Middle School Life Sciences Curriculum

*(*Adapted from *Next Generation State Standards)*

From Molecules to Organisms: Structures and Processes

Disciplinary Core Ideas:

Structure and Function

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Growth and Development of Organisms

- Animals engage in characteristic behaviors that increase the odds of reproduction.
- Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.
- Genetic factors as well as local conditions affect the growth of the adult plant.

Organization for Matter and Energy Flow in Organisms

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

Students who demonstrate understanding can:

1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Ecosystems: Interactions, Energy, and Dynamics

Disciplinary Core Ideas:

Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory , and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

Cycle of Matter and Energy Transfer in Ecosystems

- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem.
- Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Ecosystem Dynamics, Functioning, and Resilience

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

Biodiversity and Humans

- Changes in biodiversity can influence humans' resources, such as food, energy , and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.

Developing Possible Solutions

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

Students who demonstrate understanding can:

1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems
3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Heredity: Inheritance and Variation of Traits

Disciplinary Core Ideas:

Growth and Development of Organisms

- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.

Inheritance of Traits

- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.
- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.

Variation of Traits

- In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.
- In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.

Students who demonstrate understanding can:

1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Biological Evolution: Unity and Diversity

Disciplinary Core Ideas:

Evidence of Common Ancestry and Diversity

- The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.
- Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.
- Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.

Natural Selection

- Natural selection leads to the predominance of certain traits in a population, and the suppression of others.
- In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.

Adaptation

- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Students who demonstrate understanding can:

1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy
4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.
6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

LESSONS and PROJECTS

Overarching Concepts and Projects:

research and science fair projects
plastics and biological decomposition
Hydroponics

Trimester 1
TITLE of LAB BOOKS: Biology: Logical Study of Life

1. **Inside Cover: Table of Contents**
2. **Table of Contents**
3. **Syllabus**
4. **Grading Rubric**
5. **Biology Defined – age-old challenge**
6. **15 cm squared**
    1. **Materials: magnifying glass, ruler, colored pencils, specimen container**
    2. **Use 4 nails and twine to mark a square**
    3. **Sketch a map of your square in color**
    4. **Make two lists**
        1. **List Living with description and measurements**
            1. **e.g. bug with 6 legs, antenna. Brown. 2 mm long**
        2. **List Non-Living with description and measurements**
7. **How *we* will classify life**
    1. **History of the Three-Domain System**
8. **Branches of life- First Look**
    1. **Eukaryota**
    2. **Bacteria**
    3. **Archaea**
    4. **Viruses?**
9. **Unicellular Organisms**
10. **Multi-cellular Organisms**
11. **Human Anatomy and Body Systems**
12. **Lab: Hydroponic Lab:**
    1. **Choose a growth medium**
    2. **Label Variables (independent and dependent)**
13. **Lab: Plastics Decomposition**
14. **Science Fair Brainstorm**
15. **Lab: Recombinant DNA**
16. **Field Trip:**

Trimester 2
Trimester 3
Big Questions:
Can we define life?

The definition of life is an age-old mystery:
Your definition of life

Our Definition of life (assimilated and borrowed from experts):

"The current definition is that organisms maintain homeostasis, are composed of cells, undergo metabolism, can grow, adapt to their environment, respond to stimuli, and reproduce."
("Life." *Wikipedia*. N.p., n.d. Web.)

“We can say that living things:

- Can assimilate and use energy
- Can respond to their environment
- Can maintain a relatively constant internal environment
- Possess an inherited information base, encoded in DNA, that allows them to function
- Can reproduce, through use of the information encoded in DNA
- Are composed of one or more cells
- Evolved from other living things
- Are highly organized compared to inanimate objects”

(Krogh, David. *Biology: A Guide to the Natural World*. Boston: Pearson, 2005. Print.)

How can we be sure cells exist?
    History of cellular biology
    microscopy:
    history of the technology
    optical microscopy: how it works
    alternatives to optical microscopy (electron)
    abilities and limitations

Article that challenges the ability to define:
https://www.nasa.gov/vision/universe/starsgalaxies/life's_working_definition.html
History of Life
From unicellular to multicellular
Relationship to the virus
    cheek cell
    onion cell

characteristics of the cell
types of cells
parts of the cell
Organization of Life

Big Questions:
What makes you as a human different?