DNA & Bioinformatics

Fringe Lab - Dr. Trinity Hamilton

OVERVIEW & PURPOSE

Introduce students to DNA extraction and bioinformatics and the role they play in guiding environmental research. In this lesson, students will extract DNA from a known object, use computer science to determine the species present in an unknown environmental DNA sample, and hypothesis what DNA of microorganisms might be able to teach us.

EDUCATION STANDARDS

These activities will align with the Life Science 3 standards - Inheritance and Variation of Traits, specifically variation of traits, for all grade levels.

OBJECTIVES

1. I CAN… extract DNA from wheat germ.
2. I CAN… summarize how computer science helps us decode or figure out what organisms are in an unknown DNA sample.
3. I CAN… compare and contrast DNA from microorganisms in different environments
4. I CAN… hypothesize relationships between the conditions present in a given environment and the microorganisms that may live there.

QUESTIONS

How is our genetic material stored?

What tools can we use to access our genetic information?

What is the relationship between an organism’s genetic makeup and its environment?

MATERIALS NEEDED

Activity One - DNA Extraction

1. Market Science Kit* Including (click here to see visuals of each item in the kit)
    a. 2 grams of wheat germ
    b. 10 mL of rubbing alcohol
    c. 2 mL dish soap
    d. 50mL centrifuge tube
    e. 3mL transfer pipette
    f. Wooden stick
2. 20 mL warm water
3. 2 Empty Cups

*Each kit has enough for one DNA extraction.

Activity Two - Bioinformatics (beginner)

1. Market Science Kit Including
    a. Envelope with "DNA" strands
    b. Decoding Sheet
2. Clear Tape

Activity Two - Bioinformatics (intermediate)

1. Internet accessible device *(we recommend a computer)*

Activity Two - Bioinformatics (expert)

1. Internet accessible device *(we recommend a computer)*

ACTIVITIES

Activity 1 - DNA Extraction
Prepare:
Go online to The Fringe Lab website to the "DNA Extraction Activity" . Here you will find a video tutorial for the procedure as well as a downloadable/written version.

Explore:
If your student is new to the ideas of DNA and genetics/heredity, have them watch the quick introduction video titled "What is DNA & Why do we use it?" (this a nice refresher even if your student is familiar and you can learn more about the Fringe lab!)

Then, have your student(s) set out all the materials from the Market Science Kit on a table surface. Review the picture instructions and encourage your student(s) to hypothesize what each ingredient is going to do in the extraction process. Here are a few example questions.

- "What do you think the soap will do to the wheat germ?"
- "What do we use soap for? How could that impact the wheat germ"
- "How did you come up with that idea?"
  (this last question helps get a deeper sense of student's thought process)

Explain:
Have your student(s) watch the tutorial video "How to extract DNA". In this video, Anna Bennett, a graduate student in the Fringe lab, explains how each step leads to the final extracted DNA.

Assess what your student(s) learned from the tutorial. Ask your student(s) to revisit their hypotheses on what the different materials will do. You could have this conversation during the extraction process as well while adding specific items to the test tube. Additionally, there is space for your student(s) to demonstrate their understanding of the DNA extraction process through illustration or text.

Extract:

1. Lay out all the supplies from the Market Science kit.

2. Put the bottle labeled "rubbing alcohol" in the freeze or in a bowl of ice.

3. Remove the cap from the 50mL test tube and set the tube inside an empty cup.
   The empty cup is meant to act as a stand for the test tube. Set the cap aside.

4. Add ~1gram of wheat germ to the empty tube.
   1 gram is equivalent to ~0.5 tsp

5. Turn on the tap to hot water and wait for the water to warm up. When warm fill the second glass half full.
   You want the water to be hot ~120F or 50C. Most tap water on hot is 120F

6. Add 20mL of hot water to the test tube with the wheat germ using the transfer pipette.

There is some math involved since we've given you 3mL pipettes. Depending on the age of your student(s) you could encourage them to work out how many full pipettes they'll need and what the remainder will be.

7. Close the test tube with the cap and shake it for 3 minutes.
   We decided since you have 3 minutes you might want to listen to some music. We each provided our favorite songs to dance to if you want to check one of them out HERE!

8. Open the test tube and place it back inside the empty cup.

9. Add 1mL of dish soap using the transfer pipette

10. Gently shake the test tube for 2 more minutes.
    You don't want to create too much foam, so gently rock the test tube side to side

11. Remove soap foam from the test tube using the transfer pipette

12. Remove the rubbing alcohol from the freezer.

13. Add 10mL of rubbing alcohol to the test tube
    IMPORTANT - You want the alcohol to float on top of the mixture. It is easiest to add the alcohol by squirting it out SLOWLY along the side of the tube so that it runs down on top of the mixture.

14. Collect the white precipitate that forms where the alcohol meets the water/soap mixture with the wooden stick.

15. Give yourself a round of applause because you've extracted DNA!

16. Take a picture of your extracted DNA and share it with all your friends! Don't forget to share it with us too @TheFringeLab and @MarketScience or use #FringeLab and #MarketScience. We can't wait to see how you did!!

    Market Science is on Facebook and Instagram & The Fringe Lab is on Twitter and Instagram

Extension:
Don't let the DNA extractions end! Most of the ingredients provided are common household items and DNA extraction following this method can be used for a lot of other foods. A couple common examples are kiwi, strawberries, onions and spinach. If you try one of these, be sure to grind down or smush the food before beginning the extraction, and run the pureed mixture through a coffee filter before adding the rubbing alcohol.

Encourage your student to start a record log of the foods/items they try to extract DNA answering questions like: Were they successful? How were the extractions different from the wheat germ? What might be preventing an extraction in one food compared to another?

If you do extract additional DNA we'd love to see how it goes! You can share it with us by posting to social media using the hashtags #FringeLab or #MarketScience or tag us directly with @MarketScience and @TheFringeLab

Activity 2 - Bioinformatics (ages 7-11)

Prepare:

Open the envelope from the Market Science kit and lay out the paper slips on to a flat surface and set the die aside.

Explore:

Have your student(s) read a short piece on bioinformatics and interpreting DNA sequences. Here we discuss how computers and technology read DNA and use that information to assign traits and names of organisms to the strings of bases.

Explain:

Let your student(s) know they are taking on the role of the computer program in this activity. They will start with a series of unknown DNA sequences. Each slip of paper represents a forward read of DNA starting at the beginning of a DNA strand and working to the end and a reverse read of DNA starting at the end of a DNA strand and working to the beginning. Students will assemble the full DNA by finding the slips that have overlapping/matching middles. Finally, they will use a decoder to identify what organisms the DNA belongs to and hypothesis a place where they all might live together. We've created a narrated presentation, with answers, that you can use as you work through during the activity and there is a written answer key on the website.

Engage: *Information in italics is not said in the narrated presentation and is for your reference. These instructions are meant for you to help guide your student. Their instructions are separate.*

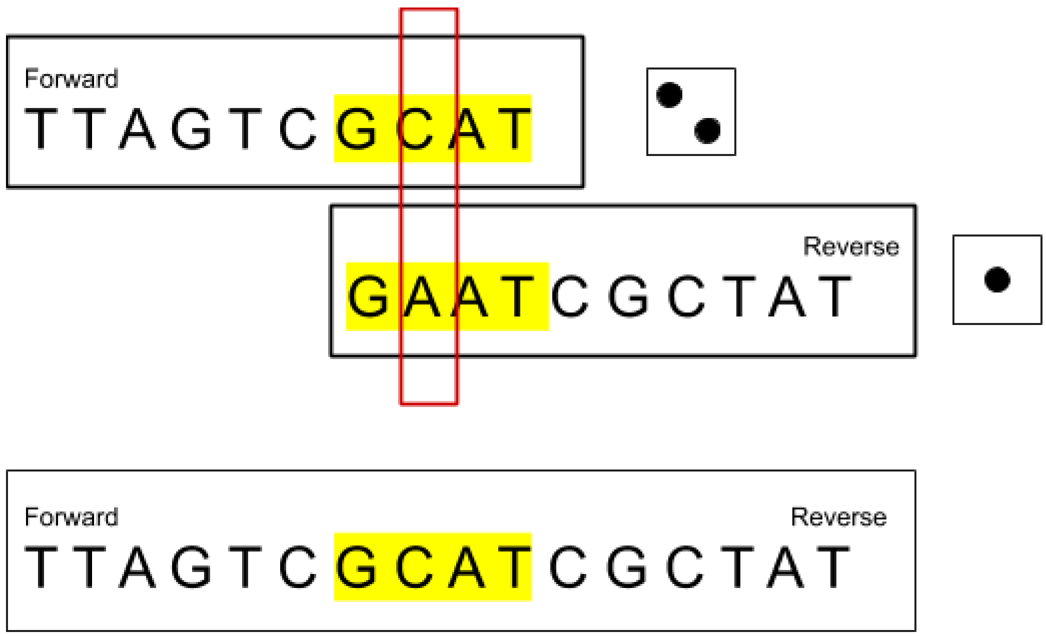
1. Begin by supplying your student with the follow-along bioinformatics worksheet and instruct them to find the forward and backward read of a single DNA sequence. Each strand has a four character overlap (highlighted in yellow) and you should have your student match the strands that have the most incommon.

   The slips that have yellow on the right side (last 4 letters) are the forward reads and the slips that have yellow on the left (first 4 letters) are the reverse reads.

Additionally, there are a few times where not all four letters will match perfectly. This is OKAY and we will discuss what to do about this next.

2. Explain to your student(s) that sequencing technology isn't perfect and sometimes there are mistakes. The mismatched letters in the highlighted areas on the DNA strands are examples of these mistakes. Luckily, the technology does tell us how confident it is by assigning a confidence number to the letter. Have your student(s) roll the die to assign a value 1-6 to two mismatched letters in the sequence. Then whichever is higher becomes the correct sequence.

3. Once you've determined the correct sequences tape the two pieces together overlapping the yellow section of one of the slips. In the cases of the mismatched DNA tape the higher confidence dice roll on top.



4. Explain that we've "cleaned up" the DNA from the sequencer and now we are ready to determine what the organism is. Using the decoder sheets, find the sequences that match your organisms. Have your student(s) write the name(s) of all the organisms they found in their sample.

5. Now that all DNA is classified, have your student(s) hypothesize a place where all the organisms in a sample might live. We have provided a place where they can illustrate and describe their hypothesis. Here are some other questions you could ask…

- *How did you decide on this environment?*
- *Can you think of a place in our home, neighborhood, city where we might find any of these organisms?*
- *What might happen to these organisms if temperatures/water levels/salt concentrations/pH increase or decrease?*