SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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National Science Education Standard—Life Science

Biological Evolution

Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.

The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every niche with life forms.

Teacher Materials

Learning Sequence Item:

1055

Prokaryotes and Eukaryotes

March 1997
Adapted by: Godrej H. Sethna

Biological Classifications: Their Basis in Evolutionary Relationships. Students should identify prokaryotes as organisms with cells that lack membrane-bound internal structures, understanding that most are one-celled organisms. They should identify eukaryotes as organisms that have cells containing internal, membrane-bound structures. Eukaryotes can be either one-celled or many celled. (*Biology, A Framework for High School Science Education, p. 111*).

Contents

This micro-unit was adapted by **Godrej H. Sethna** (University of Houston-Downtown)

1055

Learning Sequence

Biological Classifications: Their Basis in Evolutionary Relationships. Students should identify prokaryotes as organisms with cells that lack membrane-bound internal structures, understanding that most are one-celled organisms. They should identify eukaryotes as organisms that have cells containing internal, membrane-bound structures. Eukaryotes can be either one-celled or many celled. (*Biology, A Framework for High School Science Education, p. 111*).

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
Going Pro **Activity 1** Another Look at Cells **Activity 2** Pros or Not **Assessment 1**			

Suggested Sequence of Events

Event #1

Lab Activity

1. Going Pro (30–45 minutes)

Event #2

Lab Activity

2. Another Look at Cells (30–45 minutes)

Event #3

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

To be selected by teacher.

***Assessment items are at the back of this volume*.**

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple-choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay responses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Teacher Sheet

Science as Inquiry

Going Pro

A look inside blue-green algae

Overview:

In this activity students prepare and examine wet mounts of cyanobacteria (blue-green algae) as representatives of prokaryotic cells. It is assumed that students have observed plants and animals microscopically (see Micro-units 932 and 933) and have examined cell structures (see Micro-unit 1054).

Note: Cultures must be ordered in advance so that they arrive in time for the class. Alternatively, they may be ordered in advance and subcultured and maintained for use when needed.

Caution students that methyl green will stain skin and fabric.

Materials:

Per lab group

cultures of cyanobacteria:
- *Nostoc*
- *Oscillatoria*
- *Cyanophora*
- *Merismopeda*
- *Anabaena*

methyl green acidified (1%), 10 drops*
microscope slides, 10
coverslips, 10
microscope
pipettes or droppers, 5

*****methyl green acidified:
- methyl green dye, 1 g
- glacial acetic acid, 1 mL
- distilled water to make 100 mL

Procedure:

Have students prepare wet mounts of the various cyanobacteria. They should then use a dye, methyl green, to look for nuclei. To prepare methyl green acidified for nuclear staining, mix the methyl green dye with glacial acetic acid and add distilled water to make a final volume of 100 mL.

Background:

It is believed that ancestors of prokaryotic cells developed about 3 billion years ago, making prokaryotes the oldest group of organisms. The cells multiply rapidly (under favorable conditions the size of a population of these organisms can double every 20 to 30 minutes) and are believed to be responsible for turning the earth green, modifying the makeup of the earth's atmosphere, and making conditions favor-

able for intelligent life to develop on the planet. They are also the most abundant of organisms. An ounce of soil may be home to 70 billion organisms.

Prokaryotes are usually quite small, ranging in length from 1 mm to 10 mm, and are, for the most part, unicellular. They may be aerobic or anaerobic. Prokaryotes differ from eukaryotes in many significant aspects. Prokaryotic organisms are structurally simple and do not have membrane-bound internal organs (organelles). One prominent feature of prokaryotes is lack of a nuclear membrane, which results in the chromosomes, and therefore DNA, being in direct contact with the cytoplasm. The DNA present in prokaryotes is a continuous circular molecule, unlike the long form of the molecule as is found in eukaryotes. Both RNA and protein are synthesized in the cytoplasm rather than by specialized organelles as in eukaryotes.

Prokaryotic flagella are structurally simple compared to eukaryotic flagella. Cytoplasmic streaming and amoeboid movement are not exhibited. Cell walls generally have peptidoglycan but lack cellulose or chitin, which are components of the cell walls of plants and fungi. Cell division in prokaryotic organisms takes place without the processes of mitosis and meiosis. Binary fission is the most common form of cell division, but multiple fission, ternary fission, and budding also occur.

Bacteria and cyanobacteria (also known as “blue-green algae”) are the two major groups of prokaryotes. Cyanobacteria were chosen for this activity as they are larger than bacteria, not known to be pathogenic, and do not require the equipment needed to study bacteria.

Cyanobacteria grow on land or in water. At one time they were considered plants. They carry out oxygenic (oxygen-producing) photosynthesis and, unlike photosynthetic bacteria, contain *chlorophyll a*, the same type found in green plants. (Photosynthetic bacteria contain *bacteriochlorophyll*, which is chemically different from chlorophyll a.) It is important to note that some species of cyanobacteria, like *Oscillatoria limnetica*, are capable of anaerobic photosynthesis, using sulfide as an electron donor in place of water. Despite their name—blue-green algae—cyanobacteria exhibit various colors, such as light golden-yellow, blue-green, red, purple, violet, and blue-black. The coloration is due to the presence of a number of pigments in the outer polysaccharide coating of the cells.

The Red Sea is believed to have derived its name from the presence of the dense concentration (often called “bloom”) of red-colored cyanobacteria found floating on the surface of the water. Blooms arise when conditions are favorable for the rapid growth of some species of cyanobacteria. If a bloom dies quickly, it may result in a serious reduction of dissolved oxygen in the body of water and cause the death of fish and other aquatic organisms that are dependent on the oxygen. Certain species of cyanobacteria produce chemicals that are toxic to fish and other organisms.

Answers to Student Questions:

1. When the dye was added to the cells, how did it affect their color? How can you explain this result?

[The cells remained colorless. Dyes (stains) are selective in the type of materials they will act upon.]

2. What did you observe in these cells? Use diagrams if necessary.

3. What major functions do these types of cells perform?

[These cells perform all the major life functions. Since they are single-celled organisms, they have to rely on the various parts within the cell membrane to perform all the tasks necessary to live, grow, and reproduce.]

Adapted from:

Alberts, B., D. Bray, J. Lewis, M. Raff, K. Roberts, and J.D. Watson, *Molecular Biology of the Cell (3rd ed.)*. New York: Garland Publishing, 1994.

Keeton, W.T., *Biological Science (3rd ed.).* New York: W.W. Norton, 1980.

Morholt, E.L. and P.F. Brandwein, *A Sourcebook for the Biological Sciences*. New York: Harcourt Brace Jovanovich, 1986.

Singleton, P., *Introduction to Bacteria for Students of Biology, Biotechnology, and Medicine (2nd ed.).* Chichester, England: John Wiley & Sons, 1992.

Science as Inquiry

Another Look at Cells

Is bigger better?

Overview:

Students prepare and examine wet mounts of various algae as representatives of eukaryotic cells. It is assumed that students have observed plants and animals microscopically (see Micro-units 932 and 933) and have examined cell structures (see Micro-Unit 1054)

Note: Cultures must be ordered in advance so that they arrive in time for the class. Alternatively, they may be ordered in advance and subcultured and maintained for use when needed.

Materials:

Per lab group

cultures of algae:
- *Spirogyra*
- *Volvox*
- *Chlorella*
- *Chlamydomonas*
- *Ophiocytium*
- *Coleochaete*

methyl green acidified (1%), 10 drops*
microscope slides, 10
coverslips, 10
microscope
pipettes or droppers, 5

*****methyl green acidified:
- methyl green dye, 1 g
- glacial acetic acid, 1 mL
- distilled water to make 100 mL

Procedure:

Have students prepare wet mounts of the various algae. They should then use a dye, methyl green, to look for nuclei. To prepare methyl green acidified for nuclear staining, mix the methyl green dye with glacial acetic acid and add distilled water to make a final volume of 100 mL.

Background:

Ancestors of eukaryotic cells developed about 1.5 billion years ago, long after prokaryotic cells had been around. At 5 mm to 100 mm in length, eukaryotic cells are larger than prokaryotic cells, and they are structurally much more complex. Protists, fungi, plants, and animals are examples of organisms in this category.

Eukaryotes are generally multicellular, although there are some unicellular forms, and they are always aerobic. Multicellular eukaryotes may have many different types of cells that are specialized to perform specific functions. Algae were chosen for this activity as they are commonly available and are easy to maintain.

Eukaryotes are different from prokaryotes in several significant ways. One major difference is the presence in eukaryotic cells of a well-defined nucleus, which is enclosed in a nuclear membrane so that chromosomes, and therefore DNA, are not in direct contact with the cytoplasm. The term *eukaryote* means "having a true nucleus." Unlike the circular DNA of prokaryotes, that of eukaryotes is made up of very long molecules. Eukaryotic cells have a large amount of DNA. For example, cells found in humans may have as much as 1000 times the amount of DNA found in a bacterial cell.

Cell functions in eukaryotes are performed by specialized membrane-bound organelles. The following organelles may be present: cytoskeleton, endoplasmic reticulum, Golgi apparatus, mitochondrion, and chloroplast. The cytoskeleton is an internal skeleton, which gives shape to the cell, helps in locomotion, and organizes the various parts within the cell. The endoplasmic reticulum is a membranous system involved with the manufacture and transport of proteins, lipids, and other materials. The Golgi apparatus stores and transports proteins synthesized by the endoplasmic reticulum. Mitochondria are responsible for the oxidation of nutrients. Chloroplasts are chlorophyll-containing organelles found in photosynthetic eukaryotes (mainly algae and green plants).

Eukaryotic flagella are structurally complex compared to prokaryotic flagella, and cytoplasmic streaming and amoeboid movement are exhibited by eukaryotic cells. The cell walls of eukaryotic cells do not have peptidoglycan but may contain cellulose or chitin. Cellulose is an important component of the cell walls of plants; chitin is a vital component of the cell walls of fungi. Cell division in eukaryotic organisms involves the processes of mitosis and meiosis.

Answers to Student Questions:

1. When the dye was added to the cells, how did it affect their color? How can you explain this result?
   [The cells remained colorless but the nucleus was stained a greenish color. The action of the dye is specific to the nucleus.]

2. What parts are present in these cells that were missing from the cells you examined in Activity 1?
   [nuclear membrane, Golgi apparatus, endoplasmic reticulum, mitochondria, cells walls, and chloroplasts (specific to plant cells)]

3. How do the other cell parts differ from those found in Activity 1? Are there any other differences between these cells and those in Activity 1?
   [The nucleus is well-defined and enclosed by a nuclear membrane. The size of the cell is much larger (1000 times or more).]

4. What do you think would be some advantages to an organism with more parts and more cells?
   [Organisms would have the ability to perform more complex functions needed for survival, growth, and reproduction.]

Adapted from:
Alberts, B., D. Bray, J. Lewis, M. Raff, K. Roberts, and J.D. Watson, *Molecular Biology of the Cell (3rd ed.)*. New York: Garland Publishing, 1944.
Curtis, H., *Biology. (3rd ed.)*. New York: Worth Publishers, 1979.
Keeton, W.T., *Biological Science (3rd ed.)*. New York: W.W. Norton, 1980.
Morholt, E.L. and P.F. Brandwein, *A Sourcebook for the Biological Sciences*. New York: Harcourt Brace Jovanovich, 1986.
Singleton, P., *Introduction to Bacteria for Students of Biology, Biotechnology and Medicine (2nd ed.)*. Chichester, England: John Wiley & Sons, 1992.

Science as Inquiry

Pros or Not

Item:

Performance assessment using unidentified cultures.

Materials:

unidentified cultures
microscope slide with coverslip
microscope
methyl green acidified

Procedure:

Prepare a wet mount of the culture(s) provided and examine them under a microscope.

Questions:

1. What did you observe?
2. Is this culture a prokaryote or a eukaryote?
3. What evidence do you have to support your answer to Question 2?

Notes for teacher:

1. Any cultures that the students have not used in working through the activities may be used for assessment.

2. For Question 3, presence or absence of a nucleus as shown by methyl green dye will determine the category.

Consumables

Item	Quantity per lab group	Activity
Anabaena culture	2–3 drops	1
Chlamydomonas culture	2–3 drops	2
Chlorella culture	2–3 drops	2
Coleochaete culture	2–3 drops	2
Cyanophora culture	2–3 drops	1
Merismopeda culture	2–3 drops	1
methyl green acidified (1%) methyl green dye, 1 g glacial acetic acid, 1 L distilled water to make 100 mL	10 drops	1, 2
Nostoc culture	2–3 drops	1
Ophiocytium culture	2–3 drops	2
Oscillatoria culture	2–3 drops	1
Spirogyra culture	2–3 drops	2
Volvox culture	2–3 drops	2

Nonconsumables

Item	Quantity per lab group	Activity
microscope slides	10	1, 2
coverslips	10	1, 2
microscope	1	1, 2
pipettes or droppers	5	1, 2

Key to activities:
1. Going Pro
2. Another Look at Cells

Activity Sources

Alberts, B., D. Bray, J. Lewis, M. Raff, K. Roberts, and J.D. Watson, *Molecular Biology of the Cell (3rd ed.)*. New York: Garland Publishing, 1994.

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