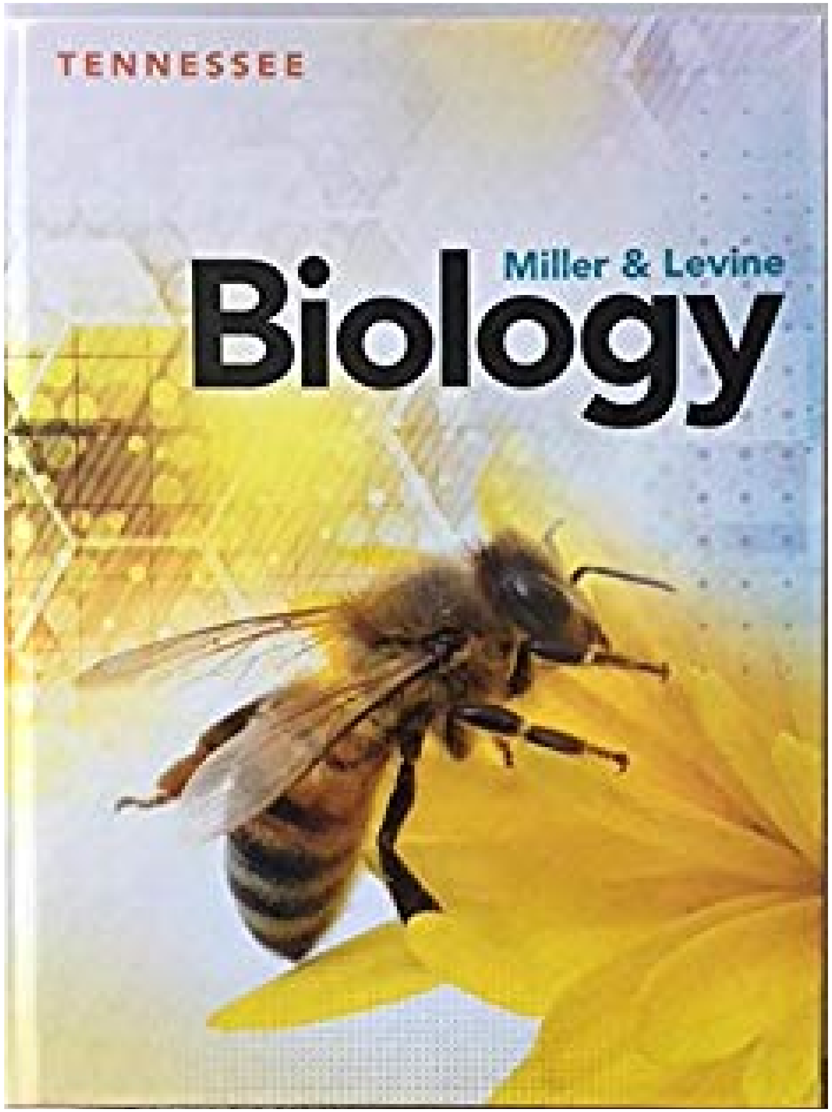


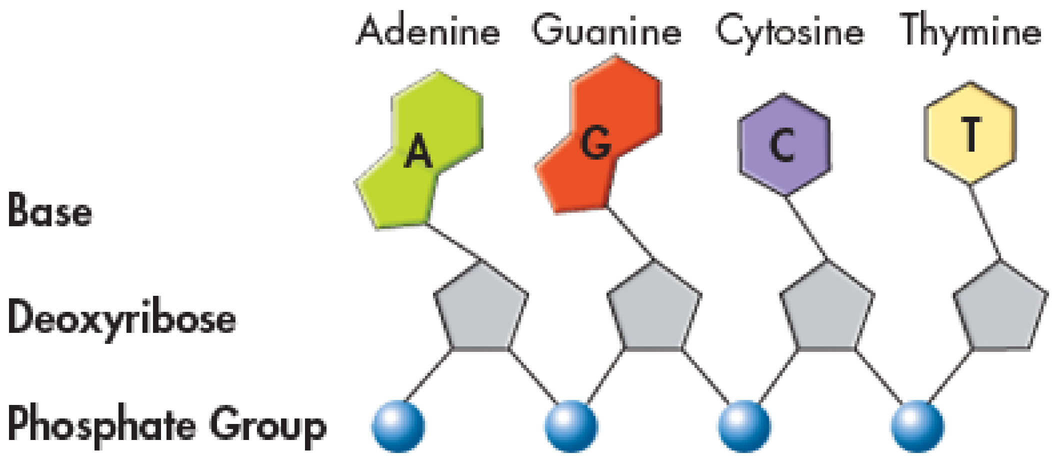
13.2 DNA structure

Nucleic Acids and Nucleotides

Nucleic acids are long, slightly acidic molecules originally identified in cell nuclei.

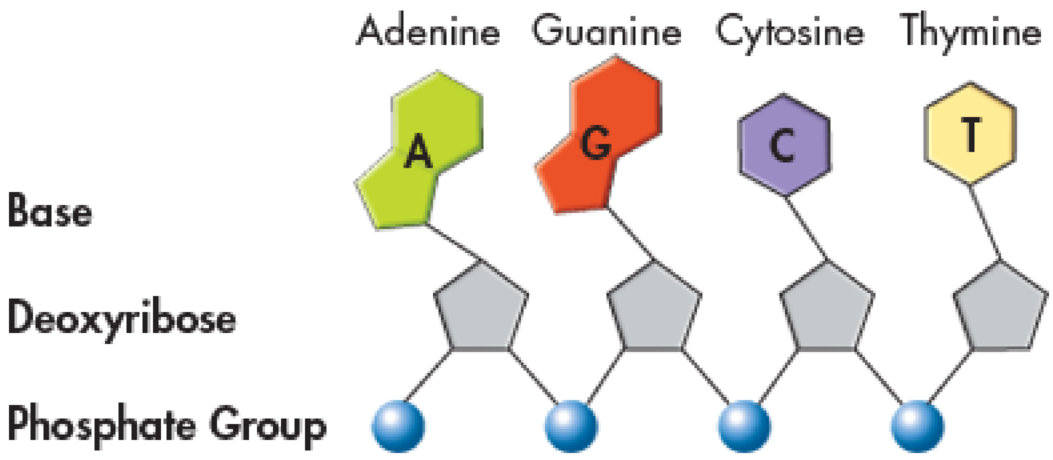
Nucleic acids are made up of nucleotides, linked together to form long chains.

The nucleotides that make up DNA are shown.



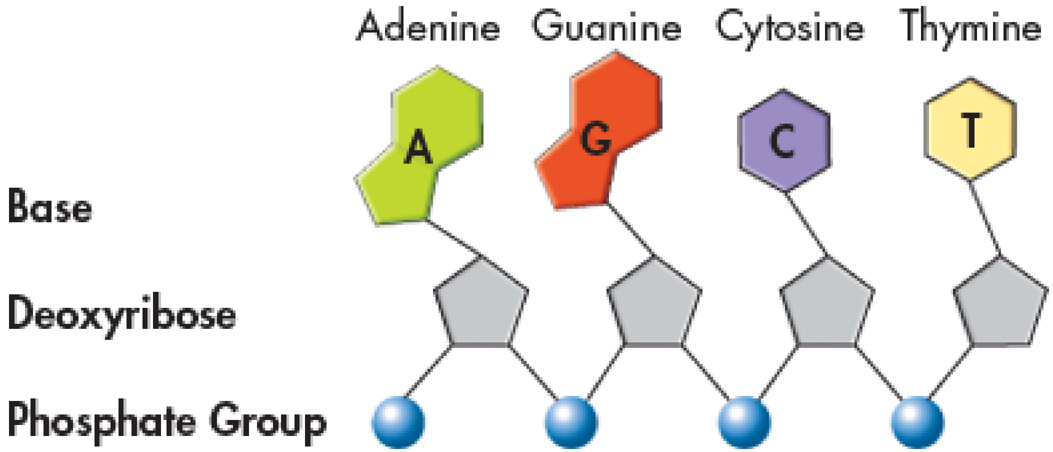
Nucleic Acids and Nucleotides

DNA's nucleotides are made up of three basic components: a 5-carbon sugar called deoxyribose, a phosphate group, and a nitrogenous base.



Nitrogenous Bases and Covalent Bonds

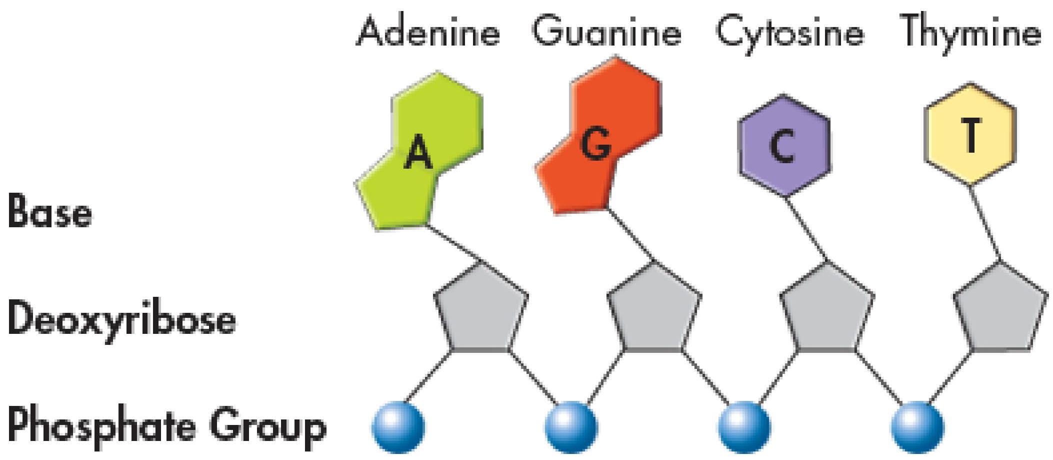
The nucleotides in a strand of DNA are joined by covalent bonds formed between their sugar and phosphate groups.



Nitrogenous Bases and Covalent Bonds

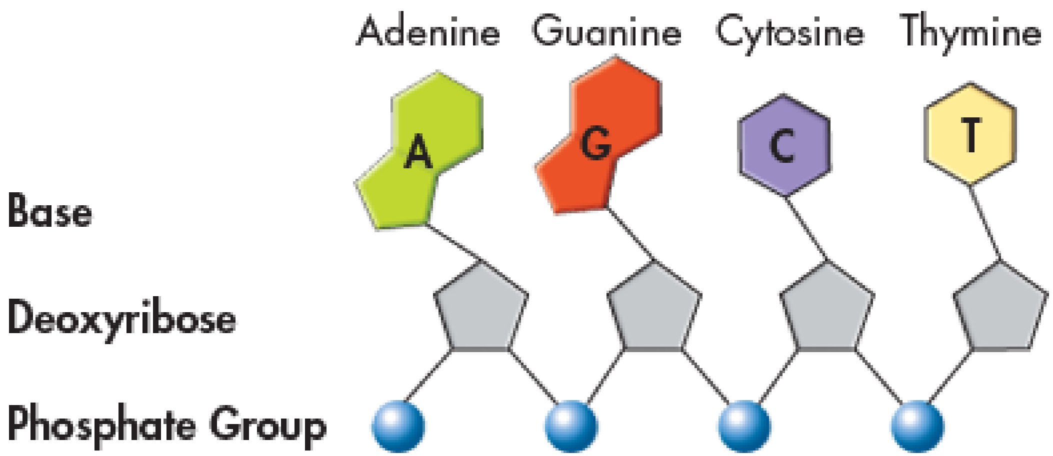
DNA has four kinds of nitrogenous bases: adenine (A), guanine (G), cytosine (C), and thymine (T).

The nitrogenous bases stick out sideways from the nucleotide chain.



Nitrogenous Bases and Covalent Bonds

The nucleotides can be joined together in any order, meaning that any sequence of bases is possible.



Chargaff's Rules

Erwin Chargaff discovered that the percentages of adenine [A] and thymine [T] bases are almost equal in any sample of DNA.

The same thing is true for the other two nucleotides, guanine [G] and cytosine [C].

The observation that [A] = [T] and [G] = [C] became known as one of "**Chargaff's rules**."

Franklin's X-Rays

In the 1950s, British scientist Rosalind Franklin used a technique called X-ray diffraction to get information about the structure of the DNA molecule.

Franklin’s X-Rays

X-ray diffraction revealed an X-shaped pattern showing that the strands in DNA are twisted around each other like the coils of a spring.

The angle of the X-shaped pattern suggested that there are two strands in the structure.

Other clues suggest that the nitrogenous bases are near the center of the DNA molecule.

The Work of Watson and Crick

At the same time, James Watson, an American biologist, and Francis Crick, a British physicist, were also trying to understand the structure of DNA.

They built three-dimensional models of the molecule.

The Work of Watson and Crick

Early in 1953, Watson was shown a copy of Franklin's X-ray pattern.

The clues in Franklin's X-ray pattern enabled Watson and Crick to build a model that explained the specific structure and properties of DNA.

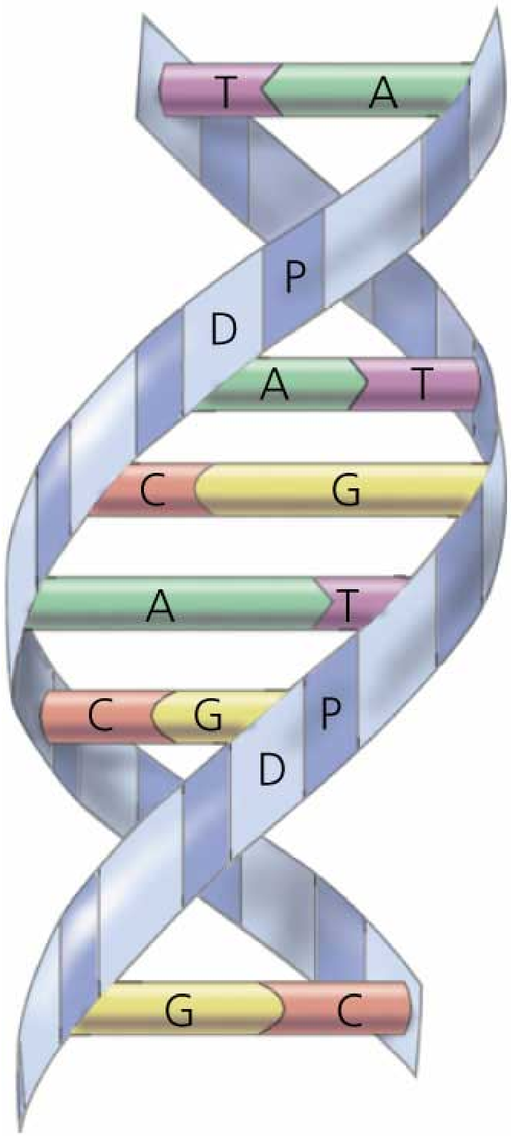
Watson and Crick's breakthrough model of DNA was a double helix, in which two strands were wound around each other.

The Double-Helix Model

A double helix looks like a twisted ladder.

In the double-helix model of DNA, the two strands twist around each other like spiral staircases.

The double helix accounted for Franklin's X-ray pattern and explains Chargaff's rule of base pairing and how the two strands of DNA are held together.



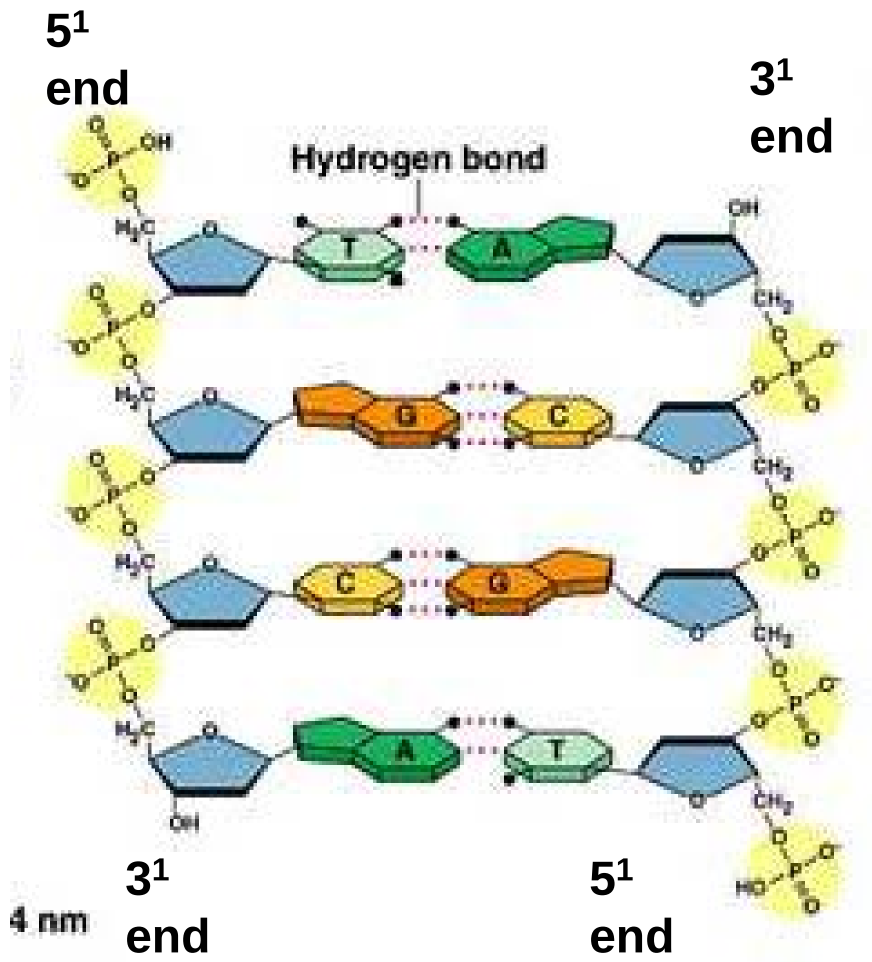
Academy Artworks

Antiparallel Strands

In the double-helix model, the two strands of DNA are “antiparallel”—they run in opposite directions.

This arrangement enables the nitrogenous bases on both strands to come into contact at the center of the molecule.

It also allows each strand of the double helix to carry a sequence of nucleotides, arranged almost like letters in a four-letter alphabet.

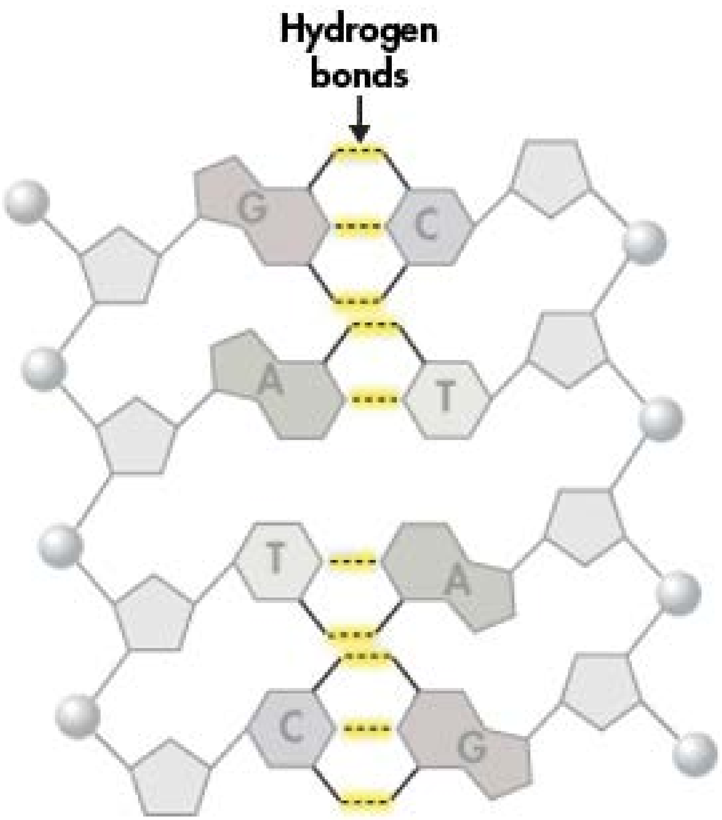


Hydrogen Bonding

Watson and Crick discovered that hydrogen bonds could form between certain nitrogenous bases, providing just enough force to hold the two DNA strands together.

Hydrogen bonds are relatively weak chemical forces that allow the two strands of the helix to separate.

The ability of the two strands to separate is critical to DNA's functions.

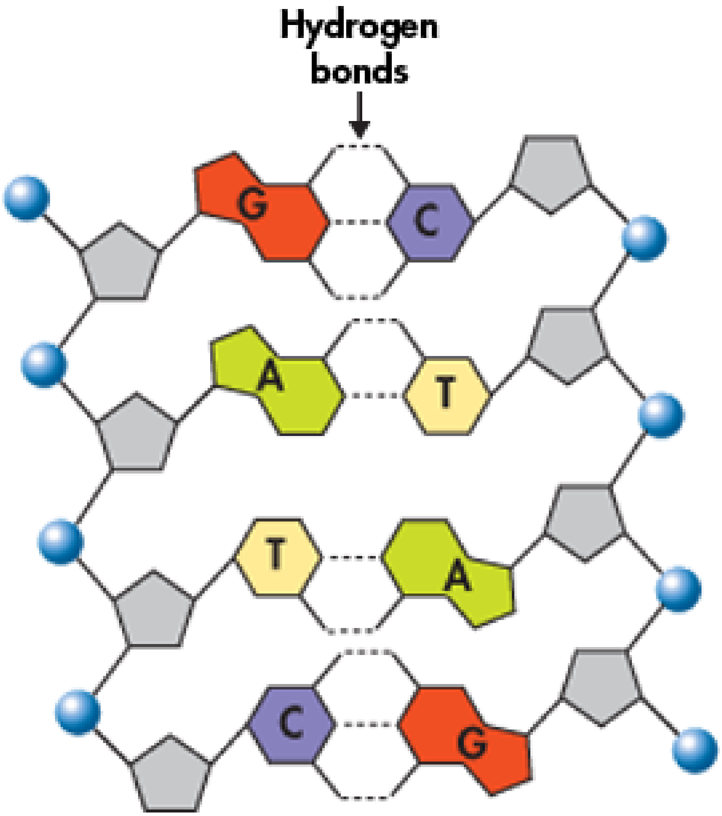


Base Pairing

Watson and Crick's model showed that hydrogen bonds could create a nearly perfect fit between nitrogenous bases along the center of the molecule.

These bonds would form only between certain base pairs—adenine with thymine, and guanine with cytosine.

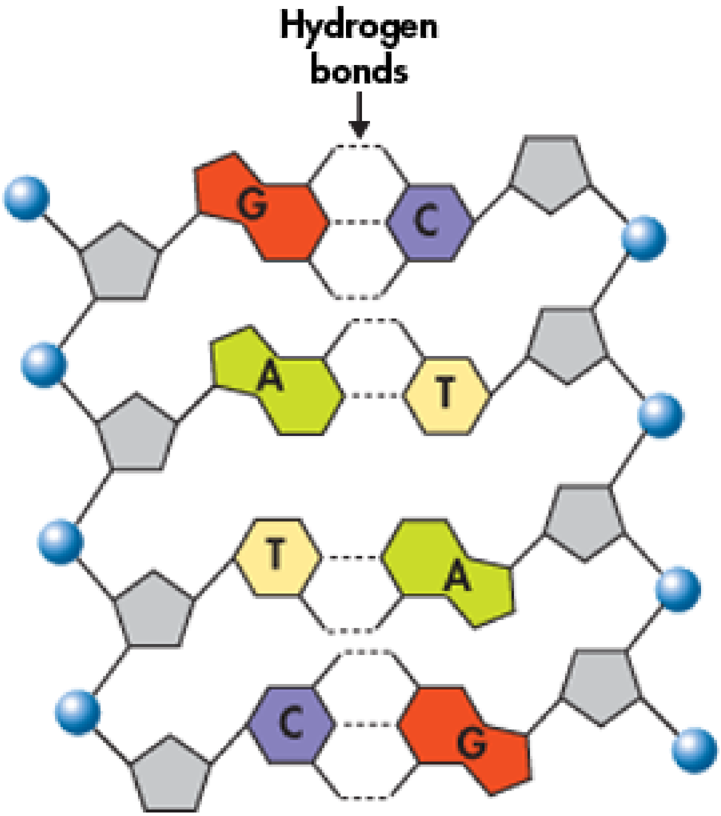
This nearly perfect fit between A–T and G–C nucleotides is known as base pairing, and is illustrated in the figure.



Base Pairing

Watson and Crick realized that base pairing explained Chargaff's rule. It gave a reason why [A] = [T] and [G] = [C].

For every adenine in a double-stranded DNA molecule, there had to be exactly one thymine. For each cytosine, there was one guanine.



1860 1880 1900 1920 1940 1960 1980 2000

1865
Gregor Mendel shows that the characteristics of pea plants are passed along in a predictable way. His discovery begins the science of genetics.

1903
◀ **Walter Sutton** shows that chromosomes carry the cell's units of inheritance.

1911
Thomas Hunt Morgan ▲ demonstrates that genes are arranged in linear fashion on the chromosomes of the fruit fly.

1928
▼ **Frederick Griffith** discovers that bacteria contain a molecule that can transfer genetic information from cell to cell.

1944
Oswald Avery, Colin Macleod, and Maclyn McCarty show the substance that Griffith discovered is DNA.

1950
Erwin Chargaff analyzes the base composition of DNA in cells. He discovers that the amounts of adenine and thymine are almost always equal, as are the amounts of guanine and cytosine.

1952
Alfred Hershey and Martha Chase confirm that the genetic material of viruses is DNA, not protein. **Rosalind Franklin** records a critical X-ray diffraction pattern, demonstrating that DNA is in the form of a helix.

1953
James Watson and Francis Crick publish their model of the DNA double helix. The model was made possible by Franklin's work.

2000
▼ **Craig Venter and Francis Collins** announce the draft DNA sequence of the human genome at a White House ceremony in Washington, D.C. The final version is published in 2003.

WRITING Use library or Internet resources to find out what James Watson or Francis Crick worked on after discovering the structure of DNA. Organize your findings about the scientist's work and make a multimedia presentation for the class.