may have emitted up to ten thousand times more ultraviolet radiation than it does today.^1 Life-destroying ultraviolet rays were therefore a constant threat to early life.

Energy sources also existed in the form of lightning from the numerous storms that must have racked the Earth during primeval times. Electrical energy is a source used often in experiments. Thermal energy from hot springs and volcanoes was also present and could possibly have supplied the necessary energy for life.

An essential component for life is, of course, water. Water comprises 80% to 90% of all living matter. We know that the surface of the Earth was virtually covered with water so that a plentiful supply was available. Mixing processes existed in the form of water currents, waves, and tides. Wind and volcanic action may also have been important in distributing and mixing various chemical elements and compounds.

Even though it could not sustain life as we know it today, the smog-like atmosphere of carbon dioxide, methane, and ammonia was perfect for the beginning of life. Life could not have begun in the oxygen-rich atmosphere we presently enjoy. It would simply have burned up (oxidized) the organic compounds through chemical combination with them.

Energy sources and the oxygen-free environment necessary for primitive life on the early Earth were present. They will be discussed in detail in the following chapter. With the important exception of the life-destroying ultraviolet radiation from the Sun, they present no severe problems for the origin of life.

Stage 3. Monomers (basic organic molecules). Monomers are simple organic molecules, sort of molecular sub-units, from which, by repeated linking actions, polymers (chains of monomers) can be made. Amino acids are monomers that form polypeptides. Sugars, phosphates, and organic bases are monomers that combine to form polynucleotides.

Amino acids. To account for the formation of amino acids is not difficult. In 1953 Stanley Miller, a biochemist working in the laboratory of Nobel Prize chemist Harold Urey, conducted significant experiments using the apparatus pictured in Figure 6.10. The gases used were those thought to have been present in the primordial atmosphere, and he used intermittent spark discharges to simulate lightning. The result was the synthesis of several common amino acid molecules.