

The DNA Files:

Workshops and Activities



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Workshop #4: Genetics of Climate Change

TEACHER'S NOTE: Things that should be said are in *italics*; instructions are plain text.

Introduction

- *Today we're going to talk about how living things adapt to change, specifically, how we expect living things to adapt to the changing climate.*
- *First, we're going to talk about what changes are happening with our climate. Then we're going to talk about the different ways that living things adapt to those changes.*

ACTIVITY # 1

Climate Change (5 min)

Educational Goal: Introduce concept of climate change and explain why it's happening

- Have you heard the word climate before? What do you think of when you hear the word climate?
Take answers.
- *Climate is an average of weather patterns over a certain period of time. It's what you expect the weather to be like year after year, based on what the weather has been like in the past.*
- *Right now, the Earth's climate is changing. Why?*
- *Well, Earth is a planet, right? Just above the surface of Earth, all around the globe, there's a layer of gases that we all call "air." And there's no air out in space. You can think of this air as being like the clothes we wear – the clothes you have on right now keep you from being too cold in this room, right? That's because they trap your body heat. The same thing happens with the air around Earth. Some of the gases in the air trap the energy that comes to Earth from the sun, and keeps our planet from being too cold.*

Ask for a volunteer. Wrap the volunteer in the blanket.

- *Unfortunately, people are adding more of the gases that trap heat into the air around Earth. Which is kind of like wearing too many clothes, or, like the planet is now wearing a thicker blanket.*

Pause for a second and glance at the volunteer.

Ask the volunteer how they feel in there. If they don't offer, ask them if they feel warm.

- *As we change the air around Earth to trap more heat, it is becoming a hotter place to live.*
- *And that is going to affect all of the living things on the planet.*

ACTIVITY # 2

Match organisms to their generation time (10 min)

Educational Goal: Show that the speed of genetic adaptation is linked to generation time, population, and genetic diversity

- *Living things do not adapt equally fast to a change in the environment. Some things adapt faster, and some adapt more slowly. Some cannot adapt fast enough and go extinct. When we're talking about how fast living things adapt to a change in the environment, one really important thing to think about is generation time.*

Write generation time up on a whiteboard, blackboard, or flipchart.

- *Generation time is how long it takes for a living thing to get old enough to reproduce.*
- *We're going to do an experiment. The generation time of bears is about 20 times longer than the generation time of mice. That means that in the time it takes a bear to reproduce, about 20 generations of mice could have been born. There are two bowls at the end of the room; one we'll say is for mice and the other for bears. There are white stones in each, to represent the mice and bears.*
- *Now let's say both bears and mice live in the same general area, but it's getting hotter. Now, in both the bear and the mouse population, there were mutations for less fur, say. Lets represent the mouse mutation with a yellow stone and the bear mutation with a blue stone.*

Put a yellow stone in the mouse bowl and a blue stone in the bear bowl.

- *Now, if there's a mutation that helps you survive, it's more likely to get passed on. That's how natural selection works, remember? So here's what we're going to do.*

Explain what to do and demonstrate: take a colored stone from the large box or bag, go to the appropriate bowl –mice or bears - and place it in. Remove a white one, to represent that the colored version is more likely to reproduce. The population becomes slowly more yellow or blue.

Have them line up and start drawing colored stones and replacing white stones in the respective bowls. (Note for teacher: There should be 20 times more yellow stones in the box or bag than blue ones.)

Continue until the mouse bowl is all colored stones and then stop.

- *Which bowl changed the fastest?*

- *That's right, the mice – that's because they reproduce faster, and so natural selection works faster for them than for the bears. Remember the moths we talked about two sessions ago? Well, they have a really short generation time, and it only took 60 years for the entire moth population of that forest in England to change color.*

- *Generation time isn't the only factor in how fast evolution happens. It also matters how big your starting population is. If we started with just two bears, which plate would have won?*

If they would like to try the experiment, go ahead. Same setup as before, but just with two white bear-stones to start.

- *So, that time, the bears (came closer or won), right? But there were only two of them! So, this shows that sometimes, the smaller your population size is, the faster evolution across your population can happen.*

- *But, with a small population, the number of mutations might be lower to begin with. Your odds of getting a beneficial mutation – that first blue stone - go down. If there were no blue stone to begin with, what would happen?*

Take answers

- *That's right, the bears would never be able to evolve quickly, even if there's only two of them. Which is why it matters how many differences existed in the bears' DNA at the start. If the bears are too similar, and there aren't a lot of them, they're probably not going to adapt very fast.*

Review:

- *The speed at which a population of living things can evolve is based on generation time. A shorter generation time and a small population size means that evolution can change a population quickly. But, you have to start with some genetic differences, or else genetic adaptation goes slower.*

ACTIVITY # 3

Generations are felt (5-10 min)

Educational Goal: Illustrate the clear differences in generation times of some living things

Put up felt board.

- *Okay, so let's talk more about generation time. I've got some living things here and I need your help figuring out how long it takes them to reproduce. Let's see if we can put them in order.*

Go through felt cutouts (bacteria, mosquito, mouse, bear, human, sea turtle) one at a time, placing them on the board according to participant suggestions, along an axis from short to long generation time.

- *Do you want to see how we did?*

Put up the chart that has the actual generation time order on it and discuss briefly.

- *According to this, this means that bacteria and mosquitos reproduce really quickly. Humans reproduce much more slowly, sea turtles reproduce really slowly – they have a generation time of more than 20 years.*

- *As we saw with the moths, and with the mice versus bears, living things that have a shorter generation time will generally be able to evolve faster in response to changes in their environment, like a warmer climate.*

Review:

- *People have longer generation times and won't be able to adapt genetically as quickly as mosquitos or mice.*

ACTIVITY # 4

Mapping (10-12 min)

Educational Goal: To give real-world examples how much different living things depend on their locations and food sources for survival

- *Changes in the DNA in response to a change in the environment in called genetic adaptation, and as you saw, people are actually on the slow end of things. But there are other ways to adapt that don't involve a genetic change; lots of living things just change the way they act, what foods they eat, where they live, and can survive better.*

- *Can you think of any animals that live around you that eat a lot different things?*

Make list on flipchart, whiteboard or blackboard. (pigeons, rats, mice, squirrels, people are examples)

Either take a group of 10 volunteers or let students work in 10 groups of 2 or 3 for the next activity.

- *We've got this map here – and I'm passing out worksheets. Each worksheet is for a different living thing. Some, but not all, are animals like we were just talking about. Take the stickers for your animal and put them on the map where those living things live. If you need help finding a place, let me know and I will help you.*

Assist as they put the stickers on the map.

When they finish, put the map on display and ask questions like those that follow.

- *Which living things are in a lot of different places? What living things are only in one place? Which living things do you think would be able to spread out if the temperature got warmer? Which ones would be able to move to a different place if the place where they live got too hot? Which animals eat the most different kinds of foods? The ones that can live in many places and eat many foods are the most adaptable ones. Those are the living things that will be able to change most easily in response to climate change.*

ACTIVITY # 5

Prognosis (5 min)

Educational Goal: To reason out what the consequences of climate change could be for several different species, based on genetic and other adaptation

- *As the Earth's climate gets hotter, living things are under pressure to adapt. Some will be able to change by evolving, because their generation times are pretty short, and some will be able to change by changing their habits, food, or location. Some will probably be able to do both.*
- *Next, we're going to be fortune tellers and try and guess what the future holds for different species:*

Make chart on whiteboard, blackboard or flipchart. Use between 4-6 of the provided pictures to mark each row. Make columns for generation time (fill in short or long, or actual numbers from previous activity), and "other flexibility," Finally, make a column for "future?"

Through discussion, lead the class through each row of the chart and finally guess as to how each creature will do, with a "+" or "-". (Note to teacher: Question marks are okay in that last column. Known changes to the organisms so far because of climate change are as follows:)

mosquito – expanded range; this is a special mosquito that only bites humans and spreads malaria

mice – no big change yet

polar bear – endangered

giant panda – endangered (because of deforestation, mostly)

people – no big change for most yet

Norway spruce – no change yet; may be restricted to smaller area
mountain frog – endangered because breeding grounds in trouble
Baltimore oriole – doing fine, migration pattern shifting northward
Antarctic hairgrass – expanded range
emperor penguin – decreasing numbers because food source (krill) can't survive

Review: *There are two different ways that living things can adapt to change --- they can fundamentally change at the DNA level, and that depends on generation time, population size, and the kinds of genetic differences they already have. Or, they can adapt in other ways by changing the way they behave.*

Conclusion

As Earth becomes a warmer place to live, a lot of things are going to change. Some living things will be able to adapt better than others, and there are a lot of things we don't know at this point. An important thing to remember about genetic adaptation through natural selection is generation time. Shorter generations mean faster genetic adaptation. But there are other ways that living things, including people, can adapt, too, like moving around or eating different foods.

People are special in that we can also do other things to actually stop climate change from making the planet too much hotter. We just have to decide to do those things, and with your help, we can.