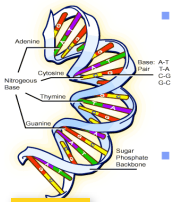
Nucleic Acids

Functions in information storage & transmission and in assisting with the building of proteins

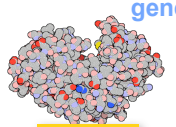
2007-2008

Nucleic Acids

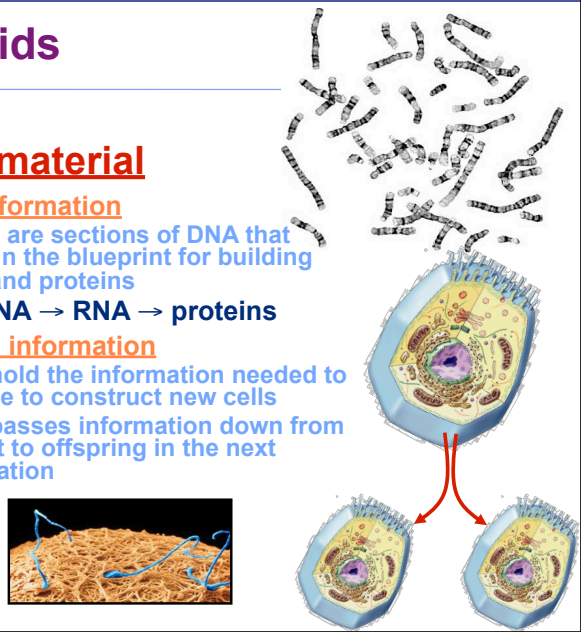
- Function:
  - genetic material
    - stores information
      - genes are sections of DNA that contain the blueprint for building RNA and proteins
        - DNA → RNA → proteins
    - transfers information
      - DNA hold the information needed to be able to construct new cells
      - DNA passes information down from parent to offspring in the next generation



DNA



proteins

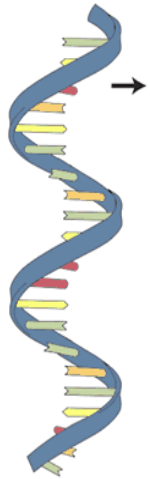


AP Biology

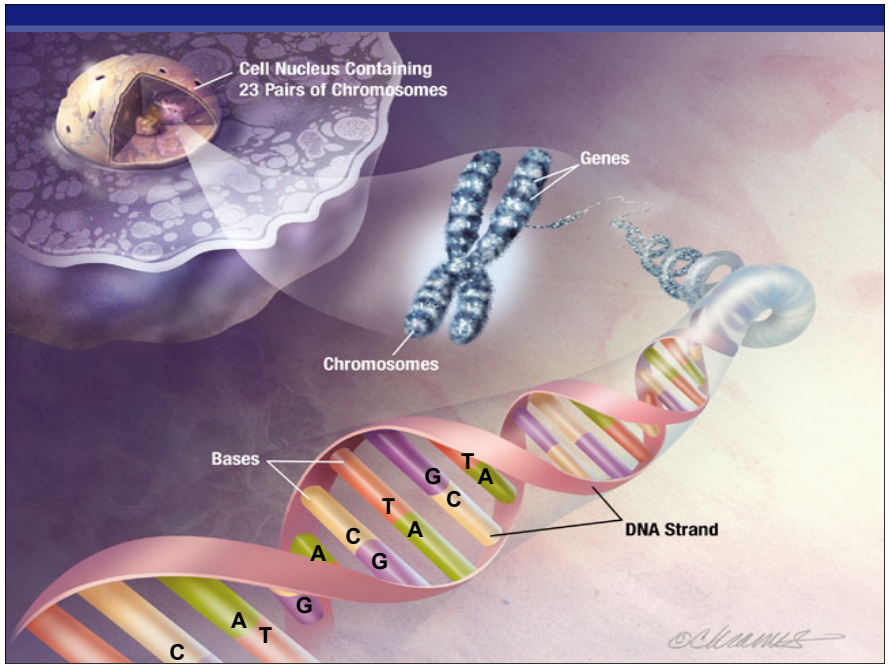
Nucleic Acids

- Examples:
  - RNA (ribonucleic acid)
    - single helix
  - DNA (deoxyribonucleic acid)
    - double helix
- Structure:
  - monomers = nucleotides

DNA

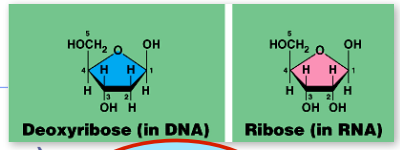


RNA



Nucleotides

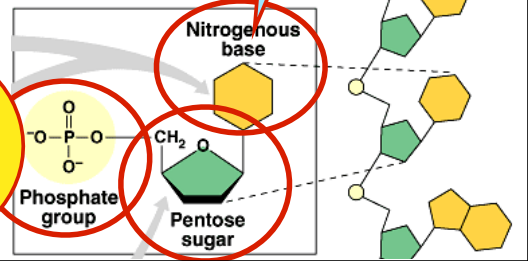
- 3 parts
  - nitrogenous base (C-N ring)
  - pentose sugar (5C)
    - ribose in RNA
    - deoxyribose in DNA
  - phosphate (PO_4) group



Nitrogen base
I'm the A,T,C,G or U part!

Are nucleic acids charged molecules?

Yes! Negatively charged! Can't cross a membrane & held in nucleus.



Types of nitrogenous bases

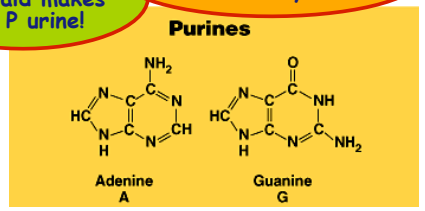
Purine = AG Pure silver!

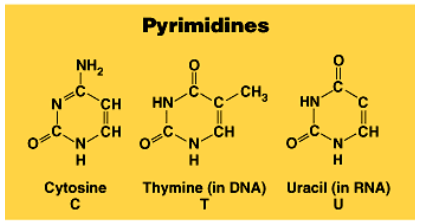
Purine = A lot of Gatoraid makes you P urine!

Pyrimidine = CUT stones to build a Pyramid.

Different nitrogen bases

- purines
  - double ring Nitrogenous base
  - adenine (A)
  - guanine (G)
- pyrimidines
  - single 6-member ring Nitrogenous base
  - cytosine (C)
  - thymine (T)
    - DNA ONLY
  - uracil (U)
    - RNA ONLY

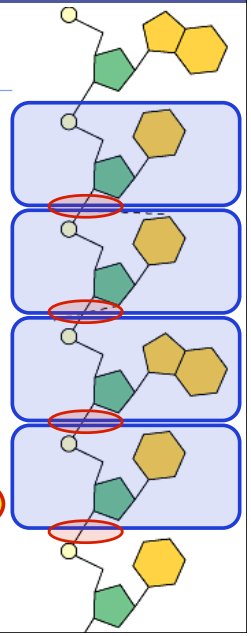




Nucleic acid polymer (polynucleotides)

- Sugar phosphate backbone
  - Phosphodiester linkage
    - Sugar to PO_4 bond
    - Nucleotide joined through phosphate
  - N bases hang off the sugar-phosphate backbone

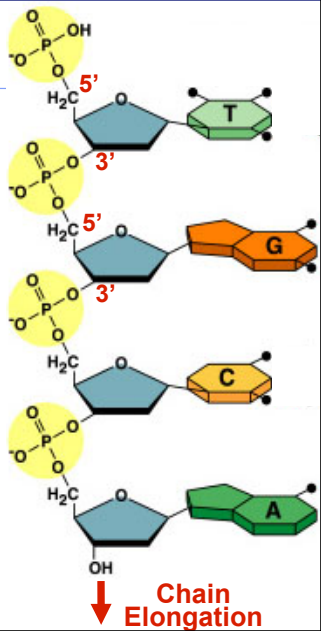
Dangling bases? Why is this important?



The Sugar Phosphate Backbone

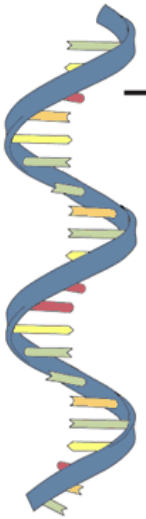
- Sugar phosphate backbone
  - Phosphate of nucleotide is covalently bonded to the sugar's 5' C
  - Phosphodiester bond exists between 3' C of one nucleotide and the phosphate of the next nucleotide
  - Polynucleotides grows in one direction
    - From the 3C' -OH (hydroxyl) end of the molecule.

5' → 3' direction



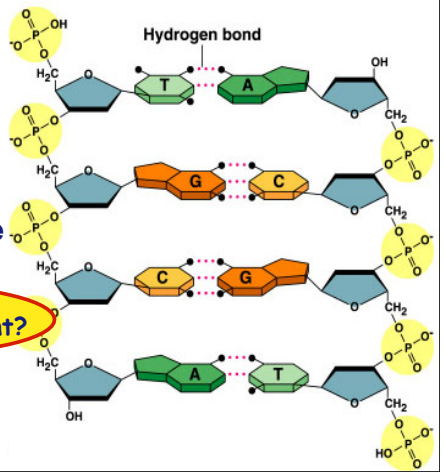
Types of Nucleic Acid

- RNA
  - Single strand
  - Substitutes U for T
- DNA
  - Double stranded
  - T instead of U



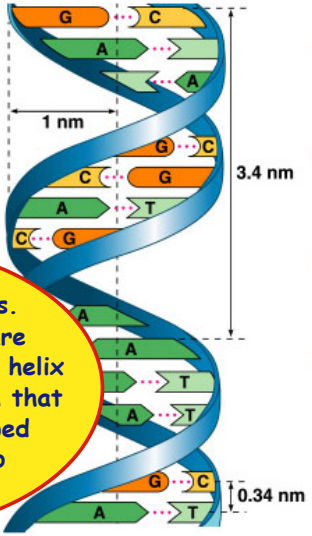
Pairing of nucleotides

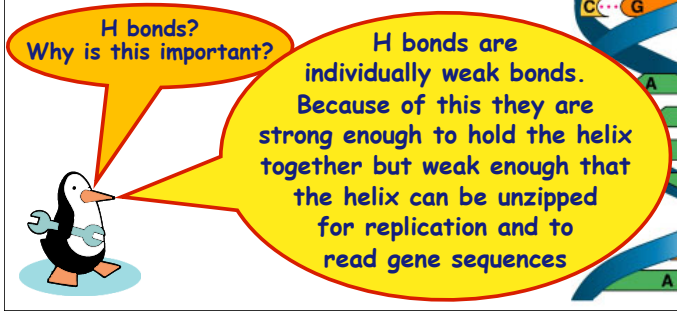
- Nucleotides of two DNA strands attract each other
  - Hydrogen bonds hold two polymers of DNA together into "one" molecule of DNA: A DNA double helix
    - purine :: pyrimidine
      - A :: T
        - 2 H bonds
      - G ::: C
        - 3 H bonds



DNA molecule made of 2 polynucleotides spiraling around imaginary axis

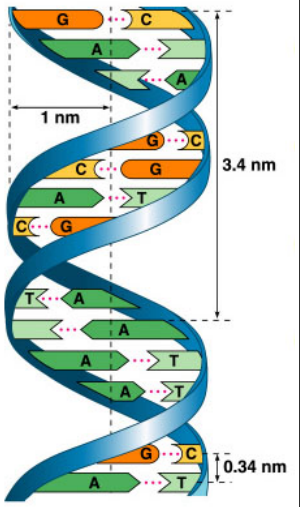
- Double helix
  - H bonds between bases join the 2 strands
    - A :: T
    - C :: G





Copying DNA

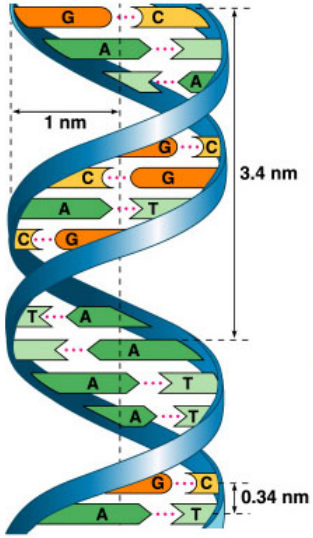
- Replication
  - 2 strands of DNA helix are complementary
    - If have one, can build other
      - One strand is the template for constructing the second
      - When cells divide, they must duplicate the DNA exactly for the two new 'daughter' cells



Copying DNA

- 2 strands are ***antiparallel***
  - Run in opposite directions
    - One 5' → 3' direction
    - Other 3' → 5' direction
- If one strand is 5'-ATTGC-3'
- What is the sequence of the complimentary strand?

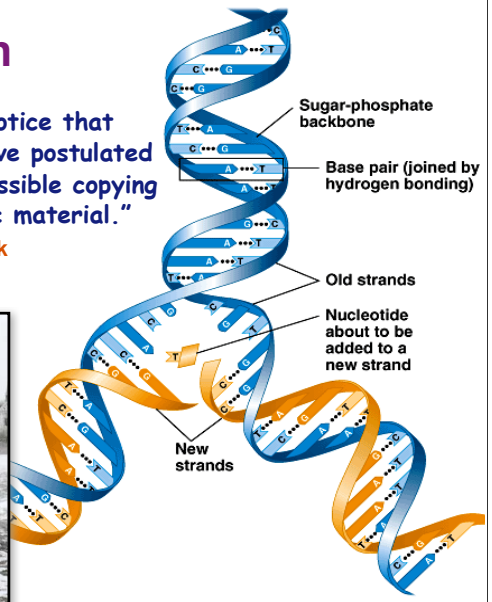
3'-TAACG-5' or 5'-GCAAT-3'



DNA replication

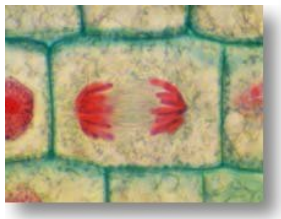
"It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material."

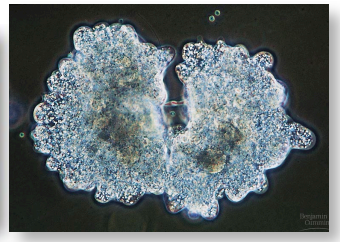
James Watson & Francis Crick
1953



When does a cell copy DNA?

- When in the life of a cell does DNA have to be copied?
  - cell reproduction
    - mitosis
  - gamete production
    - meiosis

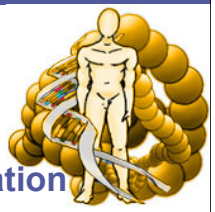




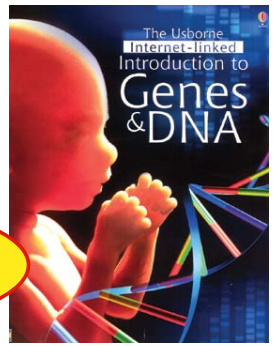
DNA structure matches purpose

- All other biomolecules we spoke about served physical or chemical functions.
- DNA & RNA are information storage molecules.
- DNA well-suited for an info storage molecule:
  1. Chemically stable
  2. Stores information in the varying sequence of nucleotides (the genetic code)
  3. Its coded sequence can be copied exactly by the synthesis of complementary strands
  4. Easily unzipped & re-zipped without damage (due to the weak Hydrogen bonds)
  5. Damage to one strand can be repaired by addition of bases that match the complementary strand

Information polymer



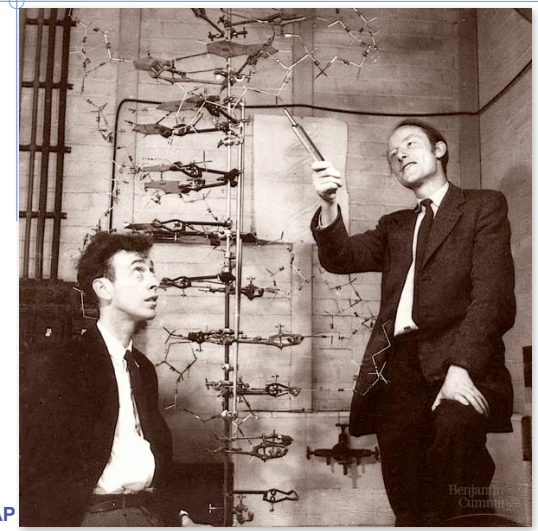
- Function
  - series of bases encodes information
    - like the letters of a book
  - stored information is passed from parent to offspring
    - need to copy accurately
  - stored information = genes
    - genetic information

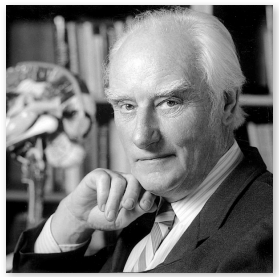


Passing on information?
Why is this important?

1953 | 1962

Watson and Crick … and others…

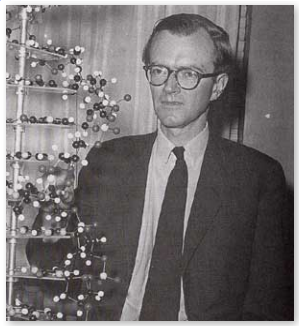


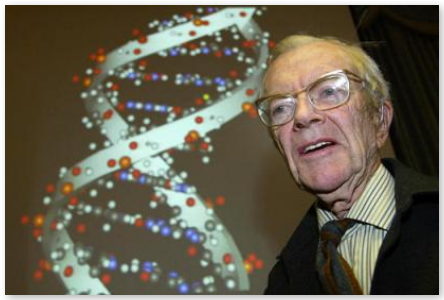


AP

Maurice Wilkins… and…

1953 | 1962





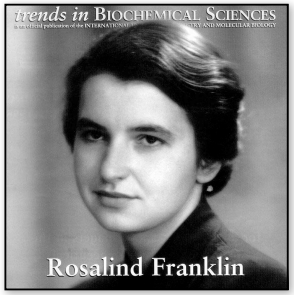
The English physicist and biophysicist, Sir John Randall set up a biophysics lab with Wilkins and others at King's College in London,

Wilkins studied biological molecules. He eventually began using X-rays to produce diffraction images of DNA molecules.

AP Biology

Wilkins shared the 1962 Nobel Prize in Physiology or Medicine with Watson and Crick, but....

Rosalind Franklin (1920-1958)



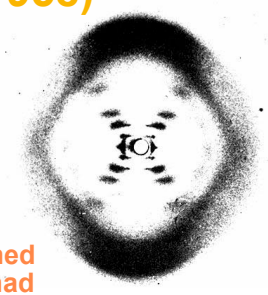
Wilkins and chemist Franklin were peers. And it was Franklin whom Randall had *given the task of elucidating DNA's structure*. The technique with which Rosalind Franklin set out to do this is called X-ray crystallography.

With this technique, the locations of atoms in any crystal can be precisely mapped by looking at the image of the crystal under an X-ray beam.

- ✓ She discovered that the sugar-phosphate backbone of DNA lies on the outside of the molecule.
- ✓ She also elucidated the basic helical structure of the molecule.

AP Biology

Rosalind Franklin (1920-1958)



After Randall presented Franklin's data and her unpublished conclusions at a routine seminar, her work was provided by Wilkins without Randall's knowledge - to her competitors at Cambridge University:

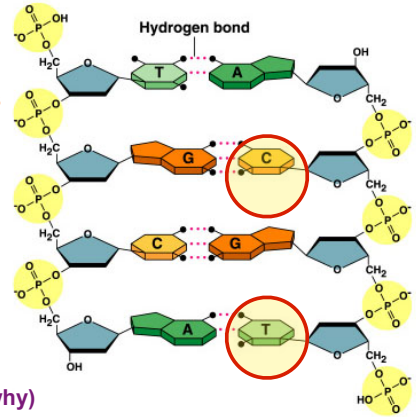
Watson and Crick.

The X-ray data Franklin obtained, confirmed the 3-D structure that Watson and Crick had theorized for DNA. The scientists used her data and that of other scientists to build their ultimately correct and detailed description of DNA's structure in 1953.

Franklin never received the Nobel Prize. It is a tremendous shame that Franklin did not receive due credit for her essential role in this discovery, either during her lifetime or after her untimely death in 1958 at age 37 due to cancer.

Interesting note…

- Ratio of A-T::G-C affects stability of DNA molecule
  - 2 H bonds vs. 3 H bonds
  - biotech procedures
    - more G-C = need higher T° to separate strands
  - high T° organisms
    - many G-C
  - parasites
    - many A-T (don't know why)



On an interesting note...in biology, molecules are often repurposed for other uses as well

- **ATP** *(Adenosine triphosphate)* is the molecule that carries energy around in the cell to processes that require energy to proceed.
  - *Evolution modifies what is already there...*
    - ATP is just a modified RNA nucleotide
      - adenine (AMP) + P_i + P_i