Table 14.1  Nutritional Classification of Organisms

<table>
<thead>
<tr>
<th>Nutritional Type</th>
<th>Energy Source</th>
<th>Carbon Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photosynthetic</td>
<td>Sunlight</td>
<td>CO₂</td>
</tr>
<tr>
<td>Chemoautotroph</td>
<td>Inorganic chemicals</td>
<td>CO₂</td>
</tr>
<tr>
<td>Photoheterotroph</td>
<td>Sunlight</td>
<td>Organic compounds</td>
</tr>
<tr>
<td>Chemoheterotroph</td>
<td>Organic compounds</td>
<td>Organic compounds</td>
</tr>
</tbody>
</table>

2 Kingdom System of Classification: Plants & Animals (Linnaeus, ~1750)

- Monera
- Protista
- Plantae
- Fungi
- Animalia

5 Kingdom System: Monera, Protista, Plantae, Fungi, Animalia (Robert Whittaker, 1969)

3 Domain System: Bacteria, Archaea, Eukarya (our current best hypothesis)

What does this timeline illustrate about the process of science?

Five Kingdoms

3 Domain System

Three Domains

The land plant Divisions

- Angiosperms
- Gymnosperms
- Ferns
- Bryophytes
- Red
- Green
- Brown
- Prokaryotes
What is botany?
Short answer: the study of plants (Kingdom Plantae, in Domain Eukarya)

For Bio 1C: the study of Kingdoms Plantae, Fungi, “Protista,” and some photosynthetic members of Domain Bacteria

What is Ecology?
• The scientific study of the interactions between organisms and their environments is called ecology
• provides a basic understanding of how natural processes and organisms interact,
• gives us the tools we need to manage the planet’s limited resources over the long term

Major Components of the Environment
• Abiotic components, which consist of nonliving chemical and physical factors, such as temperature, light, water, minerals, and air
• Biotic components, which include the living factors—all the other organisms that are part of an individual’s environment.

Hierarchy of Interactions
• We can divide ecology into four increasingly comprehensive levels: organismal ecology, population ecology, community ecology, and ecosystem ecology

The changing earth: The Origin of Life
• Early Earth was a very different place than it is now.
  – Chemically reactive atmosphere
  – Very little Oxygen
  – Very High UV and other energy sources (UV damages DNA/RNA)
Clock analogy for some key events in evolutionary history

Early (left) and modern (right) prokaryotes

Pasteur 1850s

- Spontaneous Generation vs. Biogenesis

Pasteur and biogenesis of microorganisms (Layer 1)

Pasteur and biogenesis of microorganisms (Layer 2)

Pasteur and biogenesis of microorganisms (Layer 3)

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So How did Life Originate?

- Four Stage Hypothesis
  1. Abiotic synthesis of Organic Monomers (the building blocks)
  2. Abiotic Synthesis of Polymers, including amino acids and nucleic acids.
  3. Formation of “Pre-cells” or protobionts: droplets with membranes that maintained an internal chemistry distinct from their surroundings.
  4. Self replicating molecules arose, making inheritance possible

The Miller-Urey experiment: 1953

- Origin of Life experiments
- Miller-Urey Tested for Synthesis of Organic Monomers
- Got all 20 amino acids, sugars, lipids, nucleotides, even ATP!

Deep sea hydrothermal vents could also have played a role...

- Producing organic polymers: dripping monomers onto hot sand, clay or rock.
- Conditions existed near active volcanoes and... deep sea vents

General Principles

- Prokaryotic and Eukaryotic cells and membranes (including membrane transport)
- Photosynthesis and Respiration
- Trophic Relationships

Common characteristics of cells

- Plasma membrane
  - Regulates what goes in and out
- Nucleus or nuclear area
  - Contains the DNA
- Ribosomes
  - Manufacture proteins
- Cytoplasm
  - Semifluid medium with organelles
Two Main Classes of Cells

• **Prokaryotic** (Bacteria and Archaea)
  – Pro = “Before”; Karyon = “Kernel”
  – No nucleus, DNA coiled up inside cell

• **Eukaryotic** (Everything else)
  – Eu = “True”
  – DNA inside membrane bound organelle inside cell, the nucleus

---

### Prokaryotic and Eukaryotic Cell Structure

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Prokaryotic Cell</th>
<th>Eukaryotic Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>size</td>
<td>1–10 μm</td>
<td>10–80 μm</td>
</tr>
<tr>
<td>nucleus</td>
<td>nucleus present</td>
<td>nucleus absent</td>
</tr>
<tr>
<td>chromosomes</td>
<td>single loop of naked DNA</td>
<td>linear, arranged with many loops of DNA</td>
</tr>
<tr>
<td>organelles</td>
<td>present in smaller 70S ribosomes</td>
<td>present in larger 80S ribosomes</td>
</tr>
<tr>
<td>flagella</td>
<td>solid core made of flagellin</td>
<td>associated with cytoplasmic matrix and normal reproduction</td>
</tr>
<tr>
<td>cell wall</td>
<td>present in makeup as peptidoglycan, never present in composition</td>
<td>absent or present in composition</td>
</tr>
<tr>
<td>cell reproduction</td>
<td>present in makeup as peptidoglycan, never present in composition</td>
<td>absent or present in composition</td>
</tr>
</tbody>
</table>

---

### Eukaryotic Cell Structure

• Plant and Animal Cell Structure
  – Nucleus: the control center
  – Cytoplasm and Ribosomes: site of protein synthesis
  – Endoplasmic Reticulum: plumbing, lipid and protein synthesis
  – Golgi Apparatus and the secretory pathway
  – Lysosomes: 4 types of digestive activity
  – Chloroplasts and Mitochondria: food and ATP energy
  – Vacuoles: storage
  – Cytoskeleton: structure and movement
  – Plant Cell Wall: structure, osmosis and turgor pressure

---

### Origin of Eukaryotic Cells

- **Ancient prokaryote**
- **Eukaryotic cell**
- **Photosynthetic eukaryote cell**
- **Plastid**
Single Celled to Multicelled

Diverse habitats require diverse adaptations...

What is an “adaptation”?
- From an evolutionary perspective: An adaptation is any trait or feature of an organism that increases its chances of reproducing.
- From an interpretive perspective: An adaptation is any structure or mechanism exhibited by an individual species that allows it to meet its physiological requirements under the conditions posed by a particular habitat.

Some adaptations...
- Adaptations to live near shore (algae) to take advantage of nutrients
- Transitioning to land means need water! Animals move, Fungi live underground (essentially)
- Plants developed specialized tissue systems
- The vascular system in plants
- Protected gametophytes

Linnaeus:
1750’s
Binomial nomenclature
Three members of the violet genus *Viola*. They differ in features due to local adaptations, but there is an overall similarity. This genus has about 500 species.

**Taxonomy**

- **Species**: Panthera pardus
- **Genus**: Panthera
- **Family**: Felidae
- **Order**: Carnivora
- **Class**: Mammalia
- **Phylum**: Chordata

**Five Kingdoms**

- **Protista**
- **Fungi**
- **Plantae**
- **Animalia**
- **Bacteria**

**Three Domains**

- **Eukarya**
- **Archaea**
- **Bacteria**

**Cladistics:** Cladograms and molecular data

**Evolutionary Trees**

- Outgroup: Irish elk
- Ingroup: modern humans
- Characters:
  - Long generation
  - Gestation
  - Hair, mammary glands

**What are the tools used by scientists to observe and understand evolutionary relationships?**

- 1. Artificial selection
- 2. Fossil record
- 3. Comparative anatomy
- 4. Comparative embryology
- 5. Comparative biochemistry
- 6. Biogeography
Artificial Selection: breeding

Homologous structures: anatomical signs of descent with modification

What about analogous structures?
- Co-evolution
- Convergent evolution

Comparative Embryology:
- “Ontogeny recapitulates phylogeny” - the appearance of ancestral structures in the embryos of modern descendants (Haeckel)

Molecular Data and the Evolutionary Relationships of Vertebrates

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Amino Acids That Differ from a Human Homologous Polypeptide (Total Chain Length = 146 Amino Acids)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans</td>
<td>0</td>
</tr>
<tr>
<td>Elephant</td>
<td>9</td>
</tr>
<tr>
<td>Monkey</td>
<td>37</td>
</tr>
<tr>
<td>Chicken</td>
<td>46</td>
</tr>
<tr>
<td>Frog</td>
<td>67</td>
</tr>
<tr>
<td>Lepreoney</td>
<td>123</td>
</tr>
</tbody>
</table>
Biogeography - Wallace’s line

Evidence from biogeographical studies:

Some major episodes in the history of life

Systematics: connecting phylogeny and taxonomy

- Taxonomy = the science of classifying organisms
- Phylogenetics = the study of phylogeny, or the history of evolutionary relationships among species

Figure 25.8 Taxonomy starts with the Latin binomial, and exhibits a hierarchical structure reflecting phylogenetic relationships among taxa or groups of organisms
Figure 25.9: The connection between classification and phylogeny: this phylogenetic tree organizes taxa into a hypothesized tree of evolutionary relatedness, with species at the tips of the branches.

How are these phylogenetic trees constructed?

Traditional Approach:
Phenetics
Classifications based on perceived overall similarity