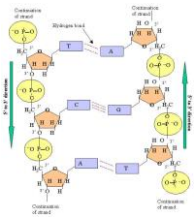
DNA and RNA

Nucleic Acids

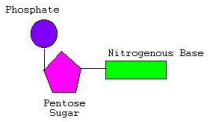
What is a Nucleic Acid?

- **Nucleic Acids** are organic molecules that carry information needed to make proteins
  - *Remember: proteins carry out ALL cellular activity*
- There are two types of nucleic acids:
  - DNA (deoxyribonucleic acid)
  - RNA (ribonucleic acid)



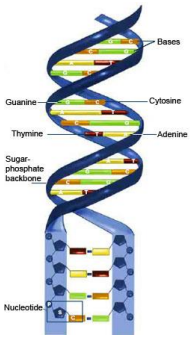
Parts of Nucleic Acid

- All nucleic acids are made up of monomers called nucleotides and have three parts:
  - Phosphate
  - Pentose sugar
  - Nitrogenous base



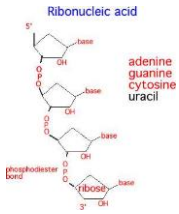
DNA Structure

- Two single chains that spiral in a double helix
- Pentose sugar is called deoxyribose
- Will have one of four nitrogenous bases:
  - Cytosine (C)
  - Guanine (G)
  - Adenine (A)
  - Thymine (T)



RNA Structure

- A single chain of nucleotides
- Has a sugar called ribose
- Has one of the following bases:
  - Cytosine (C)
  - Guanine (G)
  - Adenine (A)
  - Uracil (U)



DNA vs RNA

	DNA	RNA
Nitrogen bases	• Cytosine (C) • Guanine (G) • Adenine (A) • Thymine (T)	• Cytosine (C) • Guanine (G) • Adenine (A) • Uracil (U)
Sugar	deoxyribose	ribose
Molecule structure and shape	DOUBLE HELIX	SINGLE CHAIN OF NUCLEOTIDES

History of DNA

How was DNA's structure and function discovered?

History of DNA's Discovery

- **1869** Johann Friedrich Miescher first discovers DNA

History of DNA's discovery

- **1928** Franklin Griffith discovers that genetic information can be transferred from heat-killed bacteria cells to live ones. Provided key evidence that DNA is genetic material.

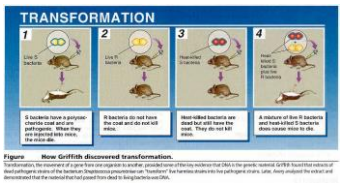
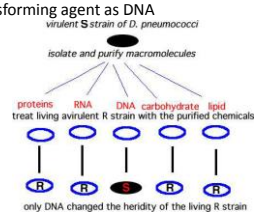


Figure How Griffith discovered transformation.

History of DNA's Discovery

- **1944** Oswald Avery, Maclyn McCarty and Colin MacLeod, identify Griffith's transforming agent as DNA

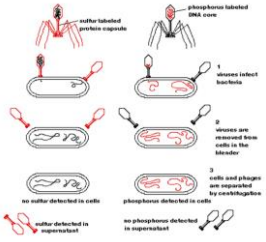


History of DNA's Discovery

- **1949** Erwin Chargaff reports that DNA composition is species-specific. Chargaff finds that the amount of adenine equals the amount of thymine, and the amount of guanine equals the amount of cytosine in DNA from every species.

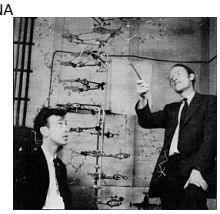
History of DNA's Discovery

- **1952:** Hershey and Chase's blender experiment confirms DNA as the genetic material



History of DNA's Discovery

- **1953** James Watson and Francis Crick discover the molecular structure of DNA



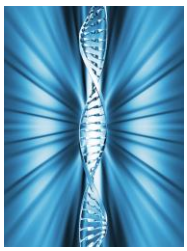
- If something is very large or very long, how do you get it to fit in a tiny space?
- The human genome is 3 billion base pairs. If lined up end to end, the DNA from a single cell would stretch about 1.8 meters. All DNA must fit in the nucleus; how do you think the cell accomplishes this?

DNA Packaging

- How does all that DNA fit in one tiny nucleus?

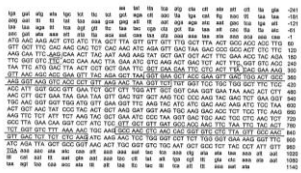
Understanding DNA

- What is DNA?
  - **DNA, genes,** and **chromosomes** are all the molecular basis for **heredity**
  - In other words, they carry all of the information and are passed on from parents to offspring



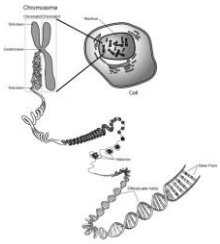
What is DNA?

- **DNA:** a **nucleic acid** made up of monomers called **nucleotides**
  - DNA carries the 'instructions' for making *proteins*
  - In other words, your body 'knows' what protein to make based on how the nucleotides are arranged

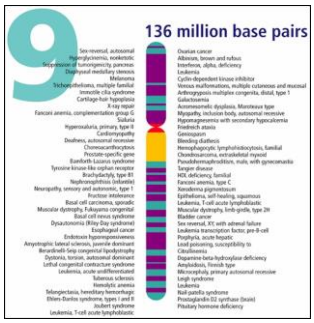


Remember this?

- **Chromosome:** a long thread of DNA that is tightly coiled



- **Gene:** specific spot on a chromosome that codes for a single protein
- Each chromosome has *thousands* of genes
- These *proteins* determine characteristics



What DNA Tells Us

- Organisms that are **closely related** may have genes that code for the **same proteins** that make the organisms similar
  - For example: sugar maples and red maples have similar DNA

Remember:

Nucleic acid: **allow organisms to transfer genetic information from one generation to the next.**

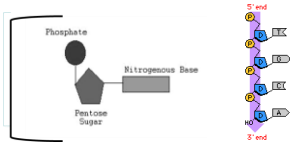
2 types of nucleic acids

DNA and RNA

***Nucleotide*:** **base unit of DNA/RNA (3 parts)**

3 Parts: Sugar, Phosphate and Nitrogenous Base

Base unit of DNA is a Nucleotide



Remember: DNA

DNA: ***Deoxyribonucleic acid***

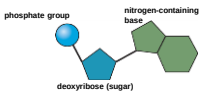
2 Chains of Nucleotides

Sugar: Deoxyribose

Bases:

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

Structure: 2 strands double helix (Twisted ladder)



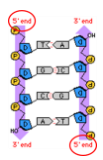
DNA Base Pairs

Each base can bond to only one type of base. Bases that bond are called *complementary bases.*

Guanine (G) will only bond with Cytosine (C).

Thymine (T) will only bond with Adenine (A).

A G
B C
C G
D T
E A
F C
G B

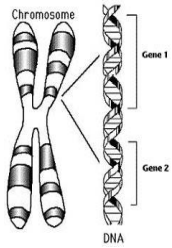


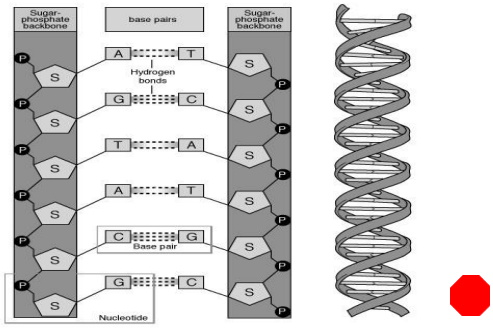
DNA strands are complimentary and run anti-parallel, 1 strand right side up and 1 upside down

DNA Genes-Chromosomes

A ***gene*** is segment of a DNA molecule that codes (is the instructions) for a particular trait (characteristic)

A ***chromosome*** is a tightly coiled DNA molecule.



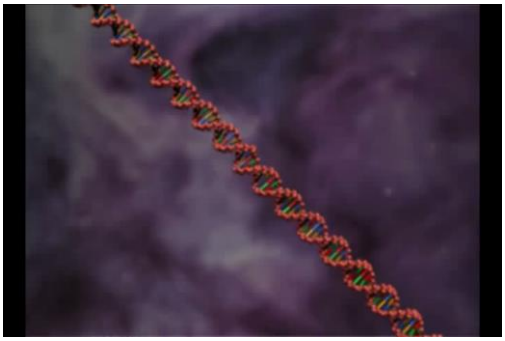


DNA Replication
(S stage of Interphase)

Replication:

Is when DNA is "unzipped" copied and 2 identical DNA molecules are created.

It occurs in the nucleus.



DNA Replication

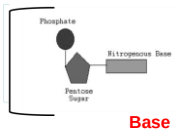
1-DNA helicase **enzyme unzips the DNA molecule**

- **Breaks hydrogen bonds**

2 DNA polymerase enzyme attaches to each strand, makes and attaches new complimentary bases and proof-reads the new identical strands.

- **End result: The result is *two identical DNA molecules*, each with one old and one new strand *(semiconservative)***

Summary



Nucleotide-Parts indiv. labeled

Base Pairs: C always G, A always T

Hydrogen Bond

DNA is replicated in S stage of interphase

Summary DNA & REPLICATION

DNA:
Deoxyribonucleic Acid

Structure:

Components
- 5 Carbon-Sugar (Deoxyribose)
- Phosphate Group
- Nitrogenous Base (G.C.A.T)

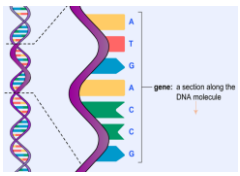
Shape
- Double Helix
- 2 Strands
- Twisted Ladder

Function:
Contains "genetic blueprint" of the organism.

Replication (summarize):
2 identical DNA molecules are made by using a single DNA molecule as a template.

Location:
Nucleus (Eukaryotes) Cytoplasm (Prokaryotes)

Genes are sections of the DNA molecule that contain the instructions for making a certain protein.

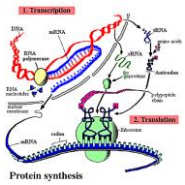


The general way a protein is created is:

DNA→RNA→Protein

Protein Synthesis

- Proteins are needed to do a lot of things in the cell. When the cell needs a protein, it has to make it through protein synthesis
- Step 1: Transcription
- Step 2: Translation

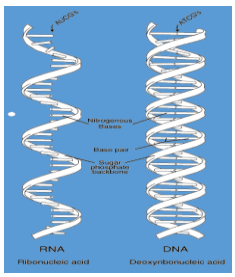


Protein synthesis

RNA

- RNA: ribonucleic acid
- Carries out *protein synthesis*
- Differences from DNA:
  - different sugar (*ribose*)
  - single strand
  - different base
    - no *thymine*
    - **URACIL** instead

U replaces T



3 Types of RNA:

- **Messenger RNA**: (*mRNA*) carries nucleotide sequence from nucleus to ribosome
- **Transfer RNA**: (*tRNA*) picks up amino acid in cytoplasm and carries them to ribosome
  then attaches a specific amino acid depending on the 3 base sequence on the mRNA
- **Ribosomal RNA**: (*rRNA*)found **in** ribosome, joins mRNA and tRNA; forms protein

Transcription & Translation

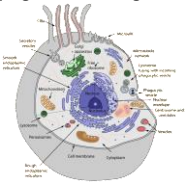
Trans**C**ription comes 1st

Trans**L**ation comes 2nd

C comes before **L** in the alphabet

Transcription

- DNA is in the nucleus, but the ribosomes are in the cytoplasm
- Transcription helps get the message out



Process of Transcription

Transcription- process that makes mRNA from DNA

1. **DNA *unzips* into 2 separate strands**
   - **A. *DNA Helicase* is the enzyme that breaks H-bond**
2. **Free floating RNA NITROGEN BASES in the nucleus ***pair up*** w/unzipped DNA NITROGEN BASES:**
   - **A. Cytosine(C) pairs with Guanine(G)**
     - *** (G) with (C)**
   - **B. *Uracil* (U) pairs with Adenine(A)**
     - *** (A) with (U)****

3. **After all the pairing is done a *single strand* of RNA has been produced.**
4. **Genetic code from DNA is *transferred* to mRNA**
5. **The code obtained from *DNA* lets the *mRNA* know which amino acids to pick up.**

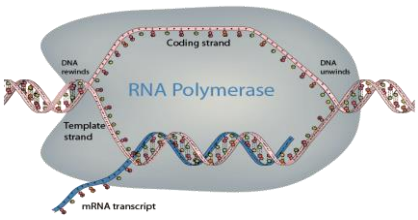
**** Each "word" of the code is a set of *3 nitrogen bases* called a Codon****

Quick Summary

Transcription of DNA Inside the Nucleus

1. DNA unzips.
2. mRNA bases attach.
3. mRNA goes to ribosome.
4. DNA zips up again.

Transcription



Remember…

- The complementary RNA to DNA works like this:

DNA exposed	RNA made
Adenine (A)	Uracil (U)
Thymine (T)	Adenine (A)
Cytosine (C)	Guanine (G)
Guanine (G)	Cytosine (C)

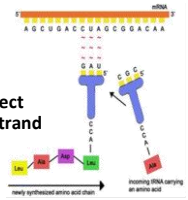
- What would the mRNA strand be for the DNA code AGCGCTTACTG?

Translation

- **Conversion of RNA into amino acid sequence that makes a protein**
- **The *mRNA* leaves the nucleus and enters the cytoplasm**
- **Ribosomes attach to mRNA**
- ***tRNA* (carrying *anti-codon*) picks up the correct amino acids and carries them to the mRNA strand forming the *protein***

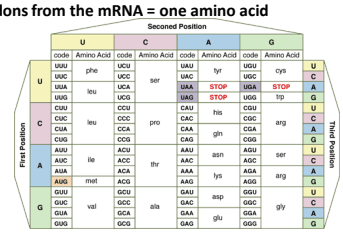
Ex:

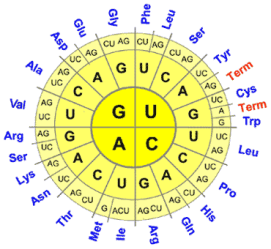
- ***tRNA carries GAU (anti-codon)& looks for CUA on mRNA***



Translation

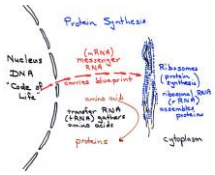
- **3 codons from the mRNA = one amino acid**





Translation: Overview

1. mRNA leaves the nucleus and enters the cytoplasm
2. mRNA goes to a ribosome (where proteins are made)
3. Protein made using ribosome, mRNA, and tRNA



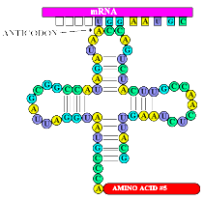
Practice

- DNA= AGTAACGGATTCGGC
- mRNA= UCAUUGCCUAAGCCG
- tRNA= AGUAACGGAUUCGGC

- DNA = GTACGTTCCGAATCG
- mRNA= CAUGCAAGGCUUAGC
- tRNA= GUACGUUCCGAAUCG

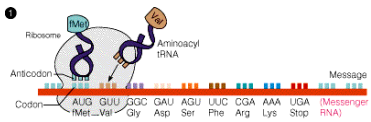
Translation

- **tRNA (transfer RNA)** is used like an adapter
  - There are 20 amino acids and 20 tRNA, so each is specific
  - The end of each tRNA has an **anticodon**, which complements the mRNA **codon**
  - The other end has the specific amino acid attached



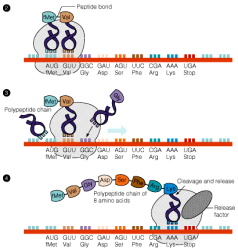
Translation

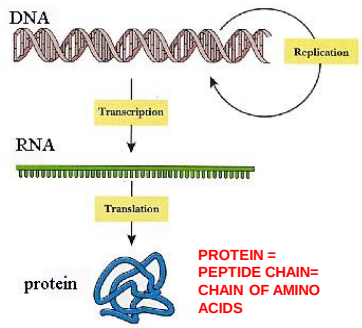
1. tRNA with amino acid pairs to mRNA codon at the ribosome
2. A second tRNA pairs with the mRNA codon next to the first one



Translation

3. The rRNA in the ribosome makes a **peptide bond** between the two amino acids
4. The empty tRNA leaves the ribosome and goes on to get another amino acid
5. Sequence repeats until a **stop codon** is reached





Comparing Transcription and translation

Transcription– When the mRNA copies the genetic blue print from the DNA—Happens in nucleus

mRNA moves to cytoplasm taking instructions from DNA with it

mRNA attaches to a ribosome (like laying on a table)

Translation-- tRNA with matching anti-codon (3 base sequence) links to mRNA and starts to build and amnino acid chain

After all mRNA has been read a protein (string of amino acid) is the results

Summary RNA

RNA (name): ***ribonucleic acid***

Structure of Molecule: (strands) ***Single strand*** ***Nucleotide chain***

Bases:

Adenine (A) & Uracil (U) ,
Cytosine (C) & **Guanine (G)**

Main Function:

Copy and carry DNA instructions to ribosome for protein synthesis

3 Types (summarize) :

Messenger RNA: copies DNA instruction into CODONS
Transfer RNA: reads codon, creates protein(anti-Codon)
Ribosomal RNA: in ribosome, translation helper

Transcription and translation summary

1. **Transcription**- mRNA is formed, genetic info transferred from DNA and mRNA carries genetic info to ribosomes (rRNA)

2. **Translation:** tRNA reads genetic blueprint on mRNA, attaches amino acids according to instructions to form a protein

Mutations

What Are Mutations?

- Changes in the nucleotide sequence of DNA
- May occur in somatic cells (aren't passed to offspring)
- May occur in gametes (eggs & sperm) and be passed to offspring

Chromosome Mutations

- May Involve:
  - **Changing the structure**

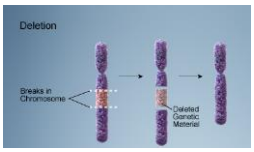
    loss or gain of chromosomes

Chromosome Mutations

- Five types exist:
  - **Deletion**
  - **Inversion**
  - **Translocation**
  - **Nondisjunction**
  - **Duplication**

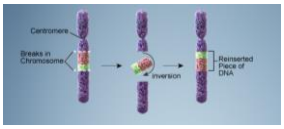
Deletion

- Due to **breakage**
- A **piece** of a chromosome is **lost**



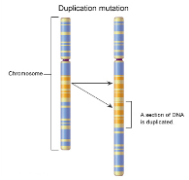
Inversion

- Chromosome segment **breaks off**
- Segment flips around **backwards**
- Segment **reattaches**



Duplication

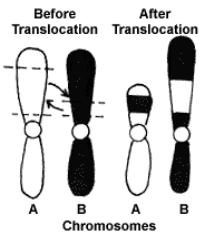
- Occurs when a gene **sequence is repeated**



Translocation

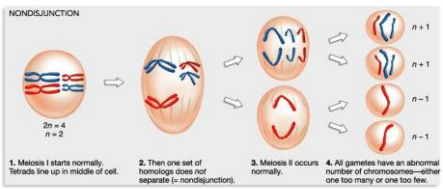
- Involves **two chromosomes** that aren't homologous
- **Part** of one chromosome is **transferred to another** chromosomes

Translocation

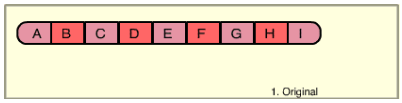


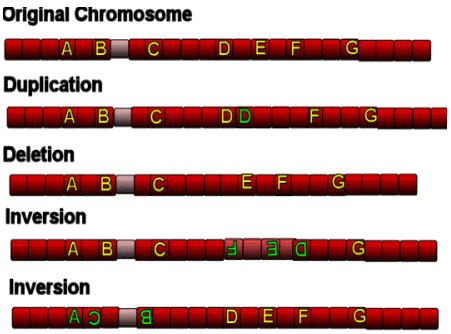
Nondisjunction

- **Failure** of chromosomes **to separate** during meiosis
- Causes gamete to have **too many** or **too few** chromosomes



Chromosome Mutation Animation





Gene Mutations

- Change in the **nucleotide sequence** of a gene
- May only involve a single nucleotide
- May be due to **copying errors**, **chemicals**, **viruses**, etc.

Types of Gene Mutations

- Include:
  - Point Mutations
  - Substitutions
  - Insertions
  - Deletions
  - Frameshift

Point Mutation

- Change of a **single** nucleotide
- Includes the deletion, insertion, or substitution of **ONE** nucleotide in a gene

Point Mutation

- **Sickle Cell disease** is the result of one nucleotide substitution
- Occurs in the **hemoglobin gene**

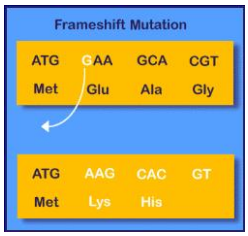
Frameshift Mutation

- Inserting or deleting one or more nucleotides
- Changes the "reading frame" like changing a sentence
- Proteins built incorrectly

Frameshift Mutation

- Original:
  - The fat cat ate the wee rat.
- Frame Shift ("a" added):
  - **The fat c a tet hew eer at.**

Amino Acid Sequence Changed



Gene Mutation Animation