# The DNA Files:

## Workshops and Activities

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# Evolution

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

## Introduction

*Today we're going to be talking about DNA and Evolution. First, we're going to talk about what exactly DNA is, where you find it, and what it says. 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 and where is DNA? (5 min)

### Education Goal: Introduce concept of DNA as information in all living things

• *DNA is a set of instructions needed to make a living thing.*

Ask participants for their ideas about where in the body they might find DNA.

Take suggestions and write them on a blackboard, whiteboard or flipchart. (Blood has DNA, of course, but not in the red blood cells – in the white blood cells. Pretty much every other cell in the body has DNA, including bone cells, organs, and skin. The hair shaft is made up of dead cells, which do have DNA, but it isn't usually good quality unless you also get the root of the hair, the follicle. There is no need to mention these specifics unless they are raised by workshop participants.) When you get five or so DNA locations on your list, stop.

• *Each of your bodies is made up of trillions of cells, and almost every cell (give examples from the list) in your body has a complete copy of the DNA instructions for how to make you.*

• *But DNA is not just in people. Every single living thing has its own set of instructions made of DNA in its cells too.*

 

## ACTIVITY #2

### What is the structure of DNA? (20 min)

### Education Goal: Illustrate the shape and structure of DNA; reveal that the information is contained in the sequence of the rungs of the DNA ladder

• *Okay, so we know DNA is instructions, and we know it's in almost all of our cells, and the cells of every living thing. But what is it made of? What does it look like?*

Show picture of DNA

• *DNA stands for deoxyribonucleic acid, which is a big name that's fun to say.*

Have them say it with you.

Point out that it's shaped like a twisted ladder or spiral, and that there are four different colors in the rungs of the ladder.

• *Instead of using colors like we're doing, scientists use four letters: A, T, C and G, to talk about the tiny molecules that make up these rungs.*

Point out the rungs of the ladder on the model worksheet, and point out A always bonds to T and C always bonds to G.

• *The instructions in DNA are spelled out in the rungs. These four different molecules are like having a four-letter alphabet to spell out instructions with.*

Write the letters on the whiteboard, blackboard or flipchart.

• *The molecules are adenine (AD-uh-neen), which bonds to thymine (THIGH-meen), amd cytosine (SIGH-tuh-seen), which bonds to guanine (GWAN-een).*

Show an assembled DNA model, and instruct participants to work in pairs to build their own.

Tell one person in each pair to cut out the two spines and the other to cut out the rungs.

Have the person who cut out the rungs fold them at the dotted lines, and have the other person start attaching rungs to the rectangles on the first spine, using plenty of gluestick and pressing firmly. The rungs can be attached in any order the pair chooses.

While one person is gluing rungs down on the first spine, have the other person apply gluestick to the rectangles on the second spine.

Turn the second spine (now with the applied glue) upside-down vs. the first spine (the one with the rungs attached). Fit the free end of the rungs on the first spine to the gluestick-coated rectangles on the second spine, curving the spines to make the rectangles correspond. Press each rung firmly as you go.

• *DNA is built so that it looks like it's been twisted, counter-clockwise, so that it goes* *around one whole turn for every 10 rungs.*

*• That's the basics of how DNA is shaped. Human DNA is not just one ladder*

*• If everyone in this class connected your DNA models end to end you'd still only have a little over (10 times the # of participants) rungs total on the ladder. But the shortest human DNA ladder is over 25 million rungs. Human DNA is over 2.4 billion rungs total. That's a big ladder. You'd need millions more workshops like this one to be able to put together a model for all of human DNA.*

*Review:*

*• DNA is shaped like a twisted ladder, and the information is in the sequence of rungs, like an alphabet. Human DNA has billions of rungs.*

## ACTIVITY #3

### What does DNA look like to the naked eye? (20 min)

### Education Goal: Show what DNA looks like from another, less magnified, perspective

*• DNA is too small to see clearly with the naked eye – but if you have enough of it, you can see a big clump. So next, we're going to extract DNA from wheat germ. Remember, I said that all living things have DNA? Well, the wheat germ is the embryo, the part of the wheat seed that grows into a new plant, and it has DNA too.*

Distribute trays of materials to each 4-6 participants.

Instruct participants to fill a plastic cup halfway with water, and demonstrate as you go along.

Add about 1 tsp of wheat germ to the cup and mix.

Add 7-10 drops soap and stir quickly for one minute.

*• The reason we add soap is to break open the cells, in order to get to the DNA inside.*

Allow the wheat germ to settle on the bottom of the cup for 1 minute.

Using a plastic dropper, transfer two or three droppers-full of just the liquid at the top of the cup (try to avoid the solids at the bottom) to a test tube.

Use a clean plastic dropper or transfer pipette to dribble an amount of alcohol equal to the amount of wheat germ liquid down the side of the tube. Make sure to tell participants to try not to mix the two layers.

*• We add alcohol because DNA does not dissolve in alcohol, like it does in water.*

*• So there you have it – that white feathery stuff floating in there is the wheat DNA.*

*(Optional: have participants reach in with a glass rod or coffee stirrer and fish out the DNA.)*

*Review:*

*• DNA is in all living things, and this is the DNA from wheat, which we extracted from inside the wheat cells.*

## ACTIVITY #4

### Taking apart the genome (10 min)

### Educational Goal: Illustrate the information composition of the human genome, show how little contains instructions

Divide the class into groups of 2 or 3 and pass out bags of beads.

*• Now that we know about what DNA looks like, let's talk about what it says about how to build living things – what is actually in those instructions. This information has only been known since about 2001. We're going to pretend that each of these bags of beads represents all of human DNA. Scientists call all of human DNA the "human genome," so each of these bags is like one copy of the human genome.*

*• There are different types of beads in here, all mixed up, right? Each bead represents a section of the human genome, and these different kinds of beads signify different kinds of messages that are spelled out using our 4-letter DNA alphabet, to tell our cells what to do.*

Show examples of the types of beads.

*• The first thing we're going to do is separate out these different kinds of messages. So go ahead and separate out each different kind of bead into a different plastic cup.*

Give the groups time to do this. When they are almost finished, continue.

*• Which type of bead is the most common?*

Take answers.

*• Yes, these plastic barrel-shaped ones are the most common. These beads represent almost half of our DNA.*

*• The thing to realize is that most of our DNA is not that useful, instructions-wise.*

*• This half of our DNA is really repetitive. If our DNA, our genome, is like an instruction manual for how to build a person, it's basically like having a whole half of that instruction manual full of just the same few sentences, or even just a couple of letters sometimes,*

*repeated over and over again, hundreds of thousands of times. This part that just says the same thing over and over again isn't likely to have a whole lot of instructions about how to build a person.*

• *Which kind of bead is the next most common?*

Take answers.

• *That's right, these sparkly clear round ones.*

• *These beads represent another huge part of our DNA. This part doesn't seem to have any information at all, as though this much of our DNA were literally just gibberish. Some of it might be physically important to have around so that our cells are stable, but there don't seem to be any instructions in it.*

• *Okay, what do we have left? Ovals and wooden beads, right? Well, these last two sets of beads represent the part of human DNA that scientists think has all the useful instructions for how to build a person.*

• *The sections of the DNA ladder that tell your cells what to make is only this much of the total number of beads.*

Hold up wooden beads.

• *The ovals, which are 3 times more common than the wooden ones, are DNA that is thought to control when and how the information in the wooden beads gets used. If the wooden beads are "what" to make, this part says "when, where, and how much." This is important, because the cells in your bones aren't using all the same genes at the same time, for instance, as the cells in, say, your skin.*

Have them re-mix the beads into the plastic bags.

Review:

• *So we just divided up all of human DNA and found that about half is repetitive stuff with not a lot of information, another almost half seems to be just gibberish. A small part, these wooden beads tell the cell what to make, and another small part tells the cell when where and how much stuff to make.*

## ACTIVITY #5

### What is Evolution? (15 min)

### Education Goal: Introduce concept of mutation, and of evolution as the spread of mutations throughout a species. Introduce concept of natural selection as an important driver of evolution.

• *DNA does not stay the same over time.*

*• As your cells divide, they duplicate all the DNA ladders 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.*

*• 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. Evolution is how species change, and also how we get different species.*

Show picture of white and black moth on white 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 were surviving and reproducing. Eventually, in 60 years, there were almost no white moths at all.*

*• There are two main ways that mutations in the DNA of one individual spreads to every member of a species. What happened with the moths is called "natural selection," because one version of the DNA was better for survival than the other. The passing-down of the mutations to more and more individuals is called evolution. Natural selection is a main cause of evolution.*

## ACTIVITY #6

### Genetic Drifting (15 min)

### Educational Goal: Introduce concept of natural selection and genetic drift as important drivers of evolution

*• But what happens if neither the original version of the DNA or the mutation is any better than the other? Well, then, the version that survives 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.*

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 learned where you find DNA, what it looks like both up close, and with the naked eye.  We also learned that not a whole lot of human DNA actually has instructions for building people.  We also talked about changes in DNA, or mutations, and how those mutations get passed down during evolution, by natural selection and genetic drift.*