The Heterotroph Hypothesis for the Evolution of the Basic Metabolic Processes

An explanatory scenario that helps to show the logic of this hypothesis

The Heterotroph Hypothesis is the proposal that the first living organism was a **HETEROTROPH**.

Heterotrophs are organisms that obtain their energy by *feeding* on *others* (or on organic compounds)

Hetero = other troph = to feed

Before there were other organisms, they would feed on surrounding "left-overs" of their origin.

The simplest process we know of today by which organisms do this is called **FERMENTATION**

There is evidence that the pre-life atmosphere and water environment was a reducing one, (no oxygen).

Evidence: There are no iron oxides (rust-red rocks) in unexposed deposits of that age.

The waste products of Fermentation are ethyl alcohol (ethanol) and carbon dioxide (CO_2)

The main useful product of Fermentation is the chemical energy extracted from the chemical bonds of organic compounds, and used to produce energy-rich packets of ATP, available for any and all biochemical processes requiring energy. Some of that energy was used to build a variety of chemicals, some of which were pigmented.

Evidence: Experiments in which a variety of organic compounds are placed in a sterile environment with energy sources randomly produce substances of various colors.

As the thick clouds of water vapor cleared over this primitive earth, the energy of sunlight filtered through. Organisms with pigments that could absorb light and transform that energy into a chemical form that could be used for biochemical processes (leading to growth and reproduction) would spread and become more efficient.

At some point, we would have the first **AUTOTROPHS**. (Modern examples: algae and green plants.)

Autotrophs are organisms that make their *own food* (using light energy to build organic compounds from available inorganic materials, like CO_2 and H_2O. Auto = self troph = feed

The main process we have now that does this is called **PHOTOSYNTHESIS** (in algae and plants).

This is a complex process now, but simpler versions have been found, probably like earliest versions.

Photosynthesis uses carbon dioxide (from fermentation, and volcanoes) water, and light.

It produces an energy-rich compound: glucose, and a toxic waste product: oxygen.

As photosynthesis-made oxygen accumulated in the atmosphere and water, organisms that detoxified the oxygen survived and reproduced. One mechanism of detoxifying the oxygen was to combine it with hydrogen that was removed during the fermentation process, making water. This also enabled far more energy to be removed from organic compounds (e.g., glucose) and used to make more ATP, with more energy for more biochemical processes (more growth, more reproduction. **RESPIRATION** had begun and it flourished.

This hypothesis does *not* pretend to explain the origin of the first heterotroph (the first living cell), the "Origin of Life." There are a fair number of hypotheses for that, and considerable progress has been made in studying them. However, no living cell has yet been produced from any simulated pre-life environment.

What the heterotroph hypothesis does do, however, is to suggest a likely sequence for the emergence (or the **evolution**) of the three main bioenergetic processes we see in the living world today: Fermentation, Photosynthesis, and Respiration. There are many qualifiers and assumptions embedded in that scenario (probablies and possiblies), but they provide a rich focus for future scientists to explore, leading to experiments and searches that could provide the evidence to refute, modify, or strengthen the hypothesis.

The accompanying **diagram sheet** illustrates the scenario described above. **Diagram A** shows the interaction over time of different forms of energy, the main types of organisms, the 3 main metabolic processes, and the simpler inorganic materials involved. **Diagram B** suggests an evolutionary tree showing when, over time, those main metabolic processes may have evolved. Note the alternative possibilities for the origin of respiration.