# WUHS Biology: DNA & Proteins Unit

## Packet 1 – How are traits determined?

# DNA & Proteins Unit – Packet 1 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


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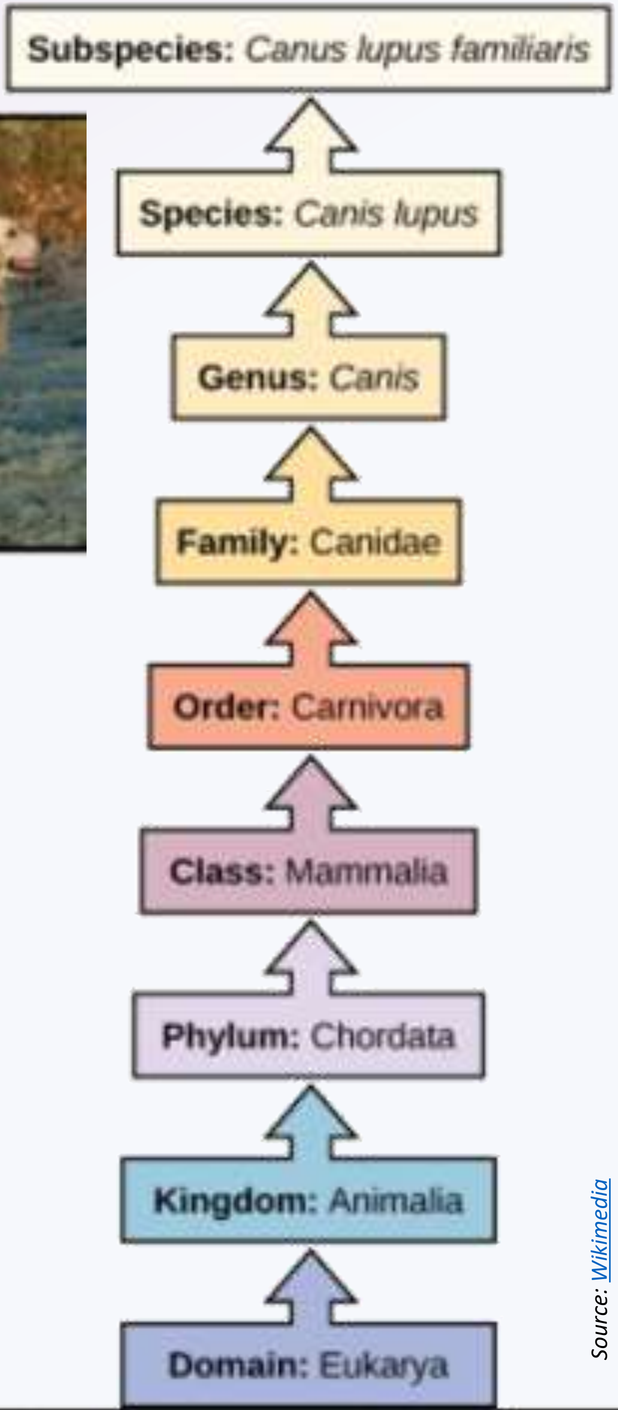
# Kingdoms of Life

- **The world is home to a seemingly endless variety of life.**
  - This includes multiple ‘kingdoms’ of living organisms (plants, animals, fungi, etc.).
  - Species are grouped based on their observable traits.

- **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 (eat meat)*, and are in the dog *family*.
  - Each level of classification describes species with traits that are more and more similar.




Source: Wikimedia

# DNA – Instructions for Life

- **While there are many differences among living species, all use DNA in their cells.**
  - DNA determines how proteins are assembled.
  - Proteins perform the work of the cell and provide organism with observable traits.
- **The primary function of DNA is to store information.**
  - DNA provides the instructions to assemble amino acids in a particular way to form specific proteins.
  - If a cell lacked DNA, it be unable to produce the proteins it needs to function.

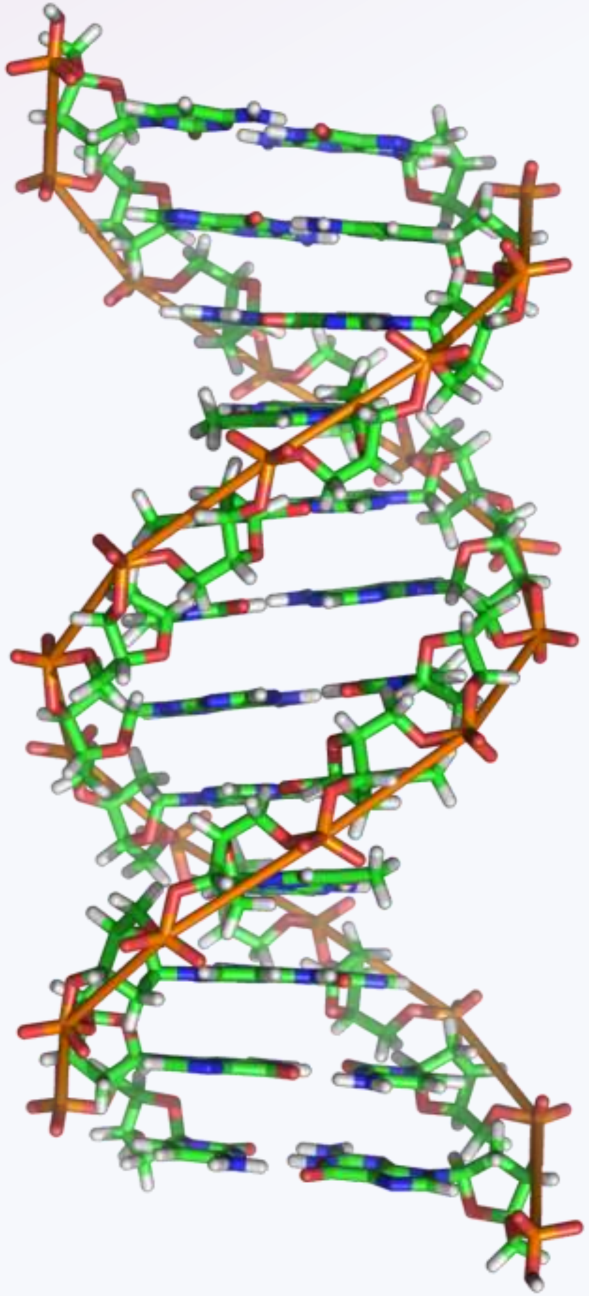
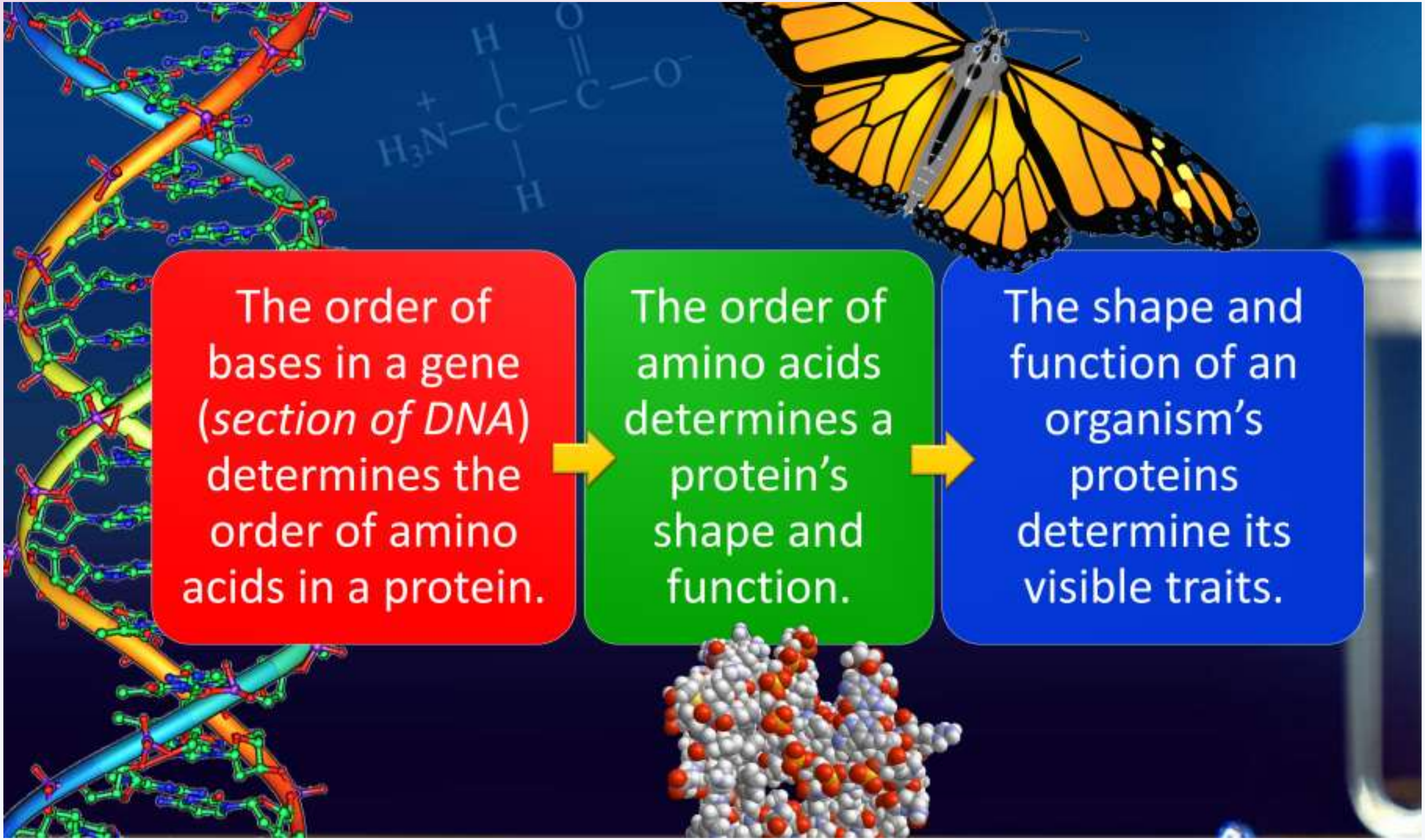
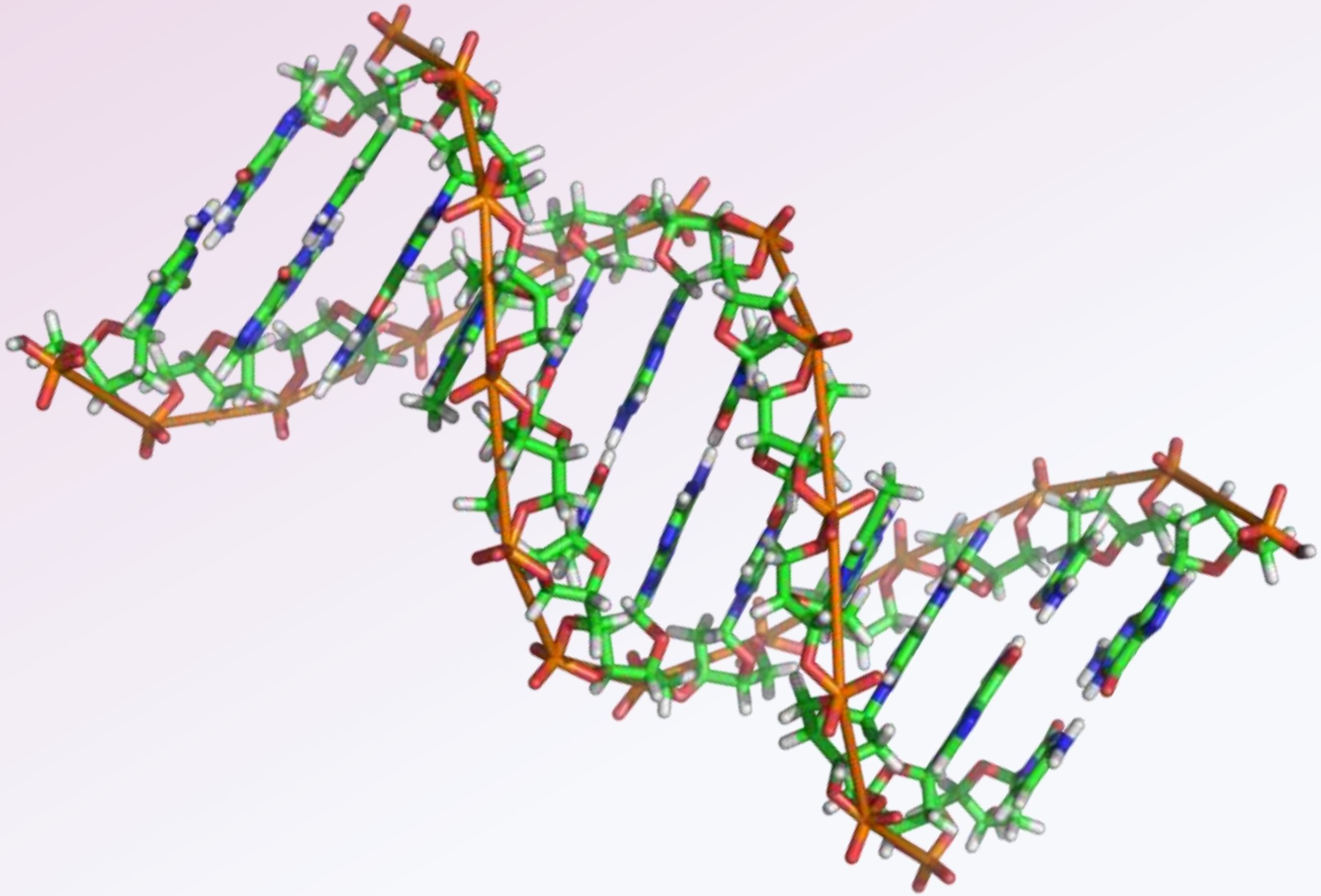


*Image Source: Wikimedia*

# DNA → Proteins → Traits





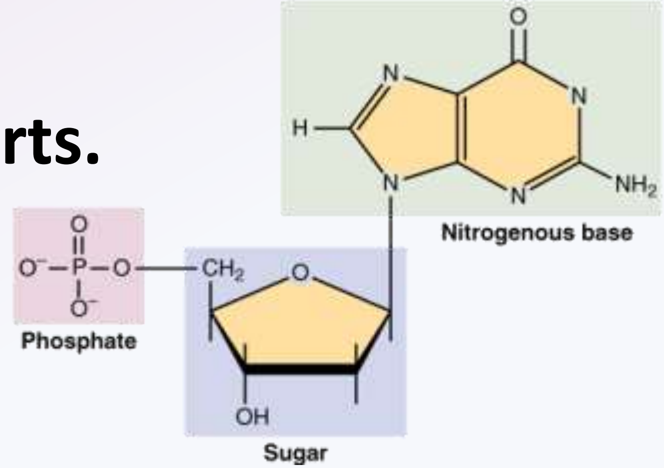
# The Structure & Function of DNA.

What is DNA made from? And how does this determine how DNA works?

Source: www.biologyjunction.com

# DNA is a Macromolecule

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




- **Each part of a nucleotide serves a specific function.**
  - The **phosphate** and the **sugar** molecules provide structure to DNA (they hold everything together).
  - The **base molecules** store information.

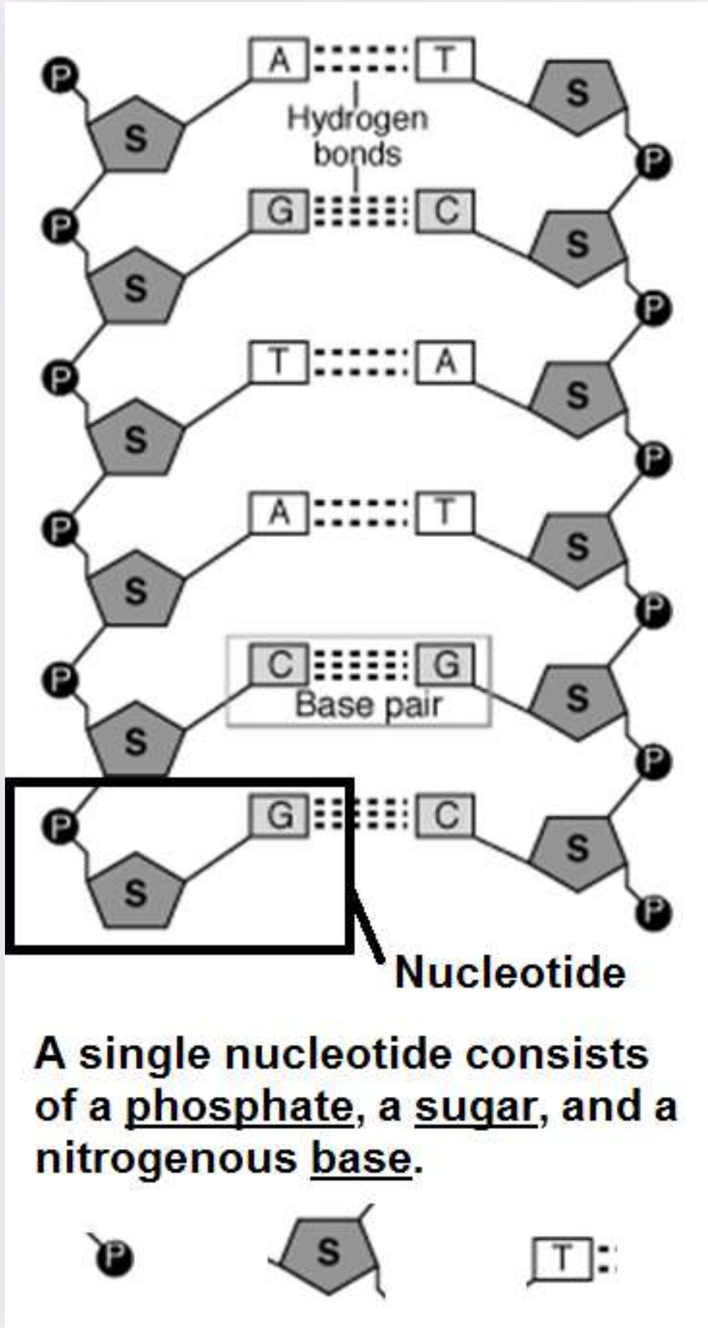
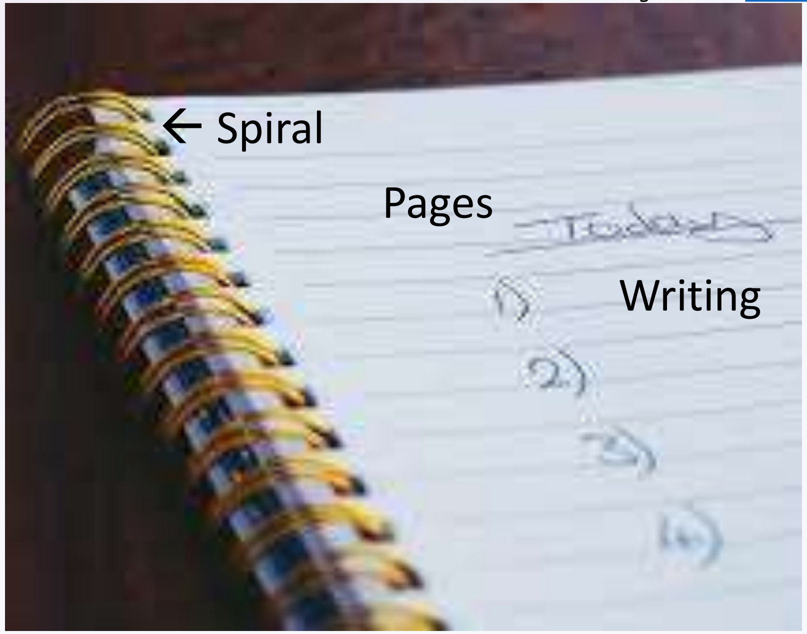



Image Source: Wikimedia

# DNA Notebook Analogy

- **Each molecule in a nucleotide functions like the parts 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 (A, T, G, & C).
  - Different combinations of bases/letters enable different kinds of information to be recorded.

*Image Source: PxHere*



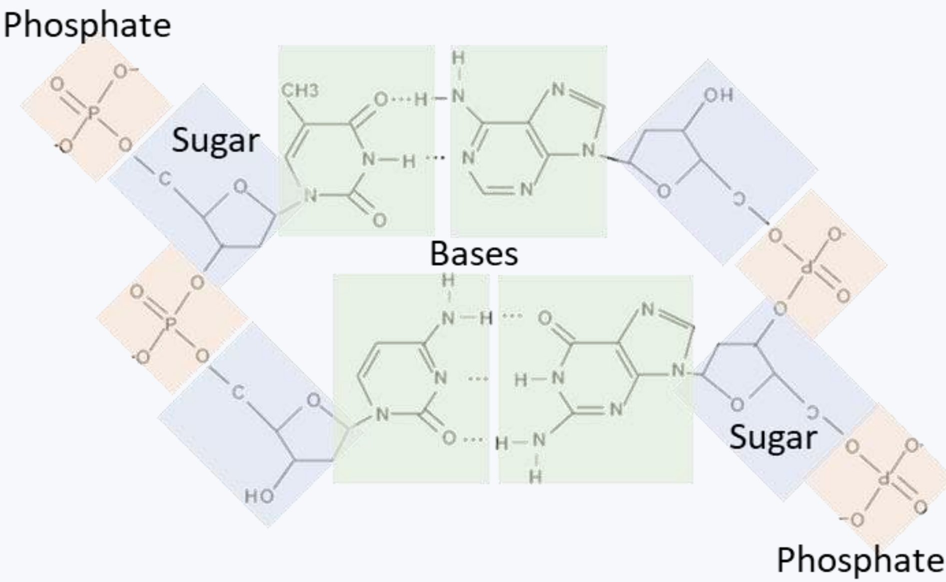
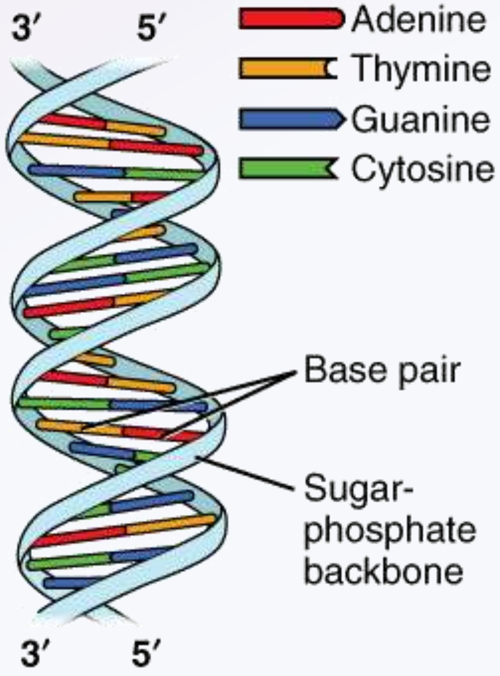




*Image Source: Flickr*

# Complementary Base Pairs




- **The four kinds of base molecules in DNA are called: Adenine (A), Thymine (T), Guanine (G), and Cytosine (C).**
  - Usually these molecules are represented by their first letters.
- **In DNA, only two combinations of bases are possible: A can only bond with T, and G can only bond with C.**
  - This is because of differences in a) size and b) bonding sites.
- **These combinations (A&T, G&C) are called <u>complementary base pairs</u>.**
  - A's are always found with T's.
  - G's are always found with C's.

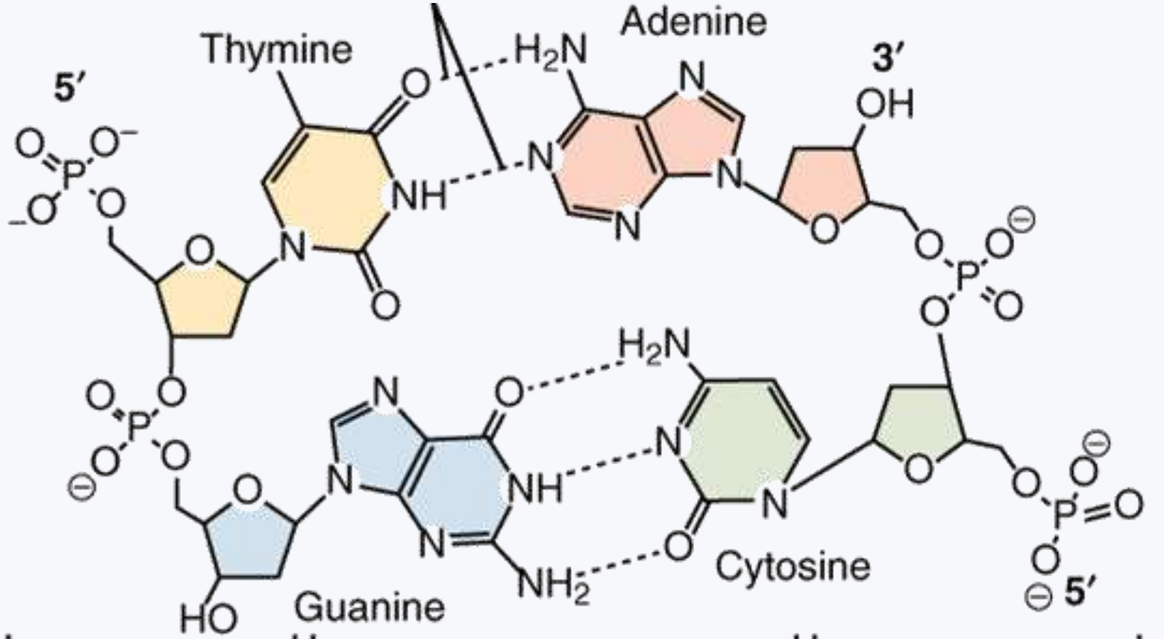
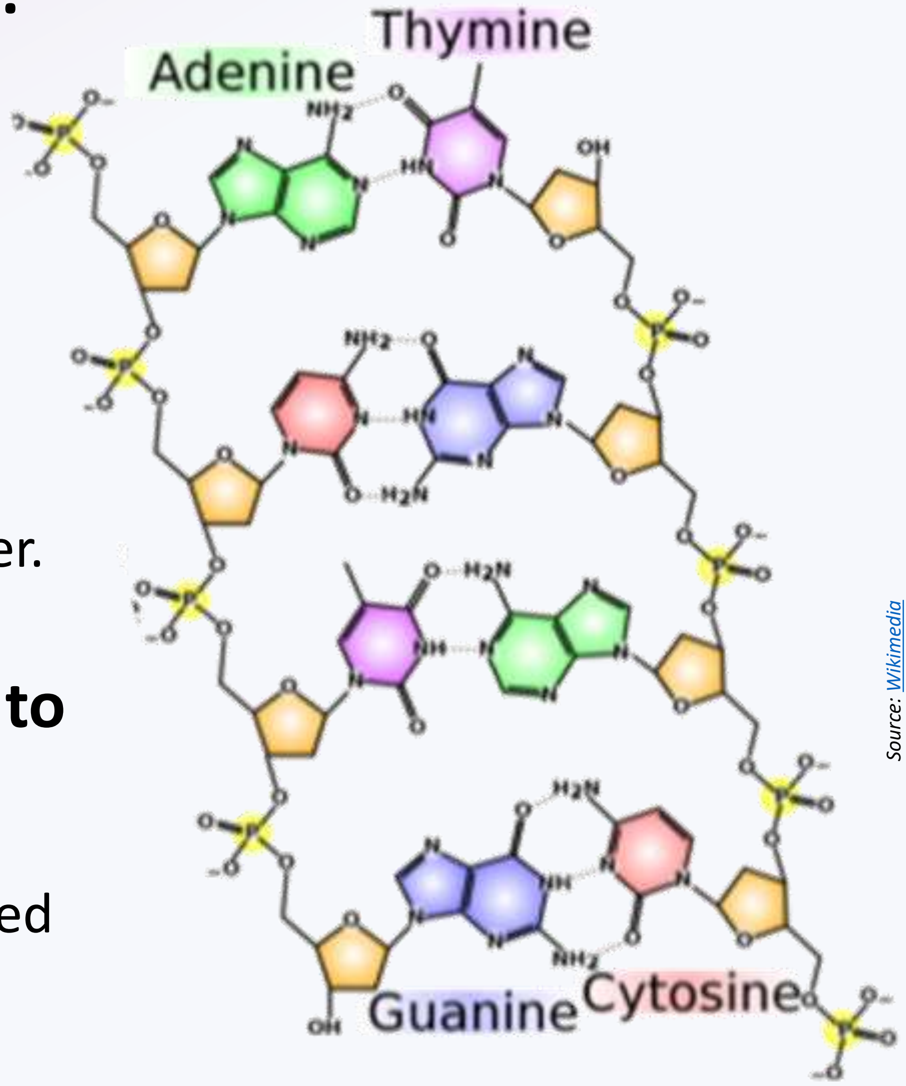




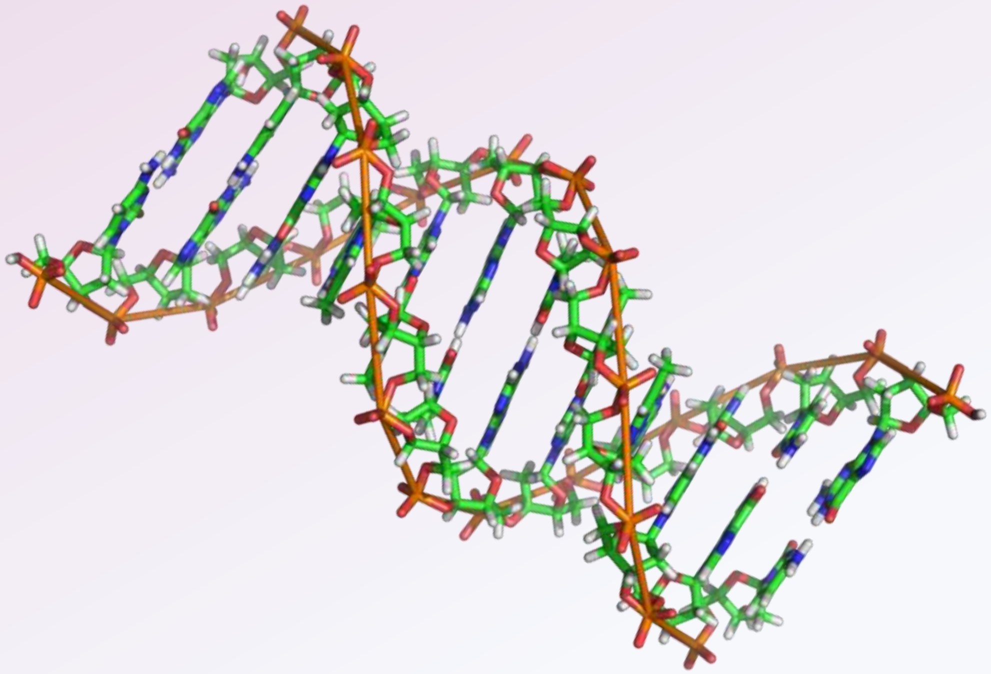

*Image Source:* [Wikimedia]

# Great Combinations are Always Together

- **A can only pair with T, and G can only pair with C.**
  - 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, differences in bonding sites prevent combinations other than A&T and G&C.**
  - C and G have three bonding sites to attach to each other.
  - A and T only have two bonding sites.
- **Pairing A with C, or T with G would be like trying to insert a three-pronged electrical plug into a two-pronged outlet.**
  - A&T and G&C are the only combinations that work based on differences in their bonding sites.




Source: Wikimedia



# Using DNA to assemble proteins.

How information stored in DNA is translated into how to assemble a protein from amino acids.



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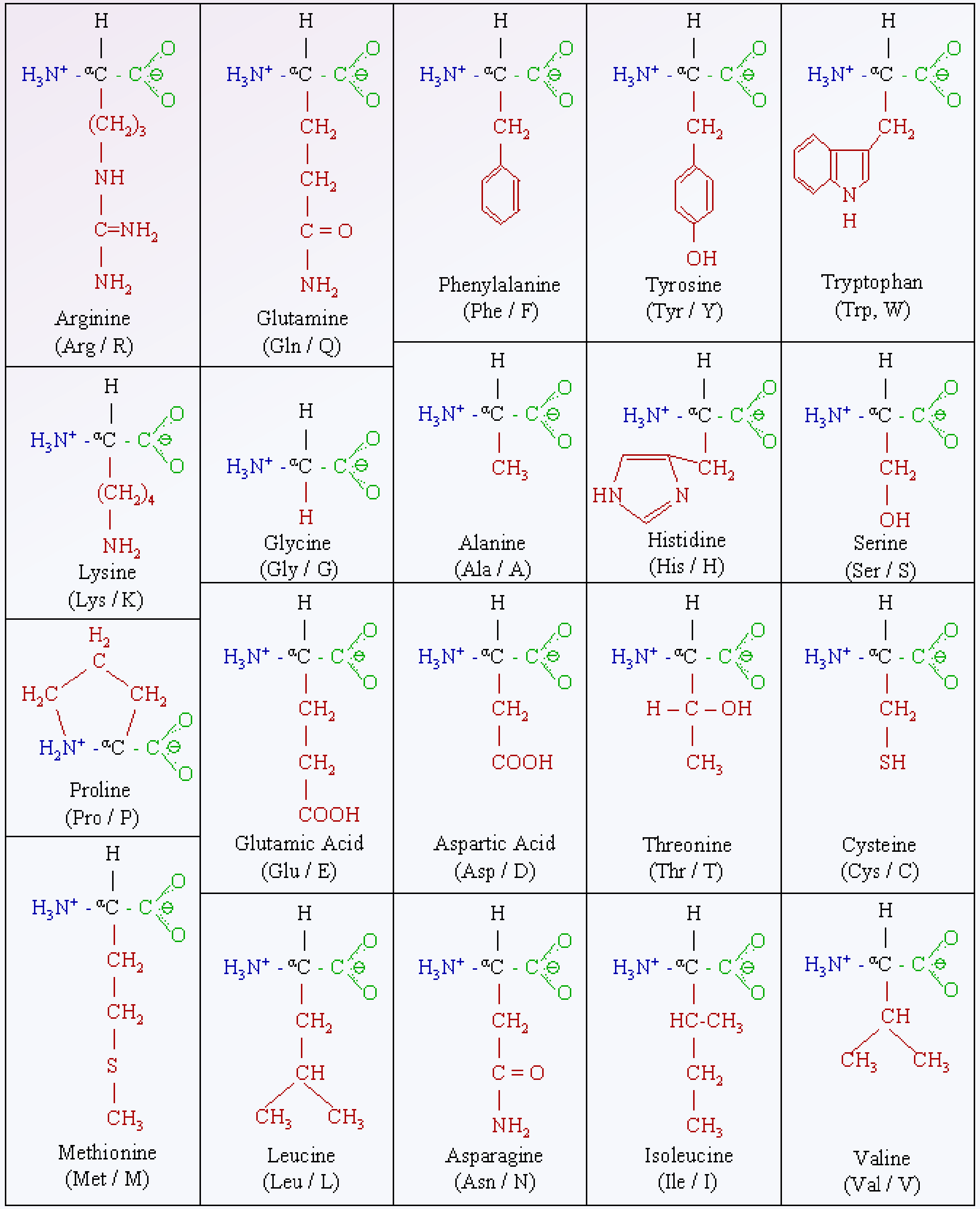
# The DNA "Code"

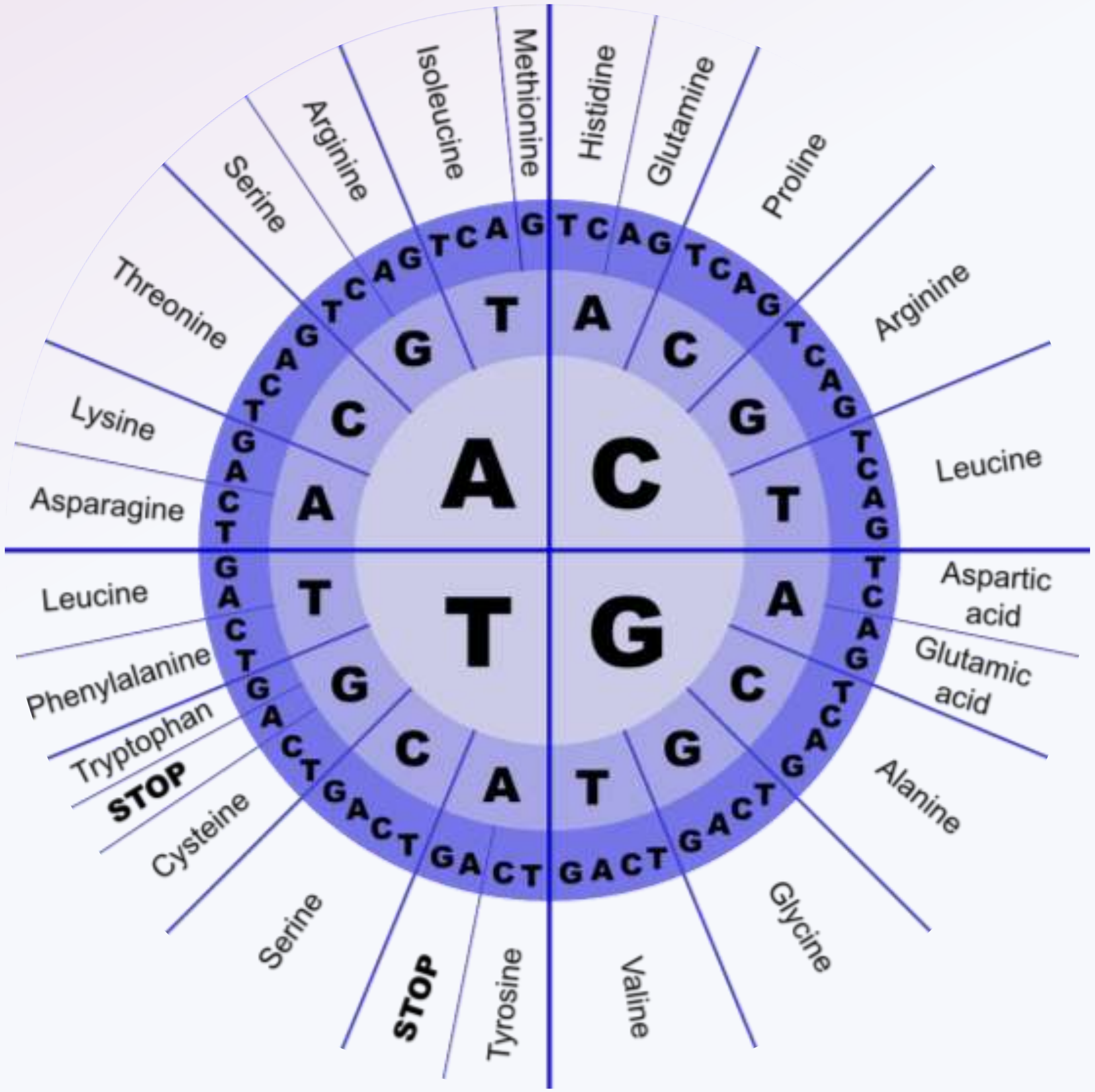
- **DNA provides the instructions for how to assemble 20 amino acids in a specific order to create a particular protein.**
  - The order in which 20 different kinds of amino acids are assembled determines the shape and function of the protein.
- **Combinations of three bases (called <u>codons</u>) code 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.

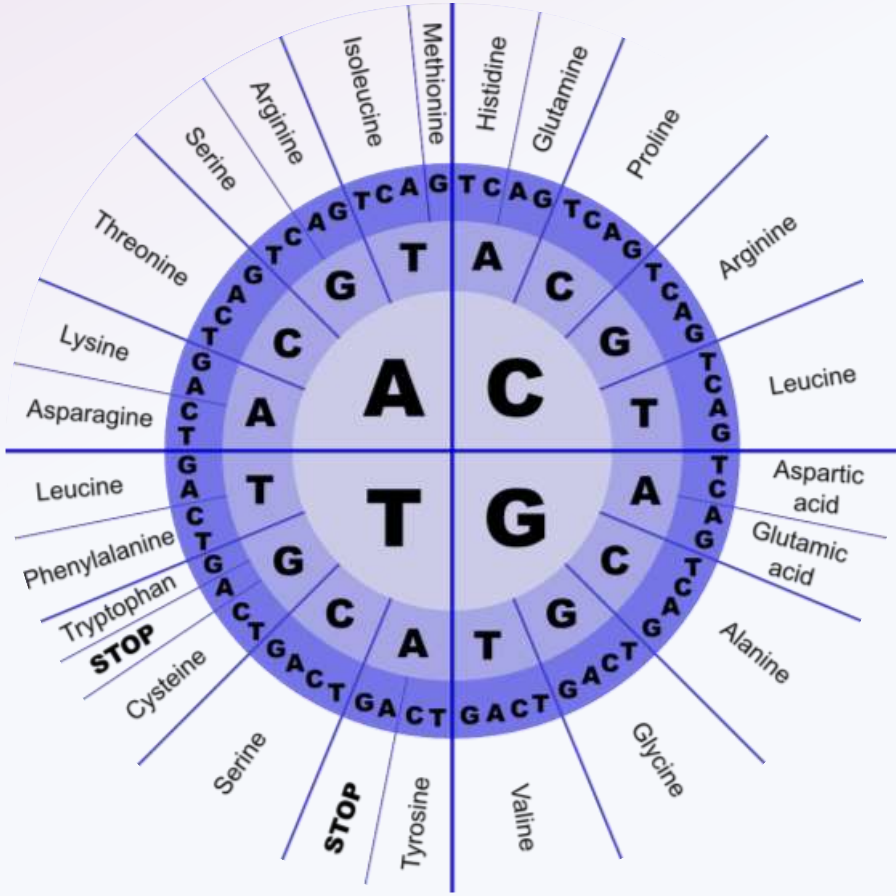
# Decoding Codons

- **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.

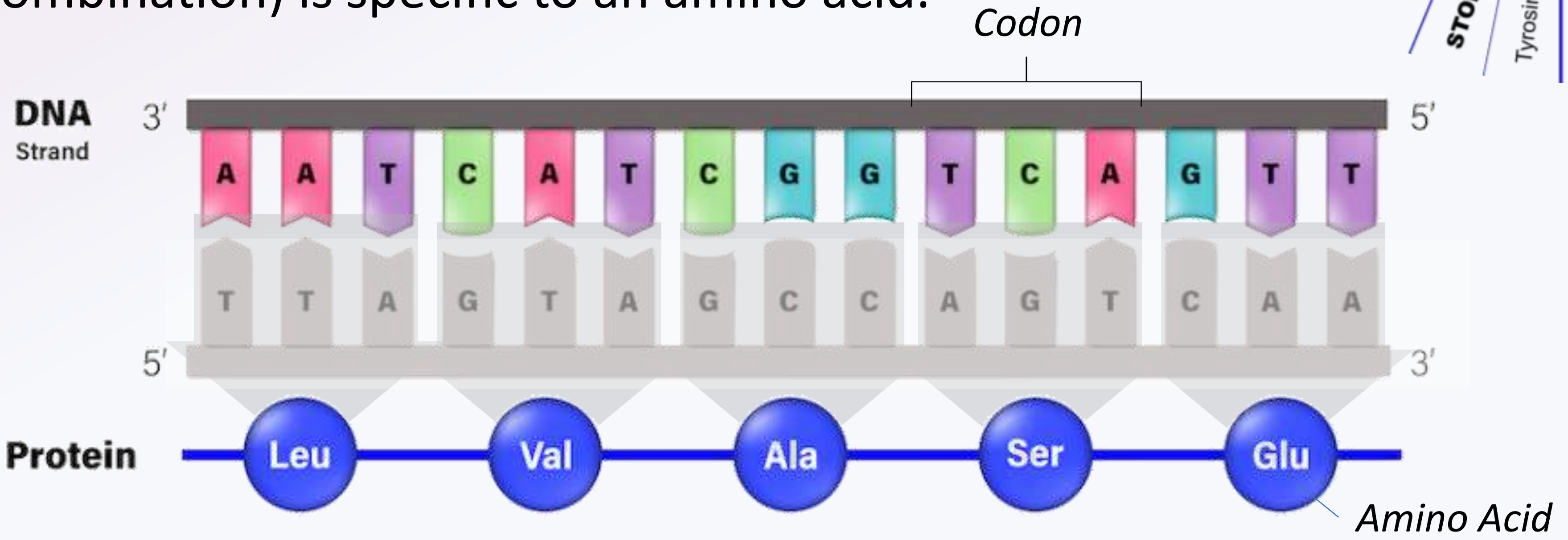



This table can be used to translate codons into different amino acids. Start in the center and work towards the outside. *E.g.*, GCA = Alanine.

# Codons → Amino Acids




- **The 3-letter combinations in each codon are specific to one kind of amino acids.**
  - The order of bases (A, G, C, T) in a <u>gene</u> (segment of DNA) directly correlates to the order of amino acids in a protein.
  - In the image below, each codon (3-letter combination) is specific to an amino acid.

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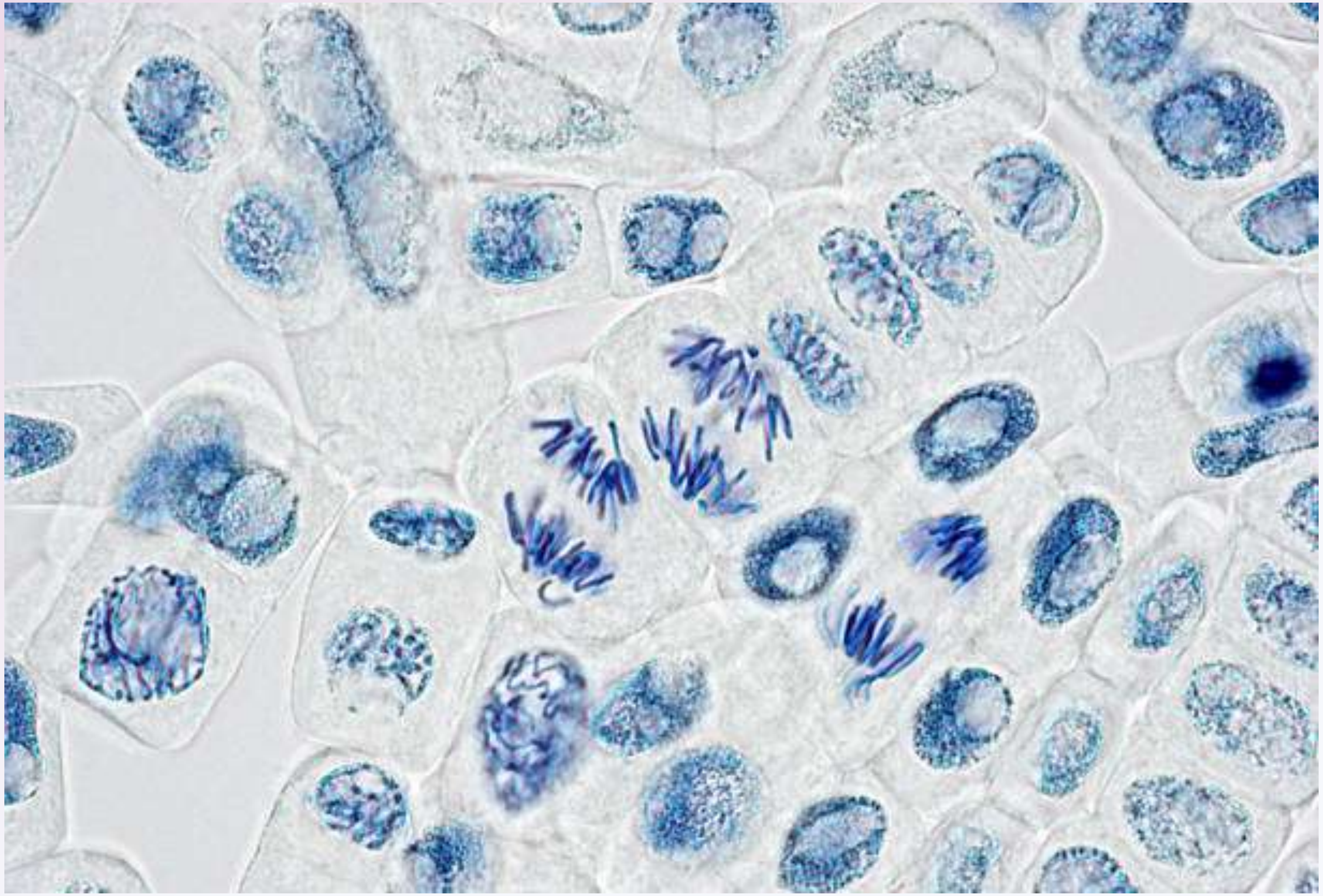
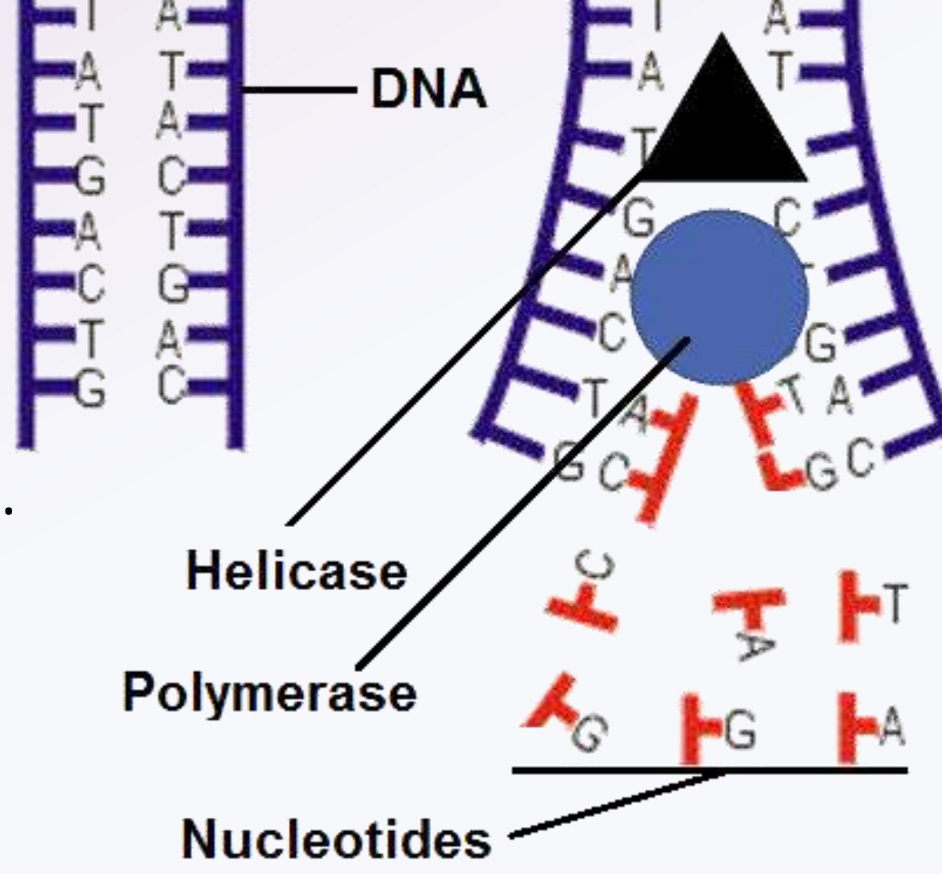


# Duplicating DNA.

How DNA copies are made during mitosis and meiosis.

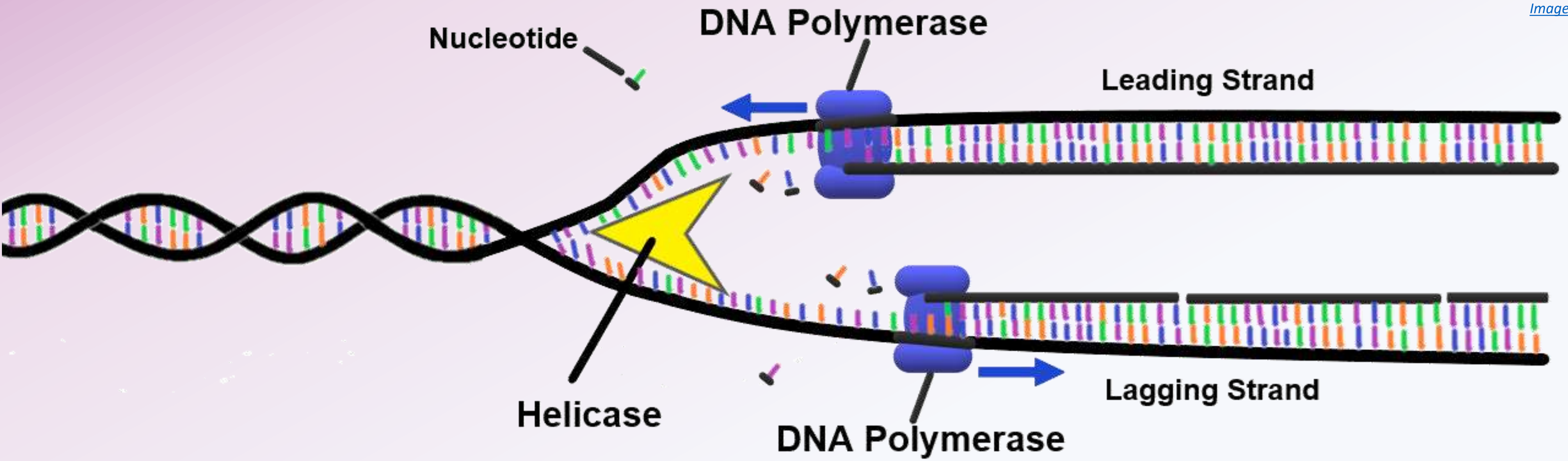
# Making Copies

- **Because A & T and G & C are always found together, a cell can easily duplicate its DNA.**
  - Each side of DNA provides a template for new copies.
- **DNA is first "unzipped" by a <u>helicase</u> protein.**
  - Then a protein called <u>DNA polymerase</u> "fills in" the other side of the DNA, creating two identical copies.
  - 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.
- **This process allows cells to make copies of their DNA before dividing.**
  - This ensures that as cells divide during mitosis, each gets a full copy of the DNA needed to assemble the proteins they need to function.




Source: biology.stackexchange.com

Image Source




- **DNA duplication requires a sense of direction to ensure DNA is copied correctly each time.**
  - However, there is no obvious top, bottom, left, or right in DNA.
- **DNA is duplicated 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.**

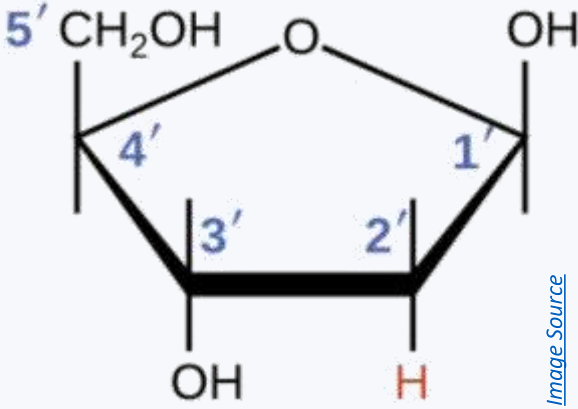
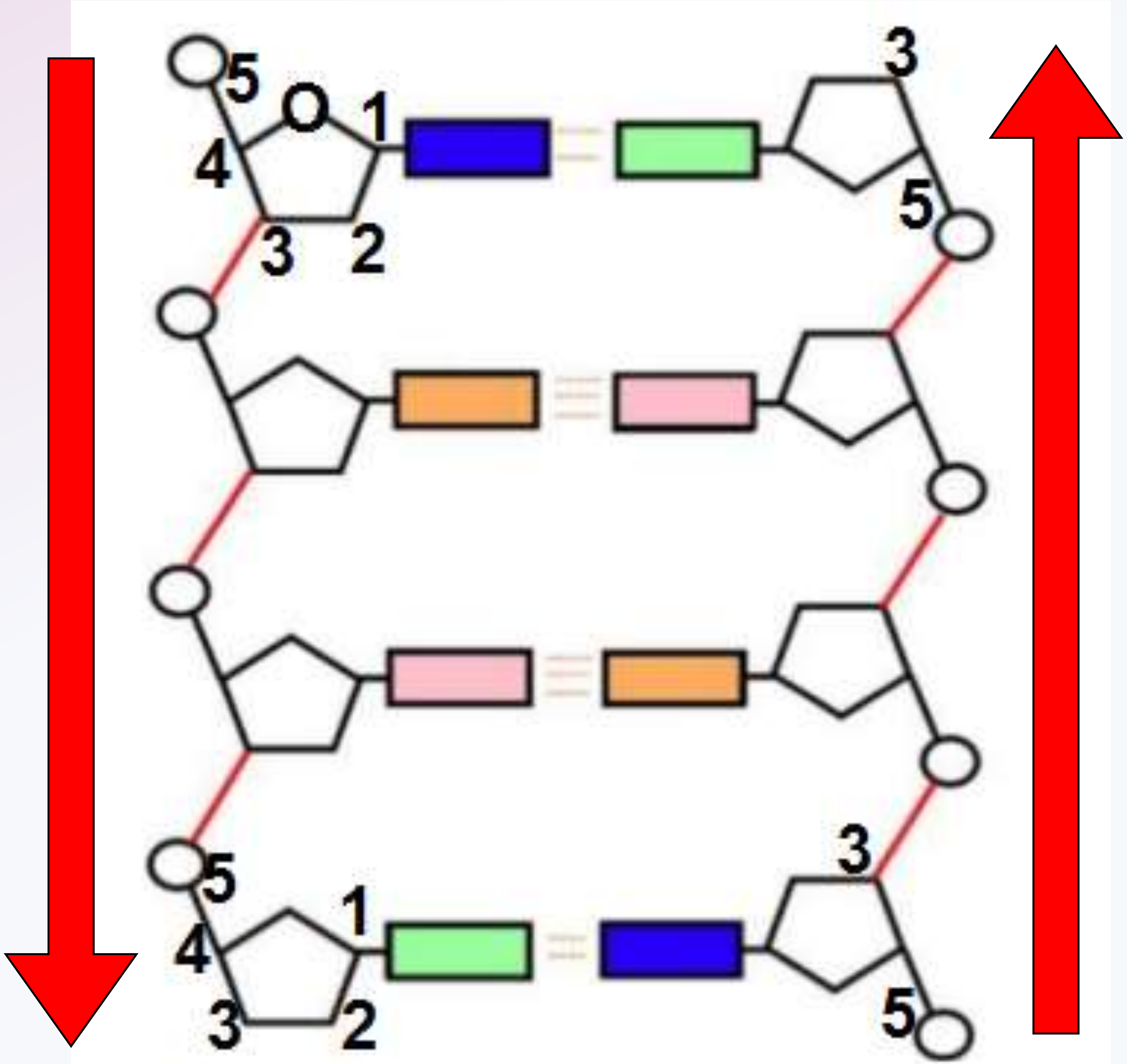



Image Source

- **DNA Polymerase always copies DNA in a 5 → 3 direction.**
  - The 5 → 3 direction on one side of DNA is opposite of the other side.
  - For example, the left side of this strand of DNA is copied from the top down.
  - However, the right side is copied from the bottom up.



# 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?

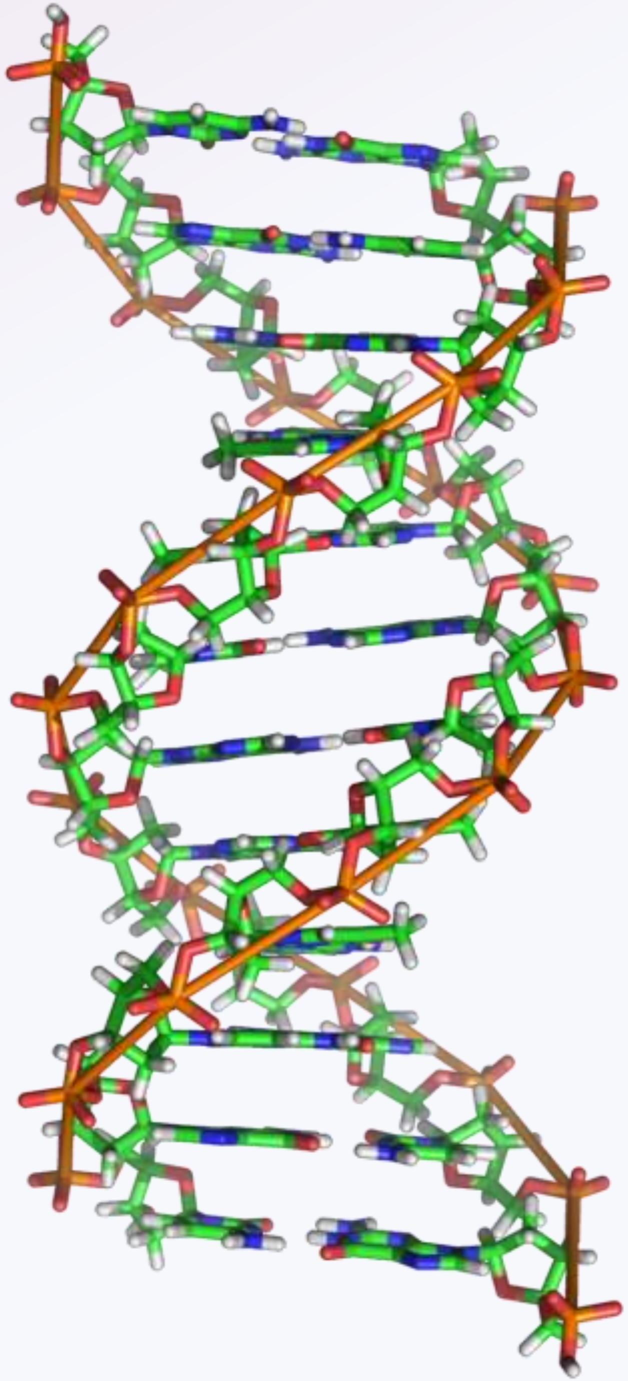


*Image Source: Wikimedia*

# 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.**
- **Traits 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.**
- **<u>DNA</u> is a polymer made of repeating molecules called nucleotides.**
- **Each <u>nucleotide</u> has 3 parts: a phosphate, a sugar, and one of four bases.**
- **<u>Phosphate</u> and <u>sugar</u> molecules provide structure to DNA; the <u>base</u> 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. These are called complementary base pairs.**
- **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.**
- **To replicate DNA, a protein called helicase separates the two strands. A protein called DNA 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.**



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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.**
- **DNA 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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