Dolan
DNA Learning Center
www.dnalc.org

The Diversity of Life

Background

As in all branches of science, organization is important in the field of Biology. Scientists have devised an orderly classification system for all diversity of life, which allows for easy identification and tracing of evolutionary connections. Organisms are placed into groups called taxonomic categories based on their similarities. Some of these categories are very narrow, such as Species and Genus, while others are broad, such as the Kingdom. The Kingdom is the most inclusive taxonomic category. Organisms in similar taxonomic categories are considered related because of the similarities they share, both morphological and cellular. The more taxonomic categories two living things have in common, the more related they are.

The classification of living things is not new. Aristotle classified all living things into 2 kingdoms: plants and animals. This system proved to be adequate for large organisms. Trees and flowers are plants, while bears and cats are animals. But some living things have characteristics of both kingdoms. Today, there is no worldwide agreement in the scientific community about the number of kingdoms. One popular model for classification has 5 kingdoms: Animalia, Plantae, Fungi, Protista and Monera. These categories classify organisms based on characteristics such as cell structure, tissue structure, nutritional requirements and developmental patterns. There are specific characteristics that an organism must possess to belong to a specific kingdom. Some of these characteristics are not visible without the aid of a microscope. Below are short descriptions and three major qualifying characteristics for each of the five kingdoms.

Animals

Structural Organization – multicellular, cells organized into tissues, tissues organized into organs
Cell structure – cells are eukaryotic (the DNA is found in a nucleus), no cell wall is present
Nutrition – ingestion and internal digestion

There are more species in kingdom Animalia than in any other kingdom. Organisms such as humans, fish, birds and even insects are members! Typically, animal cells a have a rounded shape, although this is not necessarily the case. For example, nerve cells are long and thin with hairlike projections at either end, which help to make connections with other cells. Muscle cells are long, thin and stretchy to allow for the extension and contraction of muscle tissue. Animals must acquire their nutrients from the environment, as opposed to other organisms that can make their own food.

Plants

Structural Organization – multicellular, cells organized into tissues, tissues organized into organs
Cell Structure - cells are eukaryotic, a cell wall is present
Nutrition – photosynthesis

Plant cells have organelles called chloroplasts, which contain the green pigment chlorophyll. Chlorophyll is the substance that allows plants to absorb sunlight, which is used as energy to fuel the making of food inside a plant's cells. The use of sunlight as energy for food production is called photosynthesis. This metabolic process requires CO_2 as well as sunlight, and produces O_2 as a by-product. Because of this, plants play an important ecological role. They produce oxygen for other living things, and use the carbon dioxide that is produced as a waste product in other living things. Additionally, plant cells have a sturdy cell wall made of the sugar cellulose that surrounds the cell membrane. This outer covering provides strength to plant cells, and compensates for the absence of a skeletal system. The cell wall gives the plant cell a brick-like or rectangular appearance.

Fungi

Structural Organization – multicellular (cells organized into tissues, tissues organized into organs) or unicellular (a single cell that can survive without other cells)
Cell Structure – cells are eukaryotic, cell wall present
Nutrition – external digestion, absorption

Most people would consider mushrooms and molds plants, but taxonomically they are quite different. Their cells do have cell walls and nuclei like a plant, but they cannot photosynthesize, which is why they lack the green color typical of plants. Most fungi must digest nutrients externally (extracellular digestion) by secreting enzymes onto a food source through small projections called hyphae, and then absorbing the nutrients. For example, the fungus that causes Athlete's Foot digests the cells on our feet and absorbs the nutrients. A mushroom grows on an old log by digesting it and absorbing its nutrients. Through external digestion, fungi play an important ecological role by releasing nutrients back into the soil. This is why fungi are known as decomposers. Fungi can be either multicellular like a mushroom, or unicellular like yeast.

Protists

Structural Organization – unicellular or simple multicellular
Cell Structure – cells are eukaryotic
Nutrition – ingestion, photosynthesis

Of all five kingdoms, kingdom Protista is the most diverse. There are many unique protists, with combinations of characteristics that make them similar to both animals AND plants. For example, the amoeba is a unicellular protist that can ingest food particles by engulfing them with its pseudopods (false feet), and digesting them internally like an animal. This is called phagocytosis. The amoeba changes its form due to its mode of locomotion. To move, cytoplasm streams into and out of the pseudopods, or temporary projections, causing the cell to slide forward. The Euglena is a unicellular protist that has chloroplasts, which contain chlorophyll. It can photosynthesize like a plant, OR ingest food like an animal. To move, the Euglena oscillates its hair like tail, called a flagellum, like a propeller. Algae also belong to kingdom protista, although they physically resemble plants and photosynthesize. Seaweeds, a type of algae that looks like a plant, such as Rockweed, are colonies of unicellular protists. They are also considered simple multicellular protists.

Monera

Structural Organization – unicellular
Cell Structure – cells are prokaryotic (DNA is not found in a nucleus, rather it floats in the cytoplasm)
Nutrition – absorption

Kingdom Monera represents the smallest, most numerous creatures on Earth: bacteria. Bacteria cells are much smaller than the cells of any other kingdom. They can be visualized at 400X magnification, but they look like small specks. Typically bacteria come in three shapes: cocci (spherical), bacilli (rod) and spirilli (spiral). Not all bacteria are harmful, in fact most bacteria are harmless to humans, and some are even helpful! Of the 5,000 known species of bacteria, only about 1% are harmful to humans. *E.coli* that live in our large intestines help us to digest food and produce vitamin K, which plays an important role in blood clotting. Bacteria on our skin eat mold spores that land on exposed areas. Bacteria in our mouths eat food particles that get stuck between our teeth. Bacteria cells are unique because they are prokaryotic. The DNA is not contained and organized within a nucleus. It is hypothesized that prokaryotic cells were the first to thrive on Earth and that eukaryotic cells evolved thousands of years later.

Description of Activity

During this one-hour lesson for students in grades 5-8, students will explore the diversity of life and become familiar with the Linnaean system of classification. Students will use compound microscopes to observe various cells from representative groups of life.

Learning Outcomes

Students will:

- appreciate the necessity and history of classification
- understand how taxonomists classify known organisms
- become familiar with the parts and function of a compound microscope
- observe and identify various cell components

Assumptions of Prior Knowledge

Students should know that all living things are composed of cells. They should also have a basic understanding of the structure and function of a cell. Finally, an introduction to the characteristics of all living things (to help distinguish between living and non-living), as well as familiarity with basic life functions is helpful.

Misconceptions

Students sometimes believe that living things that appear physically similar belong to the same species. They also may assume that there is only one way to classify living things. Not only do scientists rely on physical similarities and differences, but they can also use genetics to demonstrate relatedness. Finally, students may believe that living things are in fact non-living because they do not understand how organisms carry out certain life functions.

Lesson

Materials and Equipment

Per student pair:

- 1 compound light microscope (objectives 40X, 100X and 400X)
- Microscope slides (all can be purchased prepared, some can be prepared in class):
- 1-2 Human epithelial (cheek cells) slides
- 1 Onion or Elodea slide
- 1 *Penecillium* mold slide (prepared) or Baker's Yeast slide
- 1 Amoeba, Euglena, (or any other proterozoa) slides
- 1 Bacteria slide – any type (prepared)
- 1 Microslide Viewer (These can be used to view bacteria cells with greater magnification. They are small plastic viewers that come with strips of photographs taken with an electron microscope.)

If preparing microscope slides in class, you will need the following materials for each student pair:

Human Epithelial (cheek cells):

- 2 Tongue depressors
- 2 Glass or plastic microscope slides
- 2 Glass or plastic cover slips
- 2-3 drops of Methylene blue stain
- Dropper for stain

Onion Bulb or Elodea:

- Onion bulb skin or Elodea leaves
- 1 Glass or plastic microscope slide
- 1 Glass or plastic cover slip
- 2-3 drops of Lugol's iodine solution (for onion only)
- Dropper for Lugol's iodine solution

Yeast:

- 1 packet of Baker's yeast
- 1 cup warm water
- 1 Glass or plastic microscope slide
- 1 Glass or plastic cover slip
- 2-3 drops Methylene blue stain
- Dropper for stain

Protists:

- Live protists- from pond water or Carolina Biological
- 1 Glass or plastic welled microscope slide
- 1 Glass or plastic cover slip
- Dropper to transfer sample to microscope slide
- "Proto-Slo"- a quieting solution to slow protists- 15 ml bottle from Carolina Biological

Purchasing Information

- Prepared microscope slides - Carolina Biological Supply Company
- Blank microscope slides- Fisher Scientific
- Microscope cover slips- Fisher Scientific
- Methylene Blue (1%)- Fisher Scientific
- Transfer pipets- VWR Scientific
- Tongue depressors- Oriental Trading Company

- Microslide viewers – Carolina Biological Supply Company

Before Class

- Photocopy the student observation sheets and worksheets.
- Prepare wet mounted slides.

During Class

- Begin the lesson by asking students to think of and write down a particular food item that can be acquired at the grocery store. Students should write down specific details about the selected item. Poll the class: how many of the chosen items could be found in frozen foods, the bakery section, or the dairy section etc…? Choosing the section with the largest show of hands, continue to inquire about the individual food products by aisle, shelf and finally exact brand and location until only one person's item has been identified. How long would it normally take to locate that item in the store? How long would it take if the store manager decided not to stock the items on shelves, but left all deliveries in a pile on the floor?
- Introduce the need for organization, not only in daily life, but also in science. By classifying or categorizing items they become easier to locate and identify.
- Over 2000 years ago, Aristotle placed all known organisms into two groups: plants and animals. Today, some classification systems include more groups. Why might thay be?
- Taxonomy is the use of taxons, or groups, to classify living things developed by Carolus Linnaeus in the 1700's. If time permits, the teacher can review the seven common taxonomic categories from species through kingdom, and explain how they are hierarchical, and range from including only one type of living thing (species) to very inclusive (kingdom). The taxonomic breakdown for humans is:

Kingdom:	Eukarya (most inclusive)
Phylum:	Chordata
Class:	Mammalia
Order:	Primata
Family:	Hominidae
Genus:	Homo
Species:	Sapiens (least inclusive)

- Most students will recognize *Homo sapiens*, the scientific name for humans. Classifying organisms in this way requires analysis of similarities and differences in both cellular and structural characteristics.
- Review basic cellular structure and function.
- Introduce the microscope as a tool for analyzing microscopic specimens such as cells. Make sure to explain that microscopes not only magnify, but also resolve images. Point out that there is an ocular lens in the eyepiece (10X) as well as objective lenses (4X, 10X and 40X) in the rotating objectives. Depending on which objective is being used to view a specimen, it can be magnified from 40X to 400X. Mention that the fine and course adjustment knobs are for resolving, or focusing an image.
- Explain what types of cells students will observe as representatives of the different branches of life, and make sure students write these down on their observation sheets.
- If students are preparing their own cheek cell slides, demonstrate how to carefully rub the inner lining of the cheek to remove cells, place them on a clean slide, stain with Methylene blue, cover with a cover slip and blot with a paper towel to absorb excess dye. Make sure to point out proper handling (always on the edges) of a glass slide and cover slip to prevent fingerprints in the field of view.
- The Diversity Flowchart should be provided as each specimen is passed out and observed.
- Make sure that students record all observations on the appropriate observation sheets. They should note the different cell shapes and structures, and label them accordingly.

Analysis and Discussion

- Compare and contrast all of the characteristics that were observed. Use the accompanying summary chart to compile observations.
- Discuss how examining the DNA of different organisms has shed light on their relatedness.
- Discuss the evolutionary relationships between all living organisms.
- Demonstrate how some organisms can be placed in more than one category.
- Discuss various alternate methods of classification.

Further Explorations

Students can experiment with observing and preparing different specimens, leading to the discovery of the benefits and limits of a compound light microscope.

Students can choose individual groups, orders, families or species to research and present to the class.

Introduce or reinforce organizational variability. Provide groups of students with varying but similar objects, such as a set of nuts and bolts or various types of candy. Ask the groups

to classify a set of objects by grouping them by similarities and/or differences. Students can create an organizational chart to guide individuals to a specific object.

Resources

http://www.fi.edu/tfi/units/life/
A Franklin Institute website

http://www.bowfinprintworks.comlistpages/phylumspecieslist.html
Animal kingdom species count by phylum

http://www.park.edu/bhoffman/courses/bi225/labs/Dichotomous%20Keys%202.htm
Introduction to dichotomous keys using various beans and then plants

http://ebiomedia.com/gall/gallery_mail.html
BioMEDIA Galleries: Images of bacteria, teacher's guides, microscopy

Correlations

New York State
NYS Standard 4: Science
The Living Environment

- Living things are both similar to and different from each other and nonliving things.
- Plants and animals depend on each other and their physical environment.

National
Content Standard C: Life Sciences
Diversity and Adaptations of Organisms

- Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarities of their chemical processes, and the evidence of common ancestry.
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.
- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on earth no longer exist.

AAAS Benchmarks
Standard A: Diversity of Life

- A great variety of kinds of living things can be sorted into groups in many ways.
- Features used for grouping depend on the purpose of the grouping.
- One of the most general distinctions among organisms is between plants, which use sunlight to make their food, and animals, which consume energy-rich foods. Some kinds of organisms, many of them microscopic, cannot be neatly classified as either plants or animals.
- Animals and plants have a great variety of body plans and internal structures hat contribute to their being able to make or find food and reproduce.
- Similarities among organisms are found in internal anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.
- For sexually reproducing organisms, a species comprises all organisms that can mate with one another to produce fertile offspring.
- All organisms, including the human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them and finally the animals that feed on those animals. The other web includes land plants and animals that feed on them, and so forth. The cycles continue indefinitely because organisms decompose after death to return food material to the environment.

The Characteristics of Living Things

Cells

All living things are made of cells. Cells are the building blocks of life. All cells come from pre-existing cells.

Organization

All life is organized at molecular and cellular levels. Cell structures called organelles carry out specific cell functions. In multicellular organisms cells are organized into tissues, tissues are organized into organs and organs are organized into systems.

Energy Use

All organisms use energy for growth and development.

Response to the Environment

Living things respond to changes in the environment.

Movement

Living things can move. Movement allows organisms to find food, mates and safety. Parts of plants can move also; stems and leaves bend toward sunlight.

Chemical Activities

Living things perform complex chemical activities. Chemical reactions, such as the building up and breaking down of molecules, are essential to life.

Growth

All living things grow. Growth occurs through cell division. When multicellular organisms grow, they are accumulating cells and becoming more complex, not necessarily "bigger."

Reproduction

Living things reproduce or create more of themselves.

Adaptation

Adaptations are changes in traits that give an organism an advantage in its environment and prove to be beneficial to the survival of an organism. To have an adaptation, a change must occur in the genes associated with a trait. If this trait promotes reproductive success, then it may be passed down to future generations.

Compound Light Microscopes
Parts and Functions

A. **Coarse adjustment**
Used for resolving images under the low power objective lens only.

B. **Fine adjustment**
Used for resolving images under the medium and high power objective lenses.

C. **Objectives/Lenses**
For magnification.
Low Power - 4X
Medium Power - 10X
High Power - 100X

D. **Arm**
Used to tilt, lift and carry microscope.

E. **Stage Clips**
Holds microscope slide in position.

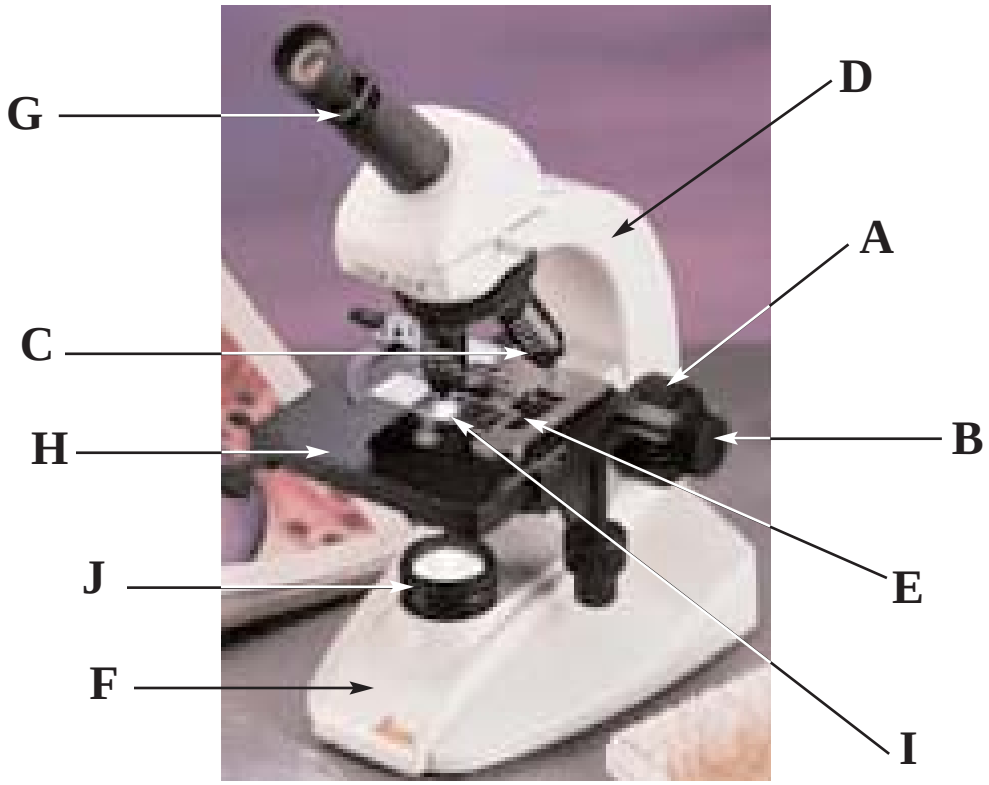
F. **Base**
Supports microscope.
To properly carry microscope, place one hand under the base and one hand around the arm.

G. **Eyepiece**
Contains the ocular lens, with a magnification of 10X.

H. **Stage**
Place for viewing the slide.

I. **Diaphragm**
Regulates the amount of light coming through the stage opening.

J. **Mirror or Illuminator**
Provides light to illuminate the specimen.



Danaus plexippus
Monarch butterfly

Animals

Canis familiaris
Dog

What are some characteristics of animals?

1.

2.

3.

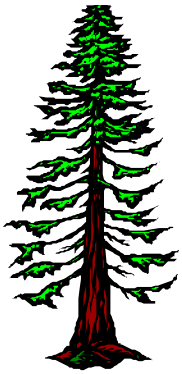
Diagram of Observations:

Observed at _____X magnification

Litoria caerulea
Green Tree Frog

Zea mays
Corn

Plants



Abies balsamea
Balsam Fir

What are some characteristics of plants?

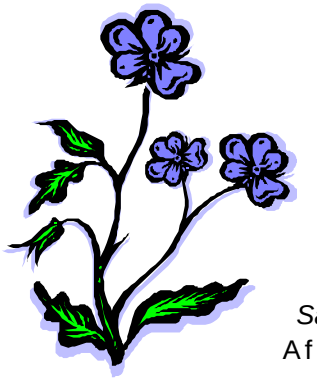
1.

2.

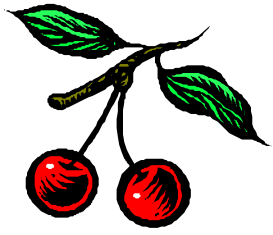
3.

Diagram of Observations:

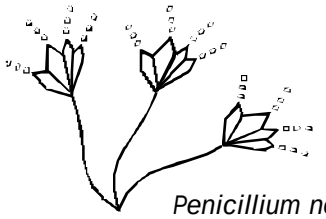
Observed at _____X magnification



Saint paulia
African violet



Prunus serotine
Wild Cherry



Penicillium notarum
Penicillium mold

Fungi

Lentinus sp.
Shiitake mushroom

What are some characteristics of fungi?

1.

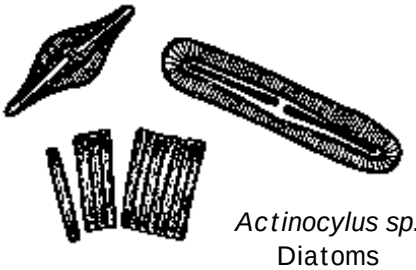
2.

3.

Diagram of Observations:

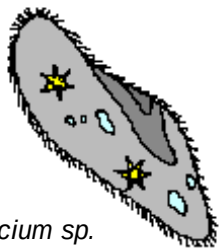
Observed at _____X magnification

Agaricus blazei
Brazilian mushroom



Actinocylus sp.
Diatoms

Protists



Paramecium sp.
Paramecium

What are some characteristics of protists?

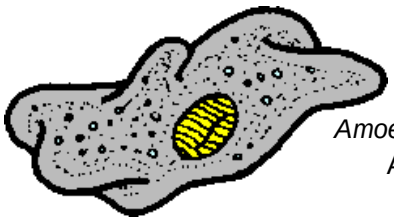
1.

2.

3.

Diagram of Observations:

Observed at _____X magnification



Amoeba proteus
Amoeba

Escherichia coli

Monera

Source: http://www.lcusd.net/lchs/mewo/ldseu/tetanus.

Clostridium tetani, responsible for causing tetanus in humans.

What are some characteristics of monera?

1.

2.

3.

Diagram of Observations:

Observed at _____X magnification

Thermus aquaticus

Source: http://res2.agr.gc.ca/crda/indust/microscope_f.htm