DNA and Genetics
7 Articles

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What's the Big Idea about Genetics?

This text is provided courtesy of OLogy, the American Museum of Natural History's website for kids.

**Genetics Is Where It All Begins**

Some scientists are curious about basic questions of life: Where did it come from? Why is it so varied? Why do children look like their parents?

To answer these questions, they study a type of biology called GENetcs (juh-net-i-cks). "Gen" means beginning.

Genetics is the science of genes and how traits are passed on from one generation to the next.

People who study genes are geneticists (juh-net-i-sists).

**Every Living Thing Has DNA**

DNA is an amazing chemical present in every cell. It contains all the information cells need to make a fish, or you YOU.

All humans start out as a single cell and grow into trillions of cells. DNA tells the single cell to divide into two cells, then four, then eight — until a whole body forms. It controls the growth of EVERYTHING, from your head to your toes.

DNA also influences many individual traits, such as whether you are a boy or a girl and whether you are tall or short.

**Genes Are Made of DNA**

Where do traits, such as eye color and shape, come from? Why do you look more like your relatives than other people? The parts of your cells that determine these traits are called genes.
In the past, no one knew what genes were. In the 20th century, scientists figured out that they were actually made of DNA.

Genes come in pairs. You get half of your genes from your mother and the other half from your father.

**We Gather Clues about Life by Studying Genes**

As we discover more about how genes work, we will be able to understand how cells build complex organisms — like humans.

Today, scientists are studying human genes to learn about traits and diseases. There are so many genes in humans — at least 30,000 of them — that it will take a long time to study every one in detail and find out what it does.

**A Genome Is All the DNA in a Cell, Including All the Genes**

Recently, new technology has enabled scientists to look closely at the entire human genome.

They have also been able to describe the whole genomes of other animals, including those of bacteria, worms, flies, and mice. The science of genomics asks questions about all of these genes at once. Scientists can also compare genomes of different animals and figure out how they are similar and different.

**Why Isn’t the Study of Genes Called Genealogy?**

Well, the name was already taken.

Genealogy is the study of family origins. It is how people trace their ancestry and create a family tree. It's not a biological science.
Genealogy has been around for a long, long time — before we discovered genes.

The science of genetics began in the 1800s when Gregor Mendel figured out how traits are inherited by studying peas. Since scientists identified genes in the mid-1900s, the field of genetics has grown by leaps and bounds.
In 1997, a 7-month-old sheep named Dolly became a celebrity. Dr. Ian Wilmut, a Scottish scientist, announced to the world that he had created her using a procedure called cloning. Cloning is a method that scientists use to produce a genetic copy of another individual. In other words, Dolly was a clone of her mother.

Well, actually, Dolly had three mothers. One mother gave Dolly her DNA, one mother supplied an egg, and the third mother, her surrogate mother, gave birth to her.

Normally, an animal gets half of its DNA from its mother and half from its father. Dolly was an identical twin of the mother who gave her her DNA. But Dolly was six years younger.

However, Dolly and her mother were not identical in every way. Since Dolly and her “DNA mother” had different experiences, they were different in many ways. Like human twins, clones have unique personalities.

It took scientists 277 tries to succeed in cloning Dolly. To make her, Dr. Wilmut used a complicated method called “nuclear transfer.” In this method, scientists remove a nucleus from one cell and transfer, or move, it to a different cell.
# Why Clone?

This text is provided courtesy of OLogy, the American Museum of Natural History's website for kids.

![Why Clone?](image)

Many people, however, strongly oppose cloning animals, no matter what the benefits. In their view, cloning is messing with nature and should be against the law.

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## What Other Animals Have Been Cloned?

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**Cows**

Some cows produce much more milk than others. By cloning these cows, farmers could make milk more quickly and cheaply.

**Mice**

Scientists use special mice to study diseases like cancer. Cloning them could help scientists research how diseases progress.

**Monkeys**

To develop new medicines for humans, scientists use animals that are as identical as possible. Cloned monkeys could help improve the development of these medicines.
Why Clone a Sheep?

There's no sheep shortage, but scientists are able to create sheep whose milk contains medicine. If scientists can then clone these special sheep, it may be possible to produce more medicine at a faster rate.

Can Cloning Bring Back Extinct Dinosaurs?

Cloning anything is tricky. You need very special conditions, and most importantly, you need DNA. In the movie *Jurassic Park*, a scientist brings extinct dinosaurs back to life by cloning DNA found in ancient dinosaur blood. *T. rex*, one of the last large dinosaurs to roam the earth, lived 65 million years ago. We've never found well-preserved DNA this old. And we probably never will.
How They Cloned A Sheep

This text is provided courtesy of the American Museum of Natural History.
What’s a Genome, Anyway?

A genome is the name for all the DNA and genes in a cell. Every kind of plant and animal has a different genome. There's a chicken genome, a celery genome, and, of course, a human genome. To understand the genome, scientists need to unlock the secrets of DNA.

During the 1950s, scientists James Watson and Francis Crick discovered that DNA is shaped like a twisted ladder, made of four chemicals called bases. These bases are identified by the letters A, T, C, and G. Most genes, which are sections of DNA, are made of at least 1,000 of these base pairs.

The entire human genome is made of more than 3 billion base pairs.

If each A, T, C, and G were a letter or number in a phone book, they would fill 140 big city phone books, which is as tall as a 40-foot building.
What is the Human Genome Project?

The goal of the Human Genome Project is to determine the order of the base pairs in the entire human genome. Remember, there are more than 3 billion base pairs.

Because DNA is super long, thousands of scientists in labs all over the world split up the work. In June of 2000, after about ten years of hard work, scientists completed a rough draft of the human genome. And, in February 2001, they discovered that humans have 30,000 genes.

The work isn't over yet! . . .

What Does it Mean to Me?

**Toby:** Hi, I'm Toby. Joining us now is genome expert Georgia Dunston, who is the Acting Director of the National Human Genome Center at Howard University.

**Georgia:** Thanks, I'm glad to be here.

**Toby:** So, Georgia, nobody sequenced my DNA for the Human Genome Project. Does this mean that our genomes are exactly the same?

**Georgia:** No. Unless you are an identical twin, you have a unique genome. But even so, humans are 99.9% the same genetically. Since we're all so alike, information from even one human
genome relates to all of us. Your friends may have different color skin or eyes, but you have thousands of more things in common.

**Toby:** How will the Human Genome Project affect kids' lives in the future?

**Georgia:** Our knowledge about the human genome will help us figure out what causes some diseases, such as cancer or diabetes. Sometimes, small changes in the gene sequence can mean the difference between health and illness.

By understanding our genes, we will be better able to diagnose and maybe even prevent many diseases in you, your kids, and your grandkids.

**Toby:** Wow! Thanks for stopping by.

**Georgia:** My pleasure. Remember, the most exciting discoveries are yet to come! So stay involved. We all need to be thinking about this—now and in the future.
Meet the Ologist: Rob DeSalle

By American Museum of Natural History

This text is provided courtesy of OLogy, the American Museum of Natural History’s website for kids.

Do other species, like chimpanzees, have similar DNA to humans?

Rob Said: Yes, this similarity is very interesting. We're 98% identical genetically with chimps.

If you compare a human and a mouse, 90% of the genes are similar.
If you compare a human and a fruit fly, 52% of the genes are similar.
If you compare a human and a roundworm, 35% of the genes are similar.

And if you compare a human and bacteria, about 9% of the genes are similar.

Were you interested in science as a kid?

Rob Said: Actually, I had no interest in biology whatsoever until I started my senior year in high school. I had a teacher who made me keep a physics laboratory notebook much like a scientist would. He essentially made me see the value of keeping track of what I did in the lab. This teacher connected what we did in class and in the lab to the notebook. Because I organized what I learned, it became my own work. I think that's what got me interested in science.

What's special about doing research in a museum?

Rob Said: The Museum is a special place because it not only has exhibitions, but also an enormous collection of specimens collected from all over the world. The Museum also has very modern research equipment. It's great to be able to study different animals—and how they're related—in one place.

How has technology changed lab work?

Rob Said: Because genetics is so high-tech, the new machinery that we have in the lab becomes very important. I think in the next few years, we're going to see a shift in what happens in the...
lab. When I started in the lab about 25 years ago, I spent most of my time doing things by hand. With new machinery, people can spend less time generating the data by hand and more time thinking about it.

New technology opens up new possibilities.

**What do you think about cloning a pet?**

**Rob Said:** Cloning is a really interesting and important subject to think about.

We have the responsibility to think about the natural world. Does cloning pets have an effect on the natural world? It might. Will cloning human beings have an effect on the natural world? I think it probably will. Will cloning endangered species have an effect? Yes, but maybe it's a positive effect. So I think we need to look at the effects of our actions.

These are questions everybody needs to consider. But in order to weigh in on the decisions, people need to be informed about what's going on.

**How did you become interested in genetics?**

**Rob Said:** When I went to college, I had an interest in science, and I got a job at the Field Museum in Chicago. Every morning I'd walk by an exhibition of the narwhal, an Arctic whale, and I became very attached to him. Narwhals are really cool animals.

At that time, I'd really never been out of Illinois. These creatures were from faraway places, the North Atlantic and Greenland and Iceland. I decided I wanted to understand them. So I went to talk to my advisor in college, and I said, "I want to work on narwhals." My advisor was a microbiologist. He looked at me and said, "Forget about the narwhals for now. Learn some genetics and come back to the narwhals." So I went back to the Field Museum and started doing genetics.
Do all species of plants and animals have the same amount of DNA?

**Rob Said:** No, there are very, very different amounts of DNA in things. But just because you have more DNA doesn't mean you're better, or you're more advanced. Certain species of amoebas, for instance, have much, much more DNA per cell than humans do. In essence, it's how genes are used that determines how complex living things are.

Now, if you want to talk about numbers of genes, it becomes a little bit more important. For example, yeast, the organisms that you put in bread to make it rise, have about 6,000 genes. Drosophila, the fruit flies you might see flying around fruit, have about 13–14,000 genes. Humans have about 30,000.

Interestingly, we don't have that many more genes than flies or even yeast. So it's really how an organism uses those genes that determines how complex an organism is.

How do you decide what to research?

**Rob Said:** Science is really about exploring what's unknown. And there are a lot of unknowns. In school, you learn mostly about the questions that have been answered already. But the really exciting stuff happens when you try to figure out problems that haven't been solved. These become great research topics.

What's important to consider about genetically modified food?

**Rob Said:** You need to make your own list of pros and cons.

As a biologist, I'm concerned about the effect of technology on the
environment. When food is genetically modified, part of the natural world is changed. We need to look carefully at what effects this can have.

On the other hand, there will be 9 billion people on the Earth in the next 30 years. That's a lot of people to feed. Genetic modifications is probably one of the few ways we can produce enough food.

It's a very complicated issue. Think about it.

**What’s it like to work on a Museum exhibition?**

Rob Said: Working on Museum exhibitions gives scientists a chance to share ideas with a large audience. It's great to be a part of creating something that reaches a quarter of a million people. Many people have become scientists because of a visit to a museum.

It's challenging to create an exhibition with a science like genomics. Explaining the science is difficult, and we also have to think of really special, interesting ways to display things. With a science like paleontology, the display is much easier—the fossils tell the story. We don't have specimens like that in genomics, so we really have to use our imaginations.

![Image](image_url)

Image credits: courtesy of NASA; Rosamond Kinzler: AMNH.

*The Earth is our home. So far, it’s the only place that we know of that has life. Everywhere you look on Earth there is life. This is possible because Earth has lots of water. It’s also just the right distance from the Sun. Some people call Earth the “Goldilocks planet.” It’s not too hot (like Venus), and not too cold (like Mars), it’s just right!*
I would like people to understand that we are more than our genes. Genes are involved in how we behave, but the environment in which we live also influences who we are.

Also, I think it's important to realize that while each person is unique at the genetic level, we also have a great deal in common with each other—no matter what the race, creed, or color.

I think people should be informed about what's going on in the scientific world. Our future depends on the decisions we make today.

**How did you become interested in studying fruit flies in Hawaii?**

**Rob Said:** When I went to graduate school at Washington University in St. Louis, I thought I wanted to work on human genetics. I talked to one of the guys in the biology department, and he gave me some advice: work somewhere fun.

Besides having a lot of white sand and sun, the Hawaiian Islands are the most isolated, relatively large area of land on Earth.

A lot of people think that fruit flies were blown to Hawaii in tropical storms from other places. When they arrived there, they adapted and changed. So the Hawaiian Islands are a wonderful, natural laboratory for studying variation and adaptation.
By looking at the pattern on the reptile skins, the officer had a hunch they were made from Yacaré caiman, a relative of the crocodile and alligator.

My blood started to boil. “But the Yacaré caiman is a protected species,” I said into the phone. “Bringing skins of that animal into the U.S. is against the law!”

“Exactly!” said the guy at the U.S. Fish and Wildlife Service. “That’s why the officer seized the shoes and handbags from the reptile skin importer.”

“So, what’s the problem?” I asked.

“The importer said it was not a protected caiman,” he said.

The importer claimed that it’s impossible to tell the difference between caimans just by comparing skin patterns. This disagreement went to court. And that’s where I came to the rescue.
First I took samples of the reptile skins to my lab at the American Museum of Natural History. There I used some high-tech machines to separate the DNA from everything else.

Then I made lots of copies of the DNA, so it was easier to study.

Next I used a machine to figure out the DNA’s sequence, which looks like a long string of letters. Every animal species has its own DNA pattern.

**Geneticists can match DNA patterns the same way police match fingerprints.**

Finally I compared this skin’s sequence with other crocodilian sequences in our DNA computer library. It was a perfect match to the Yacaré caiman! Those shoes and handbags were definitely made from a legally protected species.

I gave this report to the judge. Based on the DNA evidence, the judge agreed that the skins were illegal. The skins were taken away and the importer had to pay a fine.