

Murder Mystery: An inquiry-based webquest

Created by Ashley Grapes

Grade: high school biology

Duration: 90 -120 minutes

Purpose:

Science requires problem solving, critical thinking, and well-roundedness in order to make connections between different fields. The following activity requires the student to develop these skills in an independent but scaffolded way through a web-based adventure. The activity focuses on a hypothetical murder that the student must solve as a forensic scientist using forensic entomology, blood typing, and DNA fingerprinting using PCR and gel electrophoresis. Students will learn the nature of these scientific disciplines, how to use a dichotomous key, how to calculate the time of death, how antigens and antibodies are used to classify and determine blood types, and how basic molecular biology techniques are used in science. Forensics is a great example of an integrative field that helps develop scientific skills and an understanding of the nature of Science.

The student must use the suspect information to eliminate suspects as they go until the murderer is identified. This guided worksheet takes the students on an interactive journey doing field work and lab work to solve the murder. It requires learning different techniques and using the information to solve problems.

SOL's:

- BIO.1 The student will plan and conduct investigations in which observations of living organisms are recorded in the lab and in the field; hypotheses are formulated based on direct observations and information from scientific literature; conclusions are formed based on recorded quantitative and qualitative data; appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results; research utilizes scientific literature; a scientific viewpoint is constructed and defended (the nature of science).
- BIO.6 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include genetic variation (mutation, recombination, deletions, additions to DNA); the structure, function, and replication of nucleic acids (DNA and RNA); exploration of the impact of DNA technologies.
- BIO.7 The student will investigate and understand bases for modern classification systems. Key concepts include, comparison of developmental stages in different organisms; systems of classification that are adaptable to new scientific discoveries.

NSES Standards:

Systems, order, and organization, evidence, models, and explanation, an appreciation of "how we know" what we know in science, understanding of the nature of science, skills necessary to become independent inquirers about the natural world, the dispositions to use the skills, abilities, and attitudes associated with science, understanding about science and technology, characteristics of organisms, life cycles of organisms, organisms and environments, science as a human endeavor,

Murder Mystery! An inquiry-based webquest

Created by Ashley Grapes

You are a forensic scientist who has been called to a murder scene in your local town. A housemaid found the body of her employer, a famous local artist named Philippine Fernando, behind the estate's pool house at 9:00pm when she was leaving work. Stab wound to the abdomen. Ouch. You collect your evidence and take it back to the lab for storage and analysis. First, you would like to shorten your suspect list, and after much interviewing and questioning, you have narrowed it down to 12 suspects. You take their official statement, fingerprints, and a blood sample for lab testing.

Two nights before, the artist held an all-day invitation-only gala show/party complete with outdoor canopy tents, a string quartet, and a catering service. Using the evidence you find at the scene of the crime, you will determine the murderer from a list of suspects. Build up your evidence to support your case against whom you choose. With your help, this criminal will be in prison for life once you testify in court!

Follow this itinerary in exact order and print off the Evident Report (last 2 pages) to record on. Certain websites may require flashplayer downloads or Internet Explorer as your browser but don't give up if a plugin isn't working! All laboratory work is tedious at times! Your hard work will end up saving lives! Fill in the "Evidence Report" sheet as you go through the lab. The itinerary will guide you on where you should be on the worksheet based on the questions you can answer as you go. Additional research may be required to answer some of the questions. Understanding your findings is vital if you want to present a good case to the judge and jury of the trial!

A. Time of Death and Forensic Entomology

One of the first things you must do is take body temperature, ambient temperature, and collect the arthropods on the body for forensic entomologic analysis. Insects such as flies and beetles are highly predictable in their life cycles. Forensic entomologists can determine the time of death (TOD) down to the hour depending on the species on the body and the life stage they are in. Collect the insects from the body here and get a feel for the art of murder maggots!

Activity 1 (Questions 1 and 2)

<http://www.pbs.org/wnet/nature/episodes/crime-scene-creatures/interactive-determine-the-time-of-death/4390/>

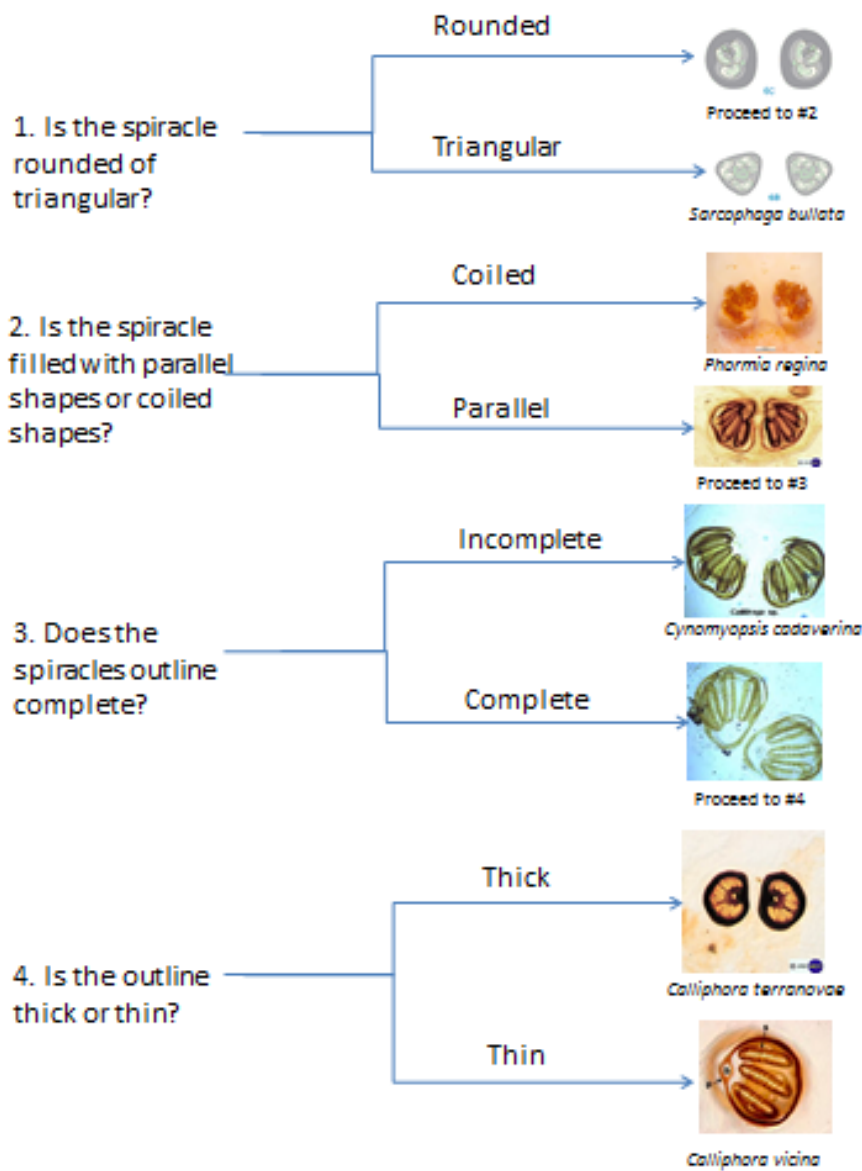
Arthropods are the largest phylum of organisms. Scientists must use classification systems to help them correctly identify the species and development stage. The dichotomous key is a very popular classification system in which you have two choices at a time. Practice using a dichotomous key here and choose this organism to identify:

Activity 2 (Questions 3 and 4)

<http://dnr.wi.gov/org/caer/ce/eek/critter/watercritter/aquatict.htm>



You found a 1st instar maggot of some fly species you do not recognize. To classify fly larvae, or maggots, you must look at their butt under a microscope! On their backend are structures known as spiracles that they use for breathing. Each fly species' spiracles are unique! Use the following dichotomous key to identify the 1st instar maggots you have found



The spiracles of a 1st instar maggot obtained from the body

After you have identified your species, determine the approximate time of death using the following chart

http://www.brazoria-county.com/sheriff/id/bugs/blowfly_lifecycle.htm

Remember, Philippine's body was found by the house maid at 9:00pm the next day. Based on records from the vandelay service, you know when each person arrived to the party and left the party. Look at the records to determine which suspects were at the party during his Time of Death.

B. DNA Blood Typing

You've narrowed your list of suspects, but not enough! You must do more lab testing. Blood can make or break a case! First you decide to blood type the sample using the ABO system since it's fast and easy! You can get results in less than a minute! Learn about how blood typing is done in this video:

Activity 3

<http://www.youtube.com/watch?v=CduLOqZb XQ>

Here is some further supplementary material. An Rh factor is the + or - in a person's blood type. They either have the Rh antigen, or they don't.

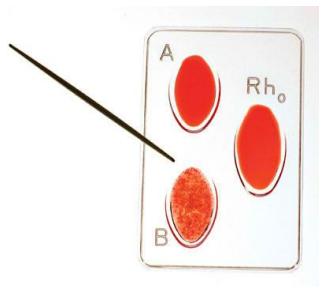
(Question 4)

<http://nobelprize.org/educational/medicine/landsteiner/readmore.html>

All of a sudden calls start flying in from the hospital down the street. There has been a mass train wreck and their hospital labs are completely full trying to blood type patients. Time to practice your blood typing skills!

Activity 4 (Question 5)

<http://nobelprize.org/educational/medicine/landsteiner/landsteiner.html>



Now that you are the bomb at blood typing, you pull out your blood typing kit and use the proper procedure to identify the blood from the scene of the crime. Coagulation looks like white "spider webs" in the well.

Here were your results

C. DNA Fingerprinting: PCR and Gel Electrophoresis

You have narrowed down your suspects but you have not pinpointed one yet. You are disappointed you have to run the tedious lab tests of PCR and gel electrophoresis to identify your suspect. You know this is the strongest evidence you could possibly present in court, though, because DNA cannot lie; it is unique to everyone! Concrete evidence here we come!

PCR:

The Polymerase Chain Reaction (PCR) has revolutionized the field of molecular biology, and to understand its mechanism is vital in genetic work. In forensics, especially, it is extremely useful in putting away the bad guys because everyone has their own unique sequences. Scientists know where these most variable regions in our genome are (thanks to the Human Genome Project!) and use DNA fingerprinting with extreme accuracy. To get to this point though, you must do PCR and run a gel electrophoresis. The following 5 minute video is a comprehensive enough overview of PCR.

Activity 5 (Question 6)

<http://www.youtube.com/watch?v=YgXcJ4n-kQ>

You still have plenty of blood from the crime scene left; it was a stab wound after all. Now that you are familiar with how PCR works, go to the next website and amplify your DNA so you have lots to work with!

Activity 6 (Question 7)

<http://learn.genetics.utah.edu/content/labs/pcr/>

Gel Electrophoresis:

Now that you have amplified your DNA you must use restriction enzymes to cut it in unique places. The first 30 seconds of this video shows a common restriction enzyme, EcoI, cutting the DNA like scissors when it reads a very specific sequence.

Activity 7

<http://www.youtube.com/watch?v=8rXizmLjegl>

You use a restriction enzyme that cuts the DNA whenever it comes to the sequence 5'-ATG-3'. Why do we want to cut the DNA, you ask? Since everyone has a unique DNA sequence, the places where the "cuts" happen will be different for everyone. Scientists can then separate the DNA according to length. They do this by using electricity!

Practice making a gel here!

Activity 8 (Question 8 and 9)

<http://learn.genetics.utah.edu/content/labs/gel/>

Ok, practice makes perfect and perfect is needed in a genetics lab! Go to the following website to run your DNA from the crime scene. Use the "who-done-it" at the end to practice.

Activity 9

<http://www.pbs.org/wgbh/nova/sheppard/analyze.html>



You have a restriction enzyme that cuts between the A and the T in the sequence 5'-ATG-3'. You prepare your electrophoresis gel and after looking at it under florescent lighting you get the following two bands.

Based on what you have learned about DNA fingerprinting, you should be able to pinpoint who the murderer is by examining the suspects DNA sequences and comparing it to the scene of the crime DNA.

Congratulations! You helped solve a fake murder!

Name: _____

Class Time: _____

Evidence Report

Suspect's information

Suspect	DNA Sequence 5' to 3'	Blood Type	Times at Gala Event
Mr. Green	CGTAATGCTAGAGGATGCCGTAAT	A-	3pm- 6:00pm
Mrs. White	CCTAAAGTACGATGACATTTACGGT	B-	6pm- 9:30pm
Mrs. Peacock	ACTCTAGACGAGTCTCTAGGGAAC	A-	8pm- 3:00am
Colonel Mustard	GGTATCTGAGTATGCTATTATGTACA	B-	9pm- 12:30am
Professor Plum	AATTCGGCATAACGGACCTTACAGTAC	B+	8:pm- 10:30pm
Ms. Scarlett	GTCATCATGTACAGTCTAGCTTATAC	B+	4pm- 8:00pm
Carmon San Diego	GTATGTGACACTATGTAAGTAGACTT	B-	5pm-9:00pm
Where's Waldo	TTAGACGATCGATATTCGGATAAAAAT	O+	4:30- 9:00pm
Bill Nye	TGCCTCATCTACATGTAGCTATCGATG	AB-	8am- 12pm
Ms. Frizzle	CGAGATCGATCGGATGTATACGGATA	A+	11am-5pm
Spongebob	TAGAGTCGATCGGCATTCGAGTDDAT	A-	7pm-10pm
Dora	GTCATGATGTCACCATACTAGCTTTCA	B-	6pm-12am

Complied Evidence Summary

Lab Test	Remaining Suspect(s)
Time of Death: Forensic Entomology	
Blood Typing	
DNA Fingerprinting	

A. Forensic Entomology; Arthropod Identification & TOD

- From activity 1, which insects from the body did you choose and didn't you choose? Why?
- Name at least five factors that could cause the almost perfectly predictable insect succession on a decomposing body to fluctuate. What do scientists have to involve in their calculations of TOD?
- From activity 2, what was the organism you were meant to identify? If this arthropod was found on a decomposing body, in what type of environment would it be in?

B. Blood Typing

4. Draw a red blood cell that is AB- and a red blood cell that is O+. Could these two individuals (with AB- and O+) blood types give each other a blood transfusion? Why or why not.
5. When you use your blood typing kit, it looks like your B well is coagulated. Did you place anti-A antigens or anti-B antigens in this well to produce this reaction? Explain your answer.

C. DNA Fingerprinting; PCR and Gel Electrophoresis

6. A DNA polymerase called taq polymerase is a special enzyme that makes PCR possible. Research where taq polymerase comes from naturally in the environment. What special characteristic does it have that other polymerases don't have? Why is this characteristic important to the process of PCR?
7. A PCR cycle lasts about 20 minutes and it runs for about 4 hours. If you started off with one copy of a desired sequence at time/generation 0, how many copies would be left after 4 hours? What is the formula to calculate this?
8. Does it matter which end the positive and negative poles are in the electric current? Why or why not?
9. When you make your agarose gel for gel electrophoresis, you may change the concentration of agarose from 2% to 16%. If you had a restriction enzyme that recognized a 4 base pair (bp) sequence and another one that recognized a 6bp sequence, how would you modify your agarose concentration? Why?