Island Biogeography Unit, 6th Grade

Created by GK12 Fellow Michelle Schuiteman, Written and modified by GK12 Fellow Erin Morgan

Unit Goals:

1.) Students understand basic structure and scale of cells, and gain experience with microscopes by making first hand observations.
2.) Students understand the structure, function, location, organization, and importance of DNA, and use models to gain a deeper appreciation of this molecule.
3.) Students become familiar with the basic process of gel electrophoresis and practice with a model.
4.) Students perceive that changes in genes can occur over time, and that this is influenced by factors such as isolation and environment.
5.) Students recognize that many species may result from a single ancestor, due to an accumulation of adaptations and isolation from other populations.

Lesson 1: Cells

Key Concepts

- Living organisms are composed of trillions of microscopic cells. Cells are the basic unit of structure, and contain organelles that help them survive.
- One of the most important of these organelles is the nucleus. The nucleus is the "information center" of the cell.
- It is possible to view cells and nuclei under a microscope.

Vocabulary

- Cell
- Nucleus
- Organelle
- Membrane

Materials

- Compound microscopes (4 or 5)
- Worksheets
- Onion
- Scalpel or razor – sharp knife for thinly sectioning onion (teacher use)
- Prepared, dyed onion epithelium slide (available from Carolina Biological Supply)
- Glass slides (1 per student)
- Coverslips (1 per student, extras recommended)

- Eyedroppers
- Small cups of water
- Cells & DNA PowerPoint Presentation (Slides 1-4) & projection equipment

Lesson Plan

Begin the lesson with an overview of the concepts covered in the Island Biogeography Unit. Ask the students what they already know about cells, and list their responses on the board. In general, my students were unfamiliar with the definition of a cell.

Next, show the students a short PowerPoint presentation introducing them to the cell and the key concepts for this lesson. I made an accompanying worksheet, and asked the students to take notes on their worksheets during the presentation. The PowerPoint I created emphasized that cells are the basic structural unit in living things and that organisms are made up of trillions of cells. I showed the students that animal cells are surrounded by membranes, while plant cells are surrounded by a cell wall. Inside each cell are small “organelles”, which help the cells function, just like our organs help us to function. Some functions of organelles include producing energy, removing waste, and storing liquids. If desired, this would be a good opportunity to name these organelles (mitochondria, vesicles, vacuoles, etc.) and relate them to the human organs that accomplish similar functions. I chose not to detail these organelles, but to focus just on the nucleus.

My final slide presented the nucleus as the information center of the cell, responsible for giving the cell its identity and telling it how to act. The nucleus contains the information a cell needs in order to “know” that it is a hair cell and not a heart cell, and to produce the types of molecules necessary to accomplish that task. Following the presentation, I responded to student questions and made sure they had taken notes.

Next, I introduced the activity for this lesson. Students may struggle with the concept of the scale of a cell. A good way to handle any misconceptions is to have the students make their own slides of an onion and view them under a microscope. Have students each take a glass microscope slide. Demonstrate how you thinly section an onion using a razor blade or scalpel. It may be worthwhile to have pre-sectioned onion slices to maintain the flow of this activity. It is very important that students see you slice the tiny section from the large onion – this puts the structures they view on the slide into their real-life context and makes it obvious that there are trillions of cells in many living organisms. Once students have an onion slice on their slide, have them add a drop of water and a coverslip. Make sure to demonstrate the proper techniques. Finally, give the students an overview of how to work the microscopes (I used a compound microscope) and allow them to work in groups, sharing the scope and observing their slides. Students can create a labeled drawing of their observations. It is also helpful to have a prepared, stained slide of onion epithelium that you can walk around and show to each group of students. This assists students in making out structures such as the nucleus, which will show up on a dyed slide more easily than a slide with a fresh onion section.

Wrap up this lesson with a review of the key concepts and ask for any questions. Collect the glass slides and have students dispose of the cover slips in the trash.

Assessment:

For this lesson, students will complete their handouts by taking notes during the PowerPoint presentation. In addition, each student will create their own slide and view it under the microscope. Each should have a colored and labeled drawing of their cell observations.

Lesson 2: DNA

Key Concepts

- The nucleus contains DNA, which gives the cell its identity within the organism and directs its actions.
- DNA is a code of information inside the cell. It is made up of base pairs A,T,C, and G.
- Sequences of DNA that code for traits are called **genes** and are heritable.
- Mutation and recombination produce changes in DNA.

Vocabulary

- DNA
- Base, base pair
- Gene
- Mutation
- Recombination
- Double helix

Materials

- Sheets of paper bases printed on different colored paper
- Pipe cleaners (2/student, or 1/student – cut in half)
- Tape
- Cells & DNA PowerPoint (Slides 5-9) and projection equipment
- Worksheet
- Scissors – students may already each have their own

Lesson Plan

Begin the lesson with a review of cell function and structure, including the key concepts from the previous week. Make sure students recall the function of the nucleus. Pass out worksheets and ask the students to take notes while you present a PowerPoint slideshow introducing DNA and the key concepts for this lesson. DNA, or “deoxyribonucleic acid”, is the molecule within the nucleus that stores the information that the cell needs to function. This molecule is coiled in a special shape called a “double helix”; this is because DNA is made up of two backbones, coiled parallel to each other like a pair of twisted train tracks. DNA uses patterns and sequences to provide information and instructions to the cell. I likened this to the number “codes” used in telephone numbers. For example, a person’s telephone number might be: 541-888-1234. The first part of this phone number, “541”, is the area code and indicates that the phone is located in

Oregon. The second part of the number, “888-1234”, indicates your house! So, a phone number is a series of digits that is like a code for a particular house.

Instead of numbers, DNA patterns are made up of four bases: A,T,C, and G. Sequences of bases provide a code that indicates a particular feature of an organism, just like a phone number is a code for a particular house. For example, the pattern: AATGCCG might indicate “yellow flowers” for a species of plant. Bases always pair up on opposite backbones of the double helix, such that A and T go together, and C and G go together. DNA is important because the way that genes are expressed determines how an organism develops. It is important to remember that a long molecule of DNA is made up of a number of genes. One last thing to note about genes…it is possible for the order of genes to change if they are recombined as an organism develops and cells divide. It is also possible for the base sequences to change due to mutations, in which bases are switched or left out. Although mutations can be neutral or even beneficial, they are usually harmful.

Students create a gene model to accompany this lesson. Begin by showing the students a completed example and explaining how to build the model. Each student should receive a sheet of each type of base, so that they each have approximately 10 of each base. Students should cut the bases out using their scissors, and can tape them onto the pipe cleaner “backbones”. It is important to remember that A & T and C & G must pair up when the backbones are put together. It is ok if the letter on the base is upside-down when it is attached…the most important thing is that the flat side of the paper base is taped to the pipe cleaner. Students should leave approximately a half inch of empty pipe cleaner at the top and bottom of their model gene, so that the genes can be attached. Once all the students have completed their genes, they can connect the genes together into one long strand of DNA (this can be twisted into a helical shape).

Finish the lesson by asking the students to tell you what their gene codes for. For example, my students had genes that coded for “purple fur” and “spiky horns”. I listed all the traits on the board, and students drew what they thought our organism looked like based on all the traits. Wrap up the class by reviewing the key concepts and answering any remaining questions.

Assessment

By the end of this lesson, students should have taken notes on their worksheet during the DNA presentation. In addition, each student should have built a gene model, described the trait it codes for, and drawn a picture of the organism with all the class traits.

Lesson 3: Determining DNA Sequences Using Gel Electrophoresis

Key Concepts

- Scientists use gel electrophoresis to discover gene sequences. This technique separates DNA based on weight and charge. Using a reference, geneticists can piece

together what the DNA sequence must have been. UV dye is added to better analyze sequences.

Vocabulary

- Gel electrophoresis
- Geneticist

Materials

- DNA and Populations PowerPoint Presentation (Slides 1-3) & projection equipment
- Black lights (enough for each student group, I used 5 for a class of 20 students)
- UV pens
- Premade "gels"
- Sequencing templates copied onto transparencies – need one template/student
- Sharpies to write on transparencies – at least a few per group
- Laminated frogs
- Island poster
- Instructor sequence key

<u>How to make "gels":</u>

1.) Cut strips of paper – I used blue paper, approximately 3" wide by 8 ½" long.
2.) Copy the DNA template outlines onto transparencies. Cut one out, and fit it over the blue paper strip.
3.) Using a pen, mark the corners of the template, and the row for each base (just with a simple dot or line – you don't want to give it away for the students)
4.) Remove the template, and place it at the bottom of the strip. Using the marks and the template, you should be able to draw bands in the appropriate rows and columns on the blue paper "gel" using the UV pens. See the DNA template key in order to know which sequence belongs to which island.
5.) Paper clip a frog and its respective "gel" together, making note of which frog goes on which island (but don't tell the students - this will be important in the last lesson). Note that the frogs are not numbered, so you can have any frog be associated with any island. I chose my associations based on frog color, and what seemed "natural" in terms of how colors might change the farther a frog population is from the mainland. In other words, if my mainland population was dark green, frogs on nearer islands were some shade of green, while those farthest from the mainland might be yellow or blue.

Lesson Plan

Begin this lesson with a review of the key concepts covered so far in the unit. Next, explain to the students that today they will learn the basic method geneticists use to figure out gene sequences. In addition, they will all have a chance to "become" geneticists and figure out gene sequences for a number of frog species.

Show students the PowerPoint presentation, taking care to carefully walk them through the basic idea of gel electrophoresis. Please note that this is a very simplified version of this

technique – it is actually quite a bit more complex, and there are several methodologies depending on the type of information a geneticist wants to obtain. However, the basic concept is most important – that geneticists break DNA apart in a predictable way in order to determine its sequence. Using different compounds, geneticists can break DNA molecules apart. Then, they add the molecule pieces to lanes in a gel. At the top and bottom of the gel are (+) and (-) electrical terminals. DNA is negatively charged, and so the pieces in the lanes migrate toward the (+) end of the gel. Longer pieces are heavier and don't move as far through the gel as shorter pieces. Geneticists can mark the pieces using a fluorescent UV dye, and then compare the trails they leave to a reference to determine the number of base pairs in the piece. Repetitions of this procedure (as well as methods that dye particular bases) can be used to determine the base sequence of a gene.

Once students have a general understanding of this procedure and you have answered any questions, explain the gel electrophoresis activity. During the activity, students will work to discover the base sequence for the skin color gene in several species of frogs. Show the students the frogs, and the island poster with the group of islands from which each species was collected. Break the class into several groups (there are 9 frogs and sequences, and groups can do more than one sequence – I had 5 groups). Each group should have a blacklight (UV light – available at novelty/party stores) and a couple sharpies to share, in addition to a laminated frog and its associated "gel". Each student should get one template transparency. On the board, draw an example while explaining the procedure. Students should take their template and place it over the blue gel paper. Next, they should shine the UV light over the top of the gel+template, in order to make the sequence bands appear. Using the sharpie, students should mark an "X" in the box where the fluorescent band appears. Once they have marked all 8 boxes, they can pass the materials (the light, gel, and sharpie) to another student in their group. Each box indicates a different base – A, T, C, or G. By reading the boxes they have marked from left to right, students can determine the base sequence of the gene (e.g. AATGCCGA). Students should write this on the bottom of their transparency.

Collect the frogs and tape them to the board. Ask the students to tell you the sequence they determined for each frog (check their sequences using the key). Write the sequence on the board next to each frog. The students should notice that some sequences are more similar than others…it would be good to tape up the frogs and write the sequences in a location that can be left up for a week. The information obtained during this lesson will be used in the next lesson. Wrap up this lesson by reviewing the key concepts and answering any remaining questions.

Assessment

The assessment for this lesson was generally informal – students should participate in the activity and have determined and written the DNA sequence for at least one gene.

Lesson 4: Speciation

Key Concepts

- Genes occur at different frequencies among members of a population. Gene frequencies can change if a few individuals are isolated from a main population, such that rare traits become common in the small, isolated daughter population.
- Over time, the accumulation of new traits in isolated populations means that those populations can no longer interbreed, and a new species is formed. This process is called **speciation.**
- Island chains are ideal locations to study speciation. By looking for similarities between gene sequences, scientists can discover the order in which an organism colonized a series of islands and the rate speciation occurred.

Vocabulary

- Species, speciation
- Isolation

Materials

- DNA and Populations PowerPoint Presentation (Slide 4) & projection equipment
- Sequence cards
- Laminated frogs
- Island poster
- Paper to record gene trees (or, instructors could consider creating a worksheet)

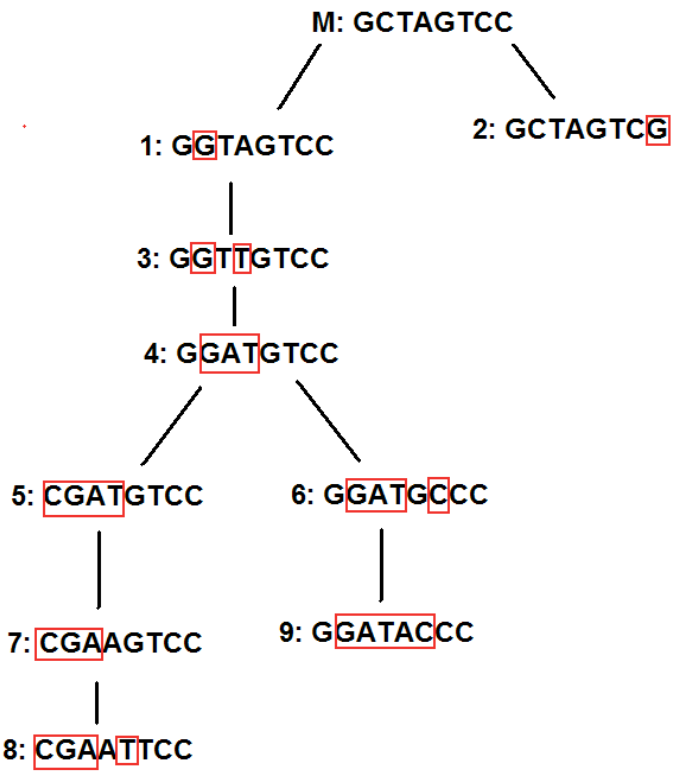
Lesson Plan

Begin the lesson with a review of the key concepts covered the previous week. Then, explain to the students that they will be working once again with the gene sequences they discovered last week. Show the students the last slide of the DNA and Populations PowerPoint presentation. The slide describes one reason that gel electrophoresis is important – determining the sequences of genes in different species can help you determine how closely those species are related. If you are studying species of frogs from different islands (like our laminated frogs from the islands on our island poster), knowing their gene sequences can help you determine the order in which the islands were colonized. Students should understand the definition of a species as organisms that can interbreed. Isolation can cause the formation of new species if new traits accumulate over time. This concept is called **speciation**.

I gave my students the following example of speciation, using the laminated frogs and island poster as visual aids. In a frog population, a few frogs were born with longer tongues. These long tongues made them a little better at catching flies. One day, four of the long-tongued frogs hopped on a log and were washed out to sea. The log ended up on the shores of an island. The long-tongued frogs interbred, and eventually all the frogs on that island had long tongues. Over time, other traits changed as well. One day, some of these island frogs hopped on a log and were washed out to sea. They ended up back on the mainland and met the original frog population. However, they were now so different, that they could not interbreed with the mainland frogs – they were a new **species.**

Just looking at the island poster…ask students to predict the island they believe was colonized first by a frog from the mainland population. Which island might have been colonized last? These questions relate to Island Biogeography theory – the students are likely to predict that those islands closest to the mainland were colonized first, and those farthest from the mainland last. Larger islands are also more likely to be colonized than small, harder to find islands.

After the students have made their predictions, explain that it is possible to determine the order the islands were colonized by the frogs, just by examining their gene sequences. Students may have noticed that some gene sequences are more similar than others. Circle the sequence for the mainland frog, and tape that frog to the mainland on the poster. Divide the students into groups and give each group a pack of sequence cards (each pack contains 10 sequences, all of the same color – the navy sequences are a key for the instructor). Explain that the pack contains all the sequences the students discovered in the previous lesson. Their job is to arrange the sequences in a "gene tree" to show the order in which they believe the frogs colonized the island (in other words, which frog species belongs to which island). At this point, refer back to the PowerPoint slide, and work through the bird example on the slide so the students understand that the more similar a sequence is to the mainland, the more likely it is that that species belongs to an island close to the mainland. Groups should record their ideas, and be able to defend their selections based on the similarity of gene sequences. The final gene tree should look like the following:



Note that sequence 7 has only 3 bases different from the mainland; however, only one change is required from sequence 5 to achieve this sequence, whereas more changes would be necessary from any other sequence. Therefore, it is most likely that the frog species on island seven came from the frog population on island 5, rather than from any other island. This is a tricky concept – students need to pay attention to both the number of bases that are different from the mainland, as well as how many changes it would take to make one sequence from another. Geneticists adopt a rule of simplicity: the fewest changes required to make one sequence from another is considered to be the correct order.

It may be helpful for students to have a worksheet with pictures of the islands on it, where they can write in the base sequence they believe belongs to a given island. Students should understand that all the species have a common ancestor on the mainland. However, some species are more closely related than others; this is what they have determined by making the gene tree (i.e. which species arose from which).

Finish the class by discussing student answers and giving the correct solution. Place the different frogs on the island poster on their home island – students should be able to see how frogs near the mainland look most similar to the mainland population, while frogs on farther islands have more exotic skin colors (because the skin color gene has accumulated the most changes as species develop further and further from the mainland). Wrap up the class by reviewing the key concepts and taking any final student questions.

Assessment

Assessment is generally informal, with groups participating in the speciation activity. Each group (or each student) should have a completed worksheet with a gene tree.

Reflection

Students really enjoy this unit. They are particularly fascinated by DNA, the concept of heredity and the types of traits that are heritable, and mutations and how they are produced. I found that my students were thoroughly engaged in all of these activities. However, it is very important to move slowly with each new concept, as they build on each other. Use multiple examples, and assess student comprehension and retention during each lesson. The review at the beginning of each lesson was critical, and assured me that students were able to recall the key concepts addressed each week. Their ability to discuss the concepts in their own words showed me that they understood the material.

I would recommend teaching a follow-up lesson specifically on natural selection. This unit would also be an appropriate precursor to more in-depth information on evolutionary theory. It would tie in well with historical or literary lessons on Charles Darwin, the voyage of the *Beagle*, the history of science, and the development of modern biology.

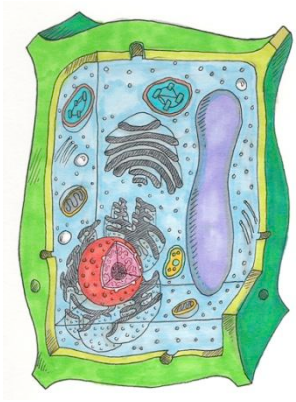


Image source: http://www.jimmyjanesays.com/sketchblog/2007/04/plant-cell.html (Plant cell)

Name: _____

Cells and DNA

I. What is a cell?

- **Cell – the basic unit of structure in a living thing**

Listen to the information about cells and take notes below. What structures do cells share? What size are they? Include any other important information.

Notes: _____

_____

_____

_____

Draw what you think a plant cell looks like before looking under the microscope. Then, draw and label a picture of the actual cell that you observed.

Before viewing

After viewing

II. The Nucleus

The cell contains a structure called the <u>nucleus</u>. The nucleus appears as a dark circle, often near the center of the cell. The nucleus is made up of molecules of DNA.

- **Nucleus – the "information center" of the cell, it directs the growth and function of the cell and ultimately the organism**

Using the word bank and definitions, label the cell below. If you have time, color the cell to highlight the different structures.

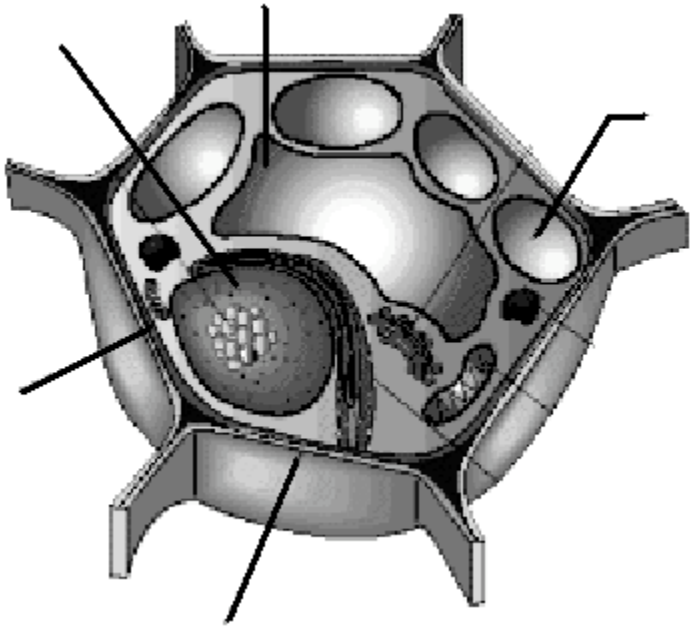


Image source: http://140.254.84.203/wiki/index.php/Cell

<u>Word Bank and Definitions</u>

- **Nucleus – "information center" where DNA is stored**
- **Cell wall – outer layer around the plant cell**
- **Cell membrane – inner layer around the plant cell**
- **Chloroplast – these oval-shaped structures make energy from the sun**
- **Vacuole – "reservoir" that holds liquid in the cell**

III. DNA

- **DNA – Deoxyribonucleic Acid – this molecule has two strands, each with a "backbone" and bases. It is coiled and, when stretched out, looks like a spiral staircase.**

Listen to the information about DNA. Take notes on important facts below. What is DNA made of? What does DNA do? Why is it important?

Notes: _____

_____

_____

_____

_____

_____

Match the base pairs. Draw a line to show which base pairs go together on DNA.

- **A <u>gene</u> is a sequence of these base pairs. DNA contains many genes in a row. The gene sequences can be read, and cause organisms to develop in a certain way. For example, the color of a flower might be due to a specific gene.**