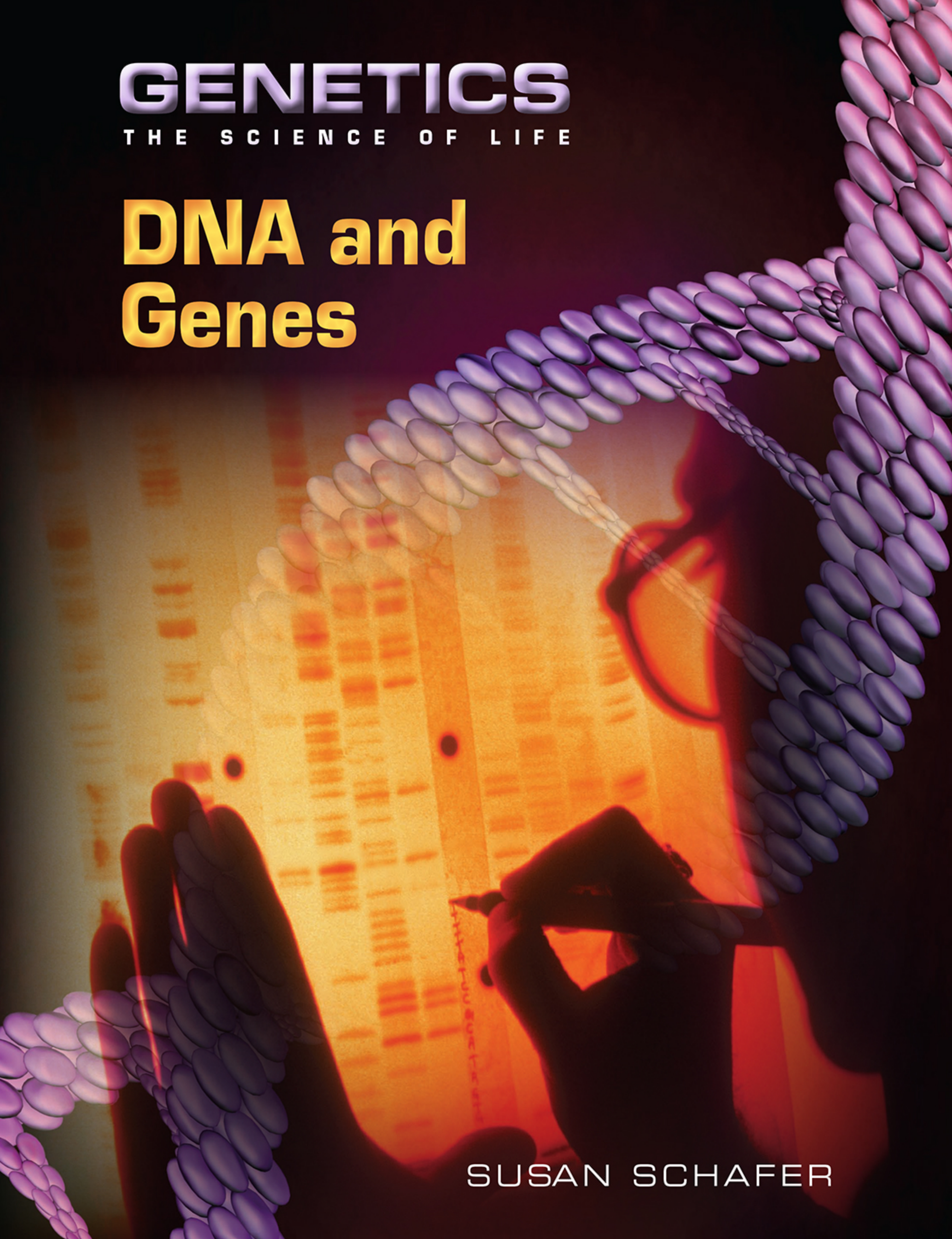
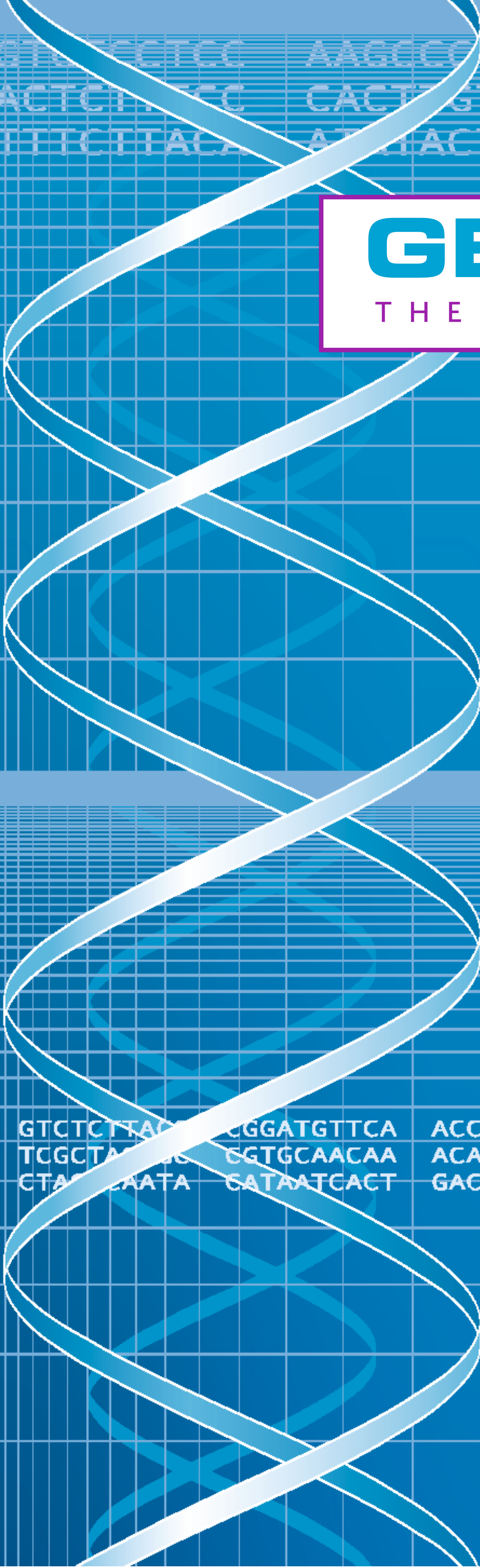
GENETICS

THE SCIENCE OF LIFE

DNA and Genes



SUSAN SCHAFER



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DNA and Genes

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Contents

Chromosomes form when long strands of DNA bundle up into sausage-like structures.

CHAPTER 1

You Are Your DNA

It all comes down to forty-six microscopic strings of a special chemical called DNA. Without DNA, the cells in your body would not have the instructions they need to survive. It would be as if you were lost in a jungle with no one to tell you where to go. Forty-six complex strands of DNA inside each of a hundred trillion cells work together like a coordinated machine to make what is called a human.

Unless you are an identical twin, your DNA is unique. It controls everything that happens in your body. It determines the person you become. You are your DNA. When you understand DNA, you understand yourself. Like any other science subject, learning about DNA is like learning to speak a new language. The more scientists discover, the more they use new words to describe what they find. So prepare yourself to learn the language of DNA.

THE CODE FOR ALL LIFE

DNA, which is short for **deoxyribonucleic acid** *(dee ahk see rye boh noo KLAY ik)*, holds the codes for life. It is found in the cells of every living

A single strand of DNA forms a double helix, which looks like a twisted ladder.

thing. Like a teacher who controls the lessons in a classroom, DNA is like an instruction manual that controls almost everything a cell does. It is responsible for **heredity,** which is the passing of traits from parents to offspring. Because DNA is passed from one **generation** to the next, it is entirely possible that you could have some of the same exact DNA that an ancestor had hundreds of years ago. People pass away, but in a way, DNA lives on.

DNA is held within a container called the cell. The cell is the basic unit of life. It is the smallest living thing. Your body is like a city teeming with trillions of individual cells. Cells cling together to hold you together. As the people work together to help their city or town prosper, your cells work as a team to keep you alive.

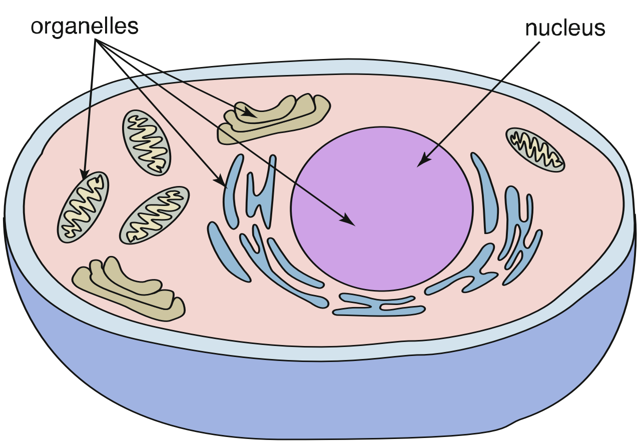
Inside each cell are smaller structures, called **organelles,** or "little organs." Each organelle has its own special job. One of these organelles, the

DOWNLOAD

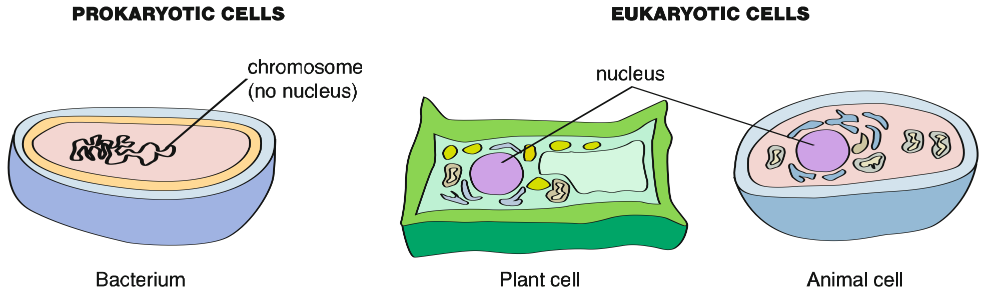
- The initials *DNA* stand for deoxyribonucleic acid.
- DNA is found in the cells of all living things.
- The twisted ladder shape of a DNA molecule is called a **double helix.**
- Instructions from the genes on DNA determine the characteristics of all living things.
- DNA is passed on through heredity.

nucleus, has the job of holding the DNA, so it is often called the control center or "brain" of the cell. The control center can be compared to a control tower at an airport. The air traffic controller guiding the planes from inside the tower is like the DNA. The word *nucleus* comes from the Latin word for "kernel" because it looks like a dark, round nut when viewed under low magnification on a microscope.

Inside the nucleus, the DNA works like a big boss, sending out instructions for the cell to make **proteins.** Proteins perform various tasks in the body, from building new organelles to speeding up chemical reactions. Only when a cell reproduces does the nucleus break down and free the DNA. At that point, the DNA has copied itself, so



Like people in a factory, organelles work together to keep a cell running smoothly. The nucleus is the organelle that holds the DNA.



Unlike eukaryotic cells, prokaryotic cells do not have membrane-covered organelles, so their DNA is not contained within a nucleus.

there is twice as much as normal. When one cell divides into two, each new cell has an exact copy of the original DNA. This copying is important, because if it did not occur the new cells would not have the necessary instructions, and they would die. Without new cells to replace old cells, your body would not last long.

You are a **eukaryote** *(yoo KAR ee oht)*, along with other plants and animals, which is just a fancy way of saying that your cells have a "true nucleus." The other type of living cell is a **prokaryote** *(proh KAR ee oht)*, which means before the nucleus. Prokaryotes are primitive cells that lived on Earth long before the eukaryotes. Prokaryotes do not have a nucleus, and their DNA simply floats inside the cell. **Bacteria** are prokaryotes.

The nucleus is not the only place eukaryotes have DNA. Organelles called **mitochondria**

Looking like a fingerprint, a mitochondrion contains many folded membranes that provide a large surface area for producing energy in a cell.

(*my tuh KAHN dree uh; singular*, mitochondrion) are like bacteria. They have DNA, but not inside a nucleus. Mitochondrial DNA uses a slightly different code for sending messages. So you actually have two different kinds of DNA in your body!

Because the DNA is different in mitochondria, some scientists believe that they were once prokaryotes that were swallowed by eukaryotes. For some reason, they were not digested. The prokaryote thrived inside the eukaryote because it was protected. The eukaryote benefited because the prokaryote made extra energy that the host eukaryote could use. When the eukaryote multiplied, the prokaryotes were also passed on to future generations. Eventually, they became mitochondria. The mitochondria now provide the energy that you need for your cells to work.

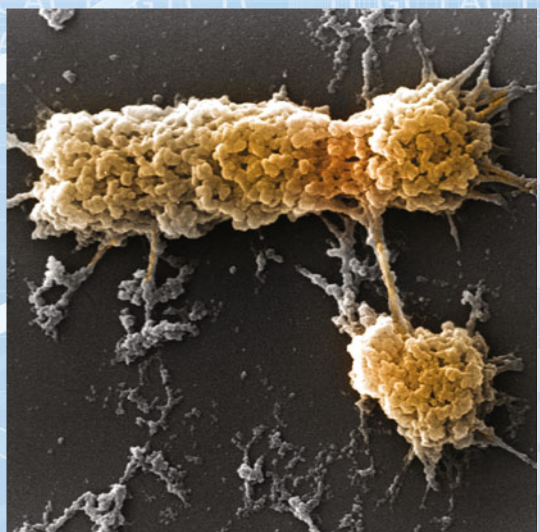
TAKING A CLOSER LOOK

DNA is so small that it takes a powerful electron microscope to see it. **Electrons** are negatively charged particles that orbit around all atoms. They have the ability to flow and create electricity. With an electron microscope, scientists shoot electrons at objects that cannot be seen in any other way. This process can magnify things up to 2 million times. The compound light microscopes that might be used in a science classroom only magnify up to ten, forty, or a hundred times.

As the electrons bounce off an object or travel through it, depending on the electron microscope, they are detected by special equipment. The equipment then sends an image to a monitor or computer. Scientists have spent many years improving tools that allow them to take a closer look at DNA **molecules.**

Look at a strand of your hair. The width of a DNA strand is about 40,000 times thinner! The length of a DNA strand varies, depending on how many messages it carries, but if all of the DNA from just one cell was laid end to end, it would stretch more than 2 meters (about 6 feet). If you took the DNA out of all the cells in an average adult human—about a 100 trillion cells—it would wrap around the earth's equator nearly 5 million times. And you thought running a mile in gym class was a long way!

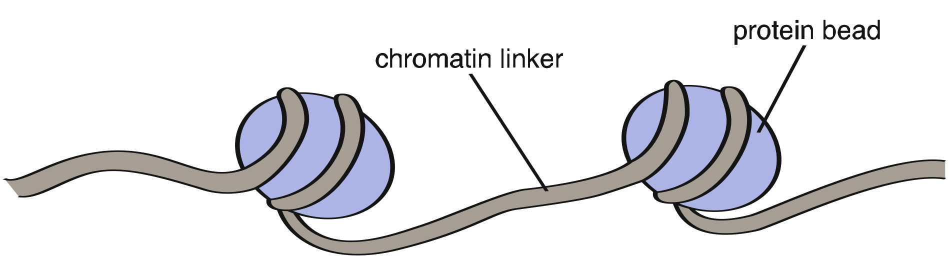
TOOL BAR



Electron microscopes, such as the one seen on the left, allow scientists to take detailed pictures of DNA and other super-microscopic objects—those objects that are so small they cannot be seen with a regular microscope. The nuclear chromosome shown on the right is an example of such an image.

The search for DNA starts with the cell, which spends most of its time in a stage of growth called **interphase.** At this time, the cell is not reproducing or dividing. During interphase, the nucleus contains many coils and loops of a material called **chromatin.** The chromatin is about half DNA and half protein.

"BEADS-ON-A-STRING" FIBER



Chromatin, which will coil to form chromosomes during cell reproduction, is made of DNA intermittently wrapped around small beads of protein. A protein bead with its linker strand of DNA is called a nucleosome.

If you pulled out the coils and loops of chromatin, you would see that the DNA wraps around bead-like clusters of proteins. The DNA goes around one protein bead about one and a half times and is then connected to the next bead by a short stretch of DNA called linker DNA. Scientists call this structure, which looks like a necklace, a "beads-on-a-string" fiber. One bead with its linker DNA is called a **nucleosome.**

If you popped the protein bead out of a nucleosome, you would be left with pure DNA, which is made of two strands of chemicals called **nucleic acids.** (That's where the *NA* in DNA comes from.) The two nucleic acids are held together in the middle by hydrogen bonds. You might recognize the

POP-UP

When a cell reproduces, the strands of looped chromatin bend, fold, and coil into rod-like structures called **chromosomes**. The **chromatin** in a chromosome is packed up to 10,000 times tighter than when it is in **interphase**. Without packing, the chromosomes might get tangled or break when they move during cell division. It would be like having 46 very long pieces of string bunched together. It would be easier to separate them if each one was rolled into a ball first. Human cells have 46 chromosomes, or 46 condensed strands of chromatin (23 from the mother and 23 from the father). Chromosomes get their name from the Greek term for "colored bodies," because they are easily seen under the low magnification of a microscope.