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The DNA Files:

Workshops and Activities

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Workshop #2: Evolution

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

Introduction

• Today we're going to talk about DNA and Evolution. Along the way, we're going to learn some new words that scientists use. So make sure to ask questions if you don't understand something.

ACTIVITY #1

What does information in DNA look like? (5 min)
Education Goal: Illustrate how genes and important regulatory regions are interspersed in our DNA and how we find them

• Last time we talked a lot about DNA, and we built models and even extracted some DNA, remember? Today we're going to talk about evolution. First, we're going to go hunting.

Have them flip over their worksheets and circle the 'instructions,' or normal sentences, among all the gibberish and repeating stuff. (Phrases derived from "Not a sentence." don't count.)

• This is exactly what scientists have done, gone through our DNA looking for the clear instructions buried in there.

• There are different kinds of instructions in DNA. How many of you have heard of a gene? (Show of hands.) Well, a gene is one kind of instruction for the cell. Each gene tells your cells how to make one specific thing.

• Remember our DNA models we built, that look like ladders? One gene usually takes up a couple hundred to several thousand rungs of the DNA ladder.

Write on the whiteboard, blackboard, or flipchart a headline: Instructions. Under that, write: "Genes = what to make."

• But if your genes tell your cells what to make, there are other important instructions in your DNA that tells your cells when to make those pieces, where in your body to make

those pieces, and how much to make.

Write underneath the part about genes: "Regulatory DNA = when, where, and how much."

• *The DNA code only uses an alphabet of four letters to store instructions. For our instruction hunt, though, we used the 26 letters of the English alphabet. We're doing that because English is easier for us to understand, but it's the same basic idea with the 4 letters of DNA.*

Review: *So we sifted through a whole bunch of text to find useful instructions --- that's just what scientists do, using computers, to pick out which parts of our DNA are important. Just like we recognize sentences in English, scientists can recognize genes and regulatory DNA in the 4-letter alphabet of DNA.*

A C T I V I T Y # 2

How does DNA change? (10 min)
Educational Goal: Introduce concept of mutation, and show how it affects DNA instructions.

• *DNA does not stay the same over time. Let's take one of those sentences we just found.*

Write on a chalkboard, whiteboard, or flipchart the sentence "Put on your gray shoes." Have a volunteer read the sentence out loud.

• *As your cells divide, they duplicate all the DNA they have inside them so that there are 2 copies, one for each cell. Sometimes, when they do this, the cells make mistakes, which changes the DNA. Those changes are called mutations.*

• *Lots of things can cause the DNA to mutate – sunlight can mutate the DNA in skin cells, for example. But only the mutations that happen in sperm and egg cells will get passed on to the next generation.*

• *What happens if we mutate this sentence? One thing that can happen is that one letter gets changed to another:*

Write "Put on your grey shoes." and have someone read it out loud.

• *Well, that was a pretty boring mutation, huh? It makes no difference whatsoever in the meaning of the sentence. So that's one kind of mutation.*

Write "Put on your tray shoes." and have someone read it out loud.

• *Now, that changes the meaning of this instruction, huh? You might say it doesn't make any sense now, or you might still be able to guess what you're supposed to do --- or you might figure out how to invent a whole new kind of shoe made of cafeteria trays or something. So that's another kind of mutation.*

• *Another thing that can happen is a letter or two gets deleted --- let's delete this "t" and* *watch what happens.*

Write "Puo ny ourb lues hoes." and have someone try to read that.

• *Wow, so that kind of mutation can really destroy the whole sentence, huh? But sometimes letters get added instead of deleted.*

Write "Put on your blue shoes and socks." and have someone read that.

• *This mutation didn't destroy the meaning in the instruction - it added meaning. These are just some examples of the kinds of mutations that can happen*

Review: *Mutations are changes in the DNA; they happen sometimes. A mutation can mean that letters of DNA were substituted, deleted, or added. And the result can mean anything from a new ability, to a loss of ability, or the mutation might make no difference at all.*

A C T I V I T Y # 3

Natural Selection (15 min)
Education Goal: Introduce concept of natural selection as an important driver of evolution

• *Over a long time, these mutations in the DNA can get passed down over generations to more and more individuals in a species, so that finally, the DNA of the entire species has changed. That is evolution.*

• *We are going to run a little experiment. Have you all played musical chairs before? Well, we're going to play musical chairs, but with a twist. There are enough chairs for everybody, but not all the chairs are going to be equal. Let's pretend the chairs represent bacteria.*

• *Have you all heard of antibiotics? (show of hands) Well, every once in a while, one bacterium, one chair, gets a mutation that means that an antibiotic can't kill it. It is antibiotic-resistant.*

Tape a piece of paper with a big letter "R" on it on one of the chairs.

• *Your job is to sit in one of these resistant chairs if you can. When the music stops, that's when the antibiotics start coming through and (pick a number between four and six) non-"R" bacteria aren't going to make it. If you can't sit in a chair marked with an "R", you can go ahead and sit anywhere else, and you might be okay anyway.*

Have participants stand up and approach chairs.

Play music, let it stop, and then arbitrarily pick (4-6) non-"R" chairs.

Evict their occupants, but tell them they can keep playing, because now it's the next generation, and even though their non-resistant, non mutant bacteria got killed in that first generation, they were replaced in the next generation by resistant bacteria which is reproducing away, and not minding the antibiotics one bit.

Tape paper with the letter "R" on the (4-6) chairs you just picked. Play music again and repeat from step 3. Continue evicting participants and creating new resistant bacteria until all the chairs are marked with an "R."

• *We started that game with just one mutation in just one bacterium. How many of our bacteria are resistant to antibiotics now? That's right, all of them.*

• *Our bacteria evolved from just one having a mutation for resistance to all of them having the mutation because of something called natural selection. Natural selection is when a mutation helps a living thing survive and reproduce and therefore that mutation gets passed down more often than the original version of the DNA.*

Have participants sit down and show picture of white and black moth on white background.

• *But natural selection doesn't just work for bacteria, it works that way for all living things.*

Show picture of white and black moth on light background.

• *These are two different color variations of the same kind of moth. Which one of these moths is easier to see? That's right, the dark one! The dark coloring is due to a mutation. Well, once upon a time, in England in the 1800's, trees used to look like this, and this kind of moth was white almost all of the time.*

• *Then, people started burning a lot of coal to build machines and other things, and the trees started getting coated in soot.*

Show picture of white and black moth on black background.

• *Which moth is easier to see now? That's right, the white speckled one! Well, the birds thought so too! And suddenly, the mutation that made the darker coloring was a big advantage. The white moths started getting eaten by birds way more often than the dark ones, and the dark moths (like our antibiotic-resistant bacteria) were surviving and reproducing. Eventually, in 60 years, there were almost no white moths at all.*

Review: *The passing-down of the mutations to more and more individuals is called evolution. Evolution is how species change, and also how we get different species. There are two main ways that mutations in the DNA of one individual spread to every member of a species. What happened with the bacteria and the moths is called "natural selection," because one version of the DNA was better for survival than the other. Natural selection is a main cause of evolution.*

ACTIVITY #4

Genetic Drifting (15 min)
Educational Goal: Introduce concept of genetic drift as an important driver of evolution

• *But what happens if neither the original version of the DNA or the mutation is any better than the other? For example, as we saw with our instruction hunt earlier, a lot of our DNA doesn't make any difference, but that DNA can have mutations too. Well, then, the version that survives does not depend on natural selection, it depends on nothing but chance. When talking about evolution, chance is called genetic drift.*

Ask for two volunteers. Have them come to the front and give them each a blue stone.

• *How does genetic drift work? Well, imagine that there is a mutation in the DNA ladder. (Hold up model to demonstrate.) Instead of this rung being blue/yellow, there was a mutation in somebody and it became yellow/blue. (Make sure they understand this before moving on.)*

Take the blue stone of a volunteer and replace it with yellow. Have them place their stones on the table in front of them and hand each volunteer a die.

• *Now, a few generations are going to go by.*

Have each volunteer roll their die twice (you may want to pause and comment after each round) and give them additional stones to represent their children and grandchildren. Alternatively, have them pull that number of other participants to stand up front with them and give each person a stone as they come to the front.

• *Okay, so now we've got two families here. Who has more people, the people with the original blue/yellow rung or the people with the yellow/blue mutation? Why does (blue or yellow) have more? Is it because one is better? That's right, it was randomly decided. That's genetic drift in action. Random things affect which version of the DNA becomes more common.*

• *Okay, now it gets even more suspenseful. This village that we're building here is unfortunately in a place that can be flooded. Natural disasters are another chance event. I'm going to have our original people here, the grandparents, roll their die one more time, and the family that gets the higher number is the one that survives.*

Have everyone from the lower-numbered group sit down again.

• *So, as you can see the (blue or yellow) group is the only one that's left! (IF BLUE IS LEFT:) So now, the original version of the DNA is all that's left and it's like the yellow mutation never happened, not because the mutation was worse, but just because of chance. It could easily have been that the yellow group was left – it was all up to chance! (IF YELLOW IS LEFT:) So now, everyone in the whole population has the yellow mutation, not because yellow is better, but just because of chance. It could easily have been that the blue group was left – it was all up to chance!*

• *Because of chance events, more or less of a mutation will get passed down in a species. Eventually, one version of the DNA wins out. That is how genetic drift causes evolution.*

• *Genetic drift is probably as important as, if not more important than, natural selection for shaping how living things evolve.*

Collect dice, stones and have everyone sit down.

• *So, natural selection and genetic drift are two of the most important ways that mutations get passed on; in other words, these are the two most important ways that evolution happens.*

Conclusion

Well, today we also talked about changes in DNA, or mutations, and how those mutations get passed down during evolution, by natural selection and genetic drift.

Any questions?