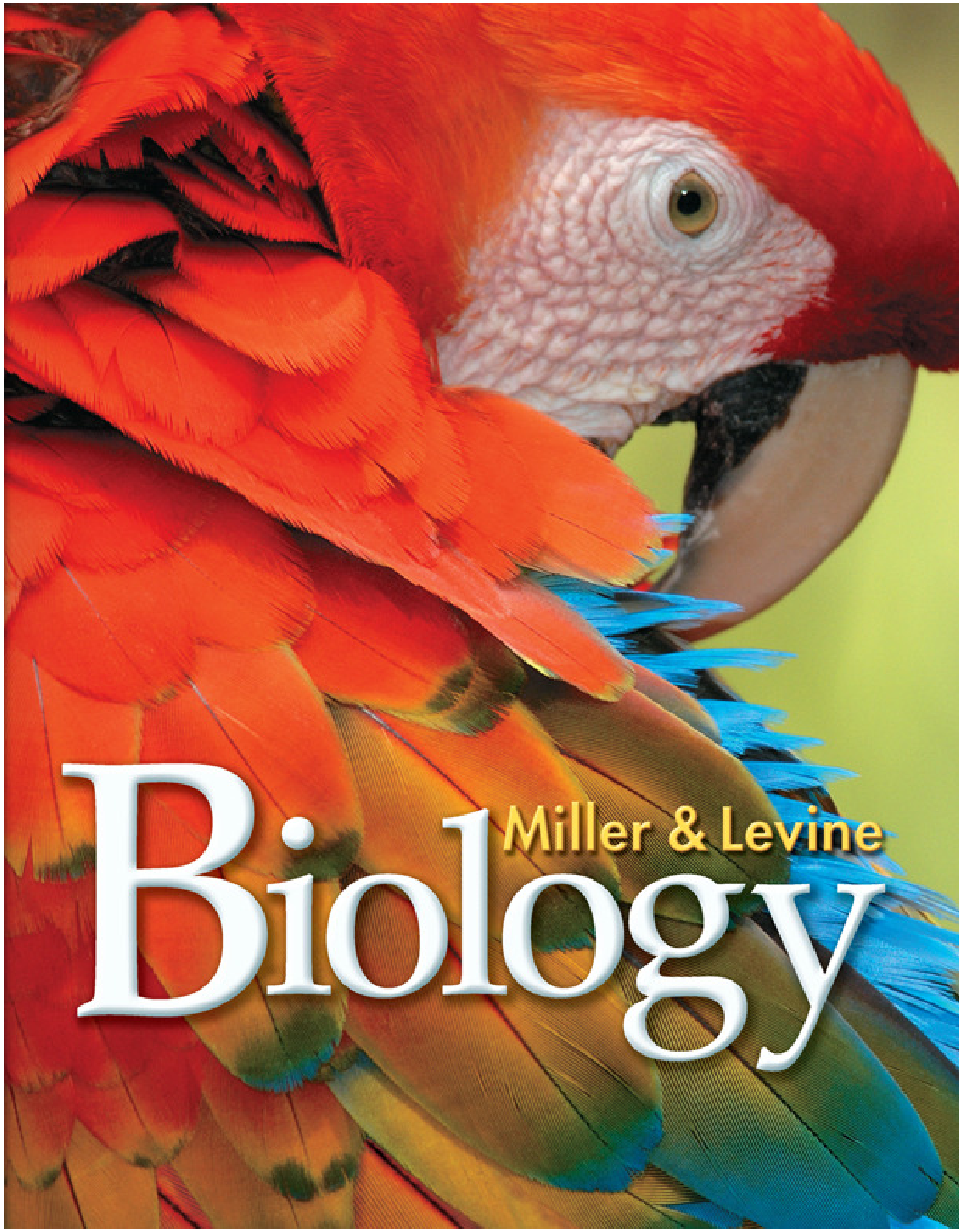



# Lesson Overview

12.1 Identifying the Substance of Genes

# THINK ABOUT IT

How do genes work?

To answer that question, the first thing you need to know is what genes are made of.

How would you go about figuring out what molecule or molecules go into making a gene?

# Bacterial Transformation

What clues did bacterial transformation yield about the gene?

# Bacterial Transformation

- What clues did bacterial transformation yield about the gene?

- By observing bacterial transformation, Avery and other scientists discovered that the nucleic acid DNA stores and transmits genetic information from one generation of bacteria to the next.

# Bacterial Transformation

To truly understand genetics, scientists realized they had to discover the chemical nature of the gene.

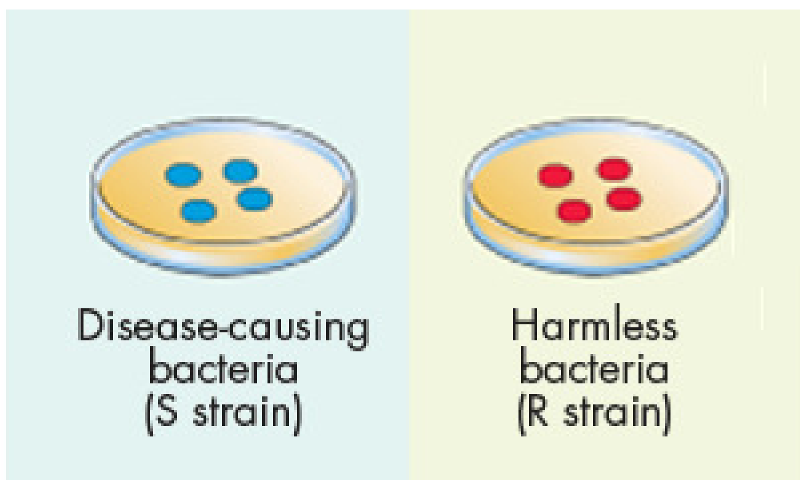
If the molecule that carries genetic information could be identified, it might be possible to understand how genes control the inherited characteristics of living things.

The discovery of the chemical nature of the gene began in 1928 with British scientist Frederick Griffith, who was trying to figure out how certain types of bacteria produce pneumonia.

# Griffith's Experiments

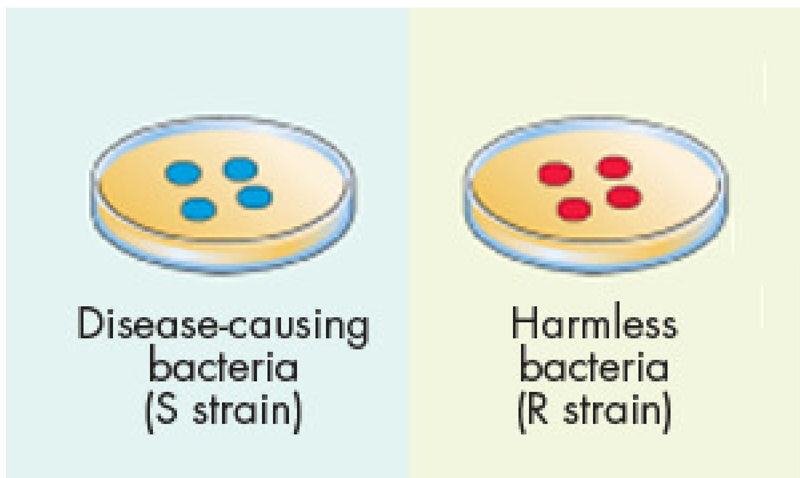
Griffith isolated two different strains of the same bacterial species.

Both strains grew very well in culture plates in Griffith's lab, but only one of the strains caused pneumonia.



# Griffith's Experiments

The disease-causing bacteria (S strain) grew into smooth colonies on culture plates, whereas the harmless bacteria (R strain) produced colonies with rough edges.

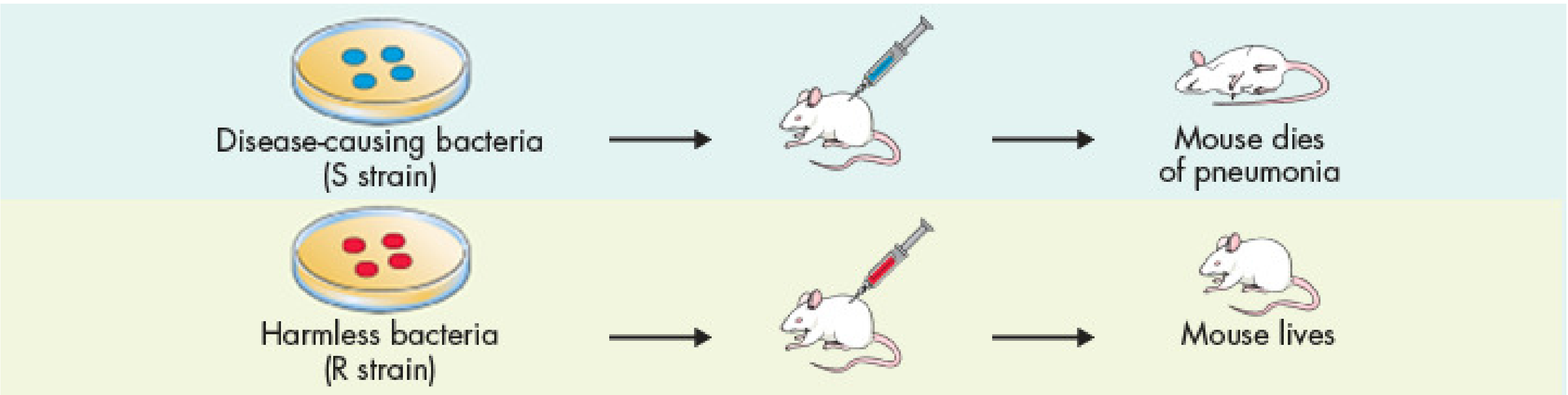


# Griffith's Experiments

When Griffith injected mice with disease-causing bacteria, the mice developed pneumonia and died.

When he injected mice with harmless bacteria, the mice stayed healthy.

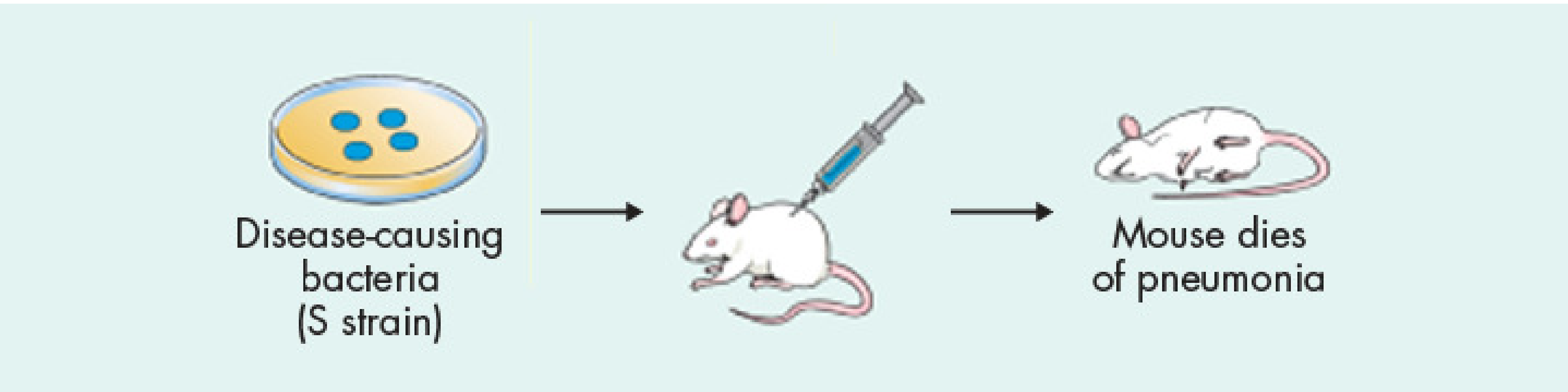
Perhaps the S-strain bacteria produced a toxin that made the mice sick? To find out, Griffith ran a series of experiments.



# Griffith's Experiments

First, Griffith took a culture of the S strain, heated the cells to kill them, and then injected the heat-killed bacteria into laboratory mice.

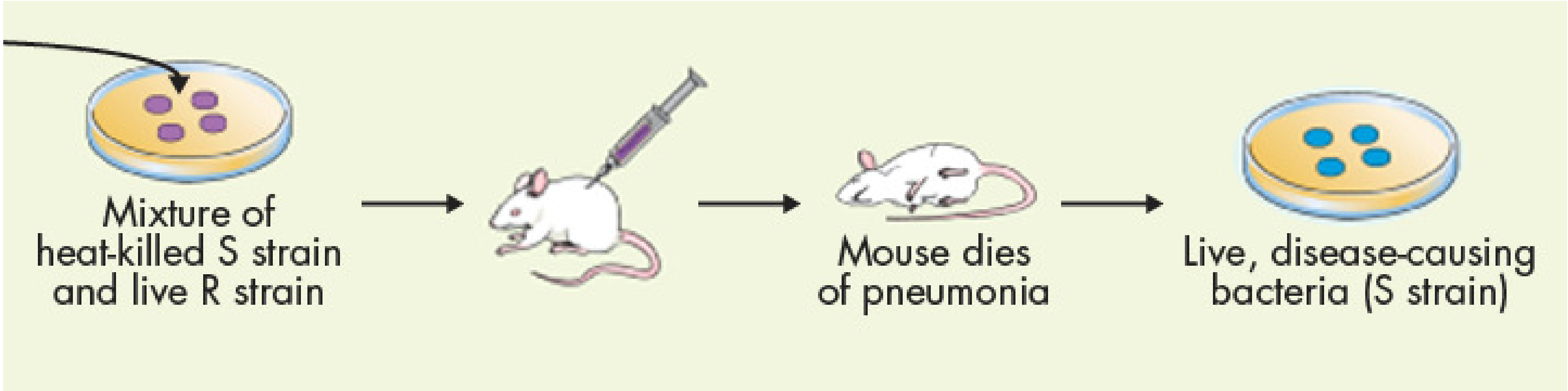
The mice survived, suggesting that the cause of pneumonia was not a toxin from these disease-causing bacteria.



# Griffith’s Experiments

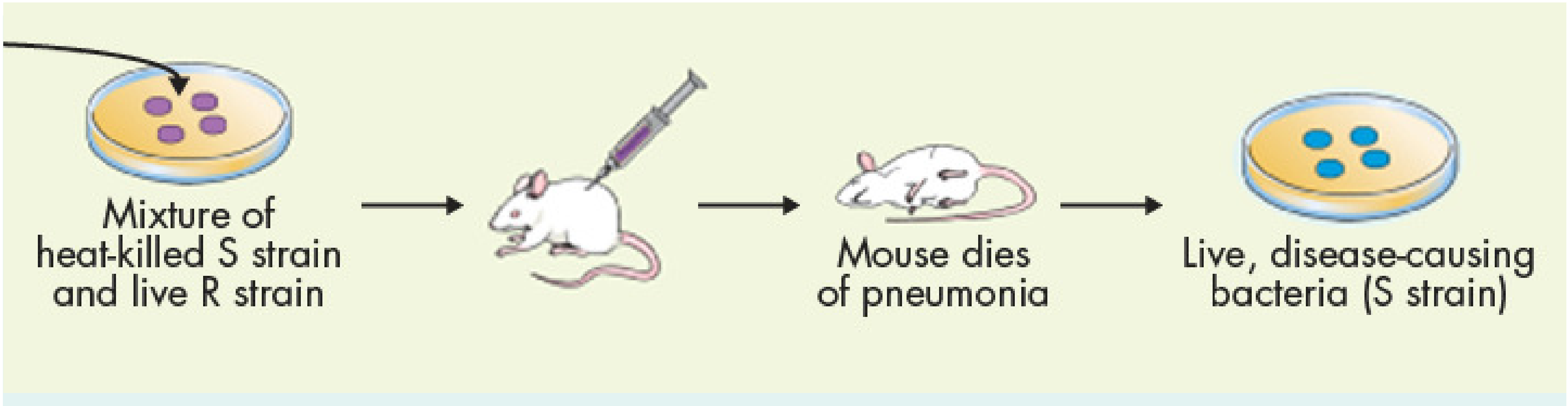
In Griffith’s next experiment, he mixed the heat-killed, S-strain bacteria with live, harmless bacteria from the R strain and injected the mixture into laboratory mice.

The injected mice developed pneumonia, and many died.



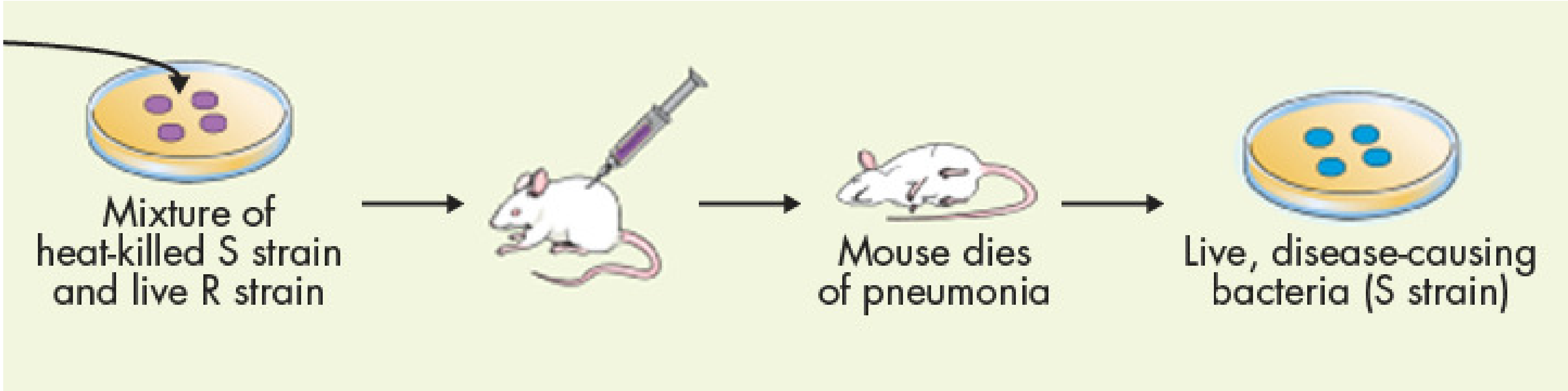
# Griffith's Experiments

The lungs of these mice were filled with the disease-causing bacteria. How could that happen if the S strain cells were dead?



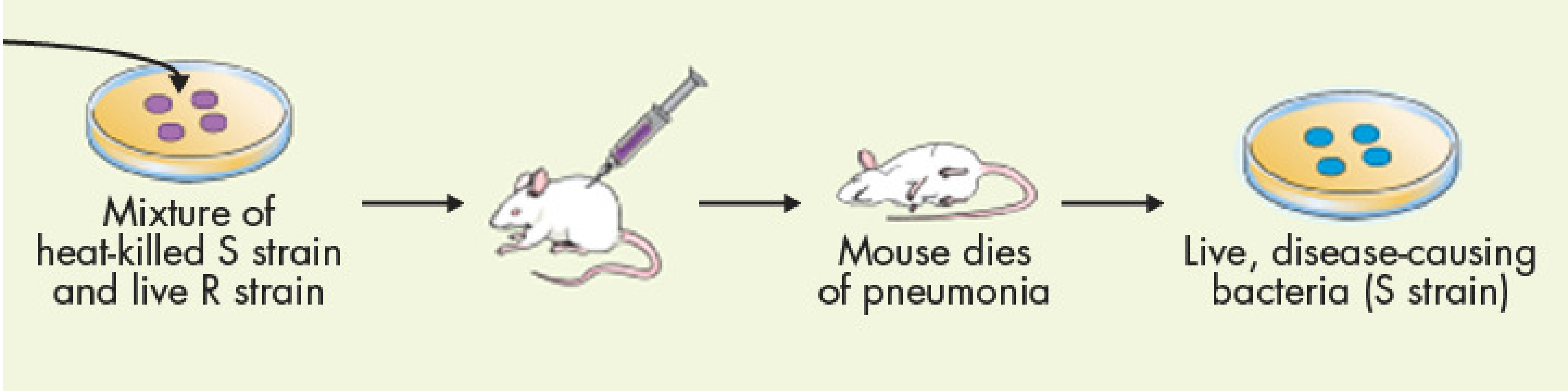
# Transformation

Griffith reasoned that some chemical factor that could change harmless bacteria into disease-causing bacteria was transferred from the heat-killed cells of the S strain into the live cells of the R strain.



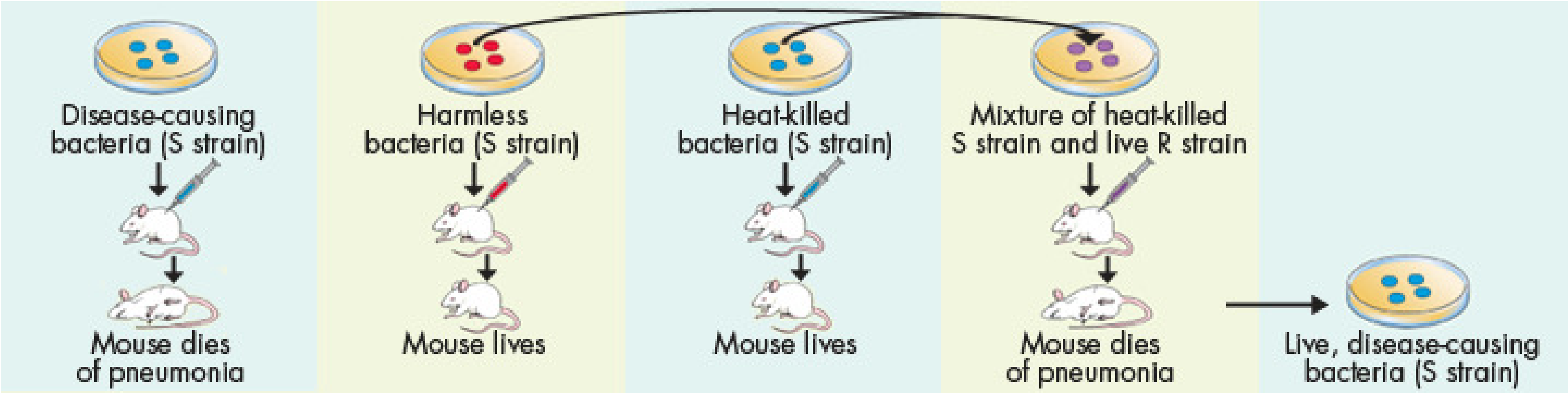
# Transformation

He called this process **transformation**, because one type of bacteria had been changed permanently into another.



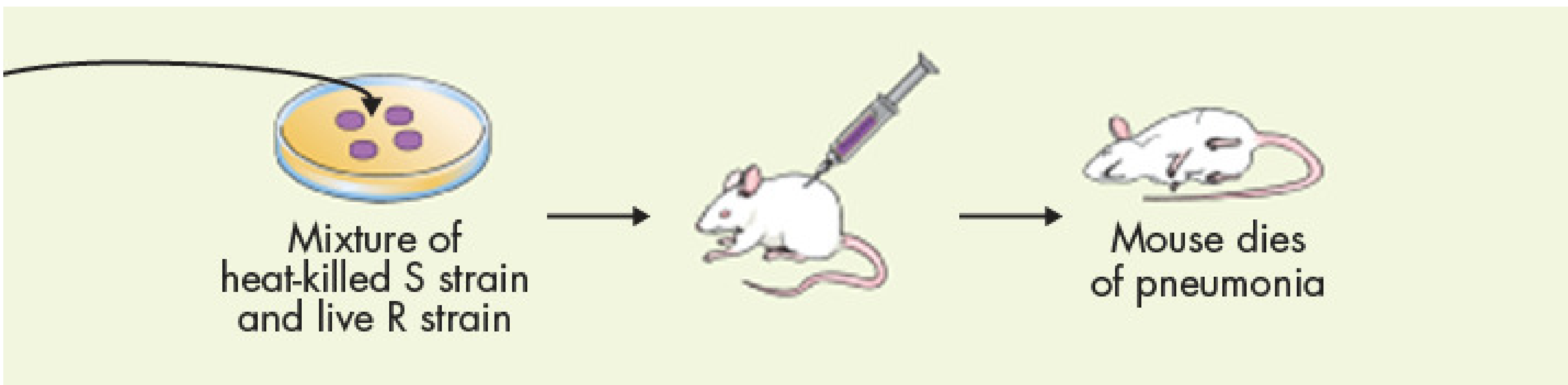
# Transformation

Because the ability to cause disease was inherited by the offspring of the transformed bacteria, Griffith concluded that the transforming factor had to be a gene.



# The Molecular Cause of Transformation

A group of scientists at the Rockefeller Institute in New York, led by the Canadian biologist Oswald Avery, wanted to determine which molecule in the heat-killed bacteria was most important for transformation.



# The Molecular Cause of Transformation

Avery and his team extracted a mixture of various molecules from the heat-killed bacteria and treated this mixture with enzymes that destroyed proteins, lipids, carbohydrates, and some other molecules, including the nucleic acid RNA.

Transformation still occurred.

# The Molecular Cause of Transformation

Avery's team repeated the experiment using enzymes that would break down DNA.

When they destroyed the DNA in the mixture, transformation did not occur.

Therefore, DNA was the transforming factor.

# Bacterial Viruses

What role did bacterial viruses play in identifying genetic material?

# Bacterial Viruses

- What role did bacterial viruses play in identifying genetic material?

- Hershey and Chase’s experiment with bacteriophages confirmed Avery’s results, convincing many scientists that DNA was the genetic material found in genes—not just in viruses and bacteria, but in all living cells.

# Bacterial Viruses

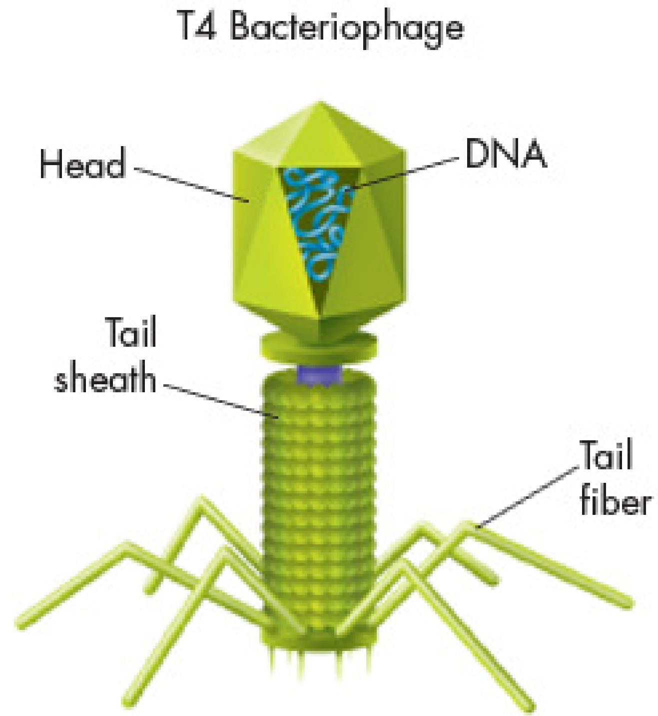
Several different scientists repeated Avery's experiments. Alfred Hershey and Martha Chase performed the most important of the experiments relating to Avery's discovery.

Hershey and Chase studied viruses—nonliving particles that can infect living cells.

# Bacteriophages

The kind of virus that infects bacteria is known as a **bacteriophage**, which means "bacteria eater."

A typical bacteriophage is shown.



# Bacteriophages

When a bacteriophage enters a bacterium, it attaches to the surface of the bacterial cell and injects its genetic information into it.

# Bacteriophages

The viral genes act to produce many new bacteriophages, which gradually destroy the bacterium.

When the cell splits open, hundreds of new viruses burst out.

# The Hershey-Chase Experiment

American scientists Alfred Hershey and Martha Chase studied a bacteriophage that was composed of a DNA core and a protein coat.

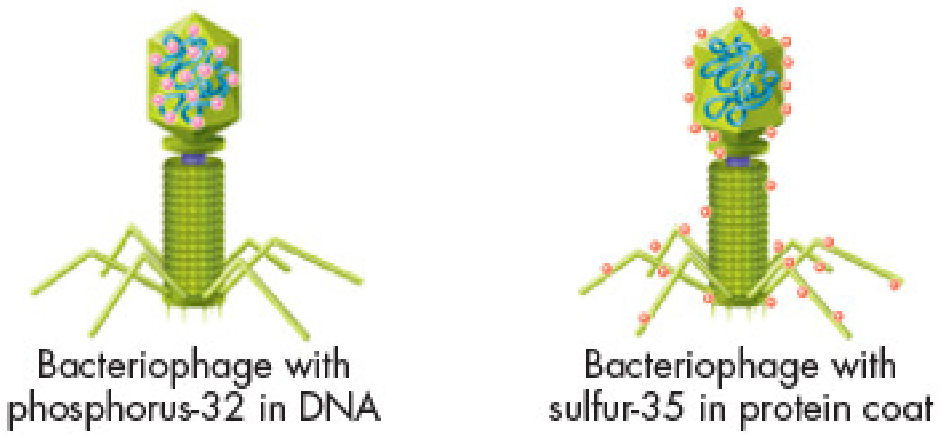
They wanted to determine which part of the virus—the protein coat or the DNA core—entered the bacterial celll

# The Hershey-Chase Experiment

Their results would either support or disprove Avery’s finding that genes were made of DNA.

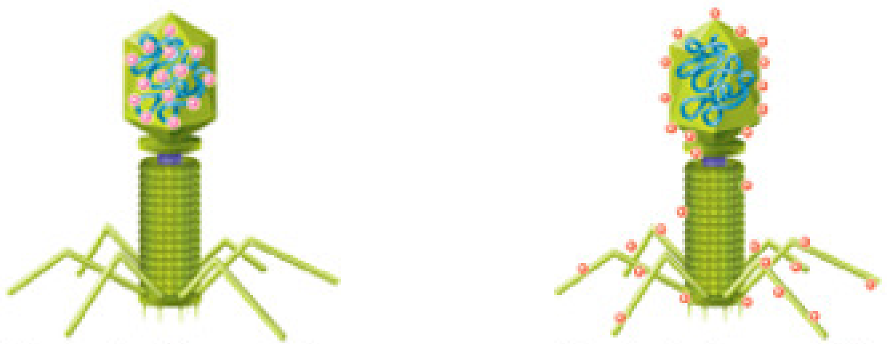
# The Hershey-Chase Experiment

Hershey and Chase grew viruses in cultures containing radioactive isotopes of phosphorus-32 (P-32) sulfur-35 (S-35)



# The Hershey-Chase Experiment

Since proteins contain almost no phosphorus and DNA contains no sulfur, these radioactive substances could be used as markers, enabling the scientists to tell which molecules actually entered the bacteria and carried the genetic information of the virus.



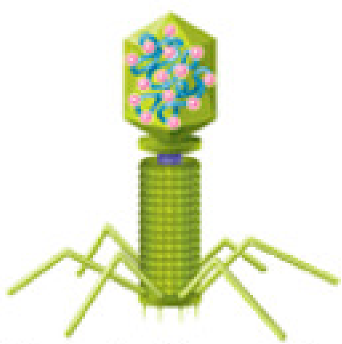
Bacteriophage with phosphorus-32 in DNA

Bacteriophage with sulfur-35 in protein coat

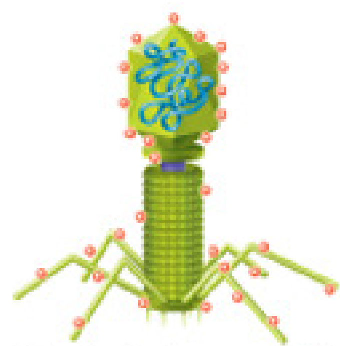
# The Hershey-Chase Experiment

If they found radioactivity from S-35 in the bacteria, it would mean that the virus's protein coat had been injected into the bacteria.

If they found P-32 then the DNA core had been injected.



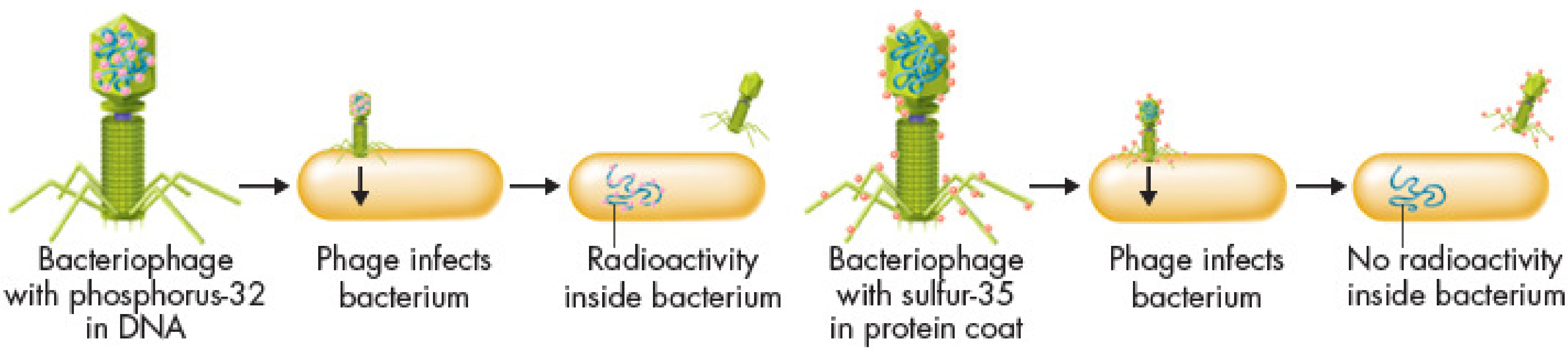
Bacteriophage with phosphorus-32 in DNA



Bacteriophage with sulfur-35 in protein coat

# The Hershey-Chase Experiment

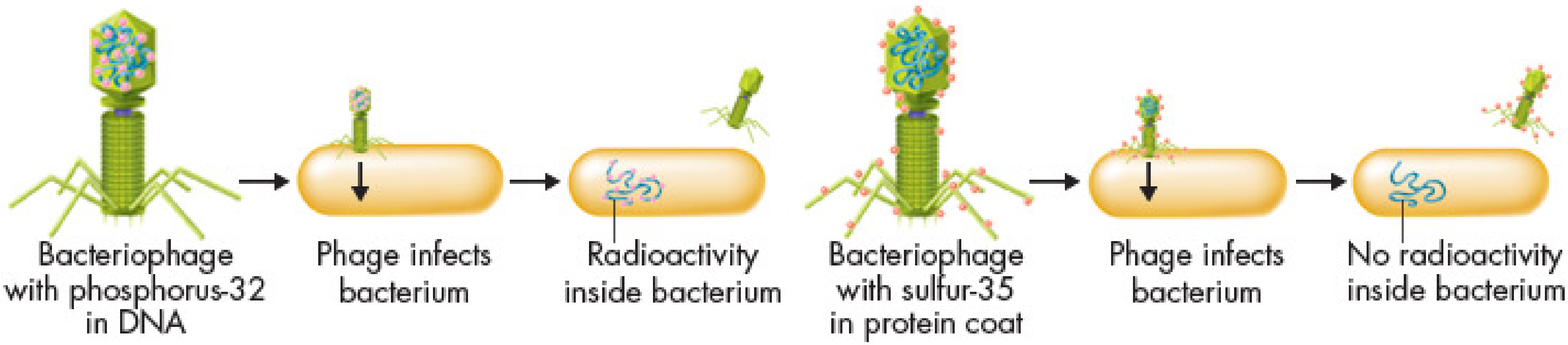
The two scientists mixed the marked viruses with bacterial cells, waited a few minutes for the viruses to inject their genetic material, and then tested the bacteria for radioactivity.



# The Hershey-Chase Experiment

Nearly all the radioactivity in the bacteria was from phosphorus P-32 , the marker found in DNA.

Hershey and Chase concluded that the genetic material of the bacteriophage was DNA, not protein.



# The Role of DNA

What is the role of DNA in heredity?

# The Role of DNA

- What is the role of DNA in heredity?

- The DNA that makes up genes must be capable of storing, copying, and transmitting the genetic information in a cell.

# The Role of DNA

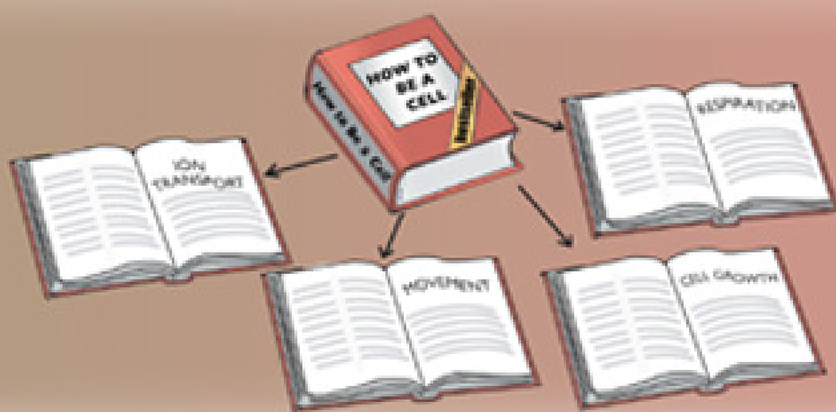
The DNA that makes up genes must be capable of storing, copying, and transmitting the genetic information in a cell.

These three functions are analogous to the way in which you might share a treasured book, as pictured in the figure.

# Storing Information

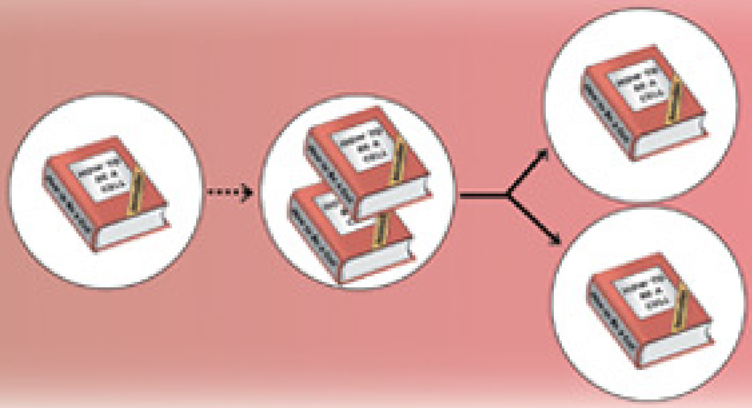
The foremost job of DNA, as the molecule of heredity, is to store information.

Genes control patterns of development, which means that the instructions that cause a single cell to develop into an oak tree, a sea urchin, or a dog must somehow be written into the DNA of each of these organisms.



# Copying Information

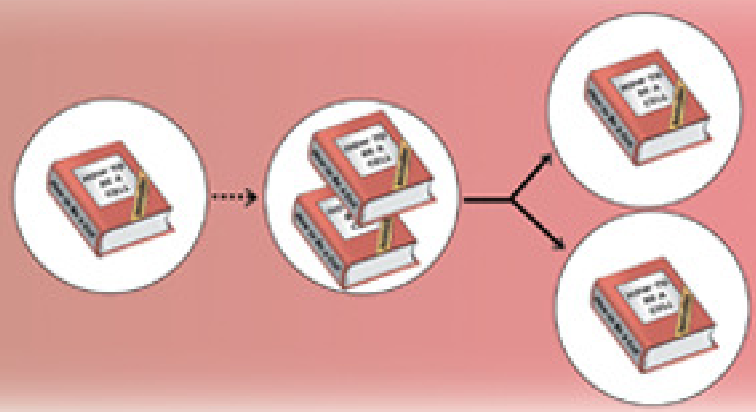
Before a cell divides, it must make a complete copy of every one of its genes, similar to the way that a book is copied.



# Copying Information

To many scientists, the most puzzling aspect of DNA was how it could be copied.

Once the structure of the DNA molecule was discovered, a copying mechanism for the genetic material was soon put forward.



# Transmitting Information

When a cell divides, each daughter cell must receive a complete copy of the genetic information.

Careful sorting is especially important during the formation of reproductive cells in meiosis.

The loss of any DNA during meiosis might mean a loss of valuable genetic information from one generation to the next.