4 THEORY SCIENTIST, ASSUMPTION AND THESIS

4.1 SCIENTIFIC THEORY: A **scientific theory** is a well-substantiated explanation of some aspect of the natural world that is acquired through the scientific method, and repeatedly confirmed through observation and experimentation. As with most (if not all) forms of scientific knowledge, scientific theories are inductive in nature and aim for predictive power and explanatory force.

The strength of a scientific theory is related to the diversity of phenomena it can explain, and to its elegance and simplicity (Occam's razor). As additional scientific evidence is gathered, a scientific theory may be rejected or modified if it does not fit the new empirical findings- in such circumstances, a more accurate theory is then desired. In certain cases, the less-accurate unmodified scientific theory can still be treated as a theory if it is useful (due to its sheer simplicity) as an approximation under specific conditions (e.g. Newton's laws of motion as an approximation to special relativity at velocities which are small relative to the speed of light).

Scientific theories are testable and make falsifiable predictions. They describe the causal elements responsible for a particular natural phenomenon, and are used to explain and predict aspects of the physical universe or specific areas of inquiry (e.g. electricity, chemistry, astronomy). Scientists use theories as a foundation to gain further scientific knowledge, as well as to accomplish goals such as inventing technology or curing disease. Scientific theories are the most reliable, rigorous, and comprehensive form of scientific knowledge. This is significantly different from the common usage of the word "theory", which implies that something is a guess (i.e., unsubstantiated and speculative)

Formation of theories

The scientific method involves the proposal and testing of hypotheses, by deriving predictions from the hypotheses about the results of future experiments, then performing those experiments to see whether the predictions are valid. This provides evidence either for or against the hypothesis. When enough experimental results have been gathered in a particular area of inquiry, scientists may propose an explanatory framework that accounts for as many of these as possible. This explanation is also tested, and if it fulfills the necessary criteria (see above), then the explanation becomes a theory. This can take many years, as it can be difficult or complicated to gather sufficient evidence.

Once all of the criteria have been met, it will be widely accepted by scientists (see scientific consensus) as the best available explanation of at least some phenomena. It will have made predictions of phenomena that previous theories could not explain or could not predict accurately, and it will have resisted attempts at falsification. The strength of the evidence is evaluated by the scientific community, and the most important experiments will have been replicated by multiple independent groups.

Theories do not have to be perfectly accurate to be scientifically useful. For example, the predictions made by classical mechanics are known to be inaccurate in the relatistivic realm, but they are almost exactly correct at the comparatively low velocities of common human experience.[9] In chemistry, there are many acid-base theories providing highly divergent explanations of the underlying nature of acidic and basic compounds, but they are very useful for predicting their chemical behavior. Like all knowledge in science, no theory can ever be completely certain, since it is possible that future experiments might conflict with the theory's predictions. However, theories supported by the scientific consensus have the highest level of certainty of any scientific knowledge; for example, that all objects are subject to gravity or that life on Earth evolved from a common ancestor.

Acceptance of a theory does not require that all of its major predictions be tested, if it is already supported by sufficiently strong evidence. For example, certain tests may be unfeasible or technically difficult. As a result, theories may make predictions that have not yet been confirmed or proven incorrect; in this case, the predicted results may be described informally with the term "theoretical." These predictions can be tested at a later time, and if they are incorrect, this may lead to revision or rejection of the theory.

MODIFICATION AND IMPROVEMENT OF THEORIES

If experimental results contrary to a theory's predictions are observed, scientists first evaluate whether the experimental design was sound, and if so they confirm the results by independent replication. A search for potential improvements to the theory then begins. Solutions may require minor or major changes to the theory, or none at all if a satisfactory explanation is found within the theory's existing framework. Over time, as successive modifications build on top of each other, theories consistently improve and greater predictive accuracy is achieved. Since each new version of a theory (or a completely new theory) must have more predictive and explanatory power than the last, scientific knowledge consistently becomes more accurate over time.

If modifications to the theory or other explanations seem to be insufficient to account for the new results, then a new theory may be required. Since scientific knowledge is usually durable, this occurs much less commonly than modification.[4] Furthermore, until such a theory is proposed and accepted, the previous theory will be retained. This is because it is still the best available explanation for many other phenomena, as verified by its predictive power in other contexts. For example, it was known in 1859 that the observed perihelion precession of Mercury violated Newtonian mechanics, but the theory remained the best explanation available until relativity was supported by sufficient evidence. Also, while new theories may be proposed by a single person or by many, the cycle of modifications eventually incorporates contributions from many different scientists.

After the changes, the accepted theory will explain more phenomena and have greater predictive power (if it did not, the changes would not be adopted); this new explanation will then be open to further replacement or modification. If a theory does not require modification despite repeated tests, this implies that the theory is very accurate. This also means that accepted theories continue to accumulate evidence over time, and the length of time that a theory (or any of its principles) remains accepted often indicates the strength of its supporting evidence.

Unification of theories

In quantum mechanics, the electrons of an atom occupy orbitals around the nucleus. This image shows the orbitals of a hydrogen atom (*s*, *p*, *d*) at three different energy levels (1, 2, 3). Brighter areas correspond to higher probability density.

In some cases, two or more theories may be replaced by a single theory which explains the previous theories as approximations or special cases, analogous to the way a theory is a unifying explanation for many confirmed hypotheses; this is referred to as *unification* of theories. For example, electricity and magnetism are now known to be two aspects of the same phenomenon, referred to as electromagnetism.

When the predictions of different theories appear to contradict each other, this is also resolved by either further evidence or unification. For example, physical theories in the 19th century implied that the Sun could not have been burning long enough to allow certain geological changes as well as the evolution of life. This was resolved by the discovery of nuclear fusion, the main energy source of the Sun. Contradictions can also be explained as the result of theories approximating more fundamental (non-contradictory) phenomena. For example, atomic theory is an approximation of quantum mechanics. Current theories describe three separate fundamental phenomena of which all other theories are approximations; the potential unification of these is sometimes called the Theory of Everything.

4.2 SCIENTIFIC MODELS: A **scientific model** is a simplified abstract view of a complex reality. Scientific models are used as a basis for scientific work. They can be used to explain, predict, and test, or to develop computer programs or mathematical equations.

An example of a complex model is the software used for weather forecasts. The program is based on equations for the variables which affect weather. Meteorological data is fed in, and the program produces predictions (graphs and data) of future weather patterns.

A scientific model represents complex objects, events, and physical processes in a logical way.

- They are an image of an original, which can be a model itself.
- Scientific models only have those details of the object or image modeled that are relevant.
- There is no strict mapping between a model, and the original object it models. Models may be valid only for a given time interval, for a given object, or for a given purpose.

EXAMPLES

For instance, models of our universe are part of astrophysics - the biggest things in nature - and physics - the smallest. This is not usually what we mean by nature, however. We mean the models studied in biology, ecology, economic, environmental health and healing. Most models of nature are of things that humans really affect directly, and which affect humans back:

TOXIC WASTE

For instance, to dump toxic waste in a river will harm others down the river. But without models of nature we do not know who, and cannot say how much is harmed or harmful.

EFFECTS

Models of nature affect human decision-making. They are very important to human health, wellness and economics. They also matter in ethics, since most people wish to reduce harm done by their decisions. They matter in law because harms can be proven to have been done in a court.

Forest

A forest is very hard to bring back to life, once it is degraded. Smaller models of bits of nature help to understand how much must be left, so future generations can use nature too.

Effects on nature

In many ways humans and nature can be said to be in conflict. Natural capital like soil and large healthy trees, which nature needs to make more of itself, is also useful to humans as natural resources. To know how much can be drawn out of nature, before it dies, is important. This is another reason for a model:

There are three main ways in which models of nature affect human life:

THE ENVIRONMENT: Environment and wellness are about human health and healing and nutrition. These focus on 'what goes in' the human body or senses, and on how to extend lifespan and increase vitality. Human happiness depends on being part of something alive outside them, according to this view. Gardening for instance can make them happy, just by focusing them on growing and putting themselves outside.

ECONOMICS: Ecology and economics study resources, waste, energy, food and diet and how choices affect nature in many other places. These ideas say to focus on how to buy local, conserve energy, and to reduce, re-use, recycle goods, to reduce competition between humans. Human bodies are part of nature, according to this view, and must be seen as part of ecology - for instance the urban ecology of cities.

ECOLOGY

Deep ecology and animal rights say nature should exist only for itself. Human morality should be about leaving it alone. This ideology says to focus only on working to conserve habitat,increase biodiversity, and buy moral to not help damage things. It says to do all this without any measurable direct benefit to humans, even themselves. Humans are more like caretakersin this view which is often part of religion. It puts ethical limits on the actions of scientists, for instance it argues against animal experiments or genetically modified food. It usually is seen as opposed to science, not part of it. Its models of nature are not usually accepted by most scientists, but they matter in politics.

Preservation

To preserve nature, ecology movement activists now cooperate in a global power network. It includes not just parties in politics but also NGOs like Greenpeace, Earth First or World Wide Fund for Nature.

4.3 PARTS OF A THEORY: Theories are analytical tools for understanding, explaining, and making predictions about a given subject matter. There are theories in many and varied fields of study, including the arts and sciences. A formal theory is syntactic in nature and is only meaningful when given a semantic component by applying it to some content (i.e. facts and relationships of the actual historical world as it is unfolding). Theories in various fields of study are expressed in natural language, but are always constructed in such a way that their general form is identical to a theory as it is expressed in the formal language of mathematical logic. Theories may be expressed mathematically, symbolically, or in common language, but are generally expected to follow principles ofrational thought or logic.

Theory is constructed of a set of sentences which consist entirely of true statements about the subject matter under consideration. However, the truth of any one of these statements is always relative to the whole theory. Therefore the same statement may be true with respect to one theory, and not true with respect to another. This is, in ordinary language, where statements such as "He is a terrible person" cannot be judged to be true or false without reference to some interpretation of who "He" is and for that matter what a "terrible person" is under the theory.[14]

Sometimes two theories have exactly the same explanatory power because they make the same predictions. A pair of such theories is called indistinguishable, and the choice between them reduces to convenience or philosophical preference.

The form of theories is studied formally in mathematical logic, especially in model theory. When theories are studied in mathematics, they are usually expressed in some formal language and their statements are closed under application of certain procedures called rules of inference. A special case of this, an axiomatic theory, consists of axioms (or axiom schemata) and rules of inference. A theorem is a statement that can be derived from those axioms by application of these rules of inference. Theories used in applications are abstractions of observed phenomena and the resulting theorems provide solutions to real-world problems. Obvious examples include arithmetic (abstracting concepts of number), geometry (concepts of space), and probability(concepts of randomness and likelihood).

Gödel's incompleteness theorem shows that no consistent, recursively enumerable theory (that is, one whose theorems form a recursively enumerable set) in which the concept of natural numbers can be expressed, can include all true statements about them. As a result, some domains of knowledge cannot be formalized, accurately and completely, as mathematical theories. (Here, formalizing accurately and completely means that all true propositions—and only true propositions—are derivable within the mathematical system.) This limitation, however, in no way precludes the construction of mathematical theories that formalize large bodies of scientific knowledge.