Chapter 01
The Science of Biology

1.1 What is Science?

- What Science is and is Not
  - Science as a Way of Knowing
    - Science = is an organized way of gathering & analyzing evidence about the natural world. It is a way of observing, a way of thinking, and "a way of knowing" about the world.
  - The Goals of Science
    - KEY = One goal of science is to provide natural explanations for events in the natural world. Science also aims to use those explanations to understand patterns in nature and to make useful predictions about natural events.
  - Science, Change, and Uncertainty
    - Science never stands still and is always moving forward
    - New discoveries lead to new questions which must be answered
    - It is an understanding of both what we know and what we don't know
- Scientific Methodology: The Heart of Science
    - KEY = Scientific methodology involves observing and asking questions, making inferences and forming hypotheses, conducting controlled experiments, collecting and analyzing data, and drawing conclusions.
  - Observing and Asking Questions
    - Observation = Noticing and describing events or processes in a careful, orderly way
      - "Think of something that nobody has thought of yet, while looking at something that everybody sees"
  - Inferring and Forming a Hypothesis
    - Inference = A logical interpretation based on what scientists already know.
    - Hypothesis = A scientific explanation for a set of observations that can be tested in ways that support or reject it.
  - Designing Controlled Experiments
    - Controlled Experiment = Experiment where only the variable being tested is allowed to change and all other variables are controlled (kept unchanged)
      - Independent Variable = Variable in an experiment that is deliberately changed
        - AKA *manipulated variable*
      - Dependent Variable = Variable that responds to the independent variable
        - AKA *responding variable*
      - Control Group = Group that is exposed to the same conditions as the experimental group except for one independent variable
  - Collecting and Analyzing Data
    - Data = Detailed records of experimental observations and gathering information
      - *Quantitative Data* = Numbers obtained by counting or measuring
      - *Qualitative Data* = Descriptive with data not able to be counted
    - Research Tools
      - Anything that helps collect or analyze data
      - Meterstick, calculator, charts, graphs, computers
    - Sources of Error
      - Each tool used to measure something have limited accuracy
      - Data analysis and sample size also affect accuracy of calculations
  - Drawing Conclusions
    - The experimental data collected can be used to support, refute, or revise the hypothesis being tested and to draw a valid conclusion
      - Often, hypotheses have to be revised, and retested over and over again
  - When Experiments are not Possible
    - Careful planning and tracking of variables must be used when dealing with things that are not easily testable

1.2 Science in Context

- Exploration and Discovery: Where Ideas Come From
  - Scientific Attitudes
    - Key = Curiosity, skepticism, open-mindedness, and creativity help scientists generate new ideas
    - Skepticism – Question current beliefs and hypotheses and test them over and over again
    - Open-mindedness – Accept different ideas that may not be their point of view
    - Creativity – Think creatively to design experiments that yield accurate data
  - Practical Problems
    - Some investigations come from practical problems such as trying to build houses on marshlands that will help protect the marshlands because they are important to maintain
  - The Role of Technology
    - Technology, Science, and Society are closely linked
      - Discoveries in science lead to development of new technologies
      - New technology allows scientists to gather and collect more accurate data
      - New data allows for even further study that can have a big impact on daily life
- Communicating Results: Reviewing and Sharing Ideas
  - Peer Review
    - Key = Publishing peer-reviewed articles in scientific journals allows researchers to share ideas and to test and evaluate each other's work
      - Scientific articles are like high-powered lab reports and contain details about experimental conditions, controls, data, analysis, and conclusions
      - Reviewers read them for oversights, unfair influences, fraud, or mistakes in techniques or reasoning
  - Sharing Knowledge and New Ideas
    - Once research is published, other scientists can use its findings for experimentation
- Scientific Theories
  - Theory = A hypothesis that is supported by many scientific studies and has no evidence that contradicts it.
    - A scientific theory is completely different from what most people refer to as theory!
  - Key = In science, the word theory applies to a well-tested explanation that unifies a broad range of observations and hypotheses and that enables scientists to make accurate predictions about new situations.
- Science and Society
  - Key = Using science involves understanding its context in society and its limitations
  - Science, Ethics, and Morality
    - Scientists explain "why" things happen in a natural sense.
    - There are no moral or ethical viewpoints in pure science… just data
    - All science can be used for good or evil… it is the person using it that determines it
  - Avoiding Bias
    - Bias = A particular preference or point of view that is personal, not scientific
    - Some scientist may misinterpret or misapply data if they have a bias
  - Understanding and Using Science
    - The more we understand and are able to use science, the better decisions we can make in our everyday lives as well as a society for the benefit of society and our planet

1.3 Studying Life

- Characteristics of Living Things
  - Biology = The study of life
  - Key = Living things have 8 things in common:
    - Living Things are Based on a Universal Genetic Code
      - DNA = Molecule in which the genetic code of all living things is stored

- Living Things Grow and Develop
    - Every organism has a particular pattern of growth and development
- Living Things Respond to Their Environment
    - Stimulus = A signal to which an organism responds
- Living Things Reproduce
    - Sexual Reproduction = Two parents are required for creation of new organism
    - Asexual Reproduction = A single parent creates the new organism
- Living Things Maintain a Stable Internal Environment
    - Homeostasis = Process of keeping the internal environment of a living organism relatively stable even when external conditions are changing
- Living Things Obtain and Use Material and Energy
    - Metabolism = The combination of chemical reactions through which an organism builds up or breaks down materials
- Living Things are Made up of Cells
    - Cells are the smallest unit that can be considered alive
- Taken as a Group, Living Things Evolve
    - Over generations, groups of organisms evolve, or change over time
    - All life has a common origin more than 3.5 billion years ago

- Big Ideas in Biology
    - Key = The study of biology revolves around several interlocking big ideas: The cellular basis of life; information and heredity; matter and energy; growth, development, and reproduction; homeostasis; interdependence in nature, and science as a way of knowing
        - Cellular Basis of Life
        - Information and Heredity
        - Matter and Energy
        - Growth, Development, and Reproduction
        - Homeostasis
        - Evolution
        - Structure and Function
        - Unity and Diversity of Life
        - Interdependence in Nature
            - Biosphere = "Living Planet" where organisms are linked t one another and to the land, water, and air around them.
        - Science as a Way of Knowing
- Fields of Biology
    - Key = Biology includes many overlapping fields that use different tools to study life from the level of molecules to the entire planet
        - Global Ecology – the global impact of living organisms
        - Biotechnology – editing and rewriting the genetic code
        - Building the Tree of Life – discovering how all species of life are related
        - Ecology and Evolution of Infectious Diseases – study of diseases and their impact
        - Genomics and Molecular Biology – use of DNA to study mysteries such as cancer
- Performing Biological Investigations
    - Scientific Measurement
        - Key = Most scientists use the metric system when collecting data and performing experiments
    - Safety
        - Following safe practices when doing research in the lab or in the field is important
        - Always following the direction of the instructor and the book during biology lab is the most important rule to follow