Invitation to Biology

Chapter 1
Biology

Scientific study of life

Lays the foundation for asking basic questions about life and the natural world
Why Study Biology?

• To learn how organisms are constructed, how they function, where they live, and what they do

• To help develop, modify, and refine ideas about life
Life’s Underlying Unity

- Life’s organization extends from the molecular level to the biosphere
- Shared features at the molecular level are the basis of life’s unity
Levels of Organization

Cell
Multicelled organism
Population
Community
Ecosystem
Biosphere
Molecules of Life

- All things are made up of the same units of matter
- Living things are made up of a certain subset of molecules:
  - Nucleic acids
  - Proteins
  - Carbohydrates
  - Lipids
DNA (deoxyribonucleic acid)

- Signature molecule of life
- Molecule of inheritance
- Directs assembly of amino acids
DNA and Inheritance

- Inheritance
  - Acquisition of traits by way of transmission of DNA from parent to offspring
- Reproduction
  - Mechanism by which an organism produces offspring
  - Governed by instructions in DNA
Nothing Lives without Energy

Energy = capacity to do work

Metabolism = reactions by which cells acquire and use energy to grow, survive, and reproduce
Interdependencies among Organisms

Producers
Make their own food

Consumers
Depend on energy stored in tissues of producers

 Decomposers
Break down remains and wastes
Energy Flow

• Usually starts with energy from the sun
• Transfers from one organism to another
• Flows in one direction
• Eventually flows back to the environment
Sensing and Responding

- Organisms sense changes in their environment and make responses to them
- Receptors detect specific forms of energy (stimuli)
- Sensing and responding allows maintenance of homeostasis
Unity of Life

All organisms
- Consist of one or more cells
- Have the capacity to reproduce based on instructions in DNA
- Engage in metabolism
- Sense and respond to the environment
Life’s Diversity

• Millions of living species
• Millions more now extinct
• Each species has some unique traits
Scientific Names

Two-part name

– Humphead parrotfish is *Scarus gibbus*
– First part (*Scarus*) is genus name
– Second name designates a particular species within the genus
Classification Systems

- Organisms are grouped together based on descent from a shared ancestor
- Three domains exist:
  - Eubacteria (Bacteria)
  - Archaebacteria (Archaea)
  - Eukaryotes (Eukarya)
Major Groups

- Protistans
- Plants
- Fungi
- Animals

Eukaryotes

- Archaebacteria
- Eubacteria

Origin of life
Prokaryotic Organisms

- Single cells
- No nucleus
- Smaller, less complex
- Archaebacteria, eubacteria

Eukaryotic Organisms

- Single- or multicellded
- Nucleus
- Larger, more complex
- Fungi, protistans, plants, animals
Mutation: Source of Variation

• Mutation = change in structure of DNA

• Basis for the variation in heritable traits

• May be harmful, neutral, or beneficial
Evolution

• Heritable change in a line of descent over time

• Populations change, not individuals
Natural Selection

- Individuals vary in some heritable traits
- Some forms of heritable traits are more helpful under prevailing conditions
- Natural selection is an outcome of differences in survival and reproduction among individuals that vary in their traits
Artificial Selection

- Breeders are selective agents
- Individuals exhibiting favored traits are bred
- Favored traits become more common in population
Scientific Method

- Observe phenomenon
- Develop hypotheses
- Make predictions
- Devise test of predictions
- Carry out test and analyze results
Role of Experiments

• Study a phenomenon under known conditions

• Allow you to predict what will happen if a hypothesis is not wrong

• Can never prove a hypothesis 100% correct
Experimental Design

• Control group
  – A standard for comparison
  – Identical to experimental group except for variable being studied

• Sampling error
  – Nonrepresentative sample skews results
  – Can be minimized by using large samples
Scientific Theory

- An explanation of the causes of a wide range of related phenomena
- Has wide-ranging explanatory power
- Still open to testing
- Example - Darwin’s theory of evolution by natural selection
Biological Therapy
Experiments

Can viruses that attack bacteria (bacteriophages) fight infections in mice?
Hypothesis: Bacteriophages will kill *E.coli* in infected mice

Prediction: Lab mice injected with bacteriophage will not die after being injected with *E.coli*

Experimental Test:
Researchers establish populations of bacteriophage and *E.coli*; they select a specific strain of laboratory mice

- **Control group**
  - 15 mice injected with *E.coli*
  - Test results: All mice die within 32 hours

- **Experimental group**
  - 15 mice injected with *E.coli* and bacteriophage
  - Test results: All mice live
Another Prediction: Bacteriophage will be more effective than a single dose of antibiotics against *E. coli*

Experimental Test:
Researchers inject 48 mice with *E. coli*; eight hours later:

- **Control:** 12 mice injected with saline → All die
- **Expt Group 1:** 12 mice injected with bacteriophage → 11 of 12 survive
- **Expt Group 2:** 12 mice injected with streptomycin 60 micrograms/gram → 3 of 12 survive
- **Expt Group 3:** 12 mice injected with streptomycin 100 micrograms/gram → 5 of 12 survive

Test results
Minimizing Variables

- All mice were same age and sex, reared under same conditions
- Each mouse in each test group received exact same treatment
- All mice in control group received same amount of saline
- Variable tested was antibiotic treatment versus bacteriophage treatment
Limits of Science

- Scientific approach cannot provide answers to subjective questions
- Cannot provide moral, aesthetic, or philosophical standards
- May conflict with supernatural beliefs
Scientists Raise Questions

The external world, not internal conviction, must be the testing ground for scientific beliefs