WUHS Biology: DNA & Proteins Unit

Week 1 – How are traits determined?

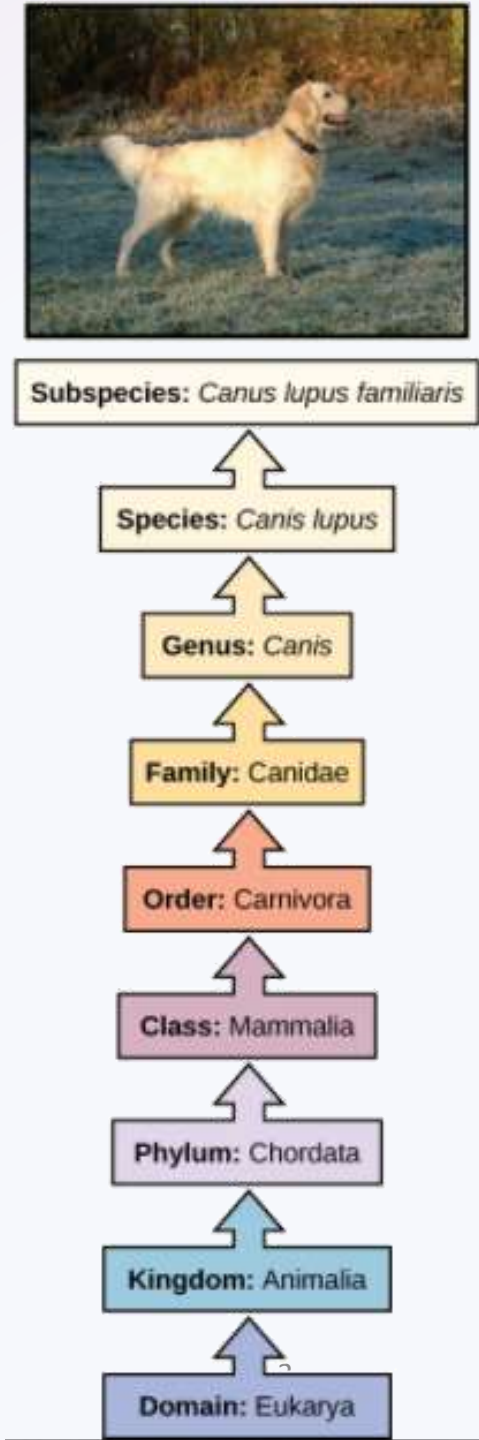
DNA & Proteins Unit – W1 Driving Question

- **Driving Question: What is DNA and how does it work?**
- What is DNA made from?
- How does the structure of DNA determine its function?
- How can a molecule provide instructions for the assembly of another molecule?

Image Source: Wikimedia

Kingdoms of Life

- **The world is home to a seemingly endless variety of life.**
  - This includes multiple ‘kingdoms’ of living organisms (plants, animals, fungi, etc.), each which is divided into smaller groups.
- **For example, a dog is *eukaryotic* (its cells have organelles) and is a part of the *animal kingdom*.**
  - Dogs have a spine (*chordata*), are *mammals* (warm blooded with fur), are *carnivores*, and are part of the dog *family*.
  - Each level of classification describes species with traits that are more and more similar.
  - Species are primarily classified by their observable traits.



Source: Wikimedia

DNA – Instructions for Life

- **While living species vary widely, all living organisms depend on DNA to function.**
  - DNA enables cells to function by providing the instructions for assembling proteins.
  - Proteins are what primarily perform the work of the cell.
  - Proteins also provide organism with observable traits.

- **The primary function of DNA is to store information.**
  - DNA provides the information needed to arrange amino acids in a particular order to form specific proteins.
  - Without DNA, a cell would lack the information needed to produce the proteins needed for cells to function.

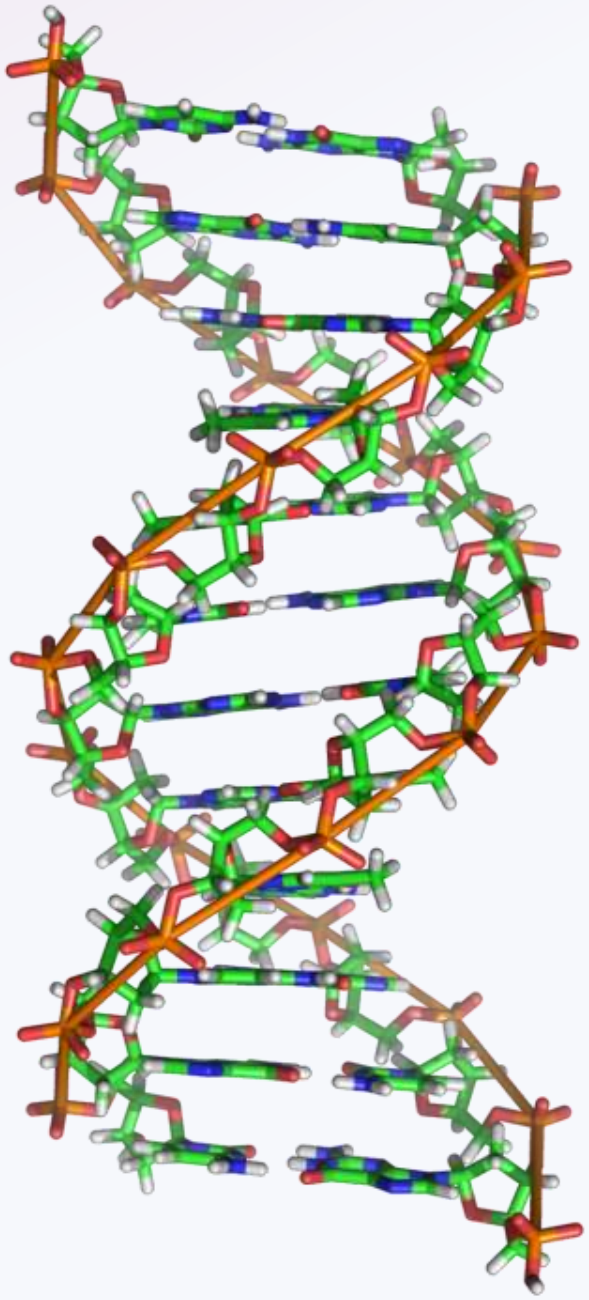


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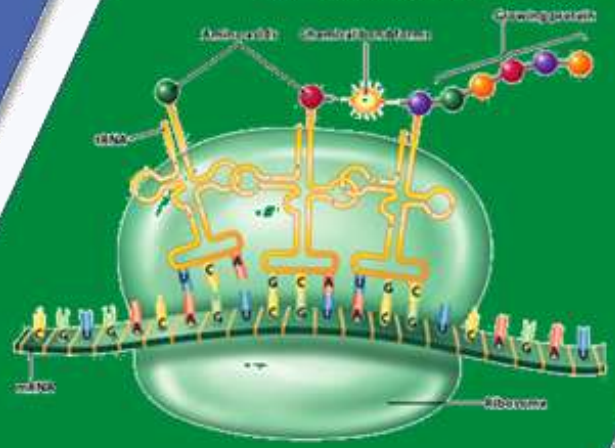
Image Source: Wikimedia

DNA → RNA → Proteins → Traits

The information stored in DNA determines the order in which amino acids are assembled.

Source: joltgum.com

The order in which amino acids are assembled determines the protein that is created.



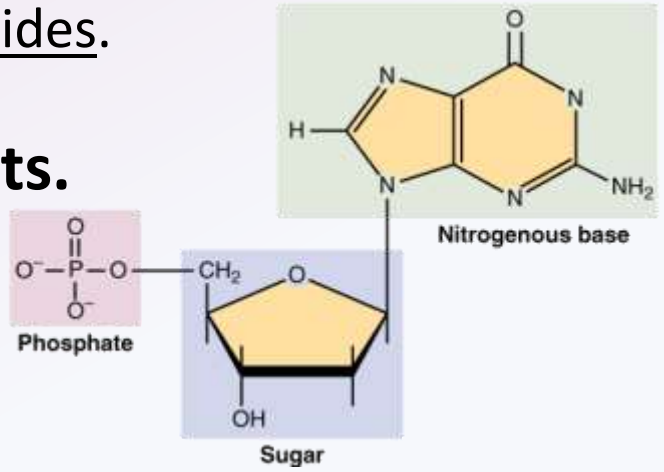
Source: mind42.com

The protein that is created determines the trait that is exhibited by an individual.

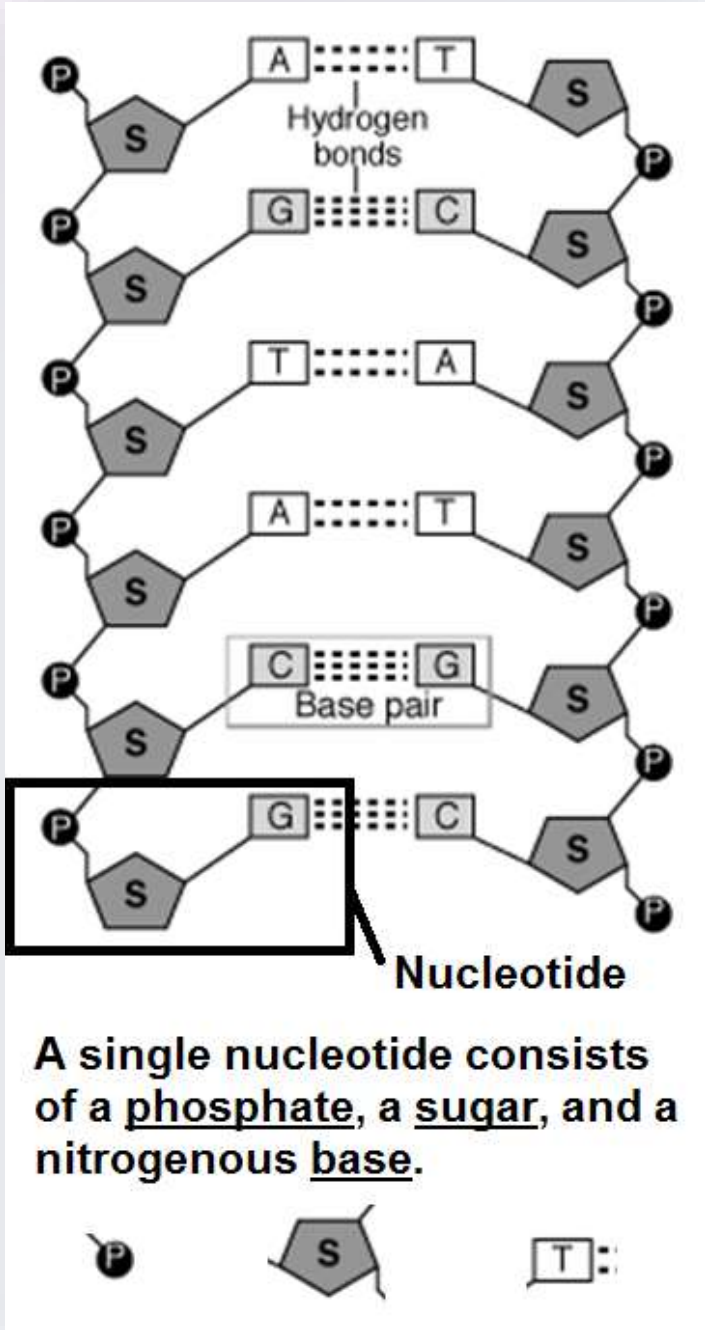
Source: www.gettyimages.com

DNA is a Macromolecule

- **DNA is a *macromolecule* (or *polymer*).**
  - DNA is composed of a long double chain of repeating *monomers* called nucleotides.
- **Each nucleotide consists of 3 parts.**
  - 1) a **phosphate** molecule.
  - 2) a 5-carbon **sugar** molecule.
  - 3) a **base** molecule.



- **Each nucleotide component provides a specific function.**
  - The **phosphate** and the **sugar** are what provide the structure of the macromolecule.
  - The **bases** contain the information needed for assembling proteins from amino acids.
    - *Four different kinds of bases exist in DNA.*

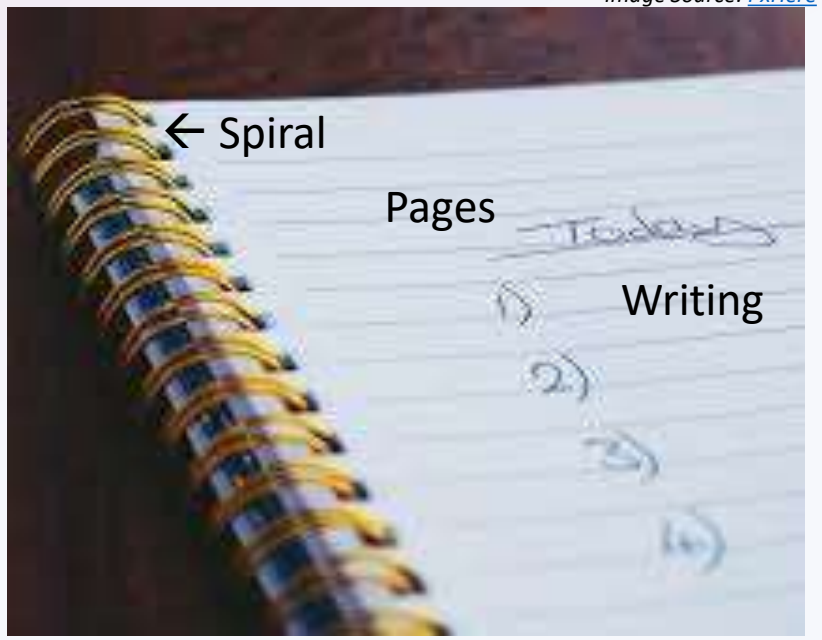


Source: www.biologyjunction.com

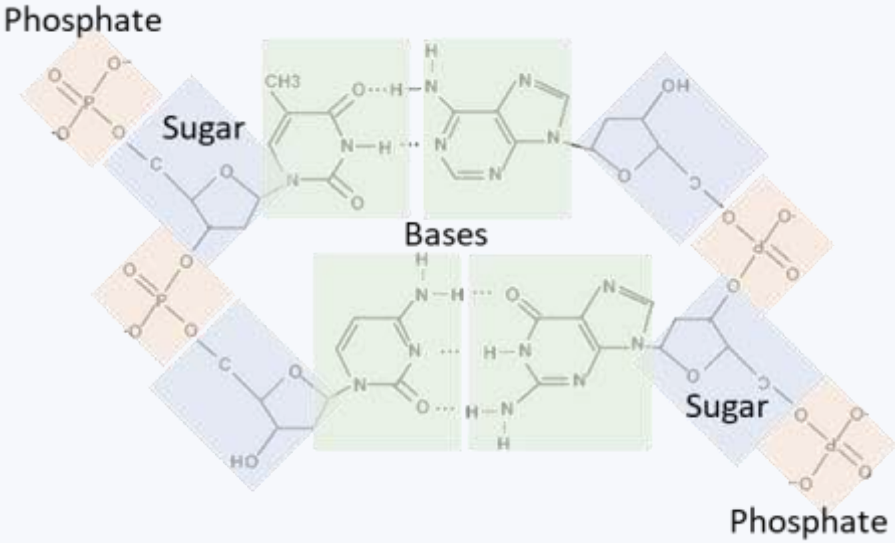
Image Source: Wikimedia

Image Source: PxHere

DNA Notebook Analogy



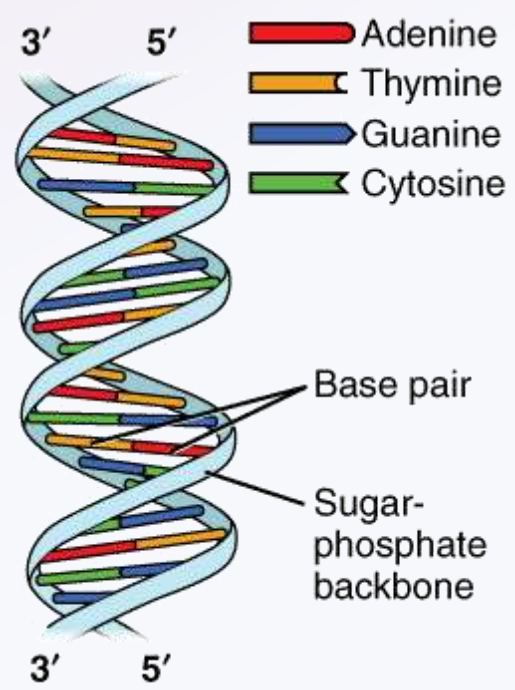
- **The molecules that comprise a nucleotide have functions like the components of a spiral notebook.**
  - The **phosphate** molecules are like the **spiral**. They are on the outside and hold everything together.
  - The **sugar** molecules are like the paper **pages**. They hold the information in place.
  - The **base** molecules are like the **writing**. The bases are what provide the actual information.



- **The combination of different base molecules of DNA are like the words written in a notebook.**
  - There are four kinds of base molecules.
  - Different combinations of bases/letters enable different kinds of information to be recorded.

Image Source: Flickr

Complementary Base Pairs



- **There are four kinds of bases that can be found in DNA: Adenine (A), Thymine (T), Guanine (G), and Cytosine (C).**
  - In DNA, only two combinations are possible among the four bases: A can only bond with T, and G can only bond with C.
  - This is due to differences in size and available bonding sites.

- **These combinations are called <u>complementary base pairs</u>.**
  - A is complementary to T; A's are always found with T's.
  - G is complementary to C; G's are always found with C's.

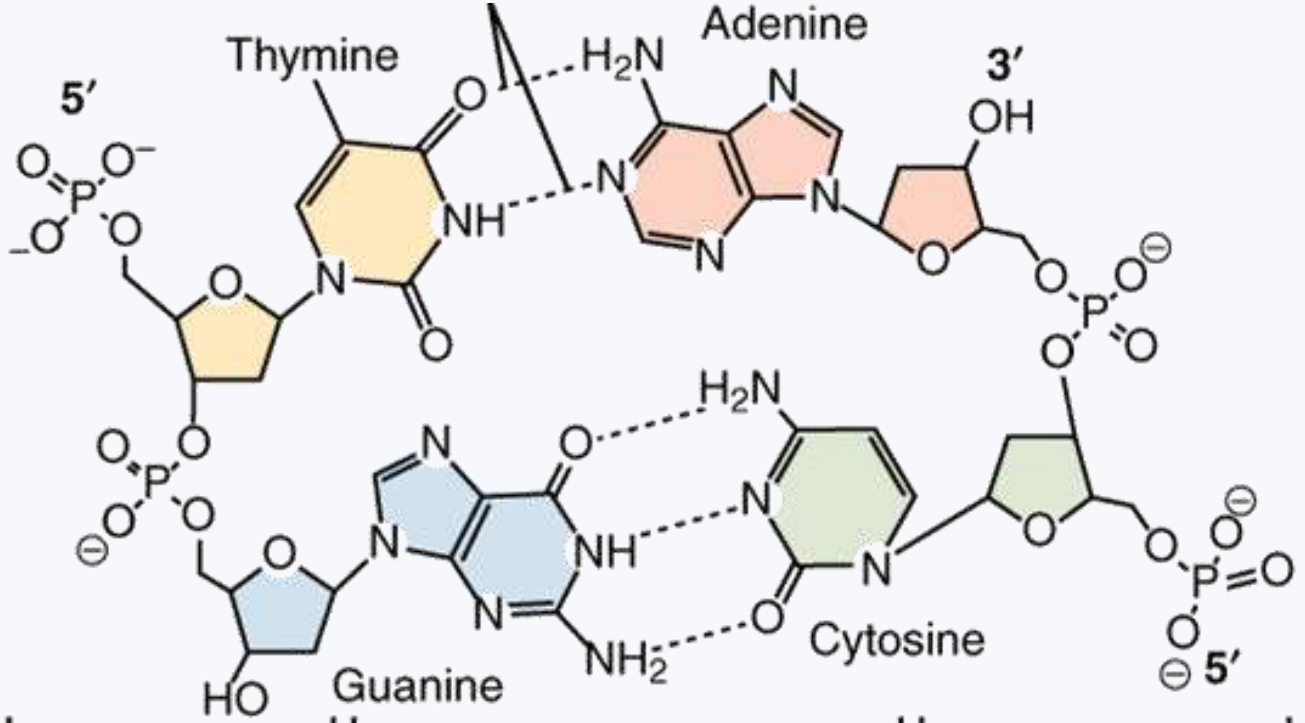
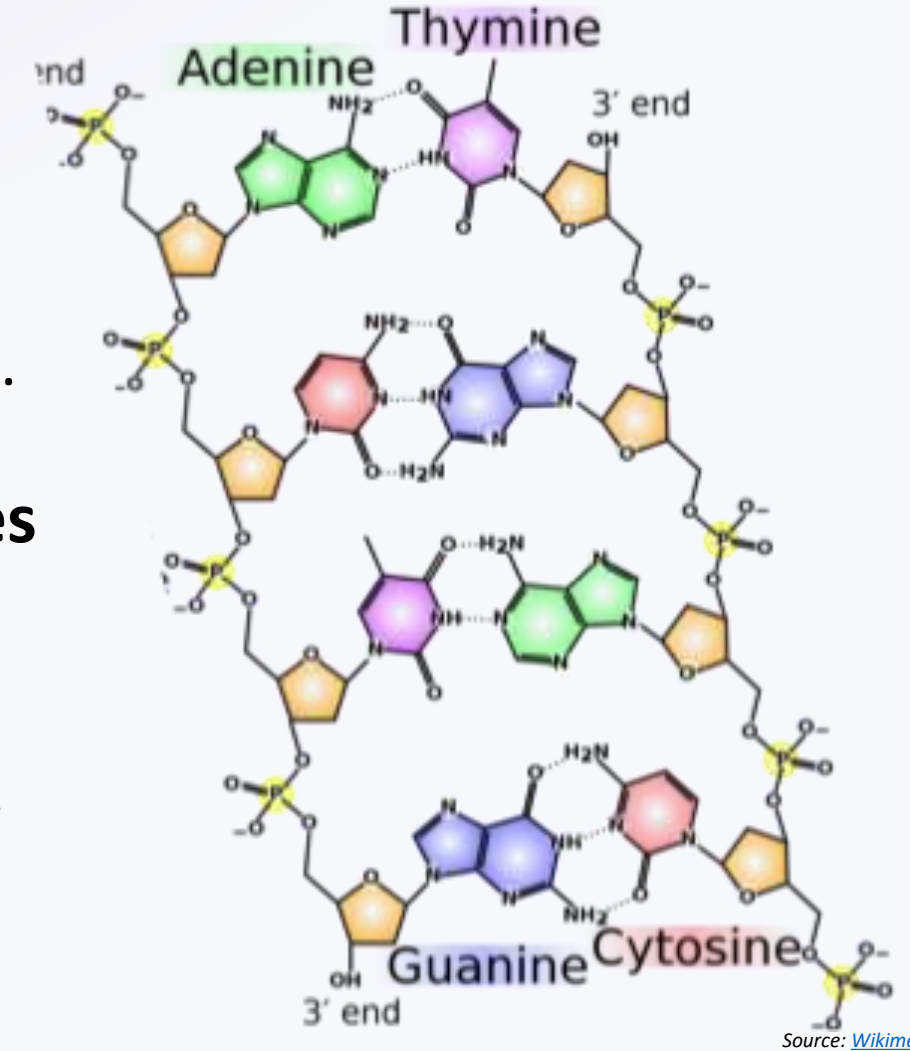


Image Source: Wikimedia

Great Combinations are Always Together

- **Because of both size and chemical bonding, A is always bonded to T and C is always bonded to G.**
  - If an A were bonded to a G, they would be too large to fit inside the width of DNA.
  - If C were bonded to T, it would be too small to reach the sides of the DNA molecule.
  - This is also why bases can't pair with themselves.

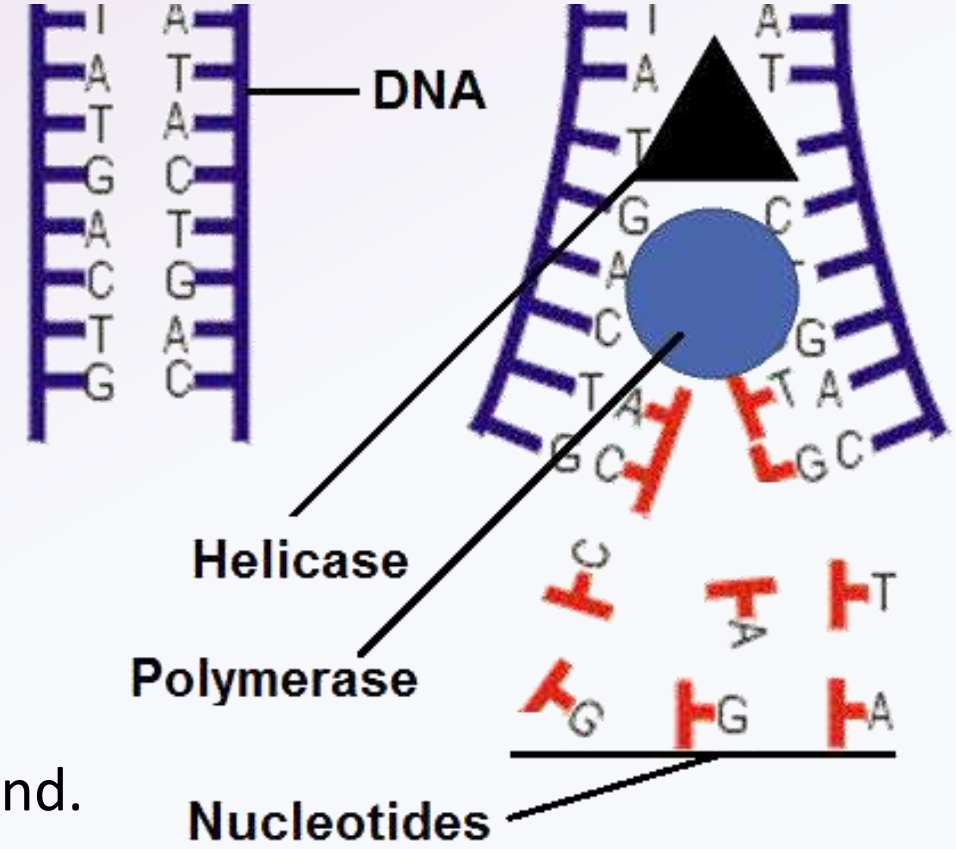
- **In addition, C and G have <u>three</u> bonding sites to attach to each other, while A and T only have <u>two</u> bonding sites.**
  - Pairing an A with a C would be like trying to insert a three-pronged electrical plug into a two-pronged outlet.



Source: Wikimedia

Source: biology.stackexchange.com

Making Copies



- **Because A is always bonded with T, and because a C is always with a G, this makes it easy for a cell to make a copy of its DNA.**
  - To replicate DNA, a cell uses a protein called helicase to separate double-stranded DNA into two single stands.
  - A different protein called polymerase then adds complementary bases to the other side of each strand.
  - This creates two identical strands of DNA.
- **For example, if a section of single stranded DNA was A - G - C - T, the polymerase enzyme would add T - C - G - A to fill in the other side.**
  - There are many free-floating nucleotide bases surrounding DNA and polymerase.
  - These are added by polymerase to DNA when making a copy.

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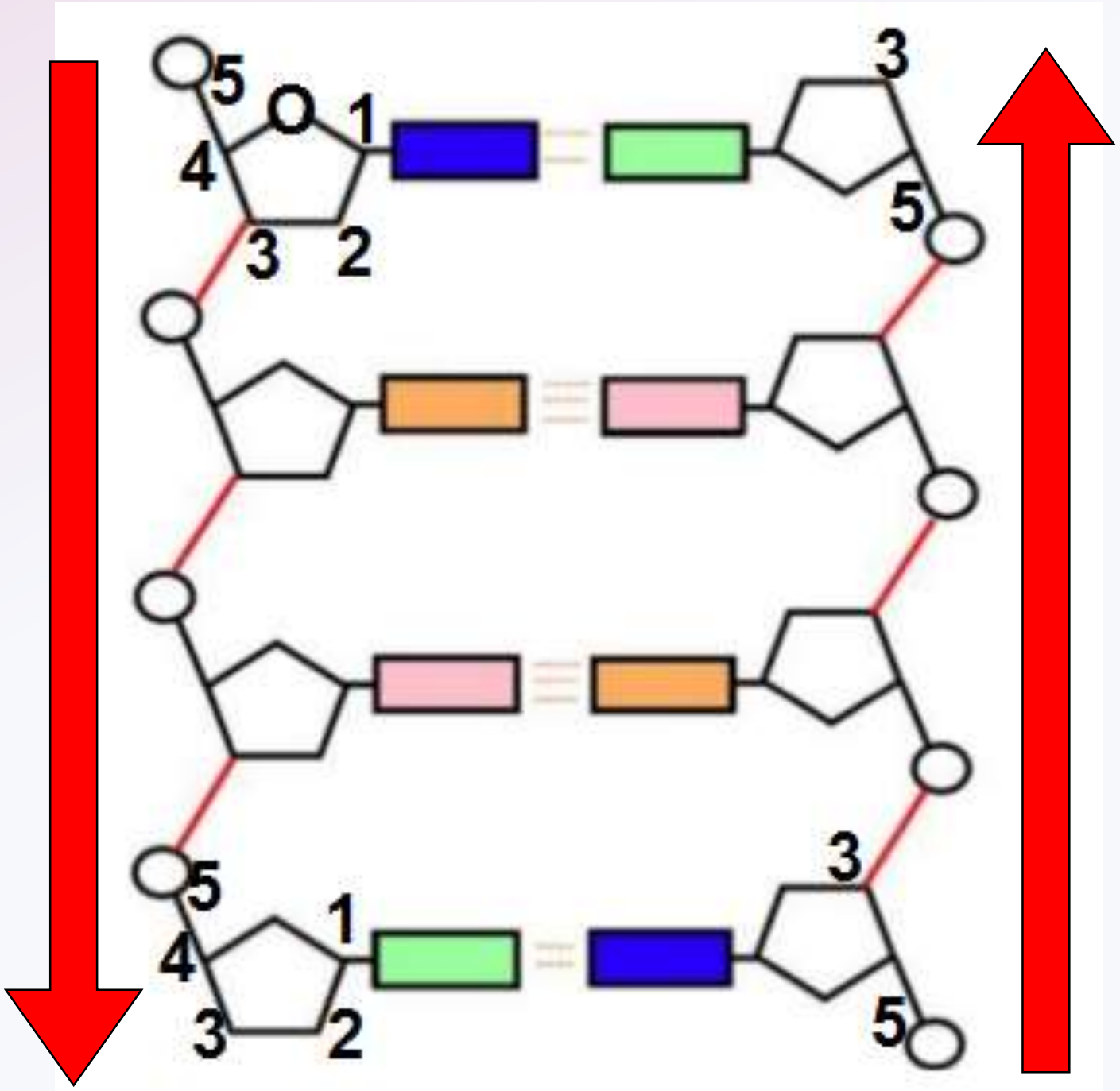
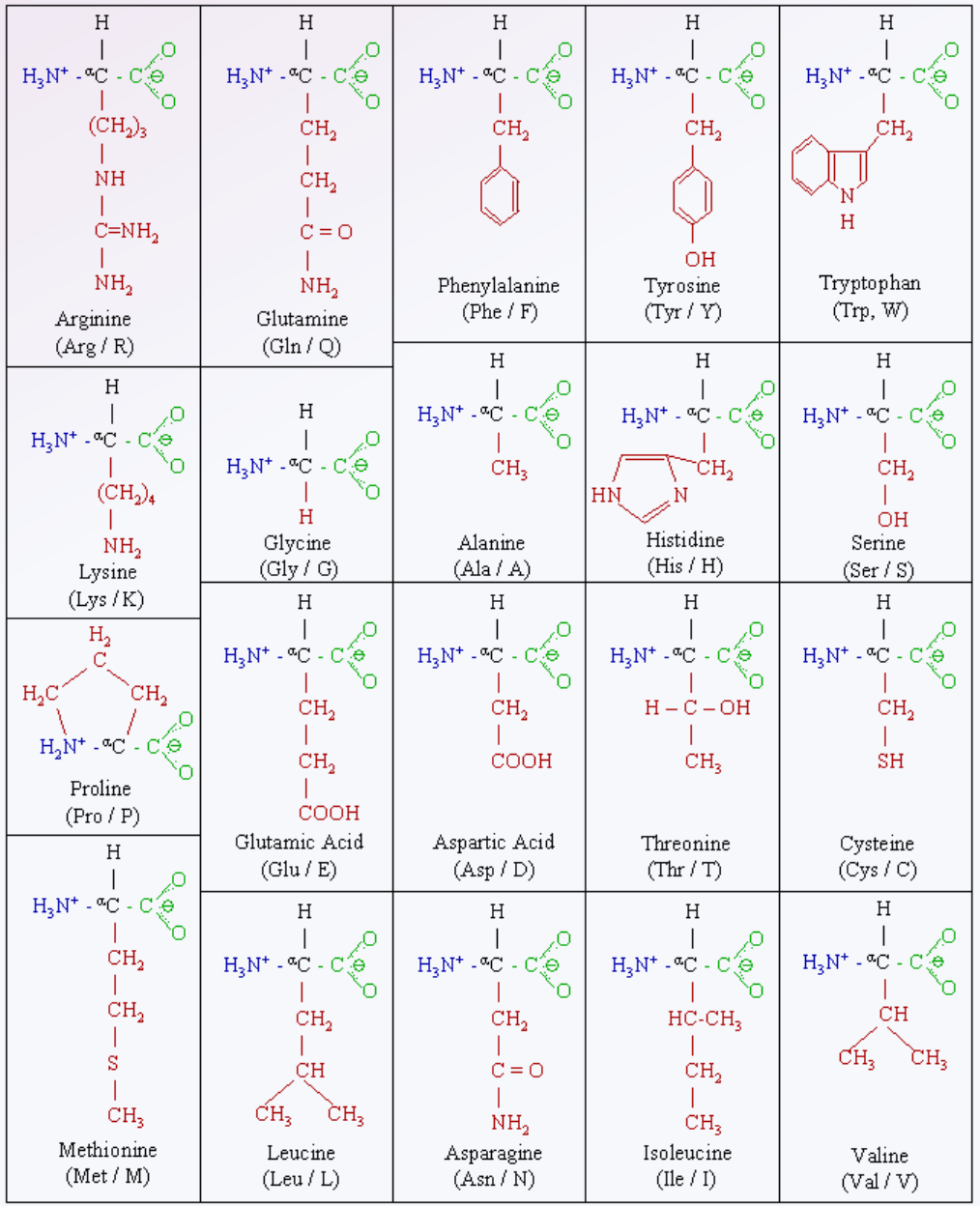
- **There is no top, bottom, left, or right inside of a cell.**
  - As such, polymerase proteins need a way to determine what direction to start copying DNA.
- **DNA is replicated in a 5’ → 3’ direction.**
  - 5’ and 3’ refer to the carbon atoms on the sugar molecule.
- **The direction DNA is copied on one side will be opposite of the direction in which it is copied on the other side.**
  - If the left side is copied from the top down, the right side will be copied from the bottom up.



The DNA “Code”

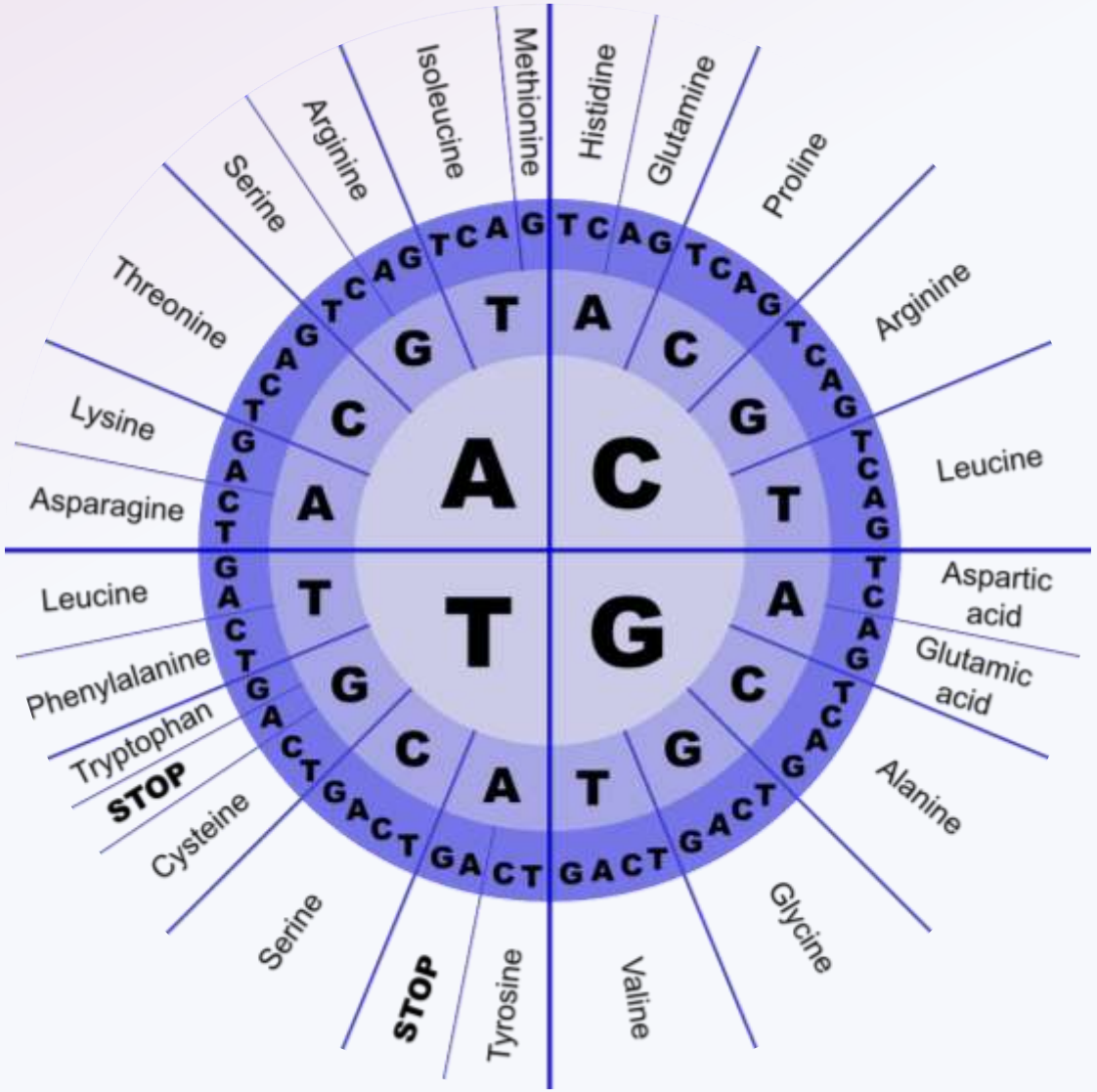
- **DNA provides the instructions for how to assemble 20 amino acids in a specific order to create a particular protein.**
  - The order in which 20 different kinds of amino acids are assembled determines the shape and function of the protein.
- **Combinations of three bases (called <u>codons</u>) code for a specific amino acid.**
  - For example, a stretch of DNA containing 9 bases would consist of 3 codons.
  - These 3 codons would each code for 3 kinds of amino acids.
  - The order of codons in a gene determines the order in which amino acids are assembled to form a protein.



There are 20 kinds of amino acids. Different combinations of amino acids make different proteins.

Decoding Codons

- **Each combination of three bases (codon) codes for a different amino acid.**
  - For example, CGA codes for *Arginine*.
  - However, AGC codes for *Serine*.
- **Some codons indicate where a gene begins and ends.**
  - All genes start with the *Methionine* amino acid (ATG).
  - Three different codons (TGA, TAG, and TAA) mark the end of a gene.



This table can be used to translate codons into different amino acids. Start in the center and work towards the outside. *E.g.*, GCA = Alanine.

Revising Our Claims

- **Revisit your ideas from Part 1.**
  - How could you improve your responses to our Driving Questions?
- **What is DNA and how does it work?**
- What is DNA made from?
- How does the structure of DNA determine its function?
- How can a molecule provide instructions for the assembly of another molecule?

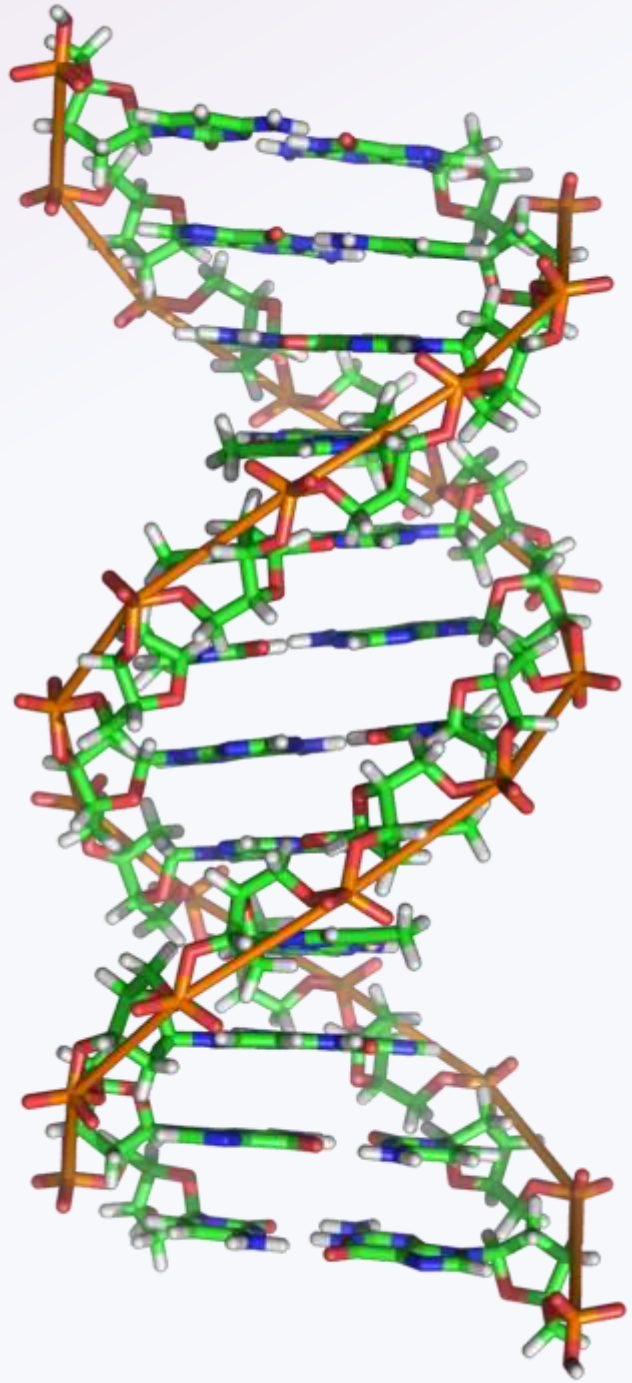


Image Source: Wikimedia

Looking Ahead: Part 3 Investigation

- **In Part 3 you will be conducting two investigations.**
  - In Part A, you will use your understanding of DNA to determine how nucleotide components fit together.
  - In Part B, you perform a similar investigation using different kinds of candies to create edible DNA.

Image Source: Michigan.gov

Key Points

- **Species are primarily classified by their traits, which are determined by the proteins their cells produce, which is determined by their DNA.**
- **The primary function of DNA in all living organisms is to store information for how to assemble proteins.**
- **DNA is a polymer made of nucleotide monomers. Each nucleotide has 3 parts: a phosphate, a sugar, and one of four bases.**
- **Phosphate and sugar molecules provide structure to DNA; the base molecules are what code information for assembling proteins.**

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Key Points

- **Due to differences in size and bonding sites, only two combinations are possible among the four bases: A only bonds with T, and G only bonds with C. This is called complementary base pairs.**
- **To replicate DNA, a protein called helicase separates the two strands. A protein called polymerase then adds complementary bases to each strand to create two identical strands.**
- **DNA is always copied in a 5' → 3' direction. These numbers refer to the carbon atoms on the sugar molecule.**
- **Groups of 3 bases (called codons) code for specific amino acids. The order of codons in a gene determines the order of amino acids in a protein. This determines the kind of protein that is assembled.**

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Key Vocab

- **DNA: a polymer made from nucleotide monomers that stores information about how to assemble proteins.**
- **Nucleotide: a monomer in the DNA polymer consisting of a phosphate, sugar, and base molecule.**
- **Phosphate: a part of a nucleotide that provides structure to DNA.**
- **Sugar: a part of a nucleotide that holds bases in place.**
- **Base: a part of a nucleotide that stores information.**
- **Complementary Base Pairs: the only combinations of bases that are possible in DNA (A pairs with T; G pairs with C).**
- **Helicase: the protein that separates the two DNA strands.**
- **Polymerase: the protein that makes copies of DNA.**
- **Codon: a group of three bases in DNA that codes for a specific amino acid.**

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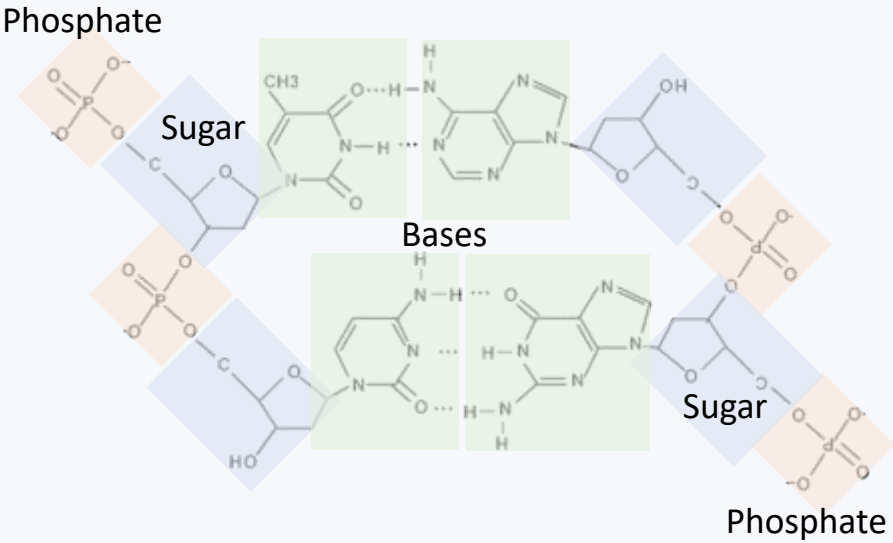

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