Extra Material

The most productive model for the structure of a *scientific explanation* is that of a valid deductive argument whose conclusion is the event to be explained. Some of the premises of this argument will be factual statements of the antecedent circumstances , while the others will be the scientific hypotheses offered as a way of linking those circumstances to the outcome stated by the conclusion . This manner of testing, where observations running contrary to those predicted are taken as evidence against the hypothesis and observations which are in agreement with those predicted are taken as corroborating the hypothesis, is known as the Hypothetico-Deductive Method.

The reliability of a hypothesis can never be established with absolute certainty. It is sometimes possible to eliminate bad hypotheses by using them as the premises of a deductive argument predicting that particular consequences will follow from a particular set of circumstances and then showing that the predicted event does not, in fact, occur. This amounts to the use of Modus Tollens to show that since the consequent is false, some part of the antecedent must also be false.

> *Hypothesis Falsified – Valid Deductive Argument (Modus Tollens)*
> P1: If hypothesis B is correct, then event x will occur.
> P2: x did not occur.
> Conclusion: Hypothesis B is false.

If the events turn out as predicted, that only tends to confirm the hypotheses; it cannot prove their truth, since that would amount to reliance on the fallacy of affirming the consequent. Empirical evidence typically underdetermines scientific explanation, leaving us with multiple hypotheses, any one of which would account for the facts.

> *Hypothesis Verified – Invalid but can be inductively strong (Affirming the Consequent)*
> P1: If Hypothesis B is correct, then event x will occur.
> P2: x did occur.
> Conclusion: Hypothesis B has some confirmation.

Q: What accounts for the relative strength of a particular inductive argument?

> *A*: This is an excellent philosophical issue about what gets to count as evidence for a hypothesis. Most straightforwardly, the number of times a hypothesis is verified by a particular type of event accounts for the strength of an inductive argument.

14.3 Evaluating Scientific Explanations

Criteria for Testing Scientific Theories:

1. Predictive Power (388) *agreement between predicted and actual events*
    a. Testable: a hypothesis is testable if an *observable fact* is deducible from it that can be empirically confirmed. Εμπειρισμός = experience…empirical
    b. Crucial experiment: the experiment whose outcome is claimed to establish the falsehood of one of two competing inconsistent scientific hypotheses.
        > If hypothesis H is true, then P.
        > If hypothesis H' is true, then ~P.
        > No matter if P or ~P, a hypothesis will be falsified.
    c. Copernican model of the Solar System vs. Kepler's model
        i. Copernican theory = the planets move *in circles* around the sun
        ii. the position of Mars in the sky did not match the position predicted by the Copernican model.

        iii. Under Kepler's theory, the planets move in ellipses. Kepler's model was able to predict the motion of Mars accurately.

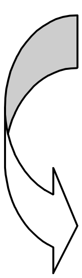
2. Compatibility (387) *agreement between a hypothesis and well-accepted theories*
    a. The goal of science is a *system* of explanatory hypotheses.
    b. Compatibility: being consistent with the totality of hypotheses accepted at any one time.
    c. Correction: A new hypothesis may be inconsistent with an older theory.
    d. Newtonian physics vs. General Relativity
        i. Newtonian physics was in conflict with *Maxwell's discoveries* in electromagnetism, which predict that we can never catch up to a light wave
        ii. According to Newtonian physics, we can catch up to a light particle.
        iii. General relativity was able to account for all the observable facts Newtonian physics was and overcome Newtonian physics' incompatibility with Maxwellian electromagnetics by describing how we can never catch up to a light particle.

3. Simplicity (390) *minimize*
    a. For any given set of data, there may be more than one way to explain the data.
    b. In choosing between two competing theories each of which explains all the observed phenomena, the criteria of simplicity suggests that we should chose the ontologically less bloated of the two.
        i. Copernican heliocentric model of celestial mechanics over the Ptolemaic geocentric model
            1. The *Ptolemaic model* posited the existence of *epicycles within the orbit of Mercury*.
            2. The Copernican model à la Kepler was able to account for this motion by displacing the Earth from the center of the solar system and replacing it with the sun as the orbital focus of planetary motions while simultaneously replacing the circular orbits of the Ptolemaic model with elliptical ones.
        ii. Mechanical theory of heat over the Caloric theory
            1. According to the Caloric theory of heat, heat is a weightless substance that can travel from one object to another.
        iii. Einsteinian theory of electromagnetism over the luminiferous aether theory
            1. During the 19th century Physicists believed that *light required a medium of transmission* (like sound waves do), called aether
            2. much effort was expended to detect aether.
            3. Einstein constructed his theory without any reference to the aether, thus providing another example of a theory chosen in part for its greater ontological simplicity.

14.5 The Scientific Method (393)

These stages are not always distinct; they blend.

1. Identifying the problem
    a. A problem is a group of facts for which we have no explanation sharply defined or vaguely troubling.
    b. Examples
        i. The Copernican model did not predict the location of Mars in the sky accurately.
        ii. Newtonian physics predicted that we could travel faster than the speed of light, even though Maxwellian electromagnetics predicts that we cannot.
2. Devising preliminary hypotheses
    a. Preliminary Theorizing
    b. The purpose of devising a preliminary hypothesis is to guide data collection because some theorizing is required to collect data.
    c. Some previous knowledge must be relied upon. Remember science does not begin from absolutely nothing.
    d. Example
        i. Aether was postulated to be the medium through which light traveled; such preliminary hypothesis guided the search for Aether.



3. Collecting additional facts
    a. The search for additional information guided by a preliminary hypothesis.
    b. Examples
        i. Galileo at the Leaning tower of Pisa drops two objects with different weights.
        ii. Watson and Crick gathering new and old information about nucleic acids.

4. Formulating the explanatory hypothesis
    a. Some hypothesis that accounts for all the data, which includes the original set of facts that created the problem, as well as the additional facts to which the preliminary hypothesis is pointed.
    b. Examples
        i. Gravity is hypothesized as a universal force acting upon bodies.
        ii. Deoxyribonucleic acid is hypothesized to be a double helix consisting of adenine, guanine, cytosine and thymine.
5. Deducing further Consequences
    a. A good hypothesis may point beyond the initial problem to new facts and perhaps even some facts whose very existence may not have previously been suspected.
    b. Examples
        i. If the structure of DNA is a double helix, then the amount of DNA found in reproductive cells would be half of what is found in ordinary cells.
        ii. If gravity is a universal force, it must apply to all objects in some lawlike way.
6. Testing the Consequences
    a. Testing may be direct or indirect (*See Section 14.2 above*)
    b. Falsifying vs. Verifying Hypotheses (*See Extra Material above*)
    c. Examples
        i. Testing to see how much DNA is found in reproductive cells.
        ii. Performing further testing to see whether a force applies to all falling objects in a systematic way.
7. Applying the Theory
    a. Use a theory to control events for our advantage.
    b. Examples
        i. Calculating how much force must be used to lift and airplane off the ground
        ii. Knowing how to prevent infection through getting rid of disease causing bacteria
        iii. DNA testing for identification purposes, birth defect detection etc.