**Chapter 1**

**Biology & the Tree of Life**

***1.1: What Does It Mean? Something Is Alive***

1. organism – living entity made of one or more cells

2. five fundamental characteristics shared by living things

a. made of cells = smallest units of life  
 membrane-bound 🢧 membrane regulates passage of materials in/out of cell

b. replication (reproduction)

c. information   
 hereditary information stored in genes  
 response to environmental information; homeostasis (maintaining internal conditions)

d. acquire and use energy

(1) photosynthesis

(2) cellular respiration

e. product of evolution; continued evolution of populations

3. Which of these is alive? ALL 5 CHARACTERISTICS MUST BE PRESENT FOR SOMETHING TO BE ALIVE.

bacteria(*E. coli*)*,* mushroom, frog, salmon, ~~salmon section~~, ~~polio virus~~

4. Nature of science 🢧 asking questions

a. Scientific Theory

(1) best explanation for a general class of observations supported by a wide body of evidence

(2) three unifying theories in biology

(a) Cell theory

(b) Chromosome theory of inheritance

(c) Theory of evolution by natural selection

b. Two methods of reasoning (logic) in science

(1) inductive reasoning

(a) based on observations or experiments, NOT speculation or anecdotal evidence

(b) how hypotheses arise

(c) may lead to a scientific theory

(d) observation/pattern ⇨ many stinging insects are black and yellow

hypothesis ⇨ black and yellow means that an insect is harmful

(2) deductive reasoning

(a) used for testing a hypothesis or theory

(b) utilizes If / Then statements

(c) requires a large volume of data in order to determine causality NOT coincidence

(d) Example: If black and yellow mean that an insect is harmful, then any black and yellow insect is harmful.

***1.2: Life is Cellular***

1. How do we know that organisms are made of cells?

a. Hooke (1665) – observed dead cells in cork from a tree

b. van Leeuwenhoek (1670s) – pond water organisms (wee beasties), sperm, blood cells

c. by the 1800s, the pattern of organisms being made of cells was clear – hundreds of observations in plants and animals

Inductive reasoning led to hypothesis that living things are made of cells.

d. Advances in microscopy allowed extensive testing of the hypothesis and the first component of the Cell Theory: All living things are made of cells.

2. If all organisms are made of cells, then where do cells come from?

a. Virchow (1858) witnessed cell division and proposed that cells come from pre-existing cells.

b. two hypotheses

(a) spontaneous generation

(b) all-cells-from-cells

c. Pasteur designed an experiment to test these 2 hypotheses.

Data supported the hypothesis that all cells arise from preexisting cells.

3. The Cell Theory now had 2 components.

Cell Theory: All organisms are made of cells, and cells come from preexisting cells.

4. Deductions from the theory led to further knowledge.

a. All cells in a multicellular organism are descended from a single ancestral cell (a fertilized egg).

b. All species are connected by common ancestry.

***1.3: Life Processes Information and Requires Energy***

1. Chromosome Theory of Inheritance (1902)

a. Cells contain genetic information encoded in genes which are located on chromosomes   
 (1) chromosomes ⇨ where DNA is found

(2) DNA 🢡 genetic material of cell

(a) double-stranded helix

(b) stores genetic information

b. How is genetic information encoded and put to work?

(1) Central Dogma of molecular biology (Crick):

DNA → RNA → protein

(2) Changes in DNA lead to differences in proteins which impact the characteristics of organism

2. Life requires energy

a. Organisms have 2 fundamental nutritional needs

(1) acquire chemical energy in the form of ATP

(2) carbon-based molecules needed to build complex molecules

b. How organisms acquire energy has contributed to the diversification of life.

***1.4: Life Evolves***

1. Proposed by Darwin and Wallace in 1858. *On the Origin of Species* published in 1859.

2. What is Evolution?

a. Both men made 2 claims

(1) Species are related by common ancestry (contrary to view that species are independent groups created in a one-time event).

(2) The characteristics of a species can be modified over generations (vs. the idea of no change).

b. Evolution 🢧 change in the characteristics of a population over time (population - group of individuals of the same species living in the same area at the same time)

3. What is Natural Selection?

a. Key idea presented by Darwin and Wallace

b. Occurs when 2 conditions are met

(1) Individuals in a population vary in heritable traits.

(2) Certain versions of these traits allow individuals to survive better and reproduce more than do other versions.

c. Traits leading to reproductive success become more common over time.

(1) fitness – the ability of an individual to survive and reproduce (measured by number of offspring)

(2) adaptation – a trait that increases the fitness of an individual in a particular environment

d. Important - Natural selection acts on individuals, whereas evolutionary change occurs in populations.

e. Natural selection may lead to divergence of populations into different species.

***1.6: Doing Biology***

1. What questions can and cannot be addressed by science?

a. must be observable and measurable

b. science and religion

(1) science ⇨ formulating hypotheses and experimentation to support/reject them

(2) religion ⇨ address questions that cannot be answered by data (ethics/morals)

2. Introduction to Hypothesis Testing

a. A scientific inquiry begins with observation of a phenomenon and a question.

Observation: Giraffes all have long necks although variation exists in length. (Neck length is a heritable trait.)

Question: What is the adaptive value of a long neck?

b. Alternative hypotheses are advanced to explain the phenomenon. Predictions made for each.

H1: Food Competition

Giraffes have long necks because the long necks enable them to reach food that is unavailable to others.

Prediction: Food competition hypothesis predicts that giraffes extend their necks to feed high in trees, especially when food is scarce.

H2: Sexual Competition

Giraffes have long necks because they are an effective weapon for one male against another during competition for mates.

Prediction: Sexual selection hypothesis predicts that longer necks result in more forceful impact so that males with longer necks compete better, win more often, and father more offspring (fitness).

c. For each hypothesis, an observational or experimental study is designed to test its predictions. Data is gathered and analyzed.

Observations of feeding behavior

1. Substantial amounts of feeding occur at low levels, even when food is scarce.
2. Giraffes typically feed with bent necks.

Observations of sexual competition

(1) Long-neck males were more successful in fights.

(2) Long-neck males mated with more females.

d. If the predictions are met, the hypothesis is supported.   
If not, a modified hypothesis or alternative hypothesis is tested.

Conclusion: The observational data support the sexual selection hypothesis. Observation is still on-going.

3. Introduction to Experimental Design

a. Experimentation is much more powerful than observational study alone. An experiment is used to isolate and test the effects of a single well-defined factor on the phenomenon in question.

(1) independent variable – the factor being tested

(2) dependent variable – the factor that depends on the independent variable – IF the hypothesis is correct

b. Criteria for sound experimental design

1. For each hypothesis, there must be testable predictions 🢧 deductive reasoning.

(2) For each hypothesis, a null hypothesis is also stated 🢧 NO DIFFERENCE between control and experimental set-ups

c. A control provides a standard for comparison by keeping factors constant that might influence the experiment’s outcome.

d. Controlling (keeping constant) all variables except the one being tested is crucial because it eliminates alternative explanations for the results.

e. A large sample size diminishes the effect of a random atypical data entry, and therefore provides more accurate results.

f. Results must be repeatable.