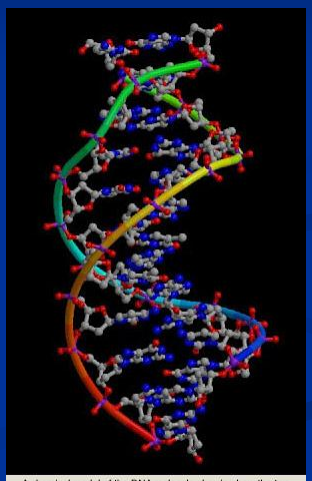
DNA: Structure and Function

Biology's biggest moment in the 20th century – The structure of DNA is discovered.



A chemical model of the DNA molecule showing how the two helixes twist around each other with the bases in the middle.

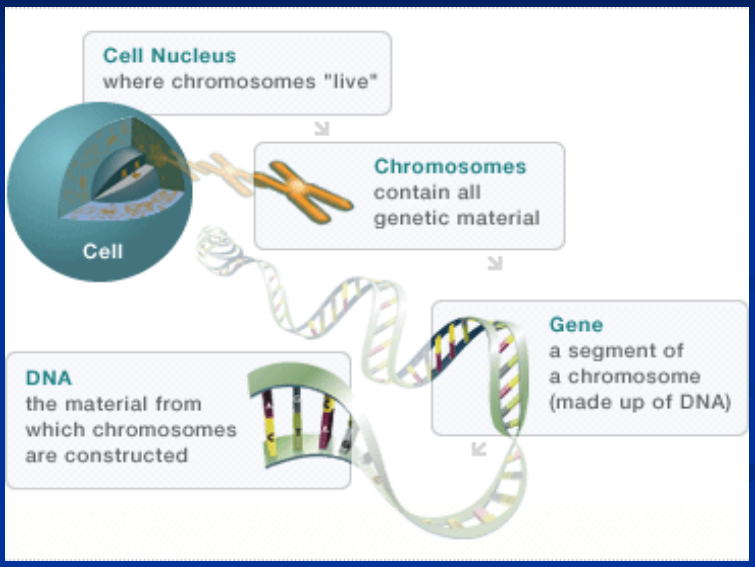
What is DNA?

- Deoxyribonucleic acid (DNA)
- DNA is the molecule of heredity—it determines an organism's traits.
- DNA achieves its control of our traits by producing proteins.
- Proteins are the structural basis of ALL living things:
  - Skin
  - Muscles
  - Bones
  - Hair, etc …
- My Big Fat Greek Wedding - Now You are Family

What is DNA? (cont.)

- Special proteins called **enzymes** are critical to ALL living things' bodily functions:
  - Eating
  - Running
  - Thinking, etc…
- Within the structure of DNA is the information for life—the complete instructions for manufacturing all proteins!

Where is DNA Stored in Our Bodies?

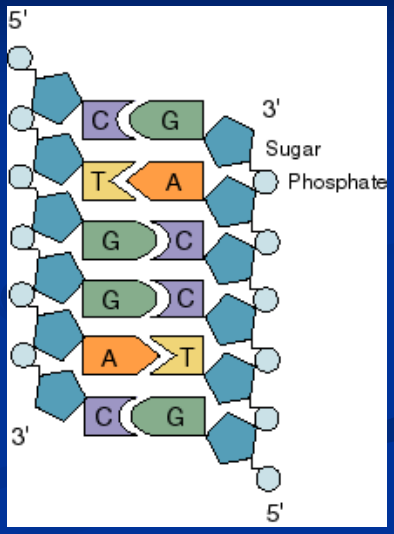


What is the Structure of DNA?

- DNA structure must be compatible with its 4 roles:
  - Make copies of itself
  - Encode information
  - Control cells and tell them what to do
  - Change by mutation

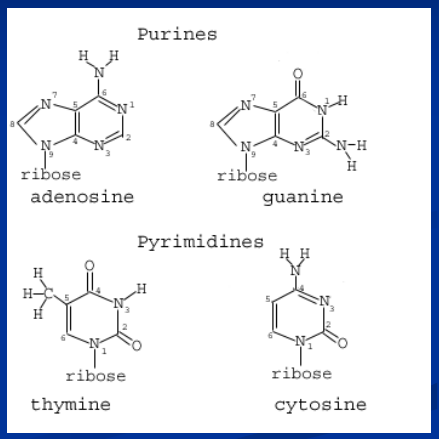
DNA is a Double Helix

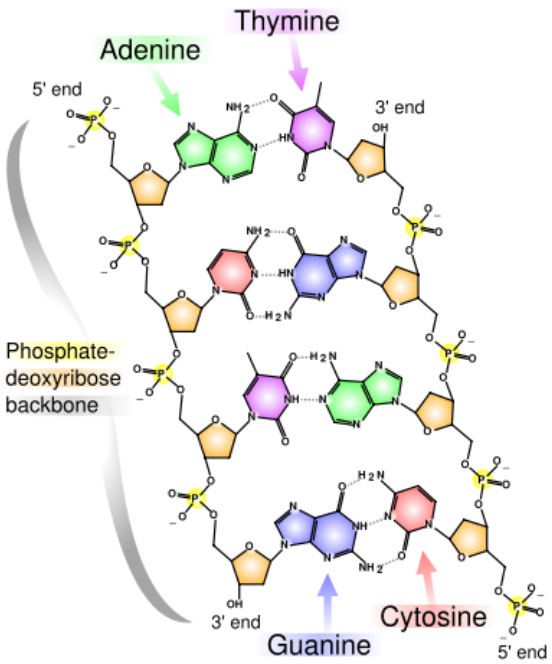
- DNA is comprised of repeating **nucleotides**.
- Nucleotides have 3 components:
  - Phosphate group
  - 5-Carbon sugar (deoxyribose)
  - Nitrogen-containing organic base (A-T, C-G)



Four Bases of DNA Nucleotides

- Adenine (A) – purine
- Guanine (G) – purine
- Thymine (T) – pyrimidine
- Cytosine (C) – pyrimidine





DNA Base Pairing

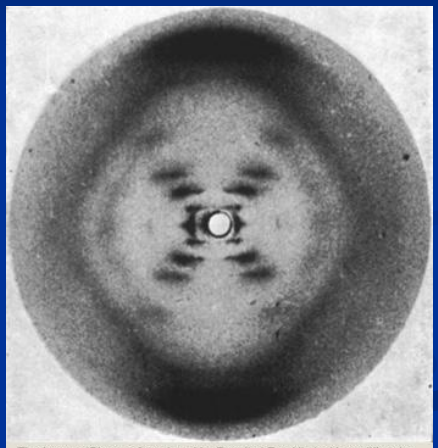
- **Adenine (A)** always pairs with **Thymine (T)**
- **Guanine (G)** always pairs with **Cytosine (C)**

- The bases of one strand can be used to determine the complementary strand:

- **A – T – G - C – T – T – A – G – G**

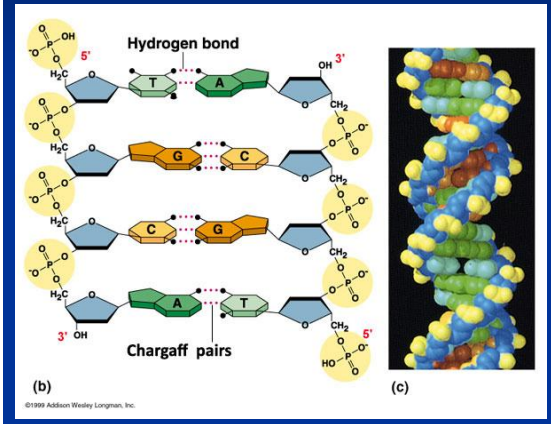
Research of DNA Structure

- Maurice Wilkins' and Rosalind Franklin's research confirmed DNA was a helix



The famous "Photo 51" produced by Rosalind Franklin by X-ray diffraction. From this photo, Watson and Crick figured out the structure of DNA.

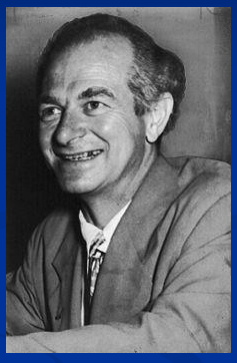
Chargaff's Rule of Ratios



- Amount of adenine always equals thymine
- Amount of cytosine always equals guanine
- Amount of A + T together is independent of C + G

3D Structure of Proteins

- L. Pauling made the discovery using X-ray crystallography:
  - Tiny bit of crystallized sample is bombarded with X-rays
  - Spots and areas thus formed reveal atomic arrangement in the sample
  - Some proteins have a regular structure

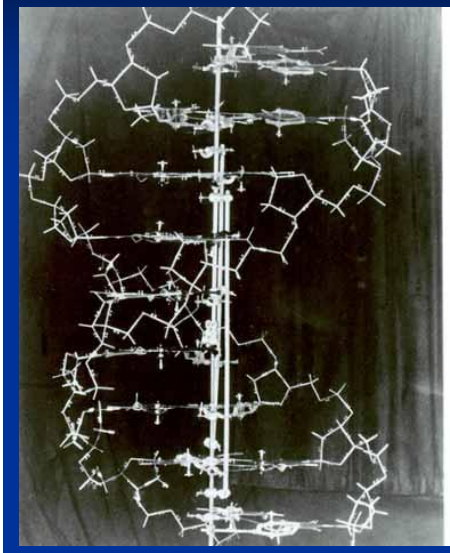


Linus Pauling
1954

3D Structure of Proteins

- Pauling made paper models to resemble amino acids and assembled them into protein model
- Model looked like twisted helix winding around axis (elongated spiral)
- Pauling called the model alpha helix

Watson and Crick 1955

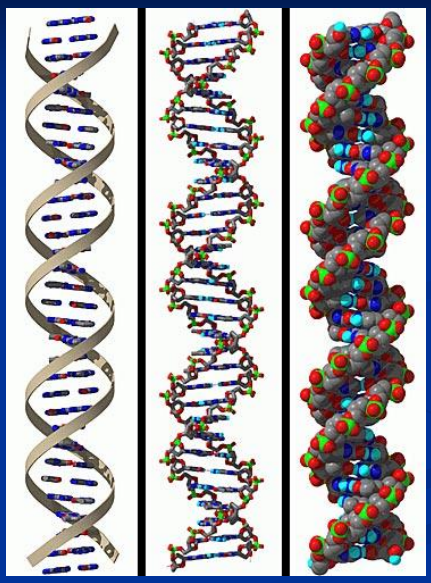


Courtesy of Cold Spring Harbor Laboratory Archives. Noncommercial, educational use only.

Francis Crick (L) and James Watson (R)

Credit: DNA From the Beginning: http://vector.cshl.org/dnaftb/asp/

Double Helix of DNA



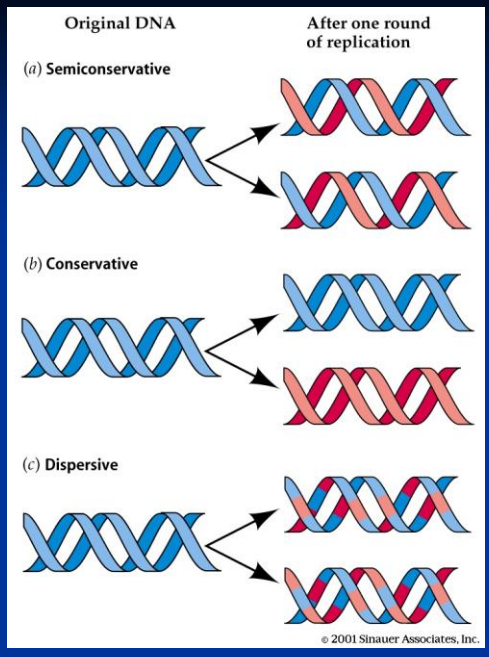
DNA Replication

- During DNA replication each new strand serves as a pattern to make a new DNA molecule …

1. An enzyme, **helicase**, breaks the bonds between the complementary bases "unzipping" the molecule ("unzipped areas are called **replication forks**).
2. As the DNA strand "unzips" free-floating nucleotides bond to the single strands by complementary base pairing with the help of another enzyme, **DNA polymerase**.

DNA Replication (cont.)

3. The process continues until the entire DNA molecule has been "unzipped" and copied (replicated).
- Each new strand formed is a complement of one of the original (parent) strands. The result is the formation of 2 DNA molecules, each of which is identical to the original molecule!



- The process of DNA Replication is said to be **semi-conservative** because the new DNA molecule contains 50% of the original genetic material from the parent!*

Speed of DNA Replication

- Replication does NOT begin at one end of the DNA molecule and end at the other …
  - At this rate it would take 33 days to replicate 1 human chromosome!
- DNA replication occurs in several sections that are several thousand nucleotides long, each section with its own starting point (several replication forks)…
  - With multiple forks working in concert 1 human chromosome can be replicated in about 8 hours!

Errors in DNA Replication

- During DNA replication errors sometimes occur and the wrong nucleotide is added to the new strand--*mutations*.
- **DNA polymerase** acts as a "proofreader"—it can only add a new nucleotide if the previous one is correctly paired to its complementary base!
- If a mismatch occurs DNA polymerase can backup, remove the incorrect nucleotide, and replace it with the correct one.
- This "proofreading" prevents most errors (mutations) during DNA replication:
  - Typically only 1 error/billion nucleotides