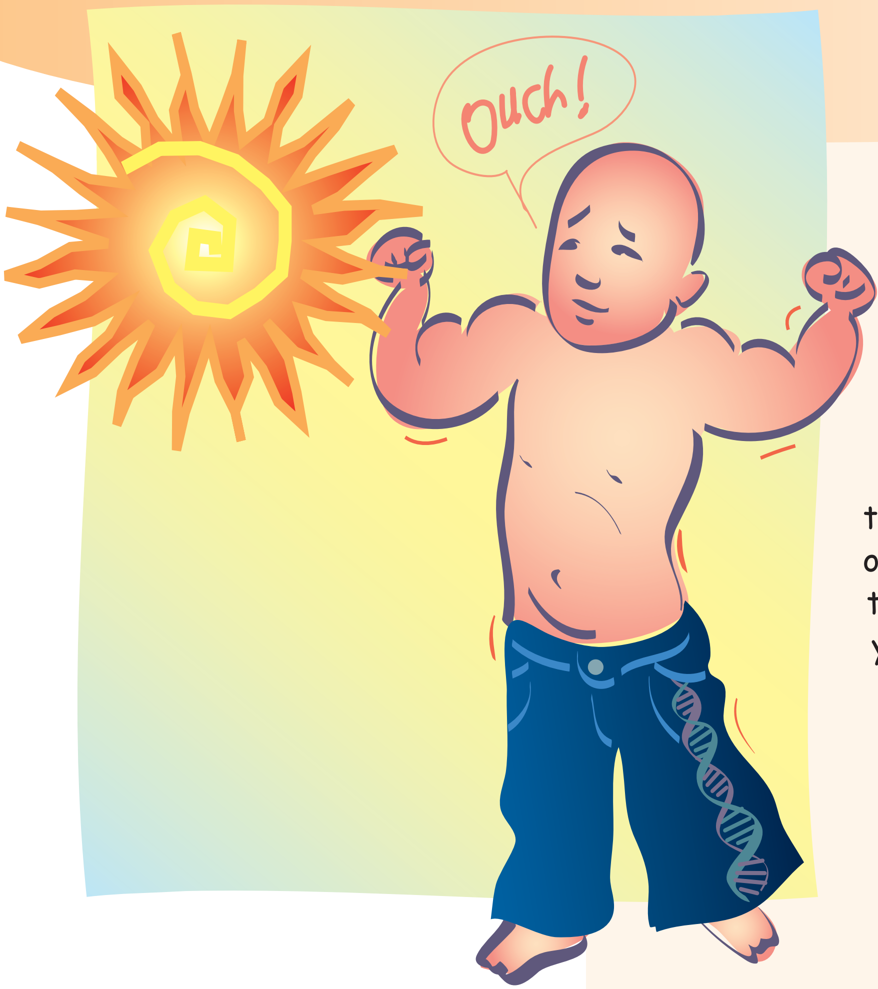
Making it in a Tough Environment

YOU and Your Genes

The National Institute of Environmental Health Sciences

Lots of things

in our homes and schools and workplaces — and in wild and natural places — can cause harm sometimes. Why "sometimes"? The harm may depend on who you are — as well as what you do, what you are exposed to, and when.



Big, muscular people look as if they can resist anything. But they can have allergies or asthma, or be injured by chemicals, too. And the bigger they come, the more skin the sun can burn!

Most of us, for example, can get sunburned on a bright day. Your reaction will be greater if you are outside, without much on, for a long time. Your reaction will be less if you cover your exposed skin with lots of sun screen. How bad you burn can depend on your age and previous exposure. (Babies and toddlers need a lot more protection.) Finally, if one or both of your parents burn very easily, they may have passed that sensitivity to you in your **genes**.

Designer Genes — They're the Boss

Genes are the instructions — the marching orders — that direct our growth, what we look like and how we react to things in our world, or environment.

Each human — whether infant, child, teen or adult — has 70,000 pairs of these orders, or genes. They tell our bodies' cells what to be and how to behave.

Do you remember transformer toys? You twisted them one way and they were space ships. You twisted them another way and they became robot warriors. Well, under the genes' orders, the cells become the ultimate in transformer robots. The genes instruct our original dab of cells, as they divide, to become different — muscle, bone, lung, or brain cells, or part of a toe. As a result of what the cells become and do, we grow. And we stand and run and catch footballs and dance — more or less with grace and skill. We breathe. We think!

Our genes, or instructions, are coded on short segments of a long chemical chain called DNA. It is in the center of each cell of our bodies. Think of genes as information bits paired along two spiraling strands of this chemical — like snap-together beads in two long, connected strings of DNA.

The complete package of genes for an animal — what makes a dog a dog — is called its **genome.** These packages or genomes are why people give birth to babies, dogs to puppies, and cats to kittens.

Many of the genes in other animals are similar to those in humans. After all, people and animals, like our dogs, all have to do certain things, like digesting food, so we need a similar gene for that. When we are loyal, frisky and bright-eyed — and tip over garbage cans — maybe it's those shared genes?!

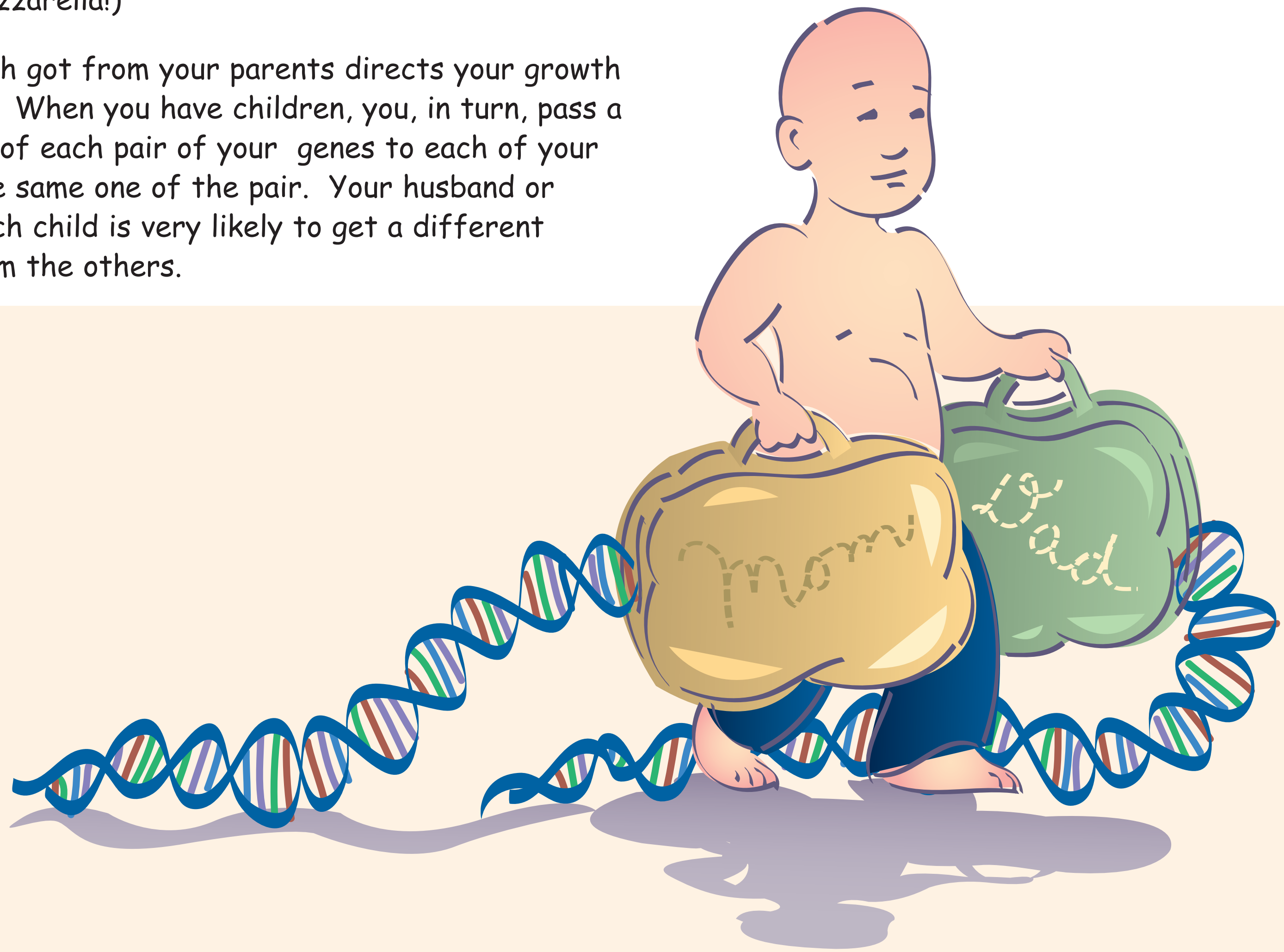
Every human has the same number and set of genes, so you might think we would all be exactly the same. But the genes themselves vary a lot or a little, just as people do — and as animals do. That's why we do. For example, everyone has a pair of genes for eye color but one variation instructs the eyes to be blue while other variations order green or brown.

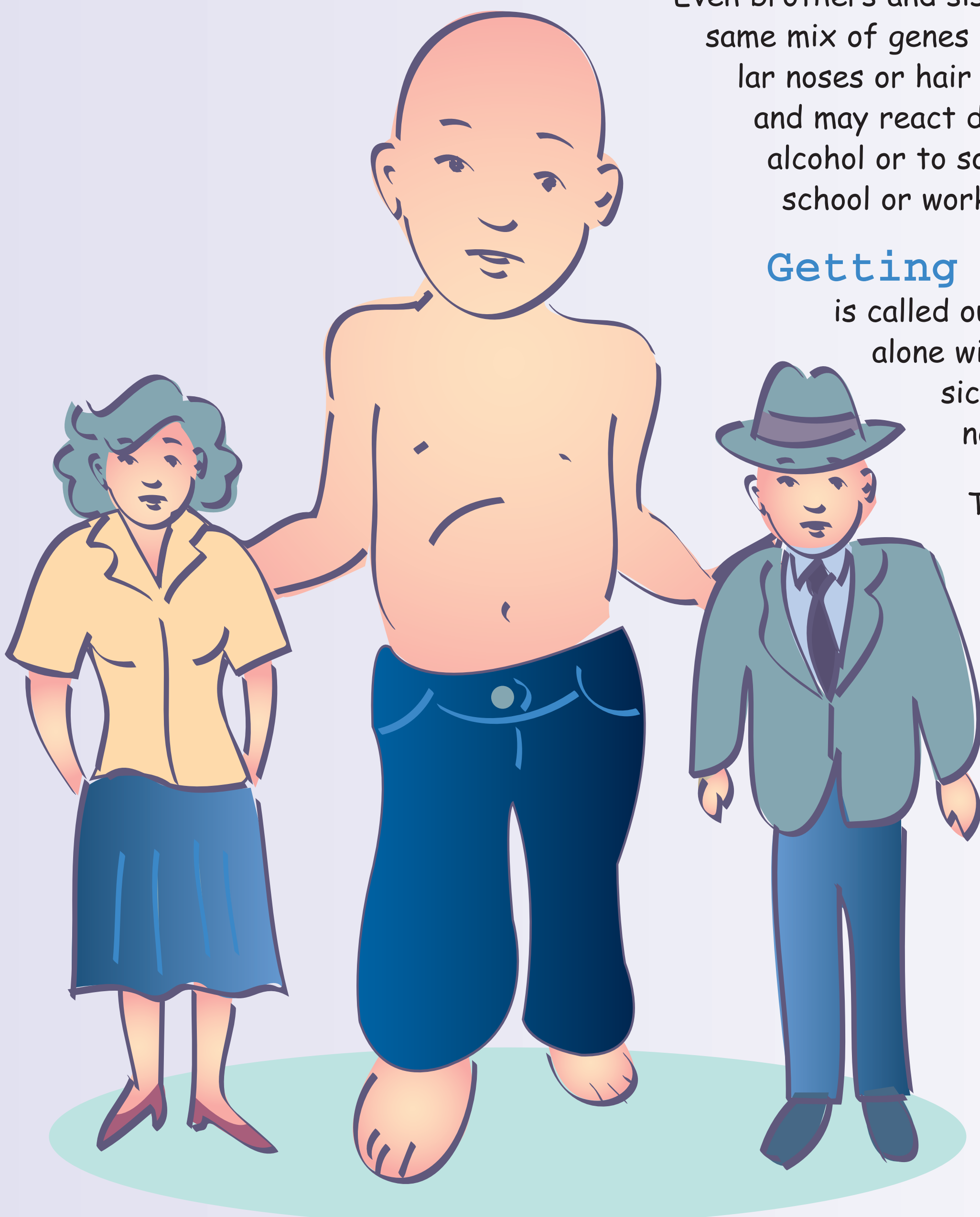
Where did you get your pairs of genes?

You got your 70,000 pairs of genes when your dad's sperm pierced your mom's egg. One gene from each pair of your mother's 70,000 pairs of genes was already waiting in the human egg. Your father's sperm added one gene from each of his 70,000 pairs of genes. Your father's and your mother's genes paired with each other inside that fertilized egg cell from which you then grew.

The original egg cell split and re-split, forming new cells for muscle, brain, skin, bone and all the rest of your body. These new cells came together (according to the genes' orders) and each new cell carried copies of the original cell's genes. The result: Two copies (a pair) of about 70,000 genes are found in each of the 100 trillion or so cells of your body. (That's a lotza mozzarella!)

The mix of genes you each got from your parents directs your growth to adulthood and old age. When you have children, you, in turn, pass a copy of one or the other of each pair of your genes to each of your kids — but not always the same one of the pair. Your husband or wife will do the same. Each child is very likely to get a different mix and be different from the others.





Even brothers and sisters (unless they are identical twins) don't get the same mix of genes from their parents. So, although they may have similar noses or hair or height, their bodies in other ways will be different and may react differently — less or more — to the sun, to tobacco, alcohol or to some chemicals in bug killers or other products at home, school or work.

Getting features from our parents is called our **heredity,** the sum of our genes. But our genes alone will not determine all things, like size. A child who is sick for a long time or doesn't eat well, for example, may not grow as tall as his or her parents.

The reverse can happen, too. Good nutrition, clean air and water, vaccines and simple hand-washing can prevent diseases and help a kid soar above shorter parents.

In such ways, the substances you touch and breathe, and your personal habits and nutrition play important roles. Along with your genes, the good and bad things in your world help decide who you are, how you feel and whether you get sick or stay well.

The Gene's Code for Life

While the English language has 26 letters, each gene's orders, or instructions, are written in a chemical code of four. The code is made up of chemical bases called **adenine**, **thymine**, **guanine** and **cytosine**. We call these **A**, **T**, **G** and **C** — the gene code's four letters. Long lines, or sequences, of these chemicals permit each of the 70,000 or so genes to have a different code that directs the making of a different protein. One gene = one code = one protein. The proteins carry out the gene's instructions.

Some Tyxpos Along the Way

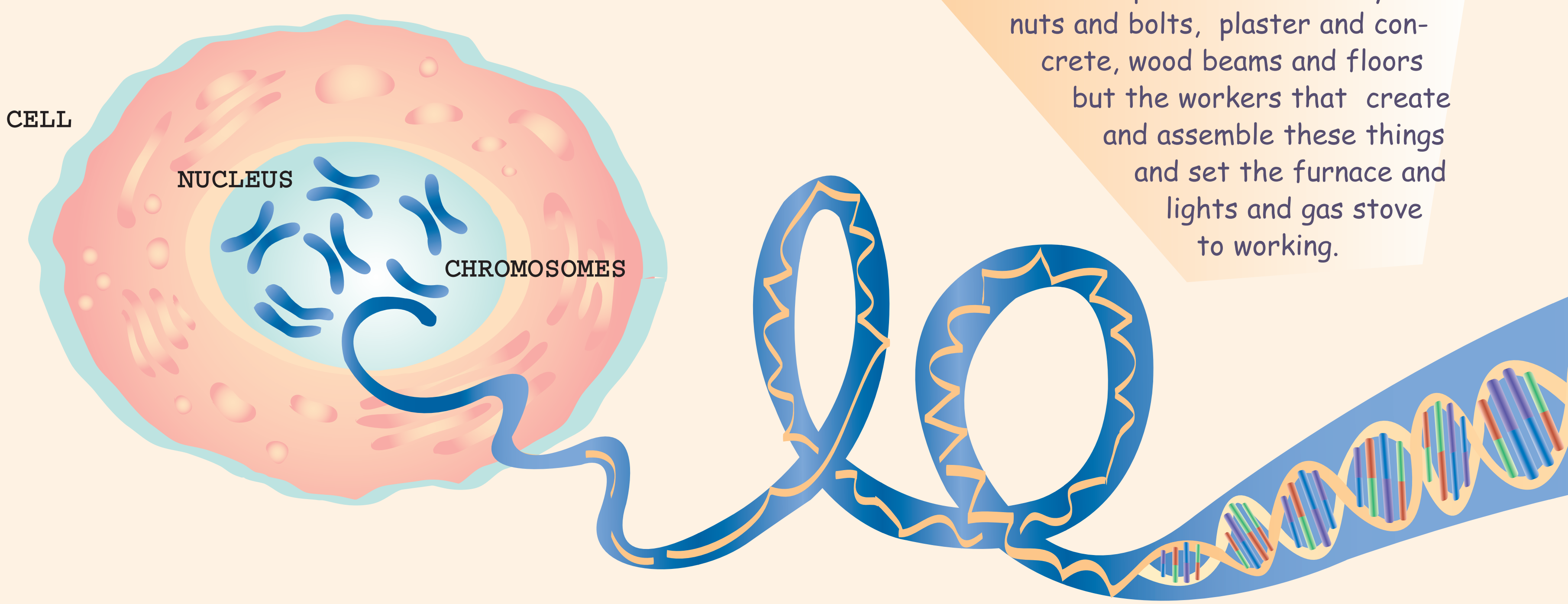
Mistakes can occur as the code is copied and re-copied when the cells divide. A substance in our environment can sometimes make a mistake occur or prevent it from being corrected by the body's "spell check." Sometimes this doesn't matter much, but sometimes it matters a lot.

Proteins —

not just beans and a big, juicy steak, but a key to all life.

There are thousands of proteins, each made up in part of nitrogen, the colorless gas that makes up most of our air. Proteins are found in animal muscle (steak) and skin, bone and all the "stuff" of life, every cell of an animal or plant. They are also what make the body work: They are necessary for the chemical reactions that make muscles flex, brains think and stomachs produce digestive fluids.

Think of genes as the orders or plans for a house. (This house could be your body, your dog's body or your petunia plant.) Picture the proteins as not only the nuts and bolts, plaster and concrete, wood beams and floors but the workers that create and assemble these things and set the furnace and lights and gas stove to working.



One ~~msi~~misplaced letter in the long-strung code of one gene can cause sickle cell anemia — a painful disorder in which the red blood cells have an odd shape like a sickle or crescent moon, instead of being round. The sickle shape makes it hard for the blood cells to get around in the blood vessels.

Another disease that is inherited in this direct way is cystic fibrosis. This is a disease in which mucus clogs the lungs.

Most diseases have a non-gene trigger.

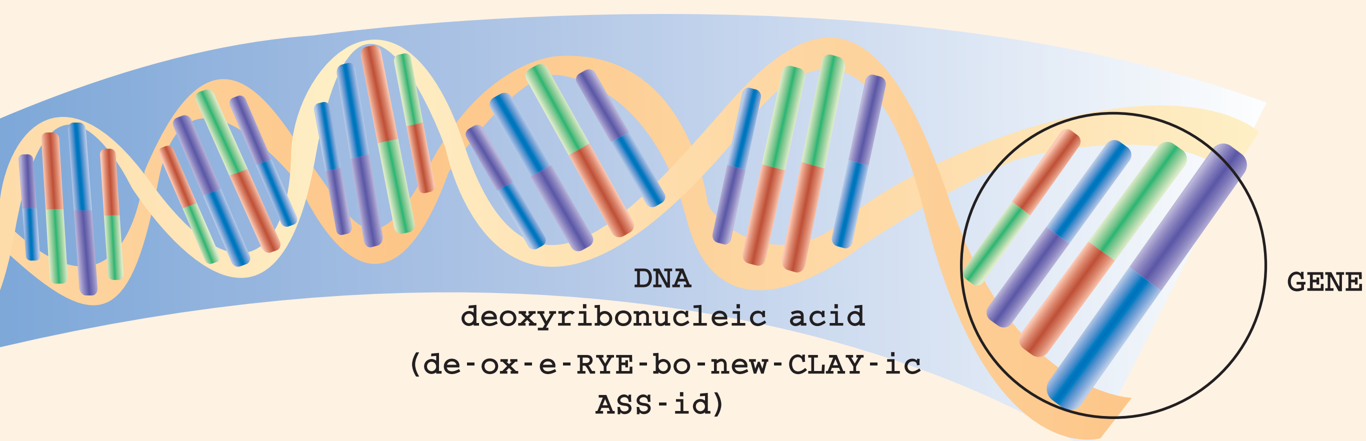
Unlike cystic fibrosis and sickle cell anemia, most diseases and disorders are not caused just by "bad" genes but by bad genes along with one or more "bad" things from the world around us. One scientist makes it very simple: Heredity loads the gun and environment pulls the trigger!

Here's an example: When you were just born, you were tested for a genetic disease that is influenced by your environment — in this case, what you eat. That disease is PKU, in which protein is not eliminated but builds up.

If protein foods are eaten, the brain will not fully develop. (One artificial sweetener has a warning that it contains this protein and should not be used by people with PKU.)

How small are your genes? When you stuff yourself into a pair of tight jeans, think that your 70,000 gene pairs are stuffed by the thousands into 23 pairs of long capsules called **chromosomes** — which are in every one of our cells. Even chromosomes are invisible to the naked eye. When these paired chromosomes have been stained, however, they can be seen under a very good magnifying microscope.

Here's some trivia that could win a prize on a TV quiz: "Chromo" is a Greek word for "color" or "stain," and "some" (rhymes with "home") is Greek for "body."



While some cancers, heart disease and diabetes run in families and may be due to "bad" genes, other things are at work, too. Our environment, our care in using chemical products, our personal habits and our diet and exercise can be important. Did you eat your broccoli today? Drink your O.J.? (Eating at least five fruits and vegetables a day appears to reduce our risk of cancer.)

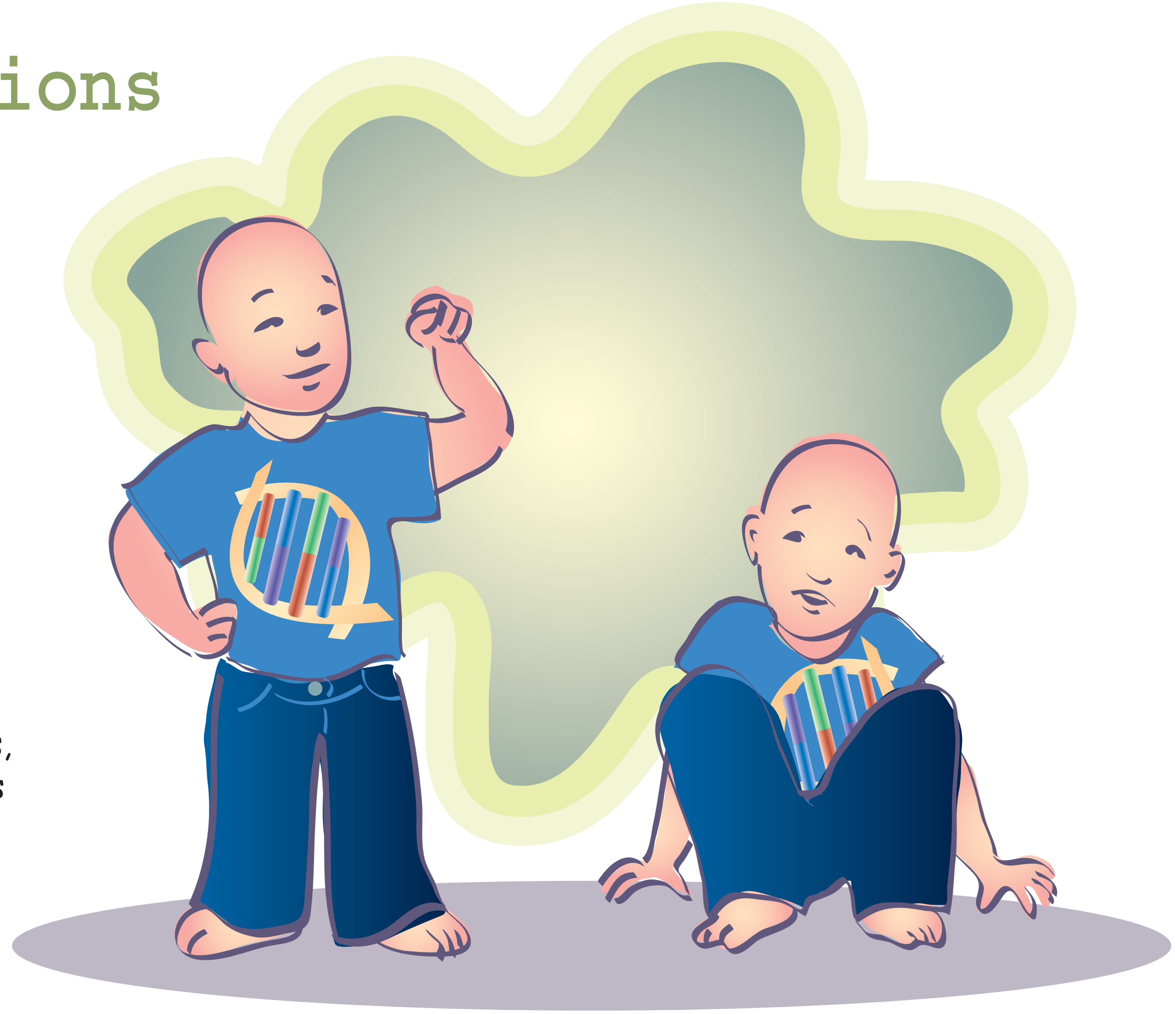
And remember that the natural substances we encounter can sometimes change a gene. Scientists say that some of our genes were modified by conditions hundreds of years ago and were passed to us from our great, great grandparents.

Today, the chemicals or X-rays we need and use also can affect genes, especially if people are careless about how they handle these things. Smoking causes changes in the genes of our lungs and other places in the body. Such a poison can garble a gene's code. The poison can affect the message that a gene sends to cells to tell them what to do, how to assemble and how to grow. It can undermine the cell's way of correcting mistakes that can occur in the DNA — the chemical chain that carries our genes.

What gene variations make people respond differently?

Researchers are studying how different people respond differently to harmful substances. They have found that common differences in genes can affect the human body's responses.

For example, some genes signal the making of proteins called enzymes, in the lungs. Ordinarily these enzymes, or active substances, destroy some of the cancer-causing substances in tobacco smoke. But researchers have found a gene variation that may reduce these enzymes and make people more susceptible to lung cancer.



Finding a gene with a variation that can cause a disease can help in the design of drugs to counter it. Some scientists also look toward correcting some diseases by substituting a "good" gene before a baby is born.

Something similar may happen in emphysema (em-fizz-ZEEM-a), a disease in which a person's lung tissue deteriorates and he or she has a hard time breathing. Tobacco smoke, solvents used in factories, and other chemicals and air pollutants can produce changes in lung tissue and cells and even in the molecules the cells are made of. Variations of a gene may mean more — or less — production of an enzyme that protects against these changes.

Learning more about these variations: At the National Institute of Environmental Health Sciences, researchers want to find out more about these variations in 200 or more of the genes that make us more, or less, sensitive to the substances around us. To do this, they have developed a project called the "Environmental Genome Project" with other parts of the National Institutes of Health.

The Environmental Genome Project meshes with the **Human** Genome Project, which seeks to map every one of the 70,000 or more genes in humans — the whole instruction book for "human being." (About half the human genes have now been located.)

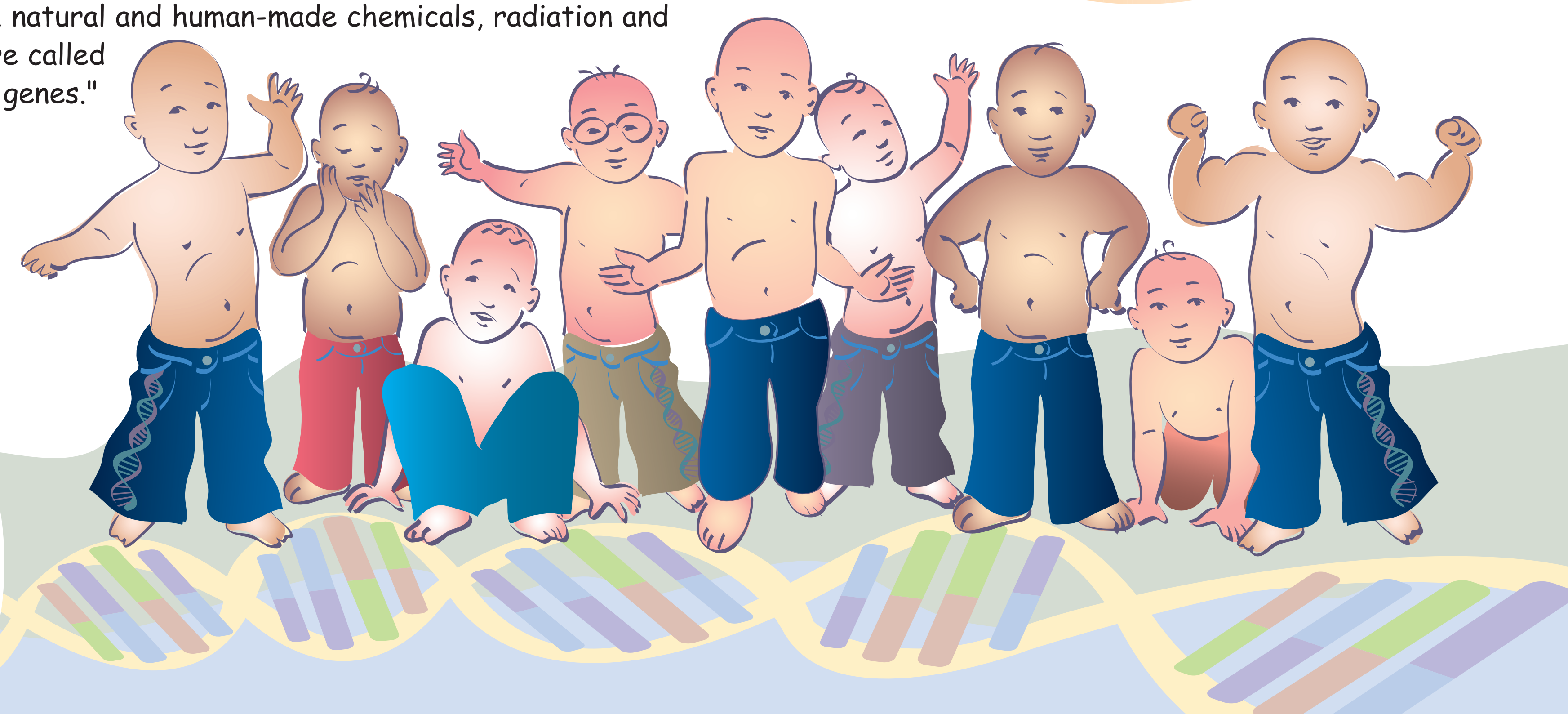
The newer, **"Environmental** Genome Project" looks at genes that have already been located. These particular genes have been shown to play a role in how we react to environmental substances. Scientists want to see how these genes differ in different people, what percentage of us have which variations and what these variations mean in terms of our reactions.

These are not genes that give clear orders for a disease, regardless of other factors. Instead, these genes determine our weakness or strength in the face of various metals, natural and human-made chemicals, radiation and such. They are called "susceptibility genes."

A few people may have a variation that makes them very resistant to a chemical.

A few may have a variation that gives them a high chance of being hurt by the same substance.

Most of us may be somewhere in between.



The scientists in this project hope to discover: Are the people with such-and-such a gene variation more likely to be harmed by a chemical? Are the people with a different variation less at risk? How many people have this variation? How many have another?

The Environmental Genome Project will help answer the "Why me?" question. A smoker told he has developed a fatal lung cancer asks this question because he knows of people who smoked as much and may have a hacking cough or breathlessness but do not have lung cancer.

Or perhaps you and your brother Joe work at a job around smoke or chemicals or smelly glues. Why might one of you be hurt and the other not?

To find out how many of us have gene variations that protect us or, in other cases, make us susceptible, scientists test blood samples from several hundred volunteers representing the American people as a whole. The blood is tested for variations in as many genes as the scientists are studying.

Tomorrow —

In the future, will doctors give you a list of foods, chemicals, metals or other substances to avoid, based on how you react to them? Someday, very probably!

Most likely, the information will help you avoid some natural hazards you're susceptible to, much as people who aren't strong swimmers try to stay out of deep water, or people with diabetes avoid sugar. And industry and unions along with state and federal regulators will have information to ensure that even those of us who react the most will be protected.

One way or another, we should gain a much better idea of which of us is at most risk — and what precautions need to be taken to best protect us.

This knowledge may help us prevent — or avoid — a lot of disease and disability, producing a better, safer future for us all.

The National Institute of Environmental Health Sciences has two big jobs:

1. Our scientists look for things in our world that may hurt our health. They discover what harm these substances can do and how we can get rid of these poisons or avoid them.

2. These scientists study how we react to these harmful things: Are we sensitive or resistant? Do you and I respond the same? Many of the differences between people are due to our genes.

Work involving genes is underway at many other institutes of the National Institutes of Health, particularly at the National Human Genome Research Institute. You can write NHGRI at NIH Building 31, Room 4B09, Bethesda MD 20892, for a booklet, "The Human Genome Project, from Maps to Medicine," NIH publication 96-3867.

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NIEHS is found on the Internet at www.niehs.nih.gov
The latest on the Environmental Genome Project is posted there.

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