Figure 15.3

A Four-Stage Hypothesis for the Origin of Life

– According to one hypothesis, the first organisms were products of chemical evolution in four stages.

Stage 1: Abiotic Synthesis of Organic Monomers

Stage 2: Abiotic Synthesis of Polymers

Stage 3: Formation of Pre-Cells

Stage 4: Origin of Self-Replicating Molecules

Stage 1: Abiotic Synthesis of Organic Monomers

– The first stage in the origin of life was the first to be extensively studied in the laboratory.

The Process of Science: Can Biological Monomers Form Spontaneously?

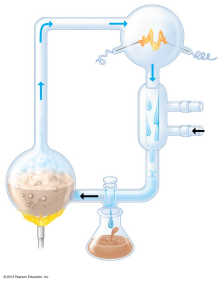
- **Observation**: Modern biological macromolecules are all composed of elements that were present in abundance on early Earth.
- **Question**: Could biological molecules arise spontaneously under conditions like those on early Earth?

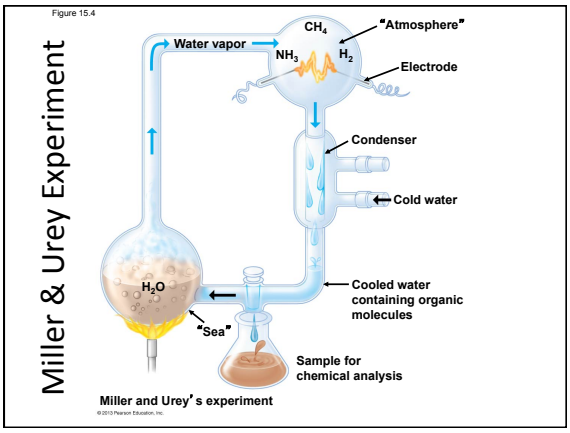
The Process of Science: Can Biological Monomers Form Spontaneously?

- **Hypothesis**: A closed system designed to simulate early Earth conditions could produce biologically important organic molecules from inorganic ingredients.
- **Prediction**: Organic molecules would form and accumulate.

The Process of Science: Can Biological Monomers Form Spontaneously?

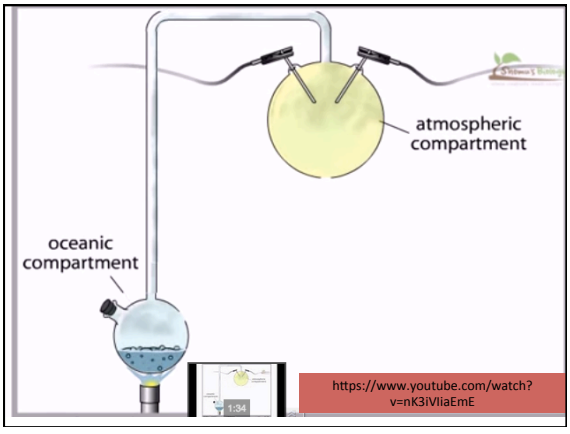
- **Experiment**: An apparatus was built to mimic the early Earth atmosphere and included
  - hydrogen gas (H_2), methane (CH_4), ammonia (NH_3), and water vapor (H_2O),
  - sparks that were discharged into the chamber to mimic the prevalent lightning of early Earth, and
  - a condenser that cooled the atmosphere, causing water and dissolved compounds to "rain" into the miniature "sea."





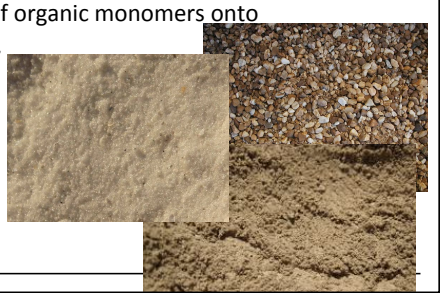
The Process of Science: Can Biological Monomers Form Spontaneously?

- **Results**: After the apparatus had run for a week, an abundance of organic molecules essential for life had collected in the "sea," including amino acids, the monomers of proteins.
- These laboratory experiments
  - have been repeated and extended by other scientists and
  - support the idea that organic molecules could have arisen abiotically on early Earth.



Stage 2: Abiotic Synthesis of Polymers

- Researchers have brought about the polymerization of monomers to form polymers, such as proteins and nucleic acids, by dripping solutions of organic monomers onto
  - hot sand,
  - clay, or
  - rock.



Stage 3: Formation of Pre-Cells

- A key step in the origin of life was the isolation of a collection of abiotically created molecules within a membrane.
- Laboratory experiments demonstrate that pre-cells could have formed spontaneously from abiotically produced organic compounds.

Stage 3: Formation of Pre-Cells

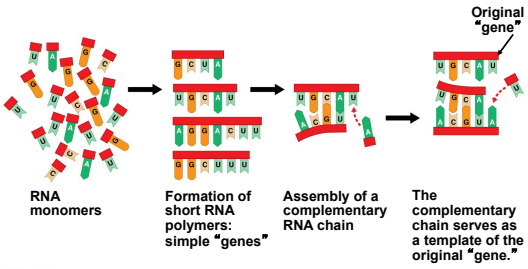
- Such pre-cells produced in the laboratory display some lifelike properties. They
  - have a selectively permeable surface,
  - can grow by absorbing molecules from their surroundings, and
  - swell or shrink when placed in solutions of different salt concentrations.

Stage 4: Origin of Self-Replicating Molecules

– Life is defined partly by the process of inheritance, which is based on self-replicating molecules.

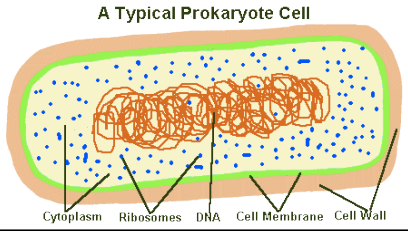
– One hypothesis is that the first genes were short strands of RNA that replicated themselves
  - without the assistance of proteins,
  - perhaps using RNAs that can act as enzymes, called **ribozymes**.

Figure 15.5-4



From Chemical Evolution to Darwinian Evolution

– Over millions of years
  - natural selection favored the most efficient pre-cells and
  - the first prokaryotic cells evolved.



PROKARYOTES

– Prokaryotes lived and evolved all alone on Earth for about 2 billion years.

They' re Everywhere!

– Prokaryotes
- are found wherever there is life,
- have a collective biomass that is at least ten times that of all eukaryotes,
- thrive in habitats too cold, too hot, too salty, too acidic, or too alkaline for any eukaryote,
- cause about half of all human diseases, and
- are more commonly benign or beneficial.

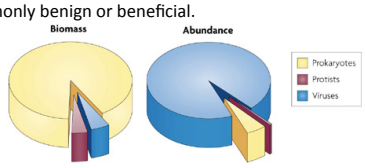


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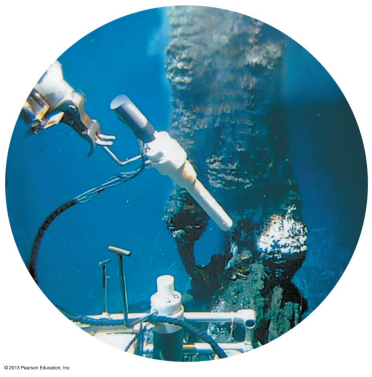
Figure 15.6



They're Everywhere!

– Compared to eukaryotes, prokaryotes are
- much more abundant and
- typically much smaller.

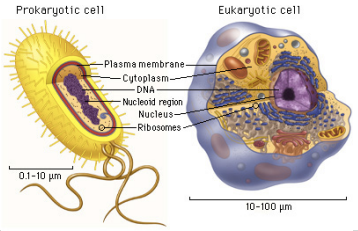
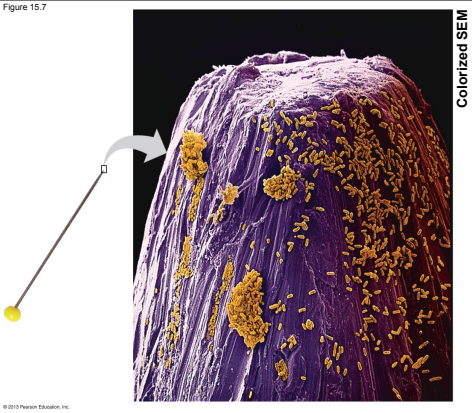


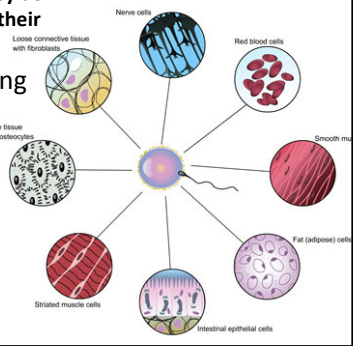
Figure 15.7



The Origin of Multicellular Life

Synergy – Together they do more than the sum of their parts

- Many cells working together allows SPECIALIZATION
  - – Feeding
  - – Waste disposal
  - – Gas exchange
  - – Protection



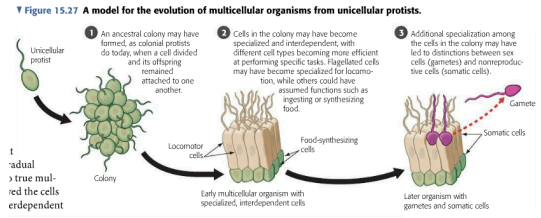
The Origin of Multicellular Life

Unicellular → Multicellular

- *Multi cellularity Evolved many times and plays a role in the diversity of life*

Colonial forms:

- Cells became increasingly independent



The Origin of Multicellular Life

Unicellular → Multicellular

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