Jr Medical Investigators Curriculum

Adapted for City of Hope by Alexandra Race

Summary of Unit:

In this unit, students will become Junior Medical Investigators and will be presented with a "patient" with an undiagnosed disease (sickle cell anemia). They will combine the diagnostics of medicine and the scientific inquiry of research to discover the mystery illness. The students will also learn about other diseases, such as lung cancer and diabetes. These diseases will share a symptom with the mystery disease, and by performing a variety of diagnostic tests, such as urinalysis, gel electrophoresis, and microscopy, the students will eliminate them as the potential mystery disease.

Lesson 1: Differential Diagnosis

Introduction

Overview
In this session, students will be introduced to the "mystery patient." They will learn the procedure and importance of differential diagnosis. They will perform a "mock" differential to prepare for the diagnosis of the "mystery patient."

Note: This lesson has been adapted from Diseases Detectives by Life Sciences Learning Center at the University of Rochester.

Student Outcomes
Students will:

- Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1)
- Learn that symptoms and laboratory tests can be used to diagnose diseases.
- Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-2),(MS-LS4-4)
- Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS4-2),(MS-LS4-4)

Suggested Time
2 60 minute sessions

Advance Preparation
The various samples for the mock differential will need to be prepared in advance. Be sure to prepare enough for students to work in groups of 2-3. The Mock Differential Test sheet will need to be printed out and placed in sheet protectors (or laminated).

Materials

For Part 1-3 each student will need:

- Differential Diagnosis Worksheet

For Part 2 each team of 2-3 students will need:

- COLOR copy of Mock Differential Test Sheet (cover in sheet protector)
- COLOR copy of CSF (cerebrospinal fluid) Testing Procedures (cover in sheet proctector)
- 2 plastic droppers labeled "Patient CSF" and "Protein Test Solution"
- Small tubes or cups labeled and filled as shown in the table below:

Label on tube/cup	**Contents of tube/cup for ONE student group**
Patient CSF	At least 2 ml of 8% sodium bicarbonate (baking soda) Solution (*8 grams baking soda + 100 ml water)*
Protein Test Solution	1 ml of 0.01 % Bromothymol blue solution (0.01 bromothymol powder + 100 ml water)

- Small bag labeled “Glucose Test Paper” containing at least 1 strip of pH 1-12 or pH 1-14 test paper.

Part 3 each team of 2-3 students will need:

- COLOR copy of Mock Differential Test Sheet (cover in sheet protector) (may be reused from Part 2)
- Droppers labeled: “Nm Antibody-Coated beads,” “Sp Antibody-Coated beads.” “Hi Antibody-Coated beads” and “Patient CSF” (may be reused from Part 2)
- Small tubes or cups labeled and filled as shown in the table below.

Label on tube/cup and dropper	**Contents of tube/cup for ONE student group**
Nm Antibody-Coated beads	1 ml 15% calcium chloride solution *(15 grams calcium chloride + 100 ml water)*
Sp Antibody-Coated beads	At least 1 ml water
Hi Antibody-Coated beads	At least 1 ml water
Patient CSF	1 ml 8% sodium bicarbonate (baking soda) Solution (*8 grams baking soda + 100 ml water)*

Teaching Sequence

Getting Started

1. **Tell the students that they will be acting as Medical Investigators, using scientific tests to discover what is wrong with our Mystery Patient.**
   Ask what they know about medical investigation. Do they know any medical tests?

2. **Introduce the Mystery Patient.**
   Provide background on patient, without revealing any symptoms.

   Our Patient’s Story: The patient reports feeling well most of the time. But he also reports odd reoccurring events of symptoms. He was often ill as a child.

   A family history reveals that he has two brothers and three sisters. None of them have this condition. His uncle and his grandmother often had similar symptoms. His grandmother died a young woman. His parents do not have this condition. His family is from the West Indies. He is of African descent.

Exploring

3. **Describe the Differential Diagnosis process.**

- In medicine, a differential diagnosis is the distinguishing of a particular disease or condition from others that present similar symptoms.
- Differential diagnosis has four steps. The physician:
  - Gathers all information about the patient and creates a symptoms list.
  - Lists all possible causes (candidate conditions) for the symptoms.
  - Prioritizes the list by placing the most urgently dangerous possible causes at the top of the list.
  - Rules out or treats possible causes, working down the list. Rule out—practically—means use tests and other scientific methods to eliminate a candidate condition

- Ask: Do you know what a symptom is? What is a disease? What diseases do you know? How are diseases caused?

4. Mock Differential. What's Wrong with Mike?

1. Assign students to work in teams of two or three students.

2. Distribute Differential Diagnosis Worksheet to each student. Read the case aloud. Ask students to work with their team to fill out the chart.

3. Ask students to complete **Part 2**. As they work, distribute the lab materials for Part 2 to each team:

- Mock Differential Test Sheet
- CSF (cerebrospinal fluid) Testing Sheet Procedures
- CSF (cerebrospinal fluid) Testing Sheet
- Patient CSF (save extra for Part 3)
- Small bag of Glucose Test Paper
- Protein Test Solution
- Droppers labeled Patient CSF and Protein Test Solution

4. Ask the students to complete **Part 3**, questions 1-4. As they work, distribute the lab materials for **Part 3** to each team:

- Antibody-Coated Bead Test Sheet

Tubes/cups of:

- Patient CSF (new tube or saved from Part 2)
- *Nm* Antibody-Coated Beads *Sp* Antibody-Coated Beads
- *Hi* Antibody-Coated Beads

Droppers labeled:

- Patient CSF
- *Nm* Antibody-Coated Beads
- *Sp* Antibody-Coated Beads
- *Hi* Antibody-Coated Beads

5. Have the students complete **Part 3** questions.

Discussing

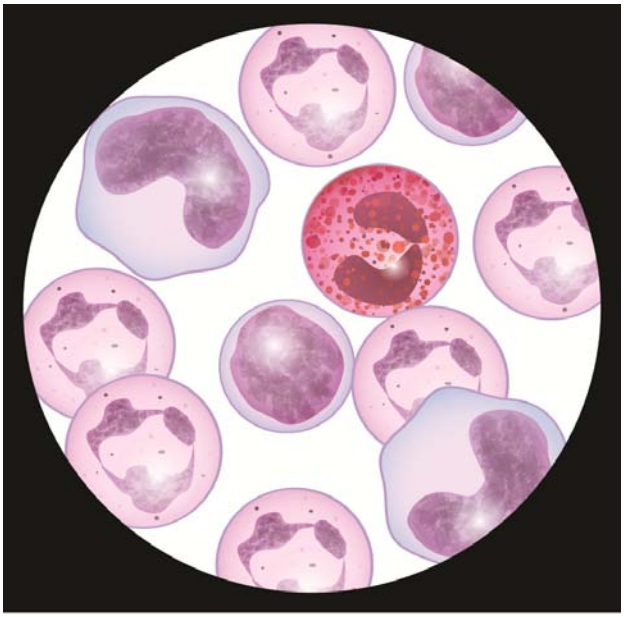
5. **Review the diagnosis. Ask students to explain how they came to the conclusions they did.** Discuss treatment options. Ask if they knew a way for the disease to be prevented.
6. **Discuss vaccines.** Review with students what vaccines are. Ask them to brainstorm with their groups two to three reasons why vaccines are important.
7. **Wrap up.** Tell students that they will be learning about the patient's first symptom tomorrow.

CSF TEST SHEET

Glucose and Protein Test Sheet

Use for Glucose Test

Use for Protein Test



Patient's White Blood Cells in CSF

Antibody-Coated Bead Agglutination Test Sheet

Neisseria meningitides (Nm)	StreptococcuSpneumonia (Sp)	Haemophilus influenza (Hi)

Day 1- Mock Differential Diagnosis

Part 1: What is wrong with Mike?

Yesterday, Mike Wright developed a severe headache, a high fever, and a stiff neck. Then, he became nauseated and began vomiting. He just wanted medicine to make him feel better and a dark quiet room so that he could sleep. Today, Mike's parents noticed that he was so sleepy that it was difficult to get him to wake up and he seemed confused. They took Mike to the hospital emergency room because they are worried that he is very sick.

1. Read the description of Mike's illness. Complete the "Mike's Symptoms" column in the chart below by putting an "X" in the appropriate boxes to indicate Mike's symptoms.

Symptoms	Mike's Symptoms	Viral Meningitis	Bacterial Meningitis	Influenza	West Nile Encephalitis
Fever					
Headache					
Cough					
Stiff Neck					
Nausea and Vomiting					
Light sensitivity					
Muscle Aches					
Confusion					

2. Use the information below on the Possible Diseases to complete the other four columns in the chart.

Viral Meningitis

Viral meningitis is an infection of the meninges (the covering of the brain and spinal cord) that is caused by a virus. People with viral meningitis usually recover completely without specific treatment. There are several viruses that can cause viral meningitis. Most viral meningitis cases are caused by enteroviruses that infect the digestive tract. Other viruses that can cause meningitis include the viruses that cause mumps, chicken pox, influenza, and measles. Viral meningitis infection is characterized by a sudden onset of fever, headache, and stiff neck. It is often accompanied by other symptoms, such as nausea, vomiting, sensitivity to light, and confusion.

Bacterial Meningitis

Bacterial meningitis is a serious and sometimes fatal infection of the meninges (the covering of the brain and spinal cord) that is caused by bacteria. While most people with bacterial meningitis recover, the disease can cause serious complications, such as brain damage, hearing loss, learning disabilities, or even death. There are several types of bacteria that can cause bacterial meningitis. Common causes of bacterial meningitis include *Streptococcus pneumoniae, Neisseria meningitidis, and Haemophilus influenza.* Early symptoms of meningitis infection include a sudden onset of fever, headache, and stiff neck. Other symptoms may include nausea, vomiting, increased sensitivity to light, and confusion. Later symptoms of bacterial meningitis include seizures and coma.

Influenza

Influenza (the flu) is a contagious respiratory illness caused by influenza viruses that infect the nose, throat, and lungs. It can cause mild to severe illness, and at times can lead to death. People who have the flu often have a fever, headache, cough, fatigue, and muscle or body aches. Some people also experience vomiting and diarrhea. Flu is unpredictable, and how severe it is can vary widely depending on the type of virus causing it. Older people, young children, pregnant women and people with certain health conditions (such as asthma, diabetes, or heart disease), and persons who live in facilities like nursing homes may be more at risk for severe flu symptoms.

West Nile Encephalitis

West Nile encephalitis is a potentially serious disease caused by the West Nile virus. This virus is often transmitted by the bite of an infected mosquito. Mosquitoes become infected when they feed on infected birds. Most people who become infected with the virus will not show any symptoms. However, some people have symptoms such as fever, headache, body aches, nausea, and vomiting. Rarely, infected people experience confusion, coma, tremors, convulsions, muscle weakness, vision loss, numbness and paralysis.

3. Based on the information in the chart, what diseases are most likely to be causing Mike's symptoms?

Day 1 Mock Differential Diagnosis - Part 2: Is it Viral or Bacterial Meningitis?

1. What is meningitis?

2. Why is it important to determine if Mike has bacterial meningitis or viral meningitis?

3. Which type of meningitis (bacterial or viral) requires immediate treatment with antibiotics?

The doctor orders a lumbar puncture to collect the patient's cerebrospinal fluid (CSF).

4. What is cerebrospinal fluid (CSF)?

You will test the patient's CSF to determine if Mike has bacterial or viral meningitis. Conduct the tests described on the **CSF Testing Procedures** sheet in your lab kit.

5. Record the results of the CSF tests in the data table below

	Glucose	Protein	Most Common White Blood Cells
Mike (Patient)			
Bacterial meningitis	Low	High	Neutrophils
Viral meningitis	Normal	Normal or High	lymphocytes

6. Based on the results of Mike Wright's CSF tests, what type of pathogen is causing his meningitis—a viral pathogen or a bacterial pathogen?

Day 1 Mock Differential Diagnosis - Part 3: Which Type of Bacteria?

There are three types of bacteria that commonly cause bacterial meningitis:

☐ *Streptococcus pneumonia* (***Sp***)
☐ *Neisseria meningitides* (***Nm***)
☐ *Haemophilus influenza* (***Hi***)

1. Explain how the three specific kinds of antibodies (*Nm* antibodies, *Hi* antibodies, and *Sp* antibodies) attached to the beads are different.

2. Explain how the three specific kinds of bacteria (*Nm* bacteria, *Hi* bacteria, and *Sp* bacteria) are different.

3. Explain why ***Nm*** bacteria clump together when mixed with beads that are coated with ***Nm*** antibodies.

4. Explain why ***Hi*** bacteria do **not** clump together when mixed with beads that are coated with ***Nm*** antibodies. Use the words antigen and antibody in your answer.

Follow the instructions below to test the Patient CSF to determine which type of bacteria is causing Mike's meningitis.

a. Place two drops of antibody-coated beads (***Nm*** beads, ***Sp*** beads, or ***Hi*** beads) in the appropriate circles on the Antibody-Coated Bead Test Sheet.
b. Place two drops of the Patient CSF into each of the circles on the Antibody-Coated Bead Test Sheet.
c. A cloudy appearance indicates that Patient CSF contains that specific type of bacteria. It is easier to see the cloudy appearance if the test sheet is placed on a dark surface.

5. Which antibody-coated beads turned cloudy when mixed with the Patient CSF?

6. Explain what caused these antibody-coated beads, and not the other antibody-coated beads, to turn cloudy. Use the words antigens and antibodies in your answer.
7. What type of bacteria is causing the patient's meningitis? Support your answer with evidence from the Antibody-Coated Bead Test.

8. What treatments can be used for a patient with this type of meningitis?

9. How could this type of meningitis be prevented?

Fact Sheet: Meningitis

Meningitis is an inflammation of the meninges (the thin membranes surrounding the brain and spinal cord). It is usually caused by a viral or bacterial infection. Viral meningitis is more common than bacterial meningitis, but it is less serious. Viral meningitis usually clears up on its own and does not cause any permanent harm. It can be caused by several types of viruses, including enteroviruses (which cause the stomach flu), the human immunodeficiency virus (HIV), and the virus that causes mumps. Bacterial meningitis is not as common as viral meningitis, but it is much more serious and requires emergency treatment. Bacterial meningitis can cause brain damage, learning disabilities, hearing loss, or even death.

To diagnose meningitis, doctors will do a lumbar puncture (spinal tap). A lumbar puncture allows the doctor to collect some of the cerebrospinal fluid (CSF) that surrounds the brain and spinal cord. During a spinal tap, patients usually lie on their side curled into a ball. First, the doctor will numb the skin with medication. Patients need to lie very still while the doctor inserts a very thin needle into the spinal column. Fluid is removed and collected in tubes. After the cerebrospinal fluid is collected, it will be examined under a microscope to see if it contains bacteria, white blood cells, or other substances that indicate inflammation or infection. Usually, by looking at the spinal fluid, a doctor will be able to tell if someone has meningitis. The fluid will also be sent to a laboratory to be tested for bacteria and viruses. Once the doctors know what pathogen is causing the meningitis, they can choose the best medication to treat the infection.

The bacteria that cause bacterial meningitis colonize in the nose and throat. From there they get into the bloodstream and enter the cerebrospinal fluid (CSF) that bathes the brain and spinal cord. This fluid is an ideal medium for the bacteria because it provides nutrients for their multiplication. When the bacteria die, toxins are released. These toxins can damage brain blood vessels and lead to shock or swelling of the brain. White blood cells circulating in the CSF are attracted to the bacteria. These white blood cells may release powerful enzymes that damage brain tissue. There are several types of bacteria that may cause bacterial meningitis. Therefore, it is important that doctors conduct tests to determine which type of bacteria is causing a patient's meningitis, so they can select the proper treatment.

One type of bacteria, Neisseria meningitides, causes a dangerously contagious and life-threatening type of meningitis. This type of bacterial meningitis is more common in people who are living in a crowded setting, such as a dormitory, school, or child care facility. Bacterial meningitis caused by Neisseria meningitides is very serious and prompt treatment is essential if the patient is to survive. Patients need to be in the hospital during treatment. Strong antibiotic medicine will be given intravenously (through an IV- a thin tube that goes into a vein to give medicine) to get rid of the bacteria. Fluids containing glucose (sugar) and minerals may also be given through the IV to help patients recover.

About 25-30% of people with bacterial meningitis die from it. People who survive bacterial meningitis may have complications including: hearing loss, seizures, cerebral edema (brain swelling), weakness on one side of the body, speech problems, visual impairment or blindness, difficulty coordinating movements, trouble breathing, respiratory arrest, and recurring meningitis. The Centers for Disease Control (CDC) recommends that children age 11 or older receive the meningococcal vaccine (MCV4) that prevents bacterial meningitis. Doctors will want to know who was in close contact with a person who has bacterial meningitis. Close contact means living with or spending a lot of time with the person, or sharing the same utensils or cups. This is important because people who have not been vaccinated for bacterial meningitis may need antibiotics for a few days, just in case they were infected with the bacteria.

Lesson 2: Microscopy and Disease Transmission

Introduction

Overview

In this session, students will be introduced to the patient's first symptom, fatigue. They will be introduced to blood as a diagnostic tool. They will practice and use microscopy to view a sample of the patient's blood. They will learn about malaria, and do an activity simulating disease spread.

Note: The disease simulation activity has been adapted from SCIENCE & SOCIETY: PREVENTING THE SPREAD OF DISEASE by the U.S. National Library of Medicine and the National Institute of Health

Student Outcomes

Students will:

- Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. (MS-LS1-1)
- Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)

Suggested Time

2 60-80 minute sessions

Advance Preparation

Design a creative way to introduce the patient's symptoms. Examples include drawing of patient on poster board, with each new symptom drawn on each day, or a digital drawing to the same affect.

Pre-number the small cups for the disease simulation activity. Pre-fill the cups with liquid, choosing three to four cups (depending on the size of your class) to be infected (will contain NaOH instead of water).

Materials

For each team of students:

- A light microscope
- Prepared Malaria Slide
- Prepared Normal Blood Cell Slide
- Prepared Sickle Cell Slide
- Blank Slides
- Q-tips
- Slide covers

Each student will need:

- Disease Symptoms Worksheet
- Microscopy Worksheet
- Disease Spread Worksheet
- Small Cup (with water or NaOH)

For the teacher:

- NaOH
- Water

- Pipette
- Phenolphthalein
- Poster board with “patient” drawn on it
- “Fatigue” representation to add to “patient”

Teaching Sequence

Getting Started

1. Introduce the Mystery Patient’s first symptom: Fatigue.
Ask students if they have ever experienced fatigue and if they know what causes fatigue.

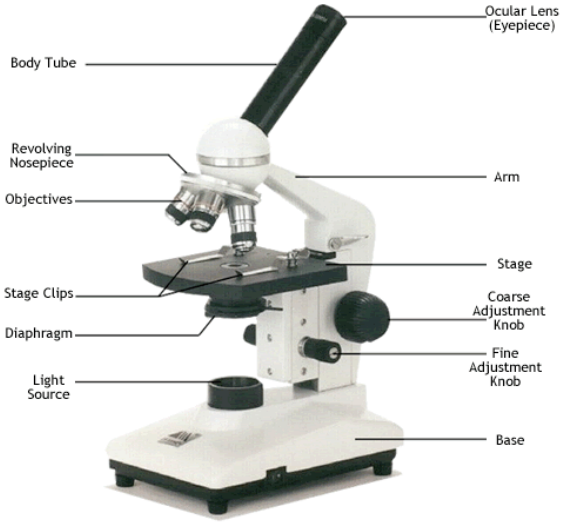
2. Pass out Disease Symptoms Worksheet.
Have students review the symptoms of the 5 potential diseases. Discuss as a class which diseases can be eliminated or kept.

3. Discuss with students diagnostic tests that can be done to find the causes of fatigue. Brainstorm with students until someone mentions blood testing.

4. Overview the diagnostic uses of blood testing.
Mention to students that blood contains important information about many things going on in your body including: mineral levels, nutrient levels, hormone levels, sugar levels, cholesterol levels, and more. This is done by separating the blood sample in each unique part and measuring the amount.

5. Mention that some diseases, such as parasitic diseases, can be diagnosed by just viewing a blood sample under a microscope.
One of the potential diseases on our lists, Malaria, is a parasitic disease. We will practice microscopy to either eliminate or confirm Malaria as the disease our patient has.

6. Review microscopy with students. Remind them of the parts of a microscope, proper handling technique, how to make slides and how to view them.
Students may or may not have used microscopes before.



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Exploring

7. Pass out the worksheet.
Students will begin microscopy practice by making slides to view various objects.

8. Allow students to pick the leaf they wish to view under the microscope. Demonstrate to the class how to make a slide. Allow the groups to make and visualize their leaf slides. After students have visualized their leaves, demonstrate how to make a slide with cheek cells.

- Gently chew on the side of your check for 10 seconds
- Using a q-tip, swap your cheek where you were chewing
- Smear the cells onto the slide
- Add a drop of iodine, which will help you visualize the cells (teachers should do this)

9. When students are done, allow them to explore the classroom or go outside to find an object to visualize.

10. Regroup the class. Discuss what the students saw under the microscopes. Tell them they will now be viewing the patient's blood sample, as well as a blood sample from someone who has malaria and a healthy blood sample.

11. Set up one microscope with each slide. It is better to focus the slides in advance and the students view the slides one by one. Viewing the blood cells requires 40x magnification and this can be difficult to focus for students.
Allow the students to rotate through each slide, having the draw their observations after viewing to speed up the process.
12. Once all the students have completed their observations, review as a class if the patient has malaria.
The patient does not have malaria.
13. Malaria is an infectious disease. Discuss with the students how they think disease is transmitted. Review infectious diseases and the different causes of the diseases.

14. Inform students they will be conducting an exchange activity that simulates how an infectious germ may be transmitted quickly from one person to another.
Provide each student with a numbered cup pre-filled with a liquid. Review the following key steps of the activity before students start their exchange activity:

a. Exchange liquid by pouring liquid from one cup into the other, then dividing the mixture evenly into the two cups.
b. Exchange your liquid with three other students, one at a time.
c. Record who (cup numbers), when (first, second or third) and what (color) for all three exchanges.

Discussing

15. Once the students have completed their exchanges, add a drop of the indicator to each cup. Tell them which cups were "infected" and have them figure out how they got "infected."

16. Wrap up the lesson with a quick discussion of how quickly diseases can spread and why it is important to wash your hands.

Name:_____

What's Wrong With Our Patient?

Symptoms	Patient's Symptoms	Lung Cancer	Type 1 Diabetes	Type 2 Diabetes	Sickle Cell Anemia	Malaria
Chest Pain						
Shortness of Breath						
Fatigue						
Sores						
Fever						
Frequent Infections						
Weight Loss						
Genetic Link						

Disease Symptoms:

Lung Cancer: A cough that does not go away or gets worse; Chest pain that is often worse with deep breathing, coughing, or laughing; Hoarseness; Weight loss and loss of appetite; Coughing up blood or rust-colored sputum (spit or phlegm); Shortness of breath; Feeling tired or weak; Infections such as bronchitis and pneumonia that don't go away or keep coming back

Diabetes Type 1: Increased thirst; Frequent urination; Bedwetting in children who previously didn't wet the bed during the night; Extreme hunger; Unintended weight loss; Irritability and other mood changes; Fatigue and weakness; Blurred vision; High levels of glucose in the blood and urine

Diabetes Type 2: Increased thirst and frequent urination; Increased hunger; Weight loss; Fatigue; Blurred vision; Slow-healing sores or frequent infections; Areas of darkened skin; High levels of glucose in the blood and urine

Sickle Cell Anemia: Shortness of breath; Headaches; Fatigue; Jaundice; Sudden Pain/aches; Hand-Foot Syndrome (swelling); Infections; Eye problems; Stroke; Ulcers on the Legs; Genetic Mutation

Malaria: Fever; Chills; Headache; Sweats; Fatigue; Nausea and vomiting

Day 2- Microscopy Worksheet

Part 1: Viewing a Leaf

1. Take one of the plastic slides and place a piece of tape on one side. Flip the slide over so the sticky side is facing up.
2. Chose a plant leaf and stick it on the tape.
3. Place another layer of tape on the slide, directly over top.
4. Draw what you see in **Figure 1.**

Figure 1 Figure 2

5. Place the slide in the Foldscope, sandwiched between two other blank slides. Center the leaf in your field of view. Draw what you see in **Figure 2**.
6. What do you see that you could not see before? _____
   _____

Part 2: Cheek Cell

7. Place a small drop of Iodine onto a clean slide.
8. Using a toothpick, gently scrape the inside of you cheek.
9. Place the toothpick tip into the iodine and mix. The iodine stains the cells so you can see them.
10. Draw what you see in **Figure 3**.

Figure 3

Part 3: Viewing the Blood Slides

1. Place the glass slide into the Foldscope. If you have difficultly placing it in the stage, please let us know.
2. Hold the Foldscope up to the light and view the slide.

Patient's Blood | Blood infected with Malaria | Healthy Blood Sample

*with Foldscope

1. We are now going to view the slides under a compound microscope. This will allow us to take a closer look at the blood cells.

Patient's Blood | Blood infected with Malaria | Healthy Blood Sample

*with Compound Microscope

Does our patient have Malaria? _____

Day 2- Disease Spread Worksheet

Step 1 Make observations on the liquid in your cup and record them below:

a. Color of the liquid: _____

b. Smell of the liquid: _____

Step 2 Record your cup number in column B of the Exchange Record Table below.

Step 3 Exchange the liquid in your cup with that of another student. First, record his or her cup number in column B of the Table below, then pour the liquid from one cup into the other student's cup. Next divide the mixture evenly into the two cups. Repeat this with two other students, so you have had a total of three exchanges.

Step 4 After competing three exchanges, record the color and smell of your liquid below:

c. Color of the liquid: _____

d. Smell of the liquid: _____

Step 5 After three exchanges, have the teacher add phenolphthalein ($C_{20}H_{14}O_4$) solution to your cup and record the color of the liquid in your cup in column C in the Exchange Table. Also, record in column C the color of the liquid in each of the three cups that you have exchanged liquids in Step 2.

A	B (Step 2): Record Each Cup number.	C (Step 4): Record the color of the liquid after your teacher adds a solution in each cup.
Your Cup		
1st Exchange		
2nd Exchange		
3rd Exchange		

Lesson 3: Urinalysis and Diabetes

Introduction

Overview

In this session, students will explore urinalysis as a diagnostic tool. They will learn about diabetes and then model and explain the disease to a "patient."

Note: The urinalysis lesson have been adapted from Urine Analysis by Creative Chemistry UK. The explaining diabetes activity has been adapted from Why Can't I Have Sugar? All About Diabetes by Eric DeJulio at University of Washington.

Objectives

Students will:

- Analyze data from tests to determine similarities and differences among several design solution to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success (MS-ETS1-2).
- Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function (MS-LS1-2).

Suggested Time

2 60 minute sessions

Advance Preparation

You will need to either prepare urine in advance or buy a kit that has prepared urine.

If you are preparing your own "urine," make the following solutions:

Patient: Dissolve 3g sodium chloride and 5g urea in $1dm^3$ water.

*Patient with Diabetes***:** Dissolve 3g sodium chloride, 5g urea and 5g glucose powder in $1dm^3$ water. Add 3 drops of 2M hydrochloric acid.

*Patient with Kidney Damage***:** Dissolve 3g sodium chloride, 5g urea and 1g albumin powder in $1dm^3$ water.

Note: You may wish to add some yellow food coloring to enhance the appearance of the samples.

Materials

For Urinalysis:

For each team of students:

- 4 simulated Urine Samples: Patient 1, 2, 3,
    - NOTE: Be sure to check your kit to see what urine samples match the diseases
- Test tube rack
- Water bath set at 70°C with test tube rack
- pH test strips
- Glucose test strips (or Benedict's solution)
- Biuret's solution (to test for protein)
- Pipettes (8 per group)
- Sharpie/labeling tape

For each student:

- Urinalysis Worksheet
- Explaining Diabetes Worksheet
- Gloves

For Teacher:

- 3B Scientific Kit: “Urinalysis Using Simulated Urine”

Or to make own simulated urine

- Sodium Chloride
- Urea
- Glucose Powder
- Albumin Powder
- 2M HCl
- Yellow Food Coloring
- DI Water
- 4 1000mL beakers

For Modeling Diabetes Activity:

For each pair of students:

- Styrofoam balls
- Toothpicks
- Tape
- Construction paper
- Marshmallows
- Butcher paper
- Markers
- Access to the internet

Teaching Sequence

Getting Started

1. Introduce the new symptom: frequent sores and infections.

Discuss these symptoms. Have the students look over the Disease Symptom Worksheet to find diseases that match our patient’s symptoms thus far.

2. Discuss urinalysis as a diagnostic tool.

Mention the different aspects of urine that make it a good tool for diagnosis. Ask students to suggest possible information that could found from a urinalysis.

Exploring

3. Go over the instructions for the urinalysis.

Review the 6 different tests: Color, Odor, Clarity, Glucose, pH and Protein. Discuss what irregular values in these tests could mean.

4. Pass out supplies for performing urinalysis.

Students should work in groups of 2 or 3. Students will have 3 patient samples and one test sample. It is best to go over each test as a class using the test sample, and then allow students to perform the tests on the patient samples on their own. Depending on whether you are using the urine from a prepared kit, or urine that you prepared in lab, the supplies/instructions will be different.

If you are using urine from a kit, continue to 5. If you are using urine you prepared in the lab, continue to 6.

5. Guide students through the urinalysis. Tell them they should do the tests in the following order:

1. *Glucose Test:*
    a. Using a graduated pipette add 3mL of each urine sample into the test tube with the matching label.
    b. Keep each pipette with the sample you used it for, you will use it again to transfer some of the urine.
    c. Add 15 drops of Benedicts Reagent to each test tube.
    d. Place the test tube rack into the water bath (or place test tubes into beaker of hot water) for 10 minutes.
    e. Be sure that no water gets into your test tubes.
    f. Remove the test tube rack to observe and record the results.
2. Observe each urine sample for color and clarity, and record your observations.
3. *pH Test:*
    a. Use pH strips (1 per sample) to test the pH of each sample and record the results.
    b. Dip one end of the pH strip into the "Control" sample for 1-2 seconds. Remove the strip and gently shake off excess liquid. Determine the pH by matching the strip to the color chart. Repeat for each sample.
4. *Protein Test:*
    a. Using the correct pipette for each sample, add 3mL of each urine sample into the labeled test tubes.
    b. Add 15 drops of Biuret Reagent to each test tube. Observe and record your results.

Lab prepared Urine:

6. Guide students through the urinalysis. Tell them they should do the tests in the following order:

1. Examine the urine carefully by eye and nose! Comment on the color of the sample- use words like yellow, amber, dark, pale. Examine the sample for its odor (smell). Observe how clear the sample is (clear or cloudy). Note: Do NOT stick your nose directly near the sample. Waft the smell using your hand.
2. Divide the sample equally between two test tubes. Put one test tube into the hot water bath and leave the other test tube at room temperature. After a few minutes, take the test tube out of the water bath and compare the heated and unheated urine. If the heated sample is bubbly, it contains protein. Dispose of the heated urine in the sink. Keep the unheated urine.
3. Dip a piece of universal indicator paper into the urine. Quickly take it out and leave it for 30 seconds. Compare the new color with the pH color chart. Record the pH.
4. Dip a Clinistix into the unheated urine samples and immediately take it out. Count to ten, and then check the color with the chart. Record whether the urine is negative, light, medium, or dark (dark means it contains a lot of glucose).

7. Allow students analysis their result. Discuss as a class if our patient had any diseases detected by the urinalysis.
Discussing

8. Students will learn that our patient does not have diabetes. However, one of the patients does. **Discuss the types, causes, and symptoms of diabetes with the class.**

9. After discussion, **assign groups either type one or type two diabetes.** Students will need either internet access or a fact sheet about diabetes to complete this activity. **Give students these instructions:**

You will create a script to help teach your patient about diabetes (you recently diagnosed him or her with the disease). This script should include the following components:

1. Description of the symptoms that led you to the diagnosis
2. Explanation of what is going on inside the patient's body
   a. Visual model of this process (drawn or built with materials provided)
   b. Verbal description of the process to accompany the model
3. Explanation of treatment or prevention options
   a. What options are available? (Provide at least two options)
   b. What do these treatments actually do? Tie it in to the process described in component 2.

Each person in the group will be responsible for presenting one of the following sections:

- Description of the symptoms (component 1)
- Processes inside the body (component 2)
- Treatment options and what they do (component 3)

You should use your model to help in the explanation of each section. This will help the patient better understand what you are talking about.

Remember that you are a doctor. It is important to come across as caring, thoughtful, and knowledgeable! You want your patient to trust you.

10. Allow students ~20-30 minutes to prepare their script and models. Decide whether you will have the groups present to the class, to another group, or to you individually.

Assessment

11. Allow groups to present their finding/information.

Day 3- Urinalysis Worksheet

Today you are going to analyze urine samples. Doctors can discover a lot about a patient from their urine, including kidney disease, diabetes and drug abuse.

*Remember- we are using artificial urine today, but it's pretty realistic, so be careful!

Let's practice with Sample 0!

Test 1: Examine the urine carefully by eye and nose! Comment on the color of the sample- use words like yellow, amber, dark, pale. Examine the sample for its odor (smell). Observe how clear the sample is (clear or cloudy).

Note: Do NOT stick your nose directly near the sample. Waft the smell using your hand.

Test 2: Our next test is to find out if the sample contains protein- protein leaks into the urine if the kidney is damaged. Divide the sample equally between two test tubes. Put one test tube into the hot water bath and leave the other test tube at room temperature. After a few minutes, take the test tube out of the water bath and compare the heated and unheated urine. If the heated sample is cloudier, it contains protein. Dispose of the heated urine in the sink. Keep the unheated urine.

Test 3: We will be finding the pH of the unheated urine. Dip a piece of universal indicator paper into the urine. Quickly take it out and leave it for 30 seconds. Compare the new color with the pH color chart. Record the pH.

Test 4: We will be testing the urine for glucose using Clinistix strips. Dip a Clinistix into the unheated urine samples and immediately take it out. Count to ten, and then check the color with the chart. Record whether the urine is negative, light, medium, or dark (dark means it contains a lot of glucose).

Record your results for Sample 0 in the table below.

Test 1	Color	
	Odor	
Test 2	Unheated	
	Heated	
Test 3	Color	
	pH	
Test 4	Clinistix result	

You can now test the rest of the sample using the same tests!

Sample 1: Our Patient

Sample 2: Patient with Diabetes

Sample 3: Patient with Kidney Disease

	Sample 1	**Sample 2**	**Sample 3**
Color			
Odor			
Protein (✓ or x)			
pH			
Glucose			

Does our patient suffer from Diabetes? _____

How do you know?

_____

_____

_____

Does our patient suffer from Kidney Disease? _____

How do you know?

_____

_____

_____

Day 3- Explaining Diabetes Worksheet

1. My group was assigned Type ___ Diabetes.
2. Description of Disease:

   _____
   _____
   _____
   _____

3. Symptoms:

   _____
   _____
   _____

4. Model Planning:

5. Treatment:

   _____
   _____
   _____
   _____

6. Additional Information:

   _____
   _____
   _____
   _____

Lesson 4: Respiratory System

Introduction

Overview

In this session, students will overview the respiratory system and make models of the lungs. The effects of smoking on the lungs are discussed and the students are asked to model a variety of lung diseases associated with smoking, like lung cancer or emphysema. The students will also measure respiratory and heart rates.

Note: This lesson was adapted from SEEK: Science Exploration Excitement & Knowledge by Children's Hospital & Research Center Oakland.

Student Outcomes

Students will:

- Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. (MS-LS1-3)
- Develop a model to describe unobservable mechanisms. (MS-LS1-7)
- Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1)

Suggested Time

2 60 minute sessions

Advance Preparation

It is best to cut the bottoms of the bottles before passing them out to the students.

Materials

Lung Modeling

For each student:

- 1 Plastic Bottles
- 2 Straws
- 2 Ballons
- Clay
- 3 Rubber Bands
- Plastic Wrap
- Scissors
- Lung Modeling Worksheet

For Lung Disease Modeling

- Scissors
- Pipe Cleaner
- Balls of paper

Respiratory Rate Activity

For each student:

- Respiratory Rate Worksheet

For each group of students:

- Stethoscope

- Timer
- Worksheet

Teaching Sequence

Getting Started

1. Introduce today's symptoms: chest pain, and shortness of breath. Have the students look over the Disease Symptom Worksheet to find diseases that match our patient's symptoms thus far. Discuss what body system would be affected by these symptoms.
2. Give a short lecture on the respiratory system. Discuss the functions of respiratory system and how gas exchange occurs. Describe the interconnection between the circulatory system and the respiratory system.

Exploring

3. Tell students they will be building a lung model. Ask them to think about what happens when they breathe in and out. What muscles are they using? When do the lungs expand? Contract? Why does this happen?

4. Build the lung model. Pass out the supplies to the student. Each student will make their own model. Step by step as a class, go over the model building instructions.

Instructions: 1. Cut off the bottom of the 2-liter bottle.
2. Use a rubber band to attach the first balloon to one of the straws. Do the same thing with the second balloon and the other straw.
3. Place the balloon-attached straws inside the bottle where the open ends of the straws are at the side of the bottle neck.
4. Make sure that the open ends of the straws are above the rim of the bottle and then insert clay around the neck of the bottle so that no air can go inside except going through the straws.
5. Cover the cut end of the bottle with a piece of plastic wrap paper. Seal the wrap paper and the bottle using a rubber band.
6. Pull the wrap paper a little bit and attach a binder clip.

5. Once the model is complete, demonstrate how it works. Discuss with the class what the various parts of the model represent, and how it mimics how our own lungs work. Allow the students time to explore their models.

6. After students have explored their models, ask students if they know of any diseases that can affect the lungs. **Tell them they will be modeling three lung diseases; asthma, emphysema, and lung cancer.** Overview the diseases with the class and discuss how they are associated with smoking.

7. **Assign one lung disease to each student**. Describe to them how to model each disease. **Asthma:** Wrap a pipe cleaner around the balloon lung to represent muscles tightening around the airways in asthma.
Emphysema: Cut holes in the balloon lung to show how emphysema enlarges and distorts the alveoli leaving large air pockets in the lungs
Lung Cancer: Stuff a small ball or foil or paper into the balloon lung to represent a tumor growing in the lung
Note: For students modeling emphysema and lung cancer, encourage them to make an "extra lung" so that they will be able to have an intact working model at the end of the lesson.

8. Once students are done modeling their disease, ask for a few volunteers to show their models. Ask students to describe how the "disease" affects their models ability to work properly.

Discussing

9. Now that the students have a better understanding of the respiratory system, re-introduce the patient's symptoms of chest pain and shortness of breath. **Ask students if they know of any ways to diagnosis lung diseases.** Do they know of anyways to visualize the lungs?

10. Students will hopefully mention a few techniques, such as MRI, CAT scan and X-ray. **Tell the students we have x-rays of our patient's lungs.** Describe how x-rays work and how doctor's read x-rays. Show the students the x-ray of the patient's lung, as well as an x-ray of someone who has lung cancer and emphysema.

11. Have the student's compare the patient's x-ray to that of a patient with lung cancer (one of the possible diseases). Students should find this difficult, and will most likely be un-certain if the patient has lung cancer or not. Tell students that the next symptom and test will help them determine which disease the patient has.

12. Tell students another way that doctors examine the lungs is by using a stethoscope. Divide the students into groups of two or three (depending on how many stethoscopes you have). Demonstrate how to use the stethoscopes.

13. Pass out the stethoscopes and describe the breathing rate activity the students will do. Allow students ~20 minutes to do the activity. Be sure they record their data on their worksheets.
Here are the instructions:

Stethoscope Practice

Place the stethoscope on your partners back and listen to the breath sounds. Write a brief description of the sounds you hear during each of the 3 trials.

1. REST: listen while partner is resting for 1 minute
2. WALKING: listen immediately after partner is finished walking for 1 minute
3. JOGGING: listen immediately after partner is finished jogging for 1 minute

Measuring Breathing Rate

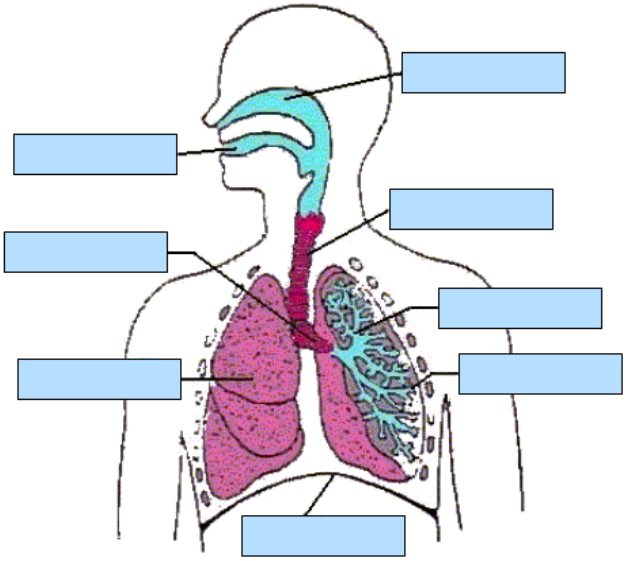
Breather: All students sit quietly (lie down if possible) with hands placed over their stomachs or chests.
WATCHERS: The watchers must watch their partners and count the breaths taken in one minute (count ONE breath for every time the stomach or chest rises). After the 60 seconds, watchers tell the breathers how many breaths were counted.

Next, do the following activities for 60 seconds before recording breathing rates as described above.
Walking
Jogging
Jumping Jacks

14. Once students have completed their recordings, have them share their findings.

DAY 4 - Lung Modeling Worksheet

Lung Diagram: Label the following parts: alveoli, trachea, bronchi, bronchioles, diaphragm, lung, mouth, and nasal passage. Now draw and label your Lung Model.



1. Describe what happens when you inhale (when you pull down on the bottom balloon in your model).

_____

_____

_____

2. Describe what happens when you exhale (when you push up on the bottom balloon in your model).

_____

_____

_____

3. Which Lung disease did you model? _____

4. What did you use to model it? _____

_____

Day 4- Respiratory Rate Worksheet

Stethoscope Practice

Place the stethoscope on your partners back and listen to the breath sounds. Write a brief description of the sounds you hear during each of the 3 trials.

1. REST: listen while partner is resting for 1 minute

Description:_____

_____

2. WALKING: listen immediately after partner is finished walking for 1 minute

Description:_____

_____

3. JOGGING : listen immediately after partner is finished jogging for 1 minute

Description:_____

_____

4. Explain what caused the changes the changes in breathing that you heard.

_____

_____

Measuring Breathing Rate

Breather: All students sit quietly (lie down if possible) with hands placed over their stomachs or chests.

WATCHERS: The watchers must watch their partners and count the breaths taken in one minute (count ONE breath for every time the stomach or chest rises). After the 60 seconds, watchers tell the breathers how many breaths were counted.

Resting Breathing Rate: _____

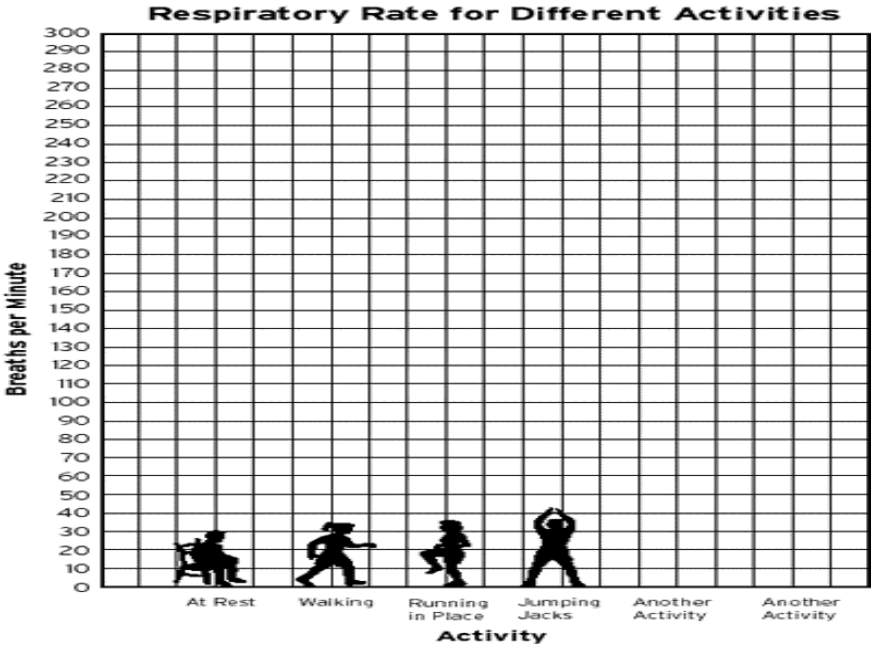
Next, do the following activities for 60 seconds before recording breathing rates as described above.

Walking: _____

Jogging: _____

Jumping Jacks: _____

Activity of your Choice_____: _____



QUESTIONS:
In which case did you breathe more? Why?

Would there be a difference in your respiration rate if you checked it when you were sleeping and then again if you were walking?

Why can't we hold our breath for 5 minutes?

Day 5: Genetics

Introduction

Overview

In this lesson, students will be introduced to the final symptom of the patient, a genetic link. They will learn to use a micropipette and will run a gel. They will learn about basic genetics and will fill out Punnett squares.

Note: This lesson was adapted from Mystery of the Crooked Cell by Donald A. DeRosa and B. Leslie Wolfe

Student Outcomes

Students will:

- 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. (MS-LS3-1)

Suggested Time

2 60 minute sessions

Advance Preparation

You will need to prepare the gel before the class.

Instructions:

First prepare the gel beds:

1. Close of the open ends of a clean and dry gel bed (casting tray) by using rubber dams or tape.

A. Using Rubber dams:

- Place a rubber dam on each end of the bed. Make sure the rubber dam fits firmly in contact with the sides and bottom of the bed.

B. Taping with labeling or masking tape:

- With ¾ inch wide tape, extend the tape over the sides and bottom edge of the bed.
- Fold the extended edges of the tape back onto the sides and bottom. Press contact points firmly to form a good seal.

2. Place a well-former template (comb) into 1 end of the gel bed. Make sure the comb is in the bed.

Preparing the agarose:

1. Use a 250 ml flask to prepare the gel solution. Add the following components to the flask as specified for your experiment (refer to Table A).

- Buffer concentrate
- Distilled water
- Agarose powder

Table A Individual 0.8% UltraSpec- Agarose Gel				
Size of Casting Tray (cm)	Amt of Agarose (g)	Concentrated Buffer (50x) (ml)	Distilled water (ml)	Total Volume (ml)
7x7	0.24	0.6	29.4	30
7x15	0.48	1.2	58.8	60

2. Swirl the mixture to disperse clumps of agarose powder.
3. With a marking pen, indicate the level of the solution volume on the outside of the flask.
4. Heat the mixture to dissolve the agarose powder. The final solution should appear clear (like water) without any undissolved particles.

A. Microwave method:

- Cover the flask with plastic wrap to minimize evaporation.
- Heat the mixture on High for 1 minute
- Swirl the mixture and heat on High in bursts of 25 seconds until all the agarose is completely dissolved.

B. Hot plate method:

- Cover the flask with aluminum foil to prevent excess evaporation.
- Heat the mixture to boiling over a burner with occasional swirling. Boil until all the agarose is completely dissolved.

5. Cool the agarose solution to 55C with careful swirling to promote even dissipation of heat. If detectable evaporation has occurred, add distilled water to bring the solution up to the original volume as marked on the flask.
6. Seal the interface of the gel bed and tape to prevent the agarose solution from leaking.

- Use a transfer pipette to deposit a small amount of cooled agarose to both inside ends of the bed.
- Wait approximately 1 minute for the agarose to solidify.

7. Pour the cooled agarose solution into the bed. Make sure the bed is on a level surface.
8. Allow the gel to completely solidify. It will become firm and cool to the touch after approximately 20 minutes.

Materials

For each student

- Colored water (in eppendorf tube)
- Plastic dish
- Gels and Genetics Worksheets

For each group of students:

- Micropipette: E20
- Micropipette tips
- Prepared gel/buffer
- Prepared Kit- http://www.edvotek.com/S-53
- Gel Electrophoresis box
- Weigh Boat

Optional: DNA modeling activity
Materials

- Gumdrops of four different colors: red, orange, green, yellow
- Licorice sticks
- Toothpicks
- Schematic picture of a nucleotide, identifying the base, phosphate, and sugar portions of the molecule

Teaching Sequence

Getting Started

1. Introduce the final symptom of the patient: a Genetic Link. Ask students to think about what this means.

2. Give an overview of genetics. Discuss concepts of inheritance, genes, dominant vs. recessive, Punnett Squares, mutation, and genetic disorders. Have students complete a fill in the blank diagram of the cell/DNA/etc. to assess their understanding of the topic.
OPTIONAL: DNA modeling activity (see below)

3. Once students have an understanding of genetics, introduce the diagnostic methods for testing for genetic diseases. Tell students they will be running a gel to determine if our patient has sickle cell anemia. Use this website to demonstrate to students how gel electrophoresis works: http://learn.genetics.utah.edu/content/labs/gel/

4. Before students can load the gel, they will need to practice using the micropipettes. Pass out the micropipettes, colored water and plastic dish for the students to practice with. Demonstrate how to use the micropipettes and then allow the students to practice using them. NOTE: If you do not have access to micropipettes, the kit comes with disposable microtipped transfer pipettes.

Exploring

5. Once students have mastered the micropipettes, you can lead them in the loading of the gel. Explain to the students that we are running a Normal Hemoglobin control, a Sickle Hemoglobin control, Carrier Hemoglobin control, Patient #1 and Patient #2. Students should work in groups of 2-3, and each student should load at least 1 well. The kit from Edvotek contains enough samples for 10 gels.
NOTE: The "patient" samples from this kit do not include a patient with sickle cell anemia, only sickle cell trait. To have the patient exhibit sickle cell anemia in the gel you will need to go against the well labels suggested in the kit. Do this by labeling the Sickle Hemoglobin control as the patient and having the students deduce from the normal hemoglobin and carrier hemoglobin band positions to what the sickle hemoglobin position would be on the gel.

6. Once the gel is loaded, allow 20-30 minutes for it to run. During this time, go into greater detail about sickle cell anemia. Show students this six-minute video entitled "Sickle Cell Anemia: A Patient's Journey" about a 17-year-old girl named Alexandria (https://www.youtube.com/watch?v=2CsgXHdWqVs&feature=plcp). Explain the genetics behind the disease and have students complete Punnett Squares.

Discussing

7. Once enough time has passed, read the gels. Students will be able to give our patient his diagnosis: Sickle Cell Anemia. Discuss possible treatments

8. Wrap up the unit with a discussion of what student's learned, what they found most interesting, and what they want to discover more about.

OPTIONAL DNA Modeling Activity:
Teaching Sequence
1. Divide the class into groups of three or four students. Give each group a copy of the nucleotide schematic and the licorice, toothpicks, and gumdrops. Tell each group to study the picture, making note of the following:

- the parts of a nucleotide
- that a DNA molecule is made up of thousands and thousands of nucleotides
- how bases pair up: adenine with thymine (AT, TA), and guanine with cytosine (CG, GC)

2. Tell students that they are going to build models of the DNA molecule, each five nucleotides long, using the materials you have given them. In other words, they're building the equivalent of genes. Remind students that, while the order of nucleotides could be critically important in a real gene, they should not be concerned about the order of their nucleotides, as long as the bases are paired correctly (see above). Write the following key on the board. Ask students to refer to the key when constructing their models.

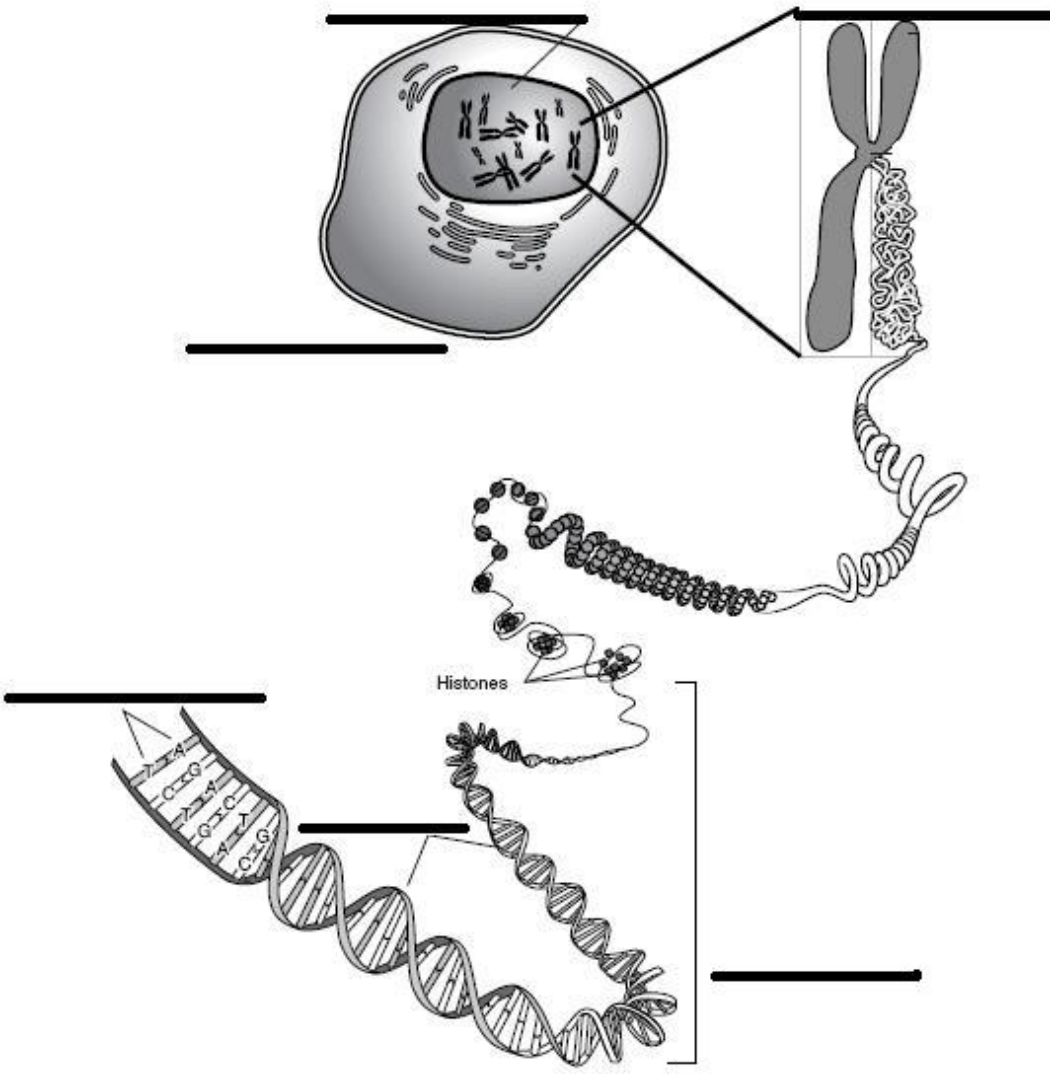
Key

- **Licorice** = phosphate "backbone" of the DNA molecule
- **Short sections of toothpicks** = sugar that connects the phosphate to the base
- **Gumdrops** = bases (red = A; orange = T; green = C; yellow = G

3. Have the groups begin producing their models, as follows: Each model should consist of two strands of licorice, with five gumdrops attached to each strand. Tell students to use short sections of toothpick to attach the gumdrops to the strands at equal intervals. Because each color gumdrop represents a different base, the gumdrops on one strand must correspond to the appropriate gumdrops on the opposite strand. For example, a red gumdrop always pairs with an orange gumdrop, while a green gumdrop always pairs with a yellow gumdrop. Instruct students to attach the gumdrop base pairs with pieces of toothpick. The resulting model can be handled carefully without it falling apart.

4. Have students write down the base pairs of their model molecules. Each group will probably have a different sequence of base pairs for each molecule.

Day 5- Genetics Word Match Activity



Word Bank:

- **base pair**
- **cell**
- **chromosome**
- **DNA (Deoxyribonucleic Acid)**
- **double helix**
- **genes**
- **nucleus**

Day 5- Gel Electrophoresis Worksheet

1. What is the function of the agarose gel?

2. Predict what would happen if you put the agarose gel at the opposite pole?

3. Describe what is occurring in the gel when the electric current is applied.

4. What must you be careful of when loading the samples into the wells?

Data/Observation Sheet

Use the diagram below to:

- Record the results of the electrophoresis (sketch the results)

1

2

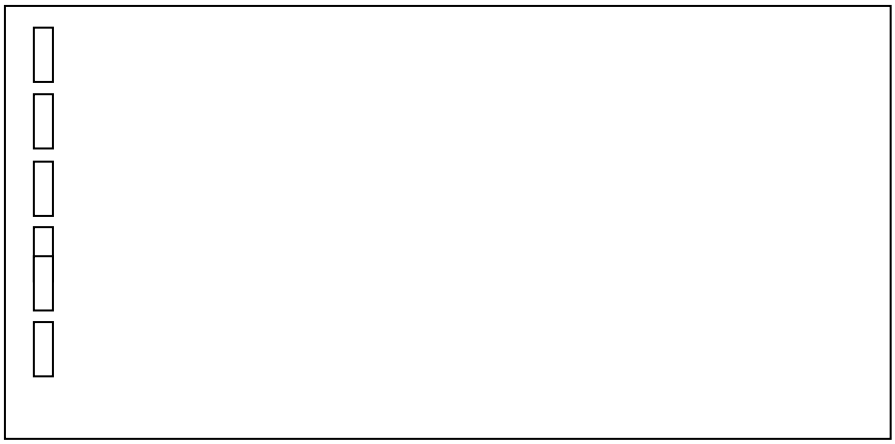
3

4

5

6

(-) (+)



Lane	Label	Sample
1	A	Normal Hemoglobin control
2	B	Sickle Hemoglobin control
3	C	Carrier Hemoglobin control
4	D	Patient #1 Hemoglobin
5	E	Patient #2 Hemoglobin

Conclusion

1. What is the purpose of sample A (normal hemoglobin)?

2. What do your results tell you about the hemoglobin in Patient #1? Patient #2?

3. How would you explain the test results to the patient? Assume the patient does not know how the test works.

Day 5- Genetics of Sickle Cell Anemia Worksheet

Suppose that a person who is heterozygous for the sickle cell allele (**Ss**) marries a person who is also heterozygous for this allele (**Ss**). Draw a Punnett Square to show the expected genetic makeup of their children, and then answer the following questions.

1. What fraction of their children will suffer from sickle cell anemia?

2. What fraction of their children will inherit the sickle cell allele, but will not suffer from sickle cell anemia? (These children will be resistant to malaria.)

3. The presence of Malaria in many countries has been eradicated and even in parts of Africa, the incidence of Malaria has been reduced substantially. Without endemic malaria from Africa, the sickle cell mutation is purely disadvantageous. What do you think will happen to the percentage of people carrying the Sickle Cell gene over time under the pressures of natural selection?

5. Complete the following genetic crosses. Show genotypes of parents, construct a Punnett square, and give the genotypic and phenotypic ratios of the offspring.
a. Normal male x carrier female
b. Sickle-cell male x normal female
c. Sickle-cell male and carrier female

