

The DNA Files: Workshops and Activities



The DNA Files workshops are an outreach component of The DNA Files public radio documentary series produced by SoundVision Productions[®] with funding from the National Science Foundation, the U.S. Department of Energy, the National Institutes of Health, and the Alfred P. Sloan Foundation.

Frequently Asked Questions

Teaching the workshop:

I'm not a scientist--how do I prepare to teach the workshop?

First, decide which workshop you're going to do, either one of the individual workshops or the series.

Then, read the materials thoroughly. The Teacher Guide is very detailed and includes a script for you to follow. Of course you don't have to follow the script word-for-word, but it's there as a way to help you learn the material and as a tool during the actual workshop. Make notes of any questions you have and use the resources provided to answer those questions.

Practice the hands-on activities, making notes as you go.

Finally, run through the workshop. Make notes of where you feel most comfortable with the science and where you'll want to refer to your notes or the script. You may want to print the glossary to have with you for the day of the workshop.

What kinds of questions do kids ask? Suppose they ask questions I don't know the answers to?

We've had kids ask wildly different questions—everything from detailed questions about proteins to questions about God. We've provided answers to some of the most frequently asked student questions (for example: Can we change the genes of a person to make them smarter, stronger, fly, breathe underwater, etc).

If you get a question you don't know the answer to you can always say, "That's a good question. I don't know. I'll do some research after the workshop and let you know what I figure out."

About the activities:

When we're sorting beads to talk about what kinds of information is in the genome, where do genes fit in?

Well, first let's talk about proteins. DNA, as you know, is instructions. It doesn't actually do much; it's just instructions for how to build a living thing. The actual work of doing the building, and, often, the building blocks themselves, are another class of molecules called proteins. A gene is a piece of DNA that contains directions on how to build a specific protein. Proteins then do the work. Other sections of the DNA ladder that aren't genes, but are still very important, have instructions on where, when, and how to build that protein, so that what should be built during infancy doesn't get built instead during adolescence, for instance, or so that your bone cells don't start making the same proteins that are made in the skin. These "when, where and how" type of instructions are called regulatory DNA.

It's slightly more complicated than that, though, because the vast majority of genes in the human genome contain pieces of other DNA that doesn't code for protein. The parts of genes that do code for protein are called exons, or sometimes, coding DNA. The parts of genes that don't code for protein are called introns. Introns and all DNA that is not part of a gene (non-exon DNA, basically) are called noncoding DNA because it doesn't contain instructions for building protein. The DNA sequence in noncoding DNA could be regulatory DNA, repetitive DNA, or just gibberish.

So, genes definitely do contain instructions for building protein, but they usually also contain introns. Introns are made up of either regulatory sequences, or sequences with no known function.

You say that we're using soap to break open cells during the DNA extraction, but the dish soap doesn't do anything to my hands --- aren't people made of cells?

Yes, people are made of cells. It turns out that some of our cells are tougher than others. Soaps that work to break open wheat germ, (and for that matter work to kill the bacterial cells on dishes) don't work too well on your tough skin cells. Other cells in your body would actually be vulnerable to dish soap, so it's a good thing your skin is there to protect you. There are detergents that scientists use in laboratories that are too strong for skin, and so the scientists have to use gloves.

About the science:

How many genes are there in the human genome?

Recent estimates say that humans have something like 20,000 genes. This is a much lower number than was originally thought before the human genome was sequenced, and indicates that there is a lot to be learned about the complexity of human beings by studying other ways that our DNA provides information – in other words, by studying regulatory DNA.

Can scientists change the DNA of a person to make them stronger or give them special abilities?

Changing the DNA of a living organism has been tried and has even worked before. One main reason that you'd want to do that in the case of people, as you can probably guess, is to correct some genetic defect. When you change the DNA of a person in order to improve their health, it's called gene therapy. There have been some successes and some failures using gene therapy, so lots of scientists are studying ways to do this better. There are many disorders for which the only cure will have to be a genetic one. However, gene therapy is nowhere near the stage where you'd be able, or consider it safe enough, to give a healthy person superhuman powers.

Does DNA tell you everything about who you are?

Not by a long shot. DNA does tell you a lot, but one thing scientists are learning is that living things are built to be pretty flexible. There are plenty of traits that you may not get, even if you have "the gene for it," because your environment plays a big role. That is called incomplete penetrance. And once you get away from single-gene traits (for instance, sickle cell anemia and cystic fibrosis are two famous disorders each caused by mutations to a single gene) you find that most traits (for example, schizophrenia, handedness, heart disease) are probably caused by many different genes and non-gene regulatory DNA, all interacting with each other and with the environment. Traits that are influenced by many different genes are called complex traits, because, well, they're complex.

Right now, scientists are doing a lot of studies to try and figure out the genetics of complex traits. They are trying to find out which genes and regulatory DNA are involved, and to examine how genetic traits are influenced by the environment. In many cases, environment is a major factor.

I thought natural selection was responsible for changing the way organisms are, but in the Comparing DNA workshop, we learned that natural selection keeps things the same. Which is it?

Well, it's both, actually. Think of natural selection like a 'justice system' of sorts. If a mutation happens and it's better than the original version for survival, then that mutation gets rewarded by getting passed on to more individuals in the next generation. This is one major way that organisms evolve, or change, over time. But natural selection also punishes mutations that are worse for survival. Those mutations disappear quickly, leaving the original version as the dominant one. In this way, it's sort of an "if it isn't broken, don't fix it" kind of system. And lots of our DNA hasn't been substantially improved upon since single-celled life forms emerged on the planet.

So, does our DNA show evidence that people are more evolved than other living things?

This is one question that can really be confusing for some people. However, saying that humans are more evolved implies that other living things have stopped evolving, usually at a more primitive stage. From a biological standpoint, this is not true, though many people would like to think that it is. You can look at it this way: every single species currently alive on the planet has been evolving for the same amount of time, since life first started on Earth. Nor have people been evolving faster in that same amount of time. The speeds at which mutations happen in humans and human generation times are both slow by comparison to a lot of other organisms.

It is true that human beings are more complex from a genetic standpoint than a lot of other organisms. However, if you wanted to measure complexity by sheer amount of DNA per cell, we're actually less complex than many plants. And if you measure complexity by number of genes, we're tied for complexity with almost every other vertebrate.

This question, about what makes us human, is the subject of a lot of study. Many scientists now think the answer is going to have to do with regulatory DNA and small differences in the way genes are expressed between us and other primates.

How do we know what DNA looks like if it's so small that most microscopes can't see it? And how small is it, anyway?

For a long time, there weren't any microscopes at all that could see it. The picture of DNA that convinced James Watson and Francis Crick of DNA's double helix structure was an image of the pattern X-rays make when they bounce off crystals of a tiny molecule, in this case crystals of DNA, taken by scientist Rosalind Franklin in the early 1950s. X-ray diffraction is the name of this technique. Microscopes that could let people look at DNA directly were not invented until later.

But how small is DNA?

Well, you know that DNA has rungs like a ladder. Each of those rungs is about 3.3 Angstroms apart. An angstrom is a unit of length that is 10,000,000,000 times smaller than a meter. If you took a meter stick and divided it into a thousand pieces, you'd get a millimeter. Most rulers will show you what a millimeter look like. If you took a millimeter and divided that into a thousand pieces, each one of those pieces would be a micrometer. If you took a micrometer (also sometimes called a micron) and divided that into a thousand pieces, each one of those is called a nanometer. If you divided a nanometer into ten pieces, each of those pieces would be an Angstrom.

DNA is small.

In the rungs of the DNA ladder, why is it that A always bonds with T, and C always bonds with G?

The reason that A (adenine) always bonds to T (thymine) and that C (cytosine) always bonds to G (guanine) has to do with the way that different atoms are arranged in each of these four molecules. Picturing the four bases as puzzle pieces isn't a bad way to think about it. The structure of thymine is actually very similar to cytosine, and the structure of adenine is similar to that of guanine. There are small differences that make A and T stick together better than A and C, or G and T.

What kinds of mutations are there?

There are almost as many ways to change DNA as you can imagine. Individual rungs of the DNA ladder can be replaced by other rungs. This is called a substitution mutation, and is generally the most common, but that does not mean it is the only thing that occurs. Rungs can be deleted, or inserted --- one at a time, or in bigger chunks. Individual rungs or whole sections of the DNA ladder can be duplicated. Duplications of DNA are thought to be a major way that new genes are created, for instance. The copy of a gene, if it gets mutated further, can begin to take on new functions.