THE COMPONENTS & STRUCTURE OF DNA

- How do genes work? –

- What are they made of, and how do they determine the characteristics of organisms? –

- Are genes single molecules, or are they longer structures made up of many molecules? -

Answer the following 5 questions:

1. What organelle is known as the “control center” of the cell?
   - Nucleus
2. What structures are found in the nucleus?
   - Chromosomes/chromatin
3. What are located on chromosomes/chromatin?
   - Genes
4. What are chromosomes/chromatin composed of?
   - DNA wound around proteins
5. How do genes and chromosomes control the activity of a cell?
   - By producing proteins that regulate cellular functions or become part of the cell structure

Objectives:

- Summarize the relationship between genes and DNA.
- Describe the overall structure of the DNA molecule.

By the end of tomorrow, you should be able to do each objective

Scientists discovered that the nucleic acid DNA stores and transmits the genetic information from one generation of an organism to the next.

Macromolecule (#4) Notes

Nucleic Acid

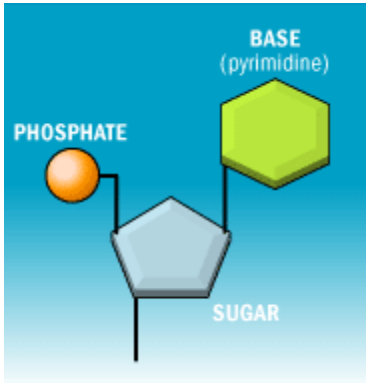
- Store and transmit hereditary, or genetic, information.

- Macromolecules containing hydrogen, oxygen, nitrogen, carbon, and phosphorus.

- Made of long chains of nucleotides.

Macromolecule Notes

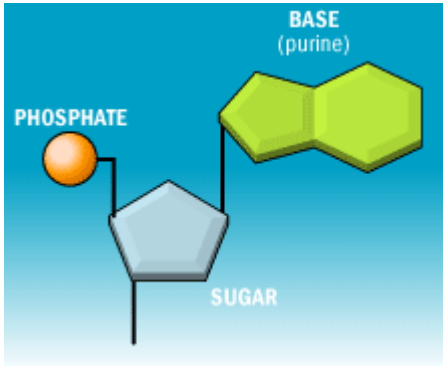
- POLYMER = nucleic acid = made up of a bunch of nucleotides
  - Two Types:
    - DNA – Deoxyribonucleic Acid
      - Double Helix in eukaryotes
    - RNA – Ribonucleic Acid
      - Single Strand in eukaryotes



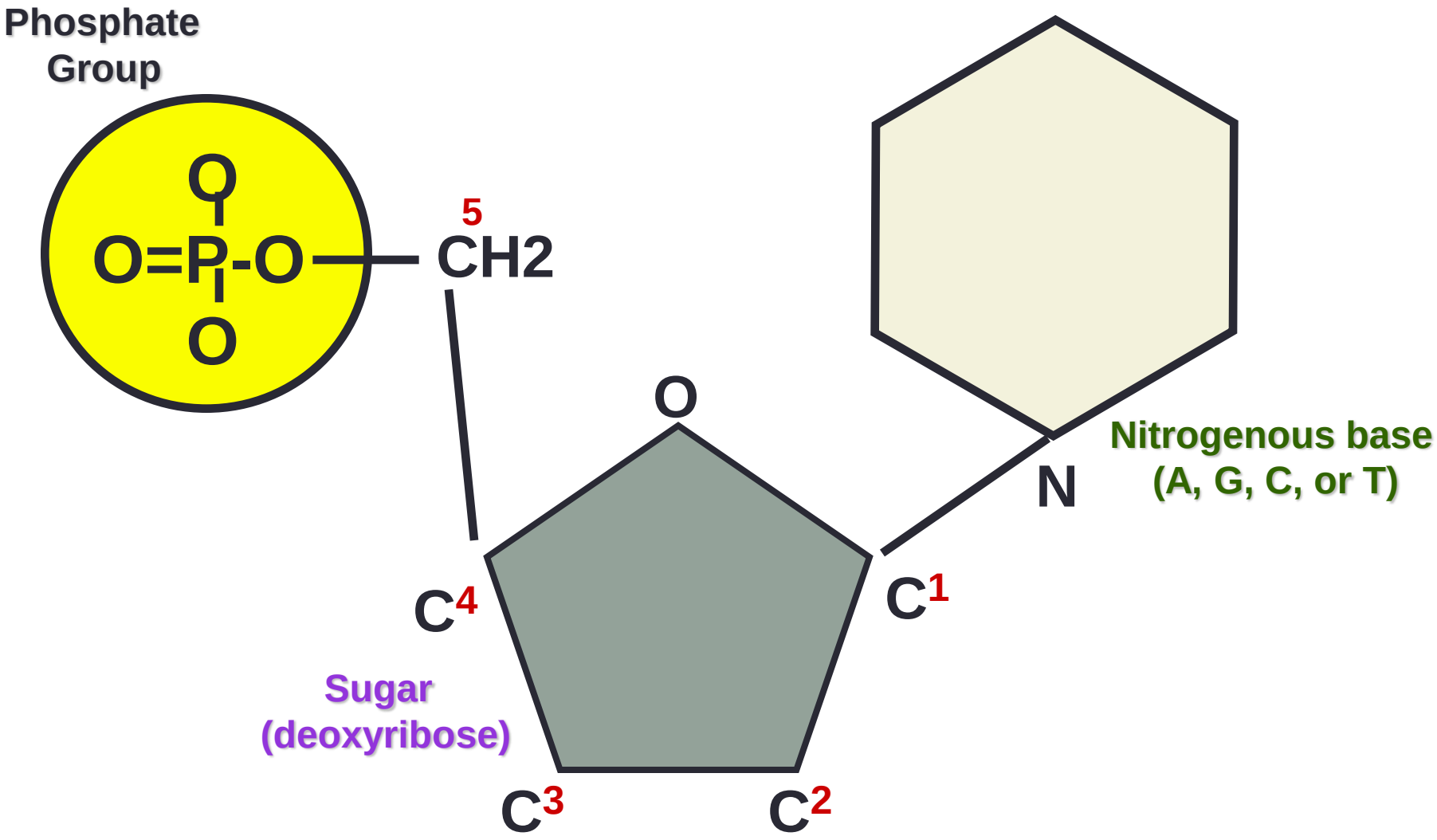
- MONOMER = nucleotides
  - Three parts:

    (1) 5-carbon sugar (2) Phosphate group

    (3) Nitrogenous base (nitrogen-base)
    - Purine (Adenine & Guanine)
    - Pyrimidines (Cytosine & Thymine)
  - Individual nucleotides joined by covalent bonds to form nucleic acids or polynucleotide.

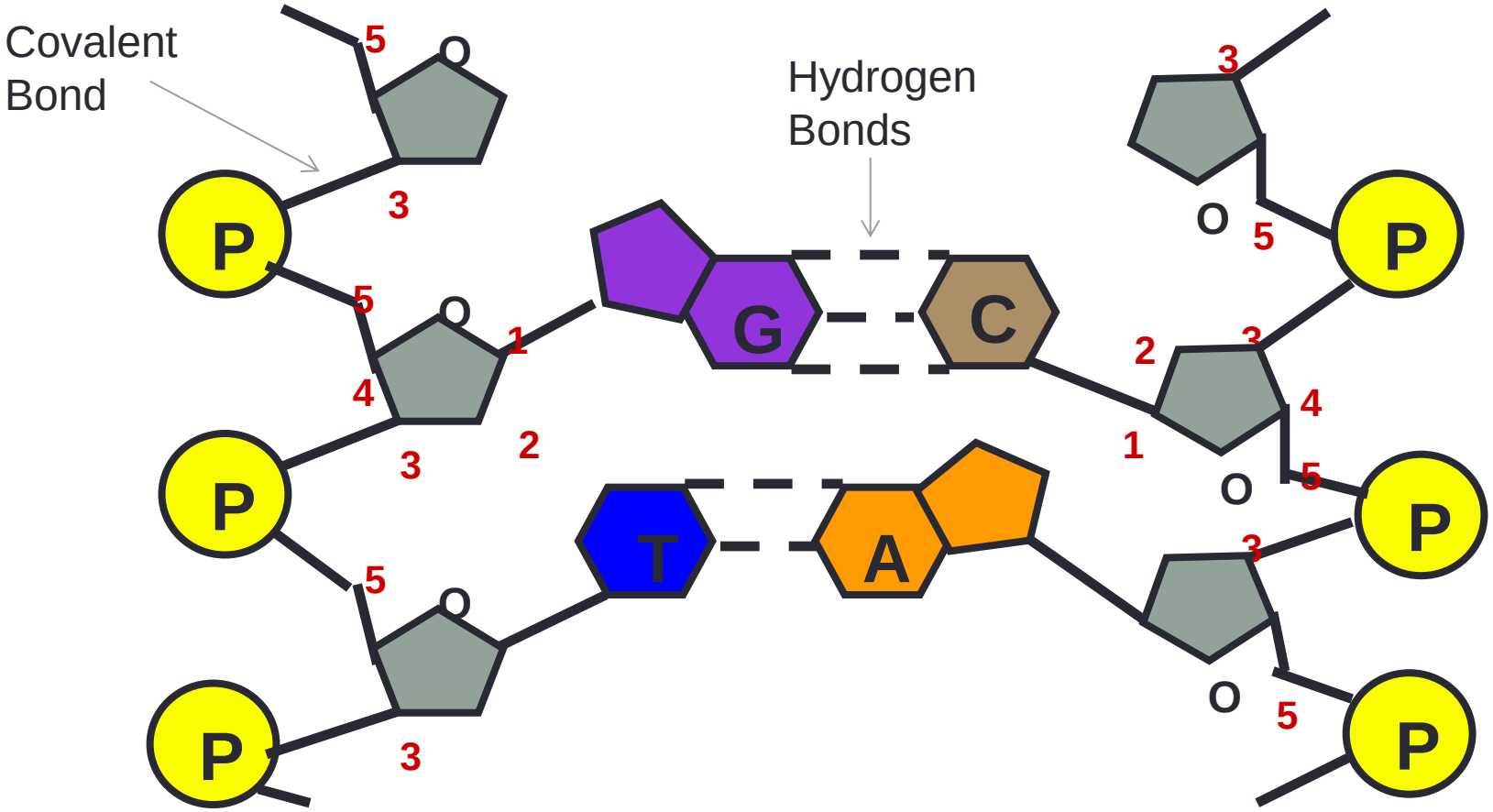


MONOMER - Nucleotide



POLYMER - Deoxyribonucleic Acid (DNA)

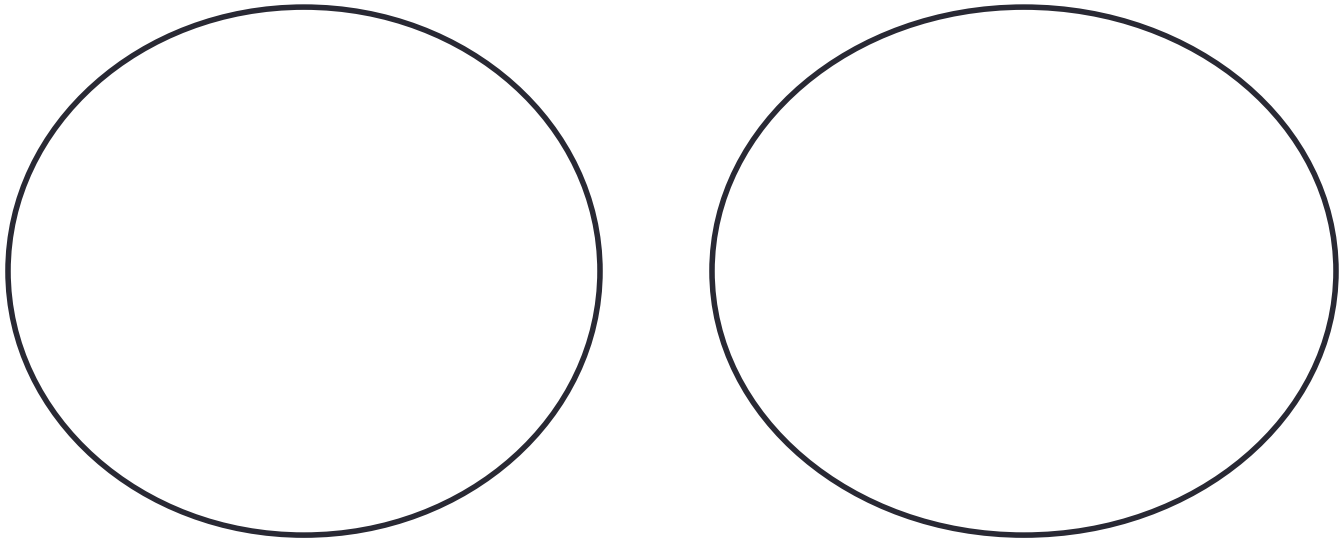
Double Helix



The Components & Structure of **DNA** Notes

DNA in Organisms

Prokaryote vs. Eukaryote



Differences in DNA

Where is found?

What form is it in?

How much is there?

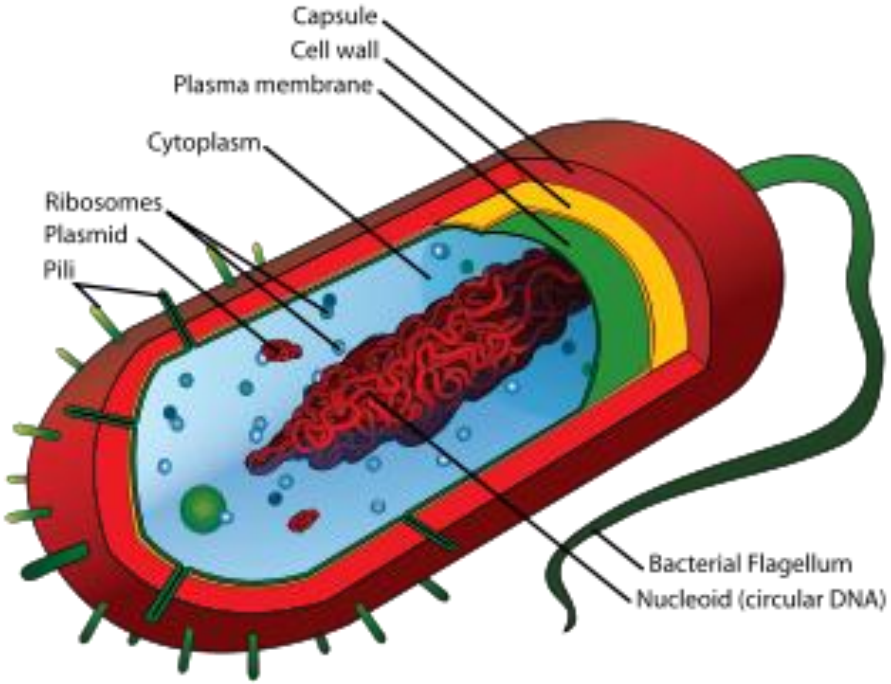
The Components & Structure of DNA Notes

Prokaryotes

Bacterial Cell

DNA in cytoplasm

Single Circular DNA Molecule



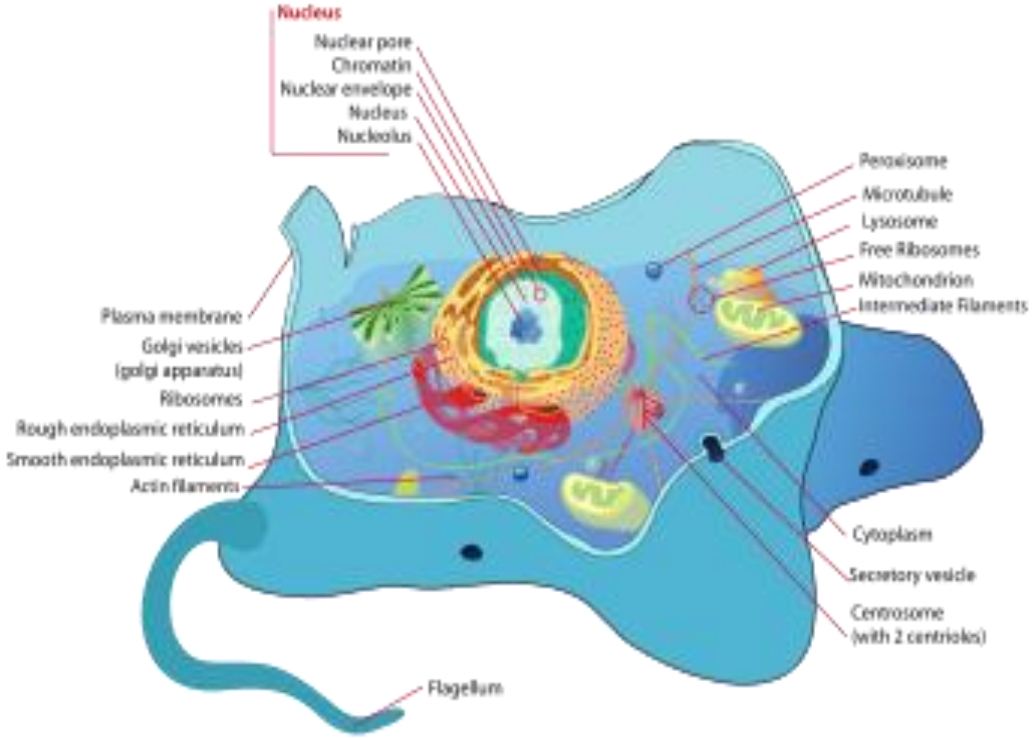
The Components & Structure of DNA Notes

Eukaryotes

DNA in nucleus

In the form of chromatin (chromosome when dividing) – double helix

1000 times as much DNA as prokaryotes



How do you think the DNA molecule is able to fit into the cell? Why is it so long?

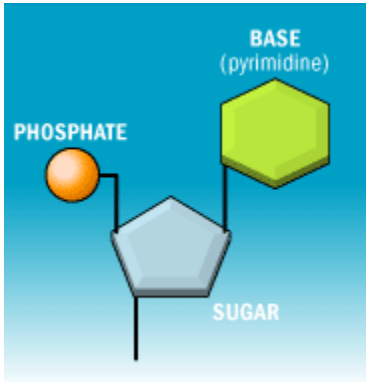
Talk with your partner.

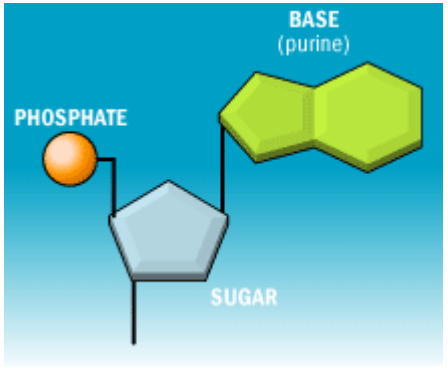
It is wound tightly into coils that allow it to fit.

It is so long because it carries all of the genetic information for organisms.

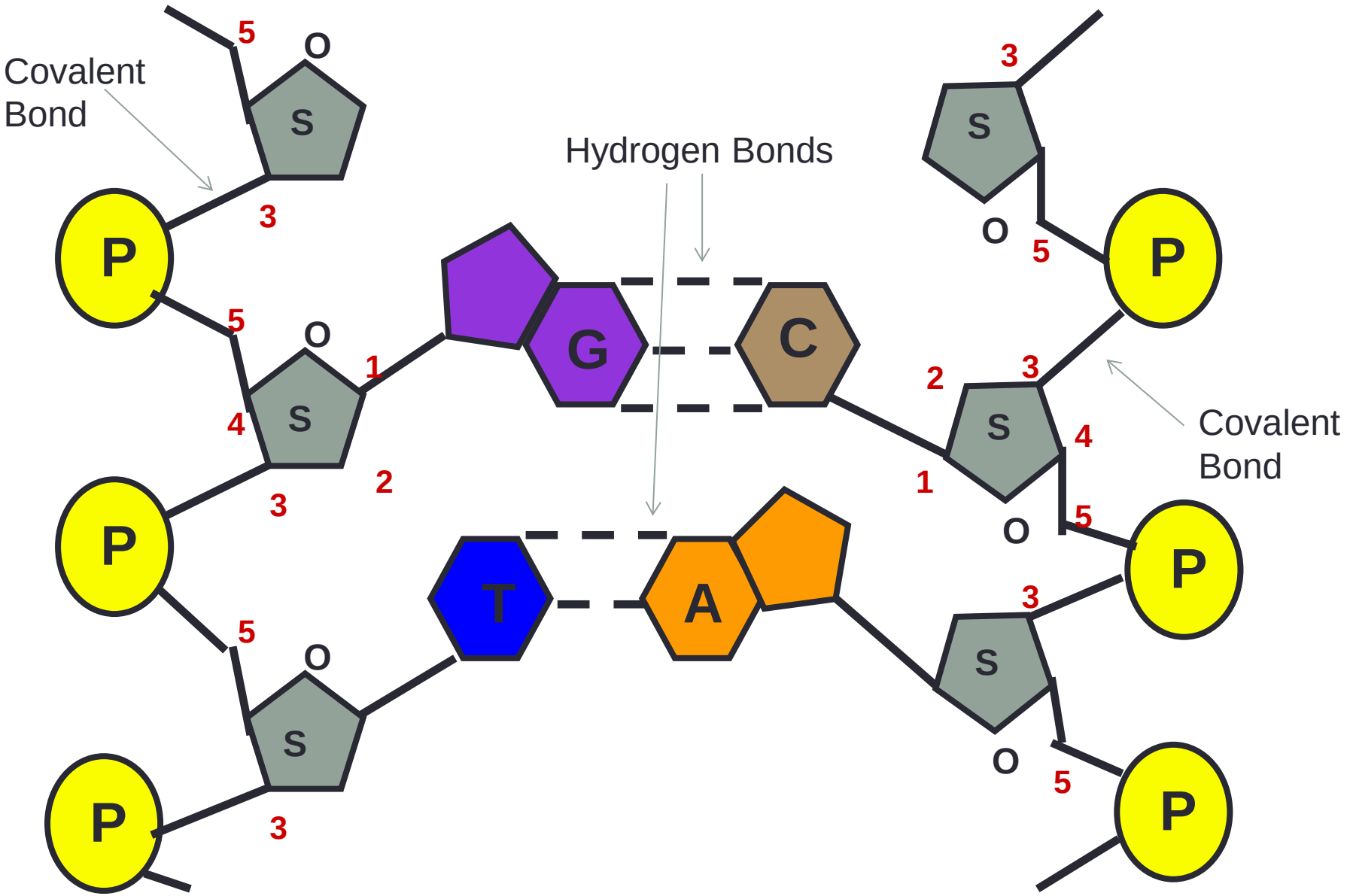
The Components & Structure of DNA

- Long chain made up of units called nucleotides
- Nucleotides are made up of three basic components
  - 5-carbon sugar = deoxyribose
  - Phosphate group
  - Nitrogenous bases
    - Purines – Adenine and Guanine
    - Pyrimidines – Thymine and Cytosine





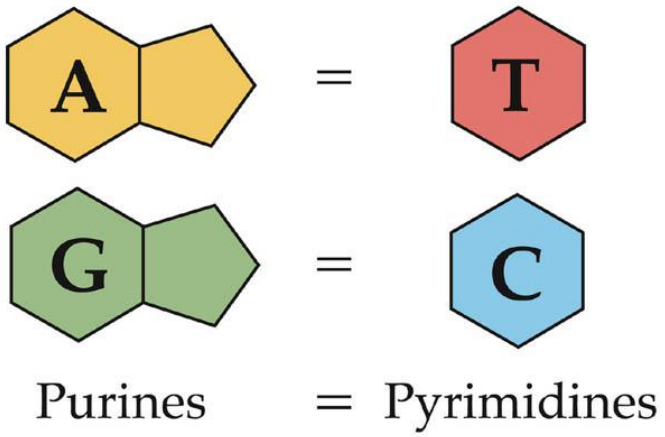
The Components & Structure of DNA



Chargaff's Rule

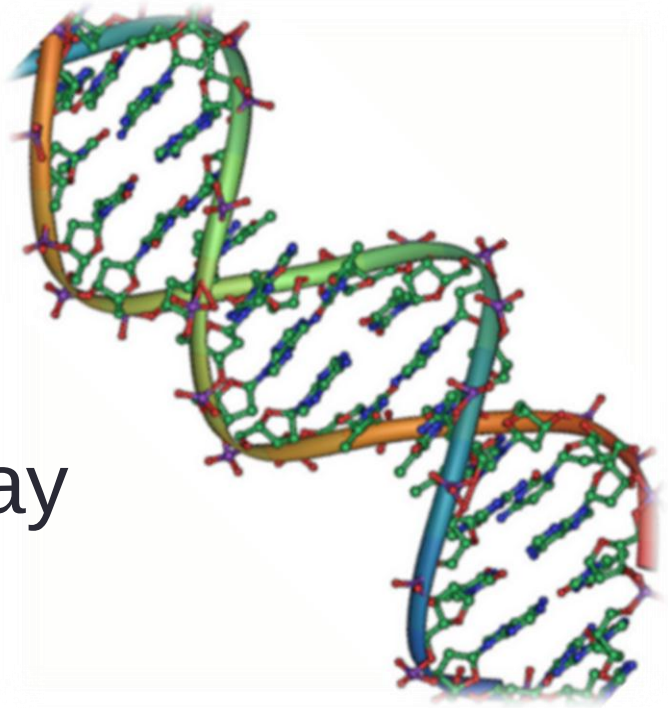
- American Biochemist Erwin Chargaff
- Discovered that the percentages of guanine (G) and cytosine (C) bases are almost equal in any sample of DNA
- Found the same thing to be true for the other two nucleotides Adenine (A) and Thymine (T)

- **CHARGAFF'S RULE**
  - A = T
  - G = C



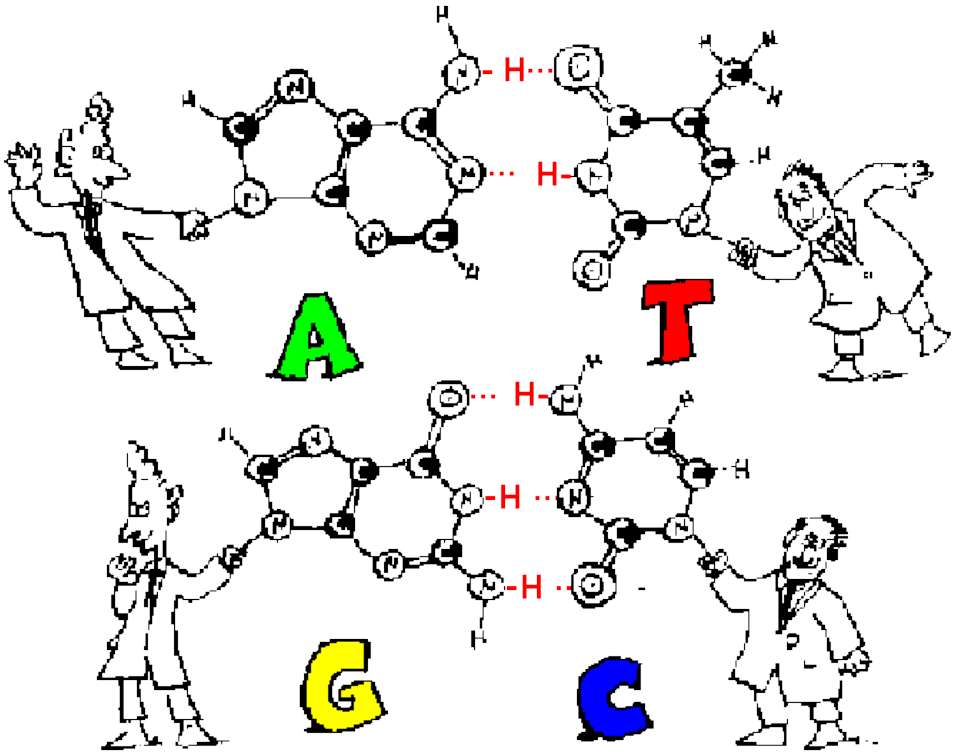
The Double Helix

- DNA is a double helix, in which two strands are wound around each other.
- Looks like a twisted ladder or spiral staircase
- How does the double helix stay together?
  - **Base Pairing!**



The Double Helix & Base Pairing

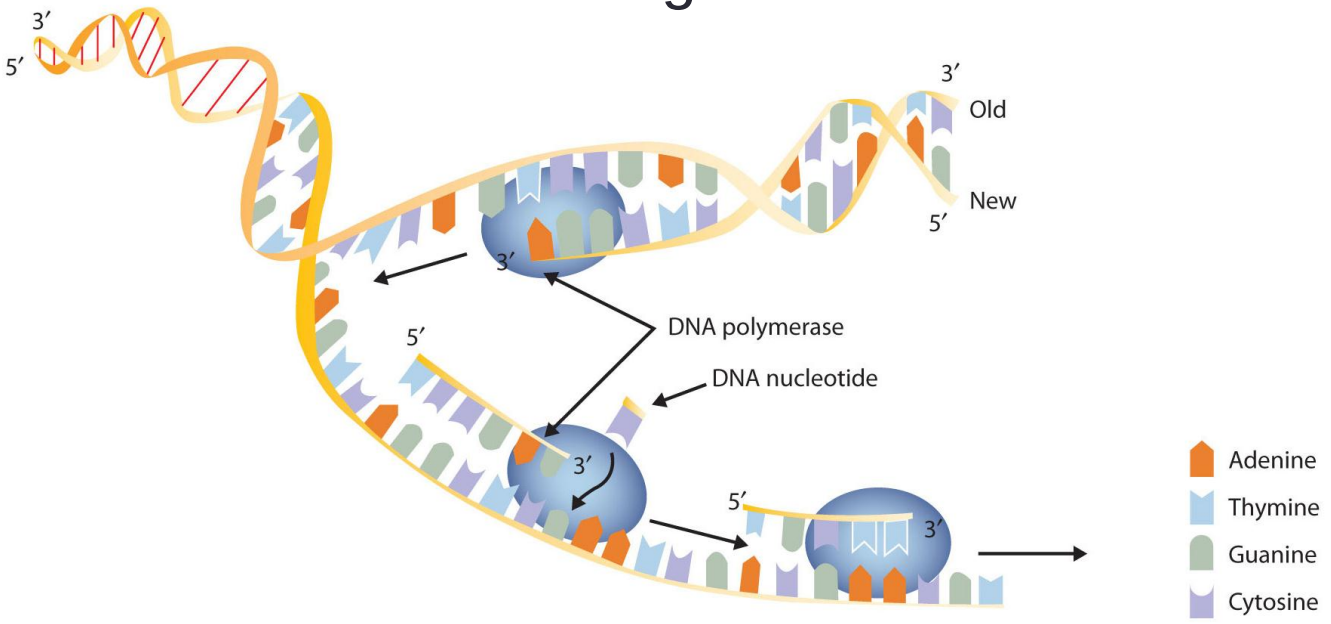
- How does the double helix stay together?
  - Base Pairing!
    - Hydrogen Bonds can only form between certain nitrogenous bases and provide just enough force to hold two strands together
    - Hydrogen bond can only form between Adenine and Thymine
    - Hydrogen bond can only form between Guanine and Cytosine



Define Replication

- Replication is copying process where a cell duplicates its DNA.

- Replication is able to make an exact copy of all the information on an entire long strand of DNA.



DNA is like a zipper…

Read about the process of replication and answer the questions on the DNA Is Like a Zipper handout

Discuss answers with your partner!

Why does DNA replication happen?

- Replication copies DNA before cells divide in mitosis or meiosis.

Where is eukaryotic DNA found?

- DNA is found in the cells nucleus of eukaryotic cells

If a section of original DNA has the bases ACGTTA, what basses will the complementary strand have?

- TGCAAT

What is the role of enzymes in replication?

- Enzymes unzip the DNA

How is DNA like a zipper?

- It is like a zipper because it can be separated by breaking bonds between base pairs. As it separates, it looks like a zipper being unzipped.

What is the role of enzymes in replication?

- Enzymes unzip the DNA

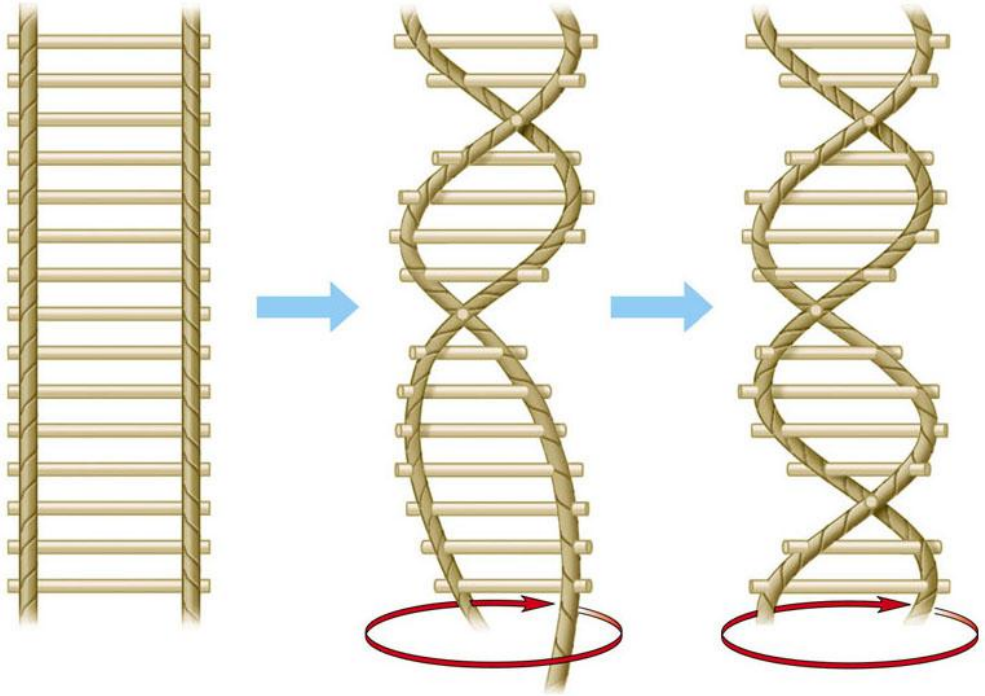
Review

DNA Guided Notes

What is DNA?

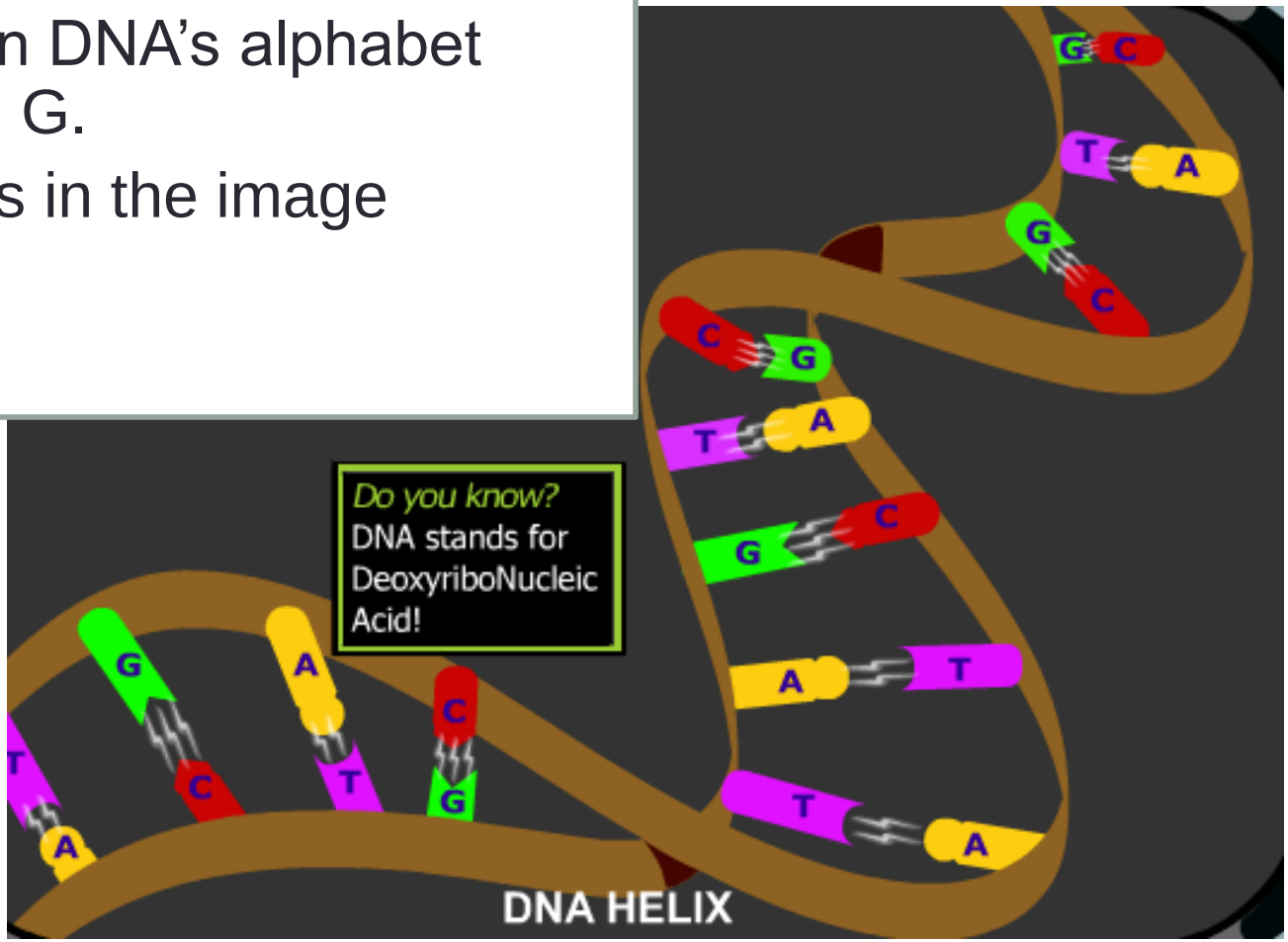
- DNA stands for Deoxyribonucleic Acid

- DNA is a **double helix** - meaning two long chains come together to form one huge molecule and that molecule spirals.



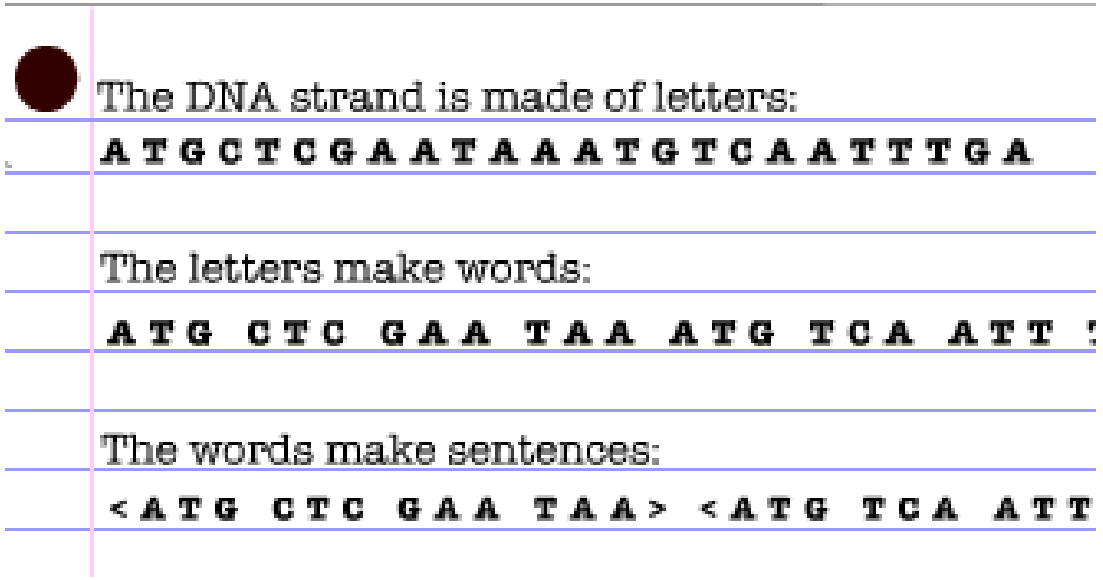
What is DNA?

- The 4 ‘letters’ in DNA’s alphabet are A, T, C and G.
- Notice the pairs in the image below:



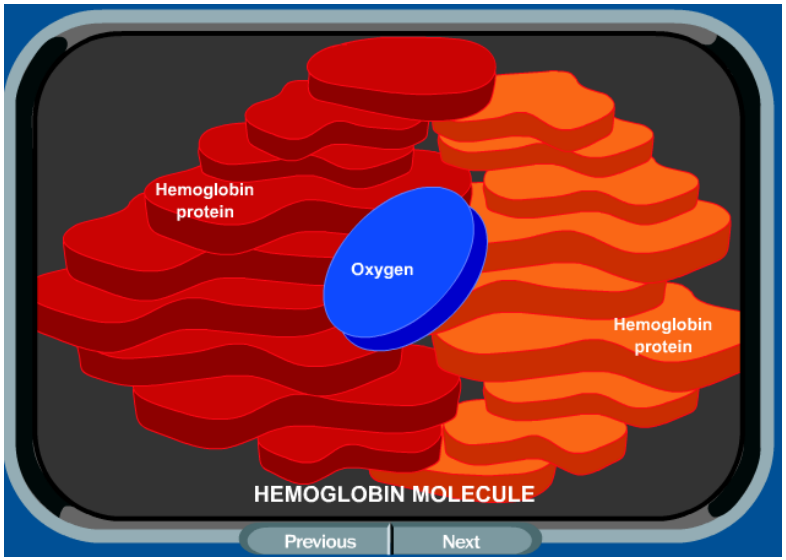
What is DNA?

- Each ‘word’ is 3 letters of DNA.
- Each sentence is a gene.



What is a gene?

- Genes are the instructions for making proteins. (1 gene = 1 protein)
- According to the picture Hemoglobin is composed of 2 proteins, encoded by 2 genes.
- When genes are mutated the proteins are not made correctly and therefore may not function.



What is a chromosome?

- Human DNA is approximately 3 meters or 6 feet in length.
- Chromosomes serve as an efficient packaging system for our DNA.

What is a protein?

- Proteins are the building blocks of life. They serve many functions including:
  - Receptor proteins that receive chemical signals from other cells
  - Structural proteins that make up the structure of our body.
  - Enzymes that speed up chemical reactions in the body.

What is a protein?

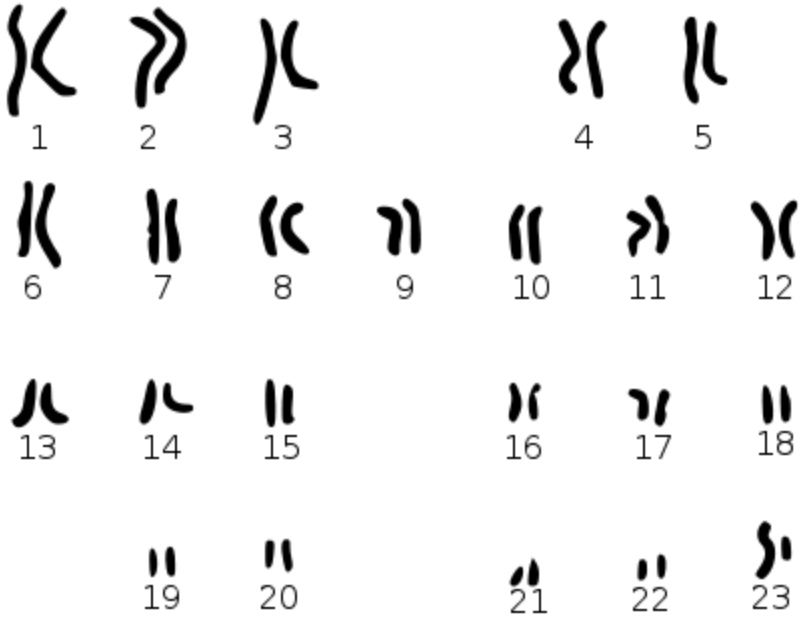
- Making proteins is a very complicated, and very important process that we will be examining in the unit. Hopefully you noticed that DNA is copied into its cousin molecule – RNA – before proteins are made. In fact, RNA, not DNA travels from the nucleus to the ribosome where proteins are made.

DNA (in nucleolus) →
RNA (travels to ribosomes) →
Proteins (made in ribosomes)

Introduction

- Human DNA is 6 billon letters (nucleotides) long
  - (3 billion on each side)

- These 6 billion letters are broken down into 46 pieces (chromosomes) in humans.

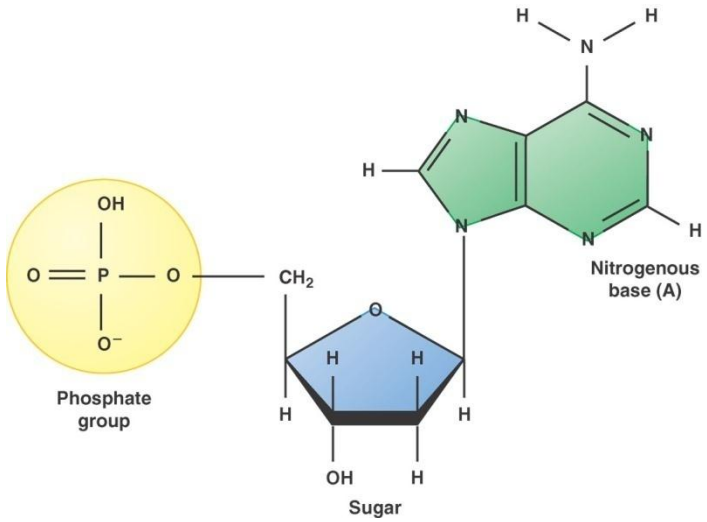


Organic Chemistry

- DNA is a nucleic acid.
  - It is called a nucleic acid because it was first found in the nucleus.
    - *Today we know that DNA floats in the cytoplasm of prokaryotic cells, and is found within the nucleus, mitochondria and chloroplasts of eukaryotic cells.*
- A polymer is a long chain of repeating units. DNA is a very long chain of repeating units.
- The repeating units (monomers) of DNA are nucleotides.

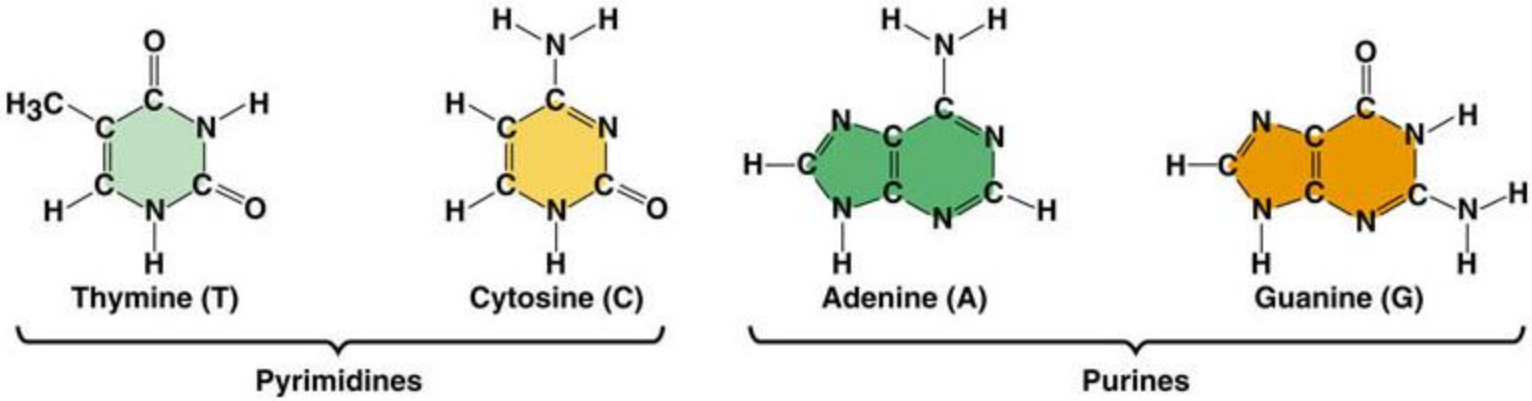
Structure

- Nucleotides
  - Each nucleotide has a:
    - Phosphate
    - **Deoxyribose** Sugar
    - Nitrogen Base
      - There are 4 nitrogen bases:
        - Adenine
        - Thymine
        - Guanine
        - Cytocine



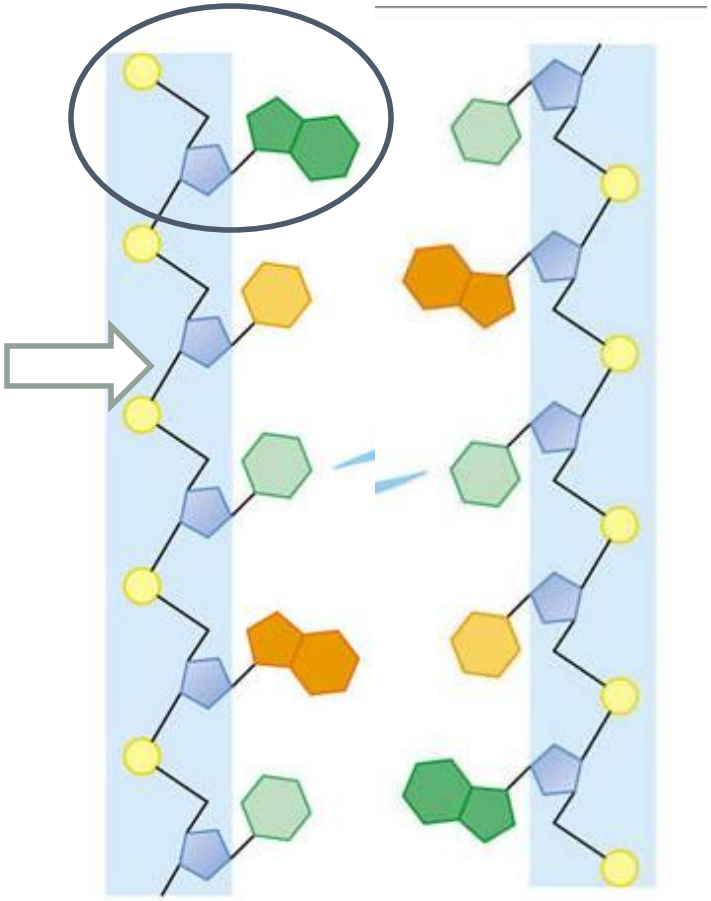
Nucleotide

- The bases are known by their coded letters
  - A, G, T, C.



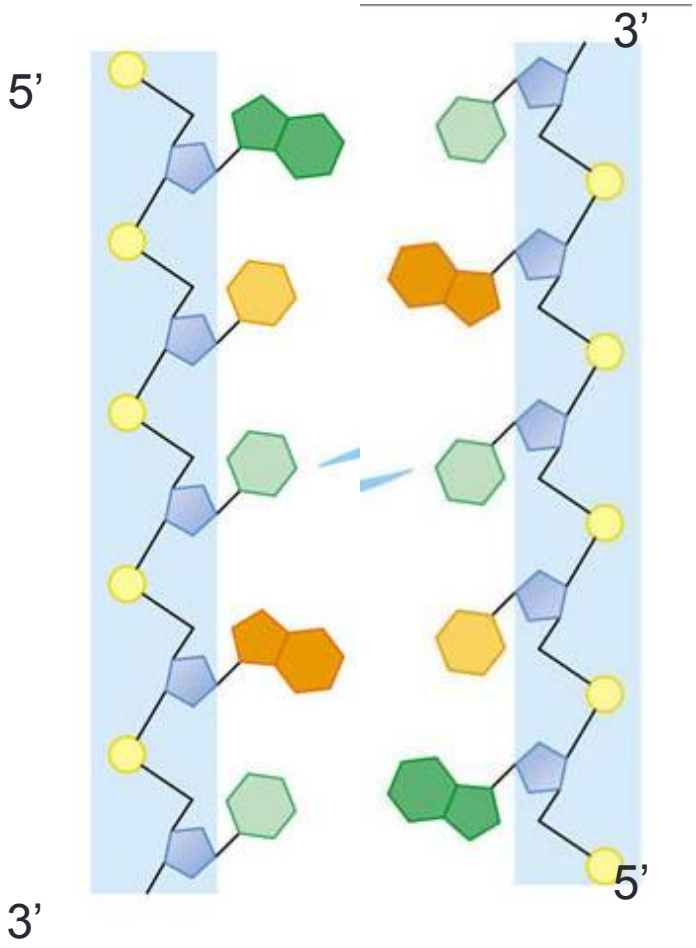
The Backbone

- The nucleotides come together in long chains.
  - See the individual nucleotides?
- The SUGAR & PHOSPHATE portion of the nucleotides make up the backbone.
- They are held together by covalent bonds
  -

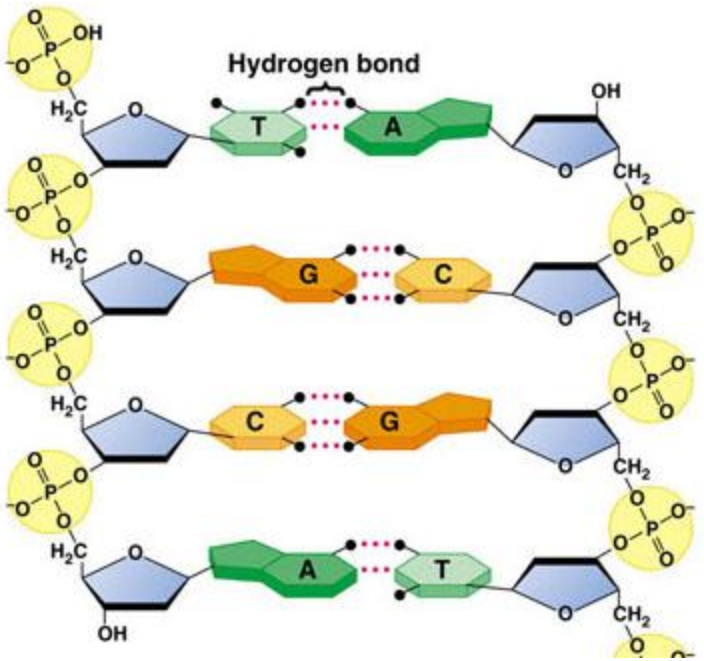


The Backbone

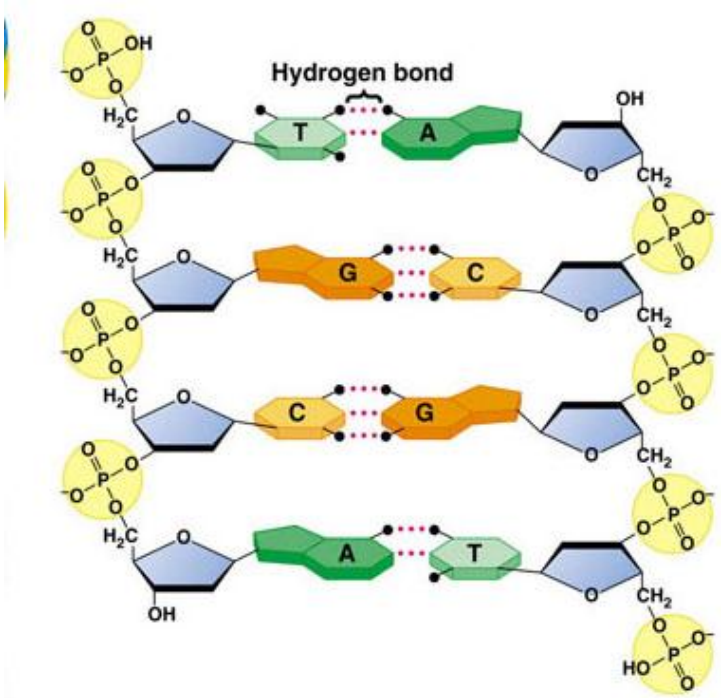
- The backbones are opposite each other (one is upside down)
- We label with the terms 3’ and 5’ – referring to the Carbon on the sugar that is pointing up.
  - *Sugar always points to the 3 end!*



- The two chains are held together by the nitrogen bases.
- They are held together by weak Hydrogen Bonds.
  - Adenine will only bond to thymine.
  - Guanine will only bond with cytosine.
  - This is known as the "Base-Pair Rule".



- It is important that the sides are strong (covalent bonds) and the middle is weak (hydrogen bonds). Because the middle is weak the two sides can pull apart so that the cell can make copies of its DNA.



Partial chemical structure

RNA

- RNA differs from DNA
  - Sugar (Ribose instead of Deoxyribose)
  - Nucleotides (Uracil instead of Thymine – rest are the same)
  - Base-pairing Rules (A-U / C-G)
  - Length (much shorter)
  - Shape (varies but it is never a double helix)

History of DNA

- In the late 1800's, Johann Friedrich Miescher discovered DNA in the nucleus of puss cells.

- In 1953, **James Watson** and **Francis Crick** established the structure of DNA.
  - There discovery was based on many scientists work including:
    - Chargaff (figured out base pairing)
    - Franklin (took x-ray pictures of DNA)

CHROMOSOMES & DNA REPLICATION

Add objectives & questions, etc.

Objectives

- Summarize the events of DNA replication
- Relate the DNA molecule to chromosome structure

By the end of today you should be able to do each of the objectives along with the two objectives from yesterday

DNA Replication

Each strand of the DNA double helix has all the information needed to reconstruct the other half by the mechanism of base pairing.

Because each strand can be used to make the other strand, the strands are said to be complementary.

Important Enzymes in DNA Replication

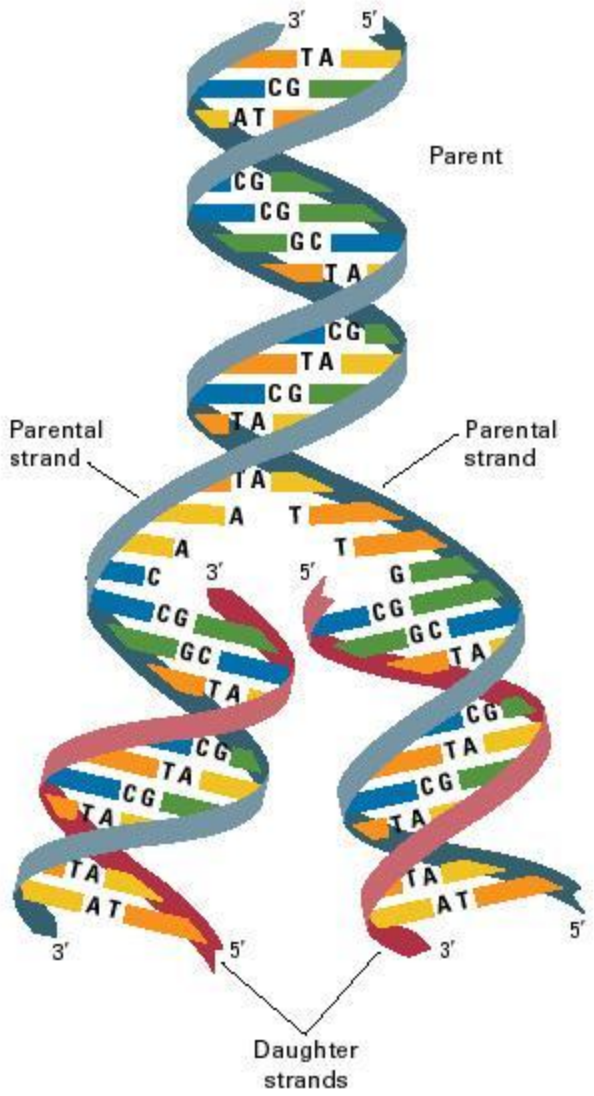
- ENZYME – protein that helps chemical reaction occur at a faster rate.
- REPLICATION FORK: The sites where separation and replication begins on a strand of DNA
- Three important enzymes
  - (1) Helicase – creates the replication fork → unwinds and unzips double helix
  - (2) DNA Polymerase – replicates the DNA → Pairs each base with its complementary base (A=T, G=C)
  - (3) DNA Ligase – attaches the replicated parts of DNA together → fills in the spaces between each site of replication

Sequence of Events in DNA Replication

1. DNA is unzipped by Helicase
    1. Hydrogen bonds between the base pairs are broken
2. DNA Polymerase joins individual nucleotides to produce a DNA molecule
    1. Each strand serves as a template for the attachment of complementary bases.
3. DNA ligase comes along to “glue” the replicated strands together to form two identical double helixes.

Replication Summary

- Quick – about 80 bases per second in humans
- Accurate – only makes one mistake in every billion nucleotides
- Remember – 2 copies of the DNA is made – each double helix is ½ original and ½ 'new' DNA



Replication Notes

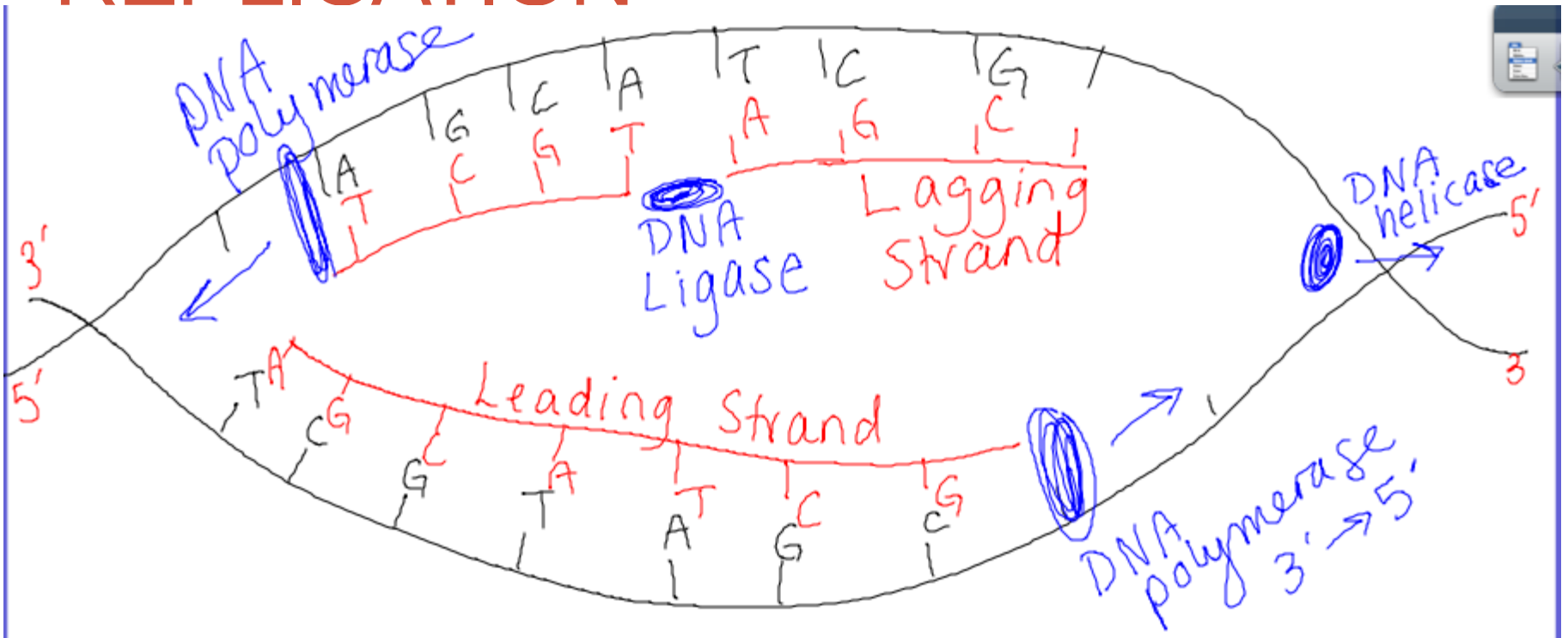
- Get blank piece of notebook paper.
- Turn it horizontally. (Landscape)

- Watch Video

  Video with leading and lagging

- We are going to draw DNA replication.
  - I will draw the template strand on the board
  - Label the location of the three enzymes
  - Label complementary bases

REPLICATION



1. **DNA Helicase** unzips the DNA, breaking H bonds
It does this at many places along the DNA creating - 'multiple points of orgin' or bubbles

2. **DNA Polymerase** begins to add new nucleotides to each side of the unziped helix following the base pairing rules. It can only move from 3' to 5' which results in a leadind and lagging strand.

3. **DNA Ligase** comes along to 'glue' the fragments together and unite the the 'bubbles' creating two identical double helixes.

Label – DNA Structure Worksheet

- Single Nucleotide
- Phosphate Group
- 5-Carbon Sugar – what is the name of the sugar?
- Nitrogenous Base –
  - What are the four bases?
- What bond is between the nitrogenous bases?

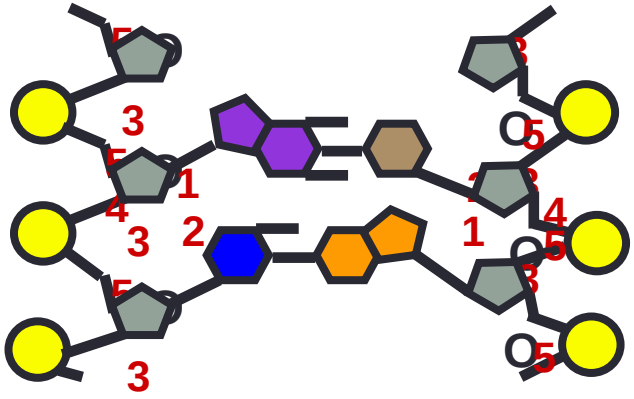
Replicate DNA on your own

VERY SIMILAR TO PART OF CORE ASSESMENT #2

- Paper cut outs
  - S = Sugar - Deoxyribose
  - P = Phosphate Group
  - N = Nitrogen-containing Base
    - A = Adenine
    - G = Guanine
    - C = Cytosine
    - T = Thymine
- One partner will make one strand of the DNA double helix (10 bases) – the other partner will have to complete the complementary strand of DNA by connecting the correct pieces
- Switch Roles!

Assessment – Write the Question & Answer

- How many basic units does a nucleotide have?
  - Three: deoxyribose (sugar), a phosphate group, and a nitrogenous (nitrogen-containing) base
- How does the arrangement of base pairs relate to Chargoff's rules?
  - Adenine and thymine are present in equal percentages because the two bases always pair together. Guanine and Cytosine are present in equal percentages because they always pair together
- What are the four kinds of bases found in DNA?
  - Adenine, Thymine, Guanine, Cytosine
- Draw a DNA molecule
  - Label all parts!



Assessment - Write the Question & Answer

1. What are chromosomes composed of?
   - Proteins and DNA
2. Why is the new strand complementary to the original strand?
   - It is made up of a base sequence of purines and pyrimidines that match, or base pair, with the sequence of purines and pyrimidines of the original strand.
3. Explain how DNA is replicated.
   - The DNA molecule separates into two strands by Helicase. The two strands serve as templates against which the new strand are made by DNA polymerase following the rules of base pairing.
4. How are the long DNA molecules found in eukaryotes packed into short chromosomes?
   - The DNA strand is wrapped around proteins
5. What is the role of DNA polymerase in DNA replication?
   - Polymerizes (process of putting together monomers to form a polymer) individual nucleotides to produce DNA

THE HUMAN GENOME PROJECT

What is it?

What is a Genome?

- All the hereditary information of an organism.
  - The complete set of genetic instructions.

What is a the Human Genome Project?

- Effort to identify and map every gene to its chromosome and determine the entire DNA sequence for the human genome

BIG QUESTION -

- What genes are found on which of our 46 chromosomes and what do they do?

Human Genome Round Robin

- Break into assigned groups
- Research the topic you were given
- Make a short PowerPoint answering questions outlined
  - Document is found in the shared drive→Franko→Shared→Acad. Bio.
  - Open Human Genome Round Robin 2013 & follow instructions
  - Links are provided in document (Control & click to open them)

- Get with other groups who did the same topic
- Compare answers
- Save PowerPoint as “HGP_Lastnames” and drop in Eggleston’s drop folder in the shared drive.

- Round Robin – answer all questions!
- Conclusion Questions – Hand in one copy per group

Group Rubric

Use of Time & Planning	You used time effectively to complete the PPT.	/4
PRESENTATION & CONTENT:		
• Design	The overall design of the presentation was attractive and showed thought.	/4
• Content	The mission you were given was clearly addressed. (x2)	/8
ROUND ROBIN		
• Rotation	You rotated to each PPT and reviewed it. You stayed focused on the task.	/4
• Conclusions	The provided thorough and thoughtful answers to the 3 conclusion questions. (x3)	/12
OVERALL TOTAL:		/32