The Logic of Testing Hypotheses in Broad Outline

- In science, we submit hypotheses to experimental test. Upon seeing the results of these tests, we either say that the hypothesis has been confirmed or that it has been disconfirmed.
  - If the hypothesis has been confirmed, then we should think that the hypothesis is more likely to be true. If the hypothesis has been disconfirmed, then we should think that the hypothesis is less likely to be true.

- Hempel: it is possible to submit hypotheses to experimental test because they have test implications. These are implications of the form:

  \[ \text{If conditions } C \text{ are realized, then event } E \text{ will occur.} \]

- If we can bring conditions \( C \) about at will, then we can subject the hypothesis to experimental test by realizing conditions \( C \) and seeing whether event \( E \) occurs. Otherwise, we could wait for nature to realize conditions \( C \) on her own, and then see whether event \( E \) occurs.
  - For instance, consider the ideal gas law, \( T = c \cdot PV \), where \( P \) is the pressure of the gas, \( V \) is the volume of the gas, \( T \) is the temperature of the gas, and \( c \) is a constant. This yields the prediction that, if we manipulate \( P \) and \( V \), \( T \) will correspondingly change.

- The basic logical form of an experimental test, then, according to Hempel, is this: if we create conditions \( C \) and observe \( E \), then we reason to the truth of the hypothesis as follows:

  \[
  H \rightarrow (C \rightarrow E).
  \\
  C \land E.
  \\
  \overline{H}
  \]

  if we create conditions \( C \) and don’t observe \( E \), then we reason to the falsehood of the hypothesis as follows:

  \[
  H \rightarrow (C \rightarrow E)
  \\
  C \land \neg E
  \\
  \overline{\neg H}
  \]
• Sometimes, it is claimed that, when testing a hypothesis like $T = c \cdot PV$, we ought only change one factors at a time.
  
  − Hempel: not only is this impossible; it is also undesirable.
  − It is impossible because there will always be indefinitely many factors changing throughout an experiment—e.g., the gas’s distance from the sun, the intensity of the ambient light, etc.

  \[ \text{P1} \] An experimenter cannot keep the experiment’s distance from the sun from changing while simultaneously keeping the experiment’s distance from Jupiter and its distance from Neptune from changing.

  \[ \text{C} \] It is impossible to keep all but one factor from changing during an experiment.

  − It is undesirable because the hypothesis claims that the law is obeyed in all circumstances; so allowing other factors to vary allows you to test the hypothesis under a wider array of circumstances—it provides more opportunities for the hypothesis to yield false predictions.

• However, Hempel claims that only varying one of the (relevant) factors at a time makes good sense in the context of discovery. If we want to see whether one factor makes a difference to another, we can test this by varying that factor while holding all other relevant factors (or the factors that we think may be relevant) fixed.

Auxiliary Hypotheses

• The basic logic of the previous subsection is actually only approximately correct. Actually, no hypothesis entails, all by itself, a test implication. We must make other, auxiliary assumptions in order to derive a test implication.

  − For instance, Semmelweis and the assumption that chloride of lime solution would sterilize cadaveric material, the Copernican hypothesis and the stellar parallax, and measurement errors.

• So, the actual logic of rejecting a scientific hypothesis looks like this

\[
\begin{align*}
(H \land A) \rightarrow I \\
\neg I \\
\hline
\neg H \lor \neg A
\end{align*}
\]

(where $I$ is the test implication.)
**Crucial Tests**

- Sometimes, two favored hypotheses can yield distinct test implications about what would happen in conditions $C$. The first hypothesis, $H_1$, could tell us that, if $C$, then $E_1$ would occur; whereas the second hypothesis, $H_2$, could tell us that, if $C$, then $E_2$ would occur. (Where $E_1$ and $E_2$ are incompatible.)

- In those cases, bringing about the conditions $C$ serves as a **crucial test** between the two hypotheses $H_1$ and $H_2$.
  - For example, Foucault’s experiments to decide between the corpuscular and the undulatory theories of light, and statistical null hypothesis significance testing.

- Hempel: however, because auxiliary assumptions are still necessary in order to derive a test implication, a crucial test cannot decisively or deductively **prove** that one of the hypotheses are false; nor that the other is true. At most, a crucial test provides good reason to believe that one of the hypotheses is true and the other is false.

**Ad Hoc Hypotheses**

- Because auxiliary assumptions are required in order to derive a test implication, it is always possible to hang on to a theory in the face of disconfirmatory experimental results by simply rejecting some of the auxiliary assumptions.
  - For example, those who thought that nature abhorred a vacuum could have responded to the results of Périer’s test of Torricelli’s hypothesis by saying that the strength of nature’s abhorrence of a vacuum depends upon location.

- Such responses to disconfirmatory test results are **ad hoc**; and, according to Hempel, it is frequently unscientific to respond to disconfirmatory experimental results in this way.

**Testability as a Criterion of Demarcation**

- Hempel: if a hypothesis is not testable even in principle, then it is not a scientific hypothesis.
  - Example: the hypothesis that gravitational attraction is the result of cosmic forces of love is not testable.
  - Hempel’s argument that such a theory is not testable:
    
    $P_1$ There could be no crucial test between the hypothesis that gravitational attraction is the result of cosmic forces of **love** and the hypothesis that gravitational attraction is the result of cosmic forces of **hate**.
    
    $C$ The hypothesis that gravitational attraction is the result of cosmic forces of love does not make any empirical predictions, and is not a properly scientific theory.