fact which was found through sense perception, a fundamentally unreliable way of knowing. This fact could turn out to be wrong; charged objects may simply be giving the illusion of being repelled, while in reality exhibiting a completely different phenomenon. Therefore, VSEPR theory itself is not completely reliable or certain, and could be proven false. This is one of the reasons why all valid scientific theories are falsifiable, as described by Karl Popper. Furthermore, the interpretations that the theory provides for other facts may be incorrect as well. In conclusion, as facts and theories are built on top of each other, they are all successively subject to change. Such transformations are observed during paradigm shifts, which involve large changes in our understanding of a subject. In a paradigm shift, many theories become obsolete and are replaced, which means that the interpretations of facts developed with those theories are also revised. However, the facts themselves are not affected by paradigm shifts, because they are truths in the natural realm which are independent from our understanding of them.

Not all theories in the natural sciences are backed directly by empirical evidence and facts. Many theories, such as string theory, are purely theoretical, conceptual, and have no experimental basis. Therefore, one might claim that this disproves the title statement, as those theories don’t seem to be based on facts. However, this isn’t completely true, as the scientific context in which a theory resides provides the underlying facts for the said theory. For example,

according to string theory, all particles are actually tiny vibrating strings and the type of vibration determines the characteristics of the particle (Whitwell). This idea relies on the principles of oscillatory motion and standing waves, which are well established and widely demonstrated concepts in Physics. It then follows that string theory, which is a non-empirical theory, is still based on certain facts from classical mechanics, thereby supporting the argument that theories must be based on facts.

Another example from the natural sciences is the baryon asymmetry problem in Physics, which is about the observed imbalance between matter and antimatter in the universe. Baryon asymmetry is an empirical fact which can't be explained or interpreted by any existing theories, which is why it is currently being used as a basis for proposing various new baryogenesis theories (Dev). One of these theories, if accepted, may then be used to help us understand other facts related to matter, antimatter, fundamental particles, or the Big Bang. So, baryogenesis theories are based on a fact and when finally established could help interpret other facts, thus confirming the title. A possible counterargument is that a theory, such as one of these baryogenesis theories, doesn't have to be based on any facts at all – it could be purely abstract and detached from all other scientific knowledge. However, there are three weaknesses in this argument. Firstly, in the case of baryogenesis theories, these are theories with the sole purpose of explaining the baryon asymmetry problem, which itself is an empirical fact; therefore, the phenomenon that a theory is addressing or revolves around serves as one of its foundational facts. Secondly, the act of establishing a theory involves peer-review and verification by others, meaning that if a theory is not backed by facts or evidence, it will be rejected by the scientific community as pseudoscience. And finally, the aim of science is to accurately describe the universe and the real world, which is why a scientific theory that describes the real world must incorporate knowledge of the real world. Admittedly, perhaps it could be possible to establish a completely abstract theory in another area of knowledge that is

detached from all other knowledge; for this reason, the title statement should be revised to read: "facts are needed to establish [accurate] theories [that describe the real world]."

A similar relationship exists in the human sciences. For instance, the theory of comparative advantage taught in IB Economics is based on facts and helps us understand facts. It is a theory about the benefits of free trade between countries, and states that a certain type of good should be produced by the country which has the least opportunity cost for that good, meaning that it is produced by the country which loses the least (in terms of production opportunities) from producing it. This economic theory is based on facts found through statistical studies, such as the one carried out by MacDougall in 1951 on the US and UK which found that there was a positive relationship between the output per worker (productivity) and the amount of exports, for a given type of good. This fact, discovered in the early stages of the comparative advantage theory, was used as a basis for validating and establishing it. The comparative advantage theory, in turn, helps us interpret real-world cases and facts, such as the scenario in which a country can benefit from ceasing to produce a good, and importing it instead; even though the country's economy loses an industry, it gains overall, given that the countries specialize at the industries they have the least opportunity costs in and trade between themselves. As the comparative advantage theory is based on facts and provides interpretations for facts, the human sciences also possess the cyclical nature described in the title.

Theories aren't always necessary to interpret facts. Many basic facts can be interpreted and explained through common knowledge, which is the fundamental knowledge in a discipline, without additional theoretical frameworks or models. For example, the previous scenario where a country benefits from importing a good rather than producing it was explained through the theory of comparative advantage, but it could also be interpreted in other ways, without theories. The country may have gained simply because the increase in trade with the

other country resulted in a trade partnership, thereby yielding social and political advantages. Hence, while theories can be used to interpret facts, they aren't necessary to do so.

Facts and theories often rely on one another; theories are built on facts and help interpret facts. Examples for this can be found in areas of knowledge such as the natural and human sciences. When answering the title, certain knowledge issues come up, such as how building facts and theories on top of each other affects their reliability; as facts aren't always completely reliable, the theories they produce and the consequent interpretations of new facts aren't either. There are three potential counterarguments to the title. The first is that some scientific theories aren't based on empirical facts, the second is that one could develop an abstract theory without using any facts, and the third is that theories aren't always necessary to interpret facts. These counterarguments were addressed, and the following conclusion was finally reached: facts are necessary to develop accurate theories that describe the real world, and theories have the ability to help us test, understand and interpret facts, but aren't necessarily required to do so.

Works Cited

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