Unit 6

All living things use DNA to pass genetic information to the next generation. Genetic information directs the development and homeostasis of organism through a process of translating the genetic code into proteins that have specific tasks. There are checks and balances built into the genetic system to ensure information is copied and interpreted properly. When the system malfunctions, it can result in disease, malformations, or even death.

Evidence 1: How could altering the flow of information from DNA affect an organism?

We are each one of a kind and no one other is like us unless you are an identical twin.

**Route to DNA discovery**

1928 Frederick Griffith was trying to prepare a vaccine against pneumonia

He worked with 2 strains (kinds) of pneumonia.

- S = smooth edged colonies with a capsule made of polysaccharides
- R = rough edged colonies with no capsule

His experiments demonstrated that something in the virulent S strain could transform nonvirulent R strain bacteria into a lethal form, even when the S strain bacteria had been killed by high temperatures. He injected mice with heat killed S and live R and the mice died but the S was still fond in their blood. He called this mystery material a transforming principle. This left scientists many questions to explore.

Evidence 2: What evidence suggested that there is a transforming principle?

- Vaccine = a substance that is prepared from killed or weakened disease causing agents
- Virulent = able to cause disease
- Transformation = a change in genotype caused when cells take up foreign genetic material

1944 Oswald Avery performed experiments on remaining S and R bacteria. His team used qualitative tests, chemical analysis and enzyme tests to get results. His

experiments showed that DNA is what was responsible for transformations in Griffith's experiments. The DNA is what was responsible for making the capsule.

Read pages 260-261 and use figure 4 to answer the following evidence statements.

Evidence 3: Why did Avery use an enzyme to destroy the protein, RNA, and DNA in each sample?

Evidence 4: In which sample did S bacteria not appear? What does this mean?

Evidence 5: What happened in the other samples?

Evidence 6: What does this tell us about these molecules?

1952 Alfred Hershey and Martha Chase helped convince everyone that DNA was that genetic material. They showed that the DNA not the protein of a bacteriophage (aka phage) virus contained the phage genes. After a phage particle attaches to a bacterium the DNA enters through a hole and the protein is what stays outside. This was successful because they showed that a viral infection was unaffected by violent agitation in a kitchen blender which removed the empty viral protein shell from the surface.

Since 1920 scientists have known that DNA is a very long polymer or chain of repeating units.

- Each strand is made up of linked nucleotides

Nucleotides are made up of 3 parts

- A phosphate group
  - One phosphorus with 4 oxygens
- A deoxyribose sugar
  - A ring shaped sugar
- A nitrogen base
  - A single or double ring built around nitrogen and carbon atoms

1 molecule of DNA contains billions of nucleotides which differ only in their nitrogen containing bases

<u>4 nitrogen bases</u>

Purines = a nitrogen base that is bulky because it is double ringed

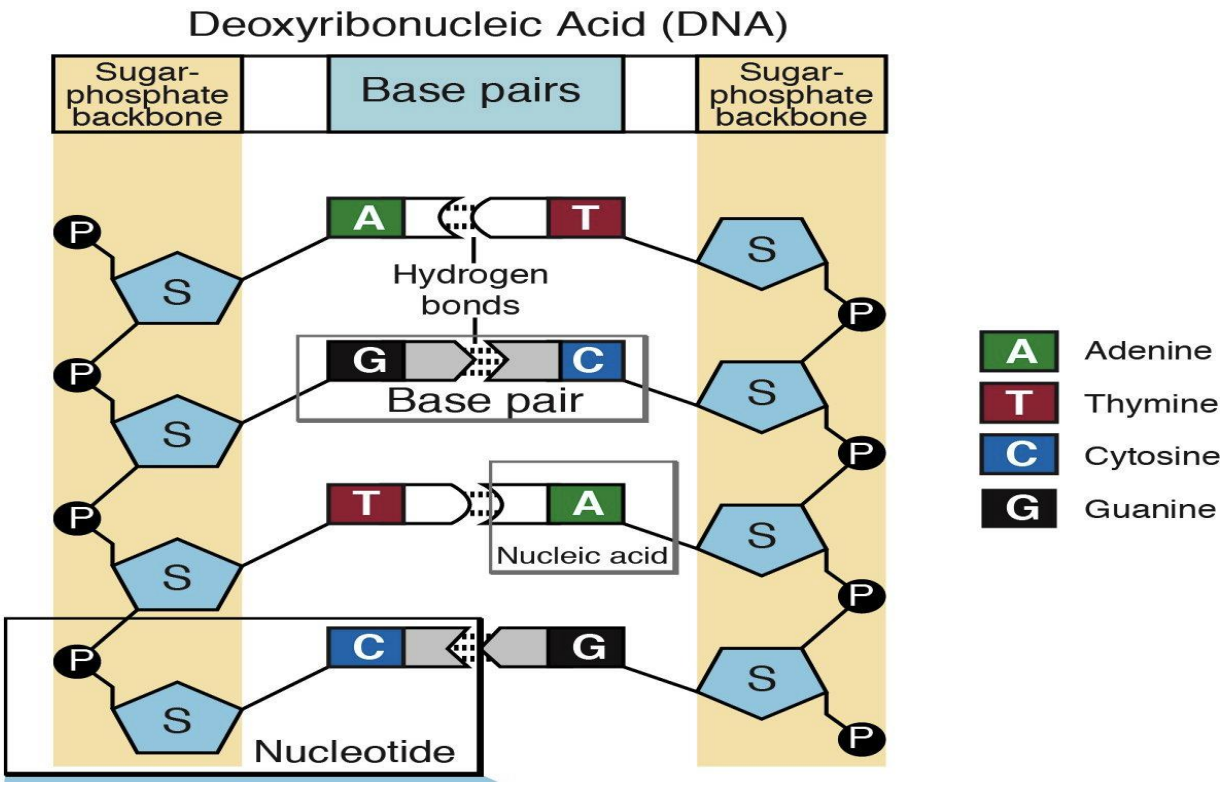
- Cytosine (C)
- Thymine (T)

Pyrimidines = a nitrogen base that is small because it is single ringed

- Guanine (G)
- Adenine (A)

DNA gets it name from the 5 carbon sugar which is called deoxyribose.

DNA = deoxyribose nucleic acid



In DNA, the sugar molecule and the phosphate are the same but the nitrogen bases can change.

Evidence 7 : What do the lines between the phosphate group and sugar and between the sugar and the base represent?

Evidence 8: DNA is a long molecule which can contain billions of nucleotides. What is the term for this type of molecule? What is the subunits that make it up?

Evidence 9: Where in the DNA molecule are the nitrogen bases located?

Evidence 10: What hold the base pairs together?

Evidence 11: Where are the deoxyribose sugars and phosphate groups?

Evidence 12: What holds sugars and phosphate groups together?

Evidence 13: Look at the hydrogen bonds between the base pairs which base pairs do you think are held together more tightly?

Evidence 14: Describe the structure of DNA using a ladder as an analogy. What makes up the rungs, or steps, of the ladder? What makes up the sides? How is the ladder shaped?

By 1949 Erwin Chargaff found that for each organism he studied that the amount of Adenine always equaled the amount of Thymine and the amount of Cytosine always equaled the amount of Guanine.

He also found that event though A/T equaled and C/G equaled the amount of DNA changed based on the organism

1950's scientists were convinced that genes were made of DNA

1950 James Watson and Francis Crick determined that a DNA was a 3 dimensional structure.

- Double helix = two strands twisted around each other like a winding staircase.

Evidence 15: By building a physical model, Watson and Crick were able to see that adenine fit with thymine and guanine fit with cytosine. How do Chargaff's results support Watson and Crick's model?

1952 Maurice Wilkins and Rosalind Franklin developed high quality x-ray diffraction photographs of strands of DNA.

They used these x-ray diffraction photos to say DNA resembled

A tightly coiled helix with 2 or 3 chains of nucleotides

1953 Watson and Crick built a 3D model of DNA. They made a double helix in the shape of a winding staircase with 2 strands of nucleotides twisting around a central axis.

This model used Chargoff's observations and the patterns of Franklin's x-ray diffraction photograph.

They proved that there were base pairing rules.

Each of these nitrogen bases are held together by hydrogen bonds. We know that 2 strands of DNA complement each other because of base pairing

Base pairing rules tell us A = T and C=G

A - T

C - G

T - A

G - C

G - C

T - A

A - T

C - G

The complementary structure of DNA is used as a basis to make exact copies of the DNA each time a cell is divided

DNA replication is the process of making a copy of DNA

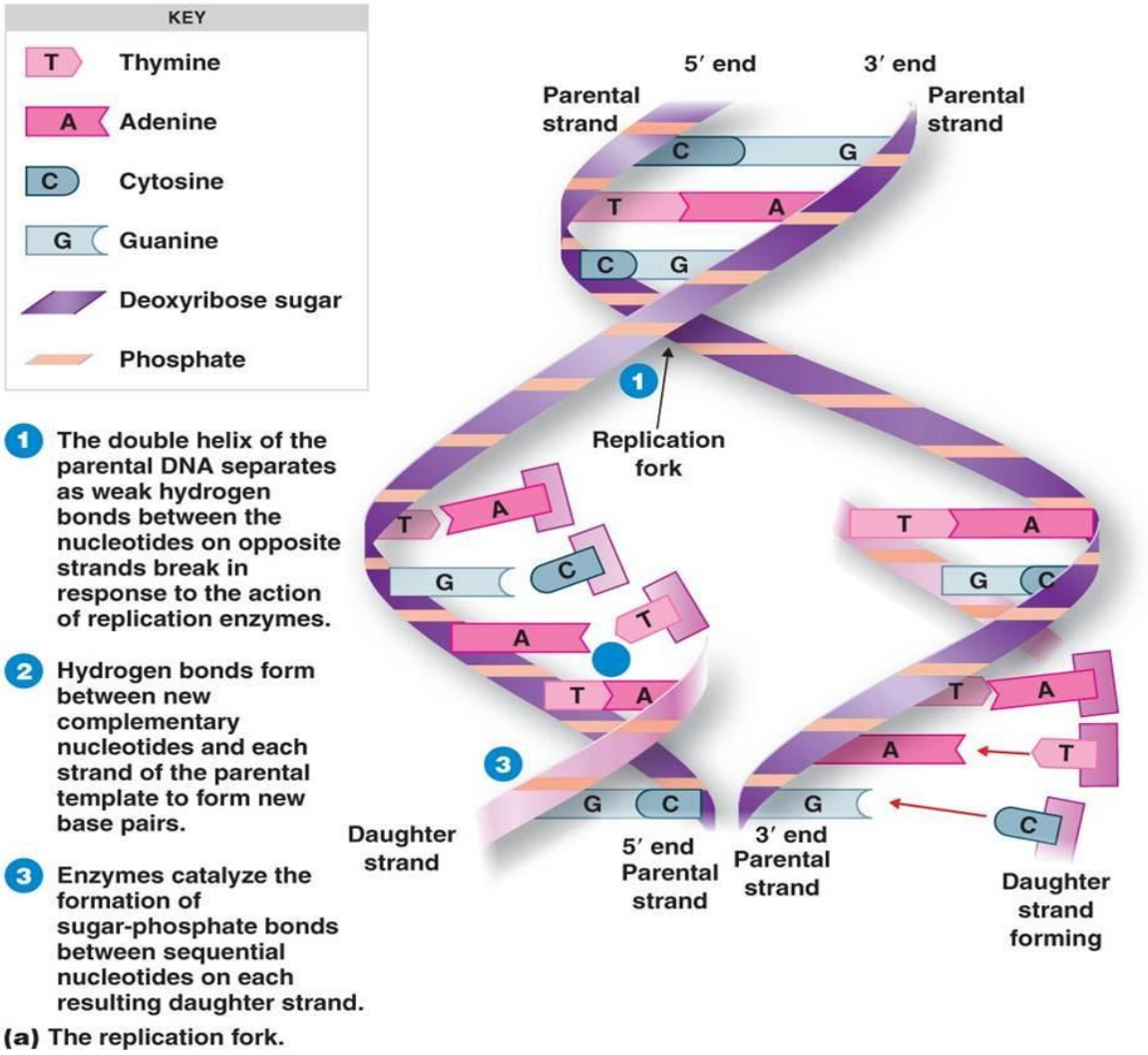
- This occurs in the synthesis phase of the cell cycle before it divides

DNA Replication Steps

1. The 2 original DNA strands separate
2. DNA polymerases (which are enzymes) add complementary nucleotides to each strand
    - These enzymes add new nucleotides to exposed bases done by base pairing rules
3. 2 DNA molecules form that are identical to the original DNA molecule

In the course of DNA replication errors sometimes occur and the wrong nucleotide is added to the new strand

The polymerases used in the process also proofread. This reduces errors in DNA replication to 1 error in 1 billion nucleotides




**(a)** The replication fork.

Evidence 16: Why is it important for the DNA polymerase to proofread the new strands of DNA before the cell divides?

Replication does not begin at one end of the DNA molecule and end at the other.

- Prokaryotes have circular DNA so they have 2 replication forks
- Eukaryotes have a long strand of DNA
  - Each human chromosome is replicated in about 100 sections that are 100000 nucleotides long each section and each section has a starting point
  - Since there are multiple replication forks working at the same time an entire human chromosome can be replicated in about 8 hours
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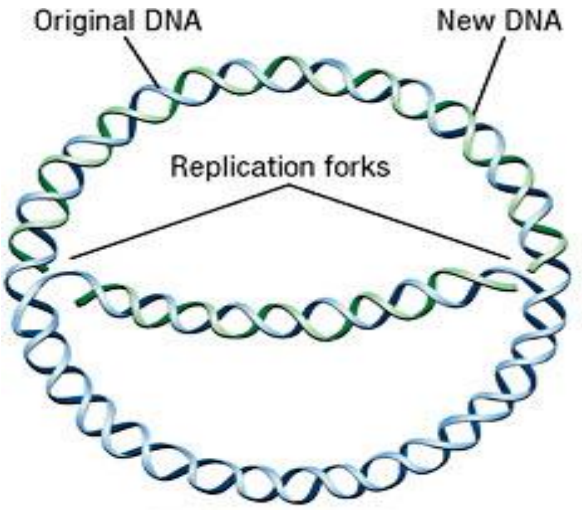
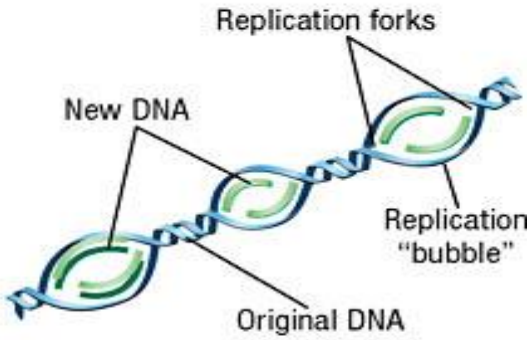



Prokaryotic DNA




Eukaryotic DNA

Traits such as eye color are determined by proteins that are built according to instructions coded in DNA and RNA

Evidence 17: How does the structure of DNA aid in its replication?

Evidence 18: Use an analogy to explain the sequence of events in the replication of DNA.

Use pages 266-268 and figures 14-15-16 to answer the following evidence statements

Evidence 19: What is a replication fork, and why do two exist during replication of the molecule?

Evidence 20: Why are stabilizing proteins needed during replication? What would happen if there were no stabilizing proteins?

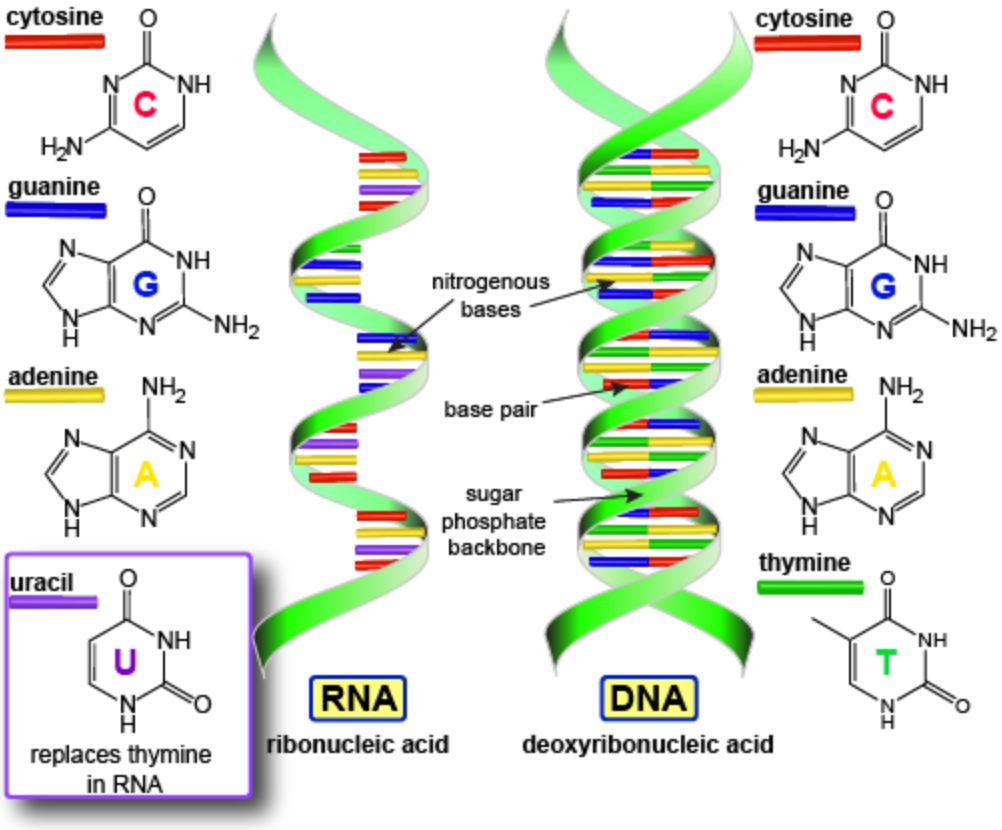
Evidence 21: If the leading and lagging strands weren't labeled in figure 15, could you tell which was which?

RNA is like DNA

- A molecule made of nucleotides linked together

Differences in RNA and DNA

| RNA | DNA |
|---|---|
| Consists of a single strand of nucleotides | Consists of 2 strands of nucleotides |
| 5 carbon sugar called ribose | 5 carbon sugar called deoxyribose |
| Nitrogen bases<br>C – G<br>A – U ( U = uracil) | Nitrogen bases<br>C – G<br>A - T |




Transcription

- Where the instructions for making a protein are transferred from a gene to an RNA molecule

Translation

- Where cells us 2 different types of RNA to read the instruction on the RNA molecule and put together the amino acid that make up the protein

Gene expression

- The entire process by which proteins are made based on the information encoded in DNA aka protein synthesis

DNA – transcription – RNA – translation – protein

Transfer of info from DNA to RNA

1. RNA polymerase binds to the gene's promoter
    - This is a start signal for transcription
2. The 2 DNA strands unwind and separate
    - Exposes nucleotides
3. Complimentary RNA nucleotides are added
    - Complementary strand is made by RNA polymerase

Different types of RNA are made during transcription – it depends on the gene being expressed

1. Messenger RNA (mRNA) = form of RNA that carries the instructions for making a protein from a gene and delivers it to the site of translation
- When a particular protein is needed mRNA is made
- Info is translated to amino acids
- RNA instructions are written as a series of 3 nucleotides sequences on the mRnA called codons
- There are 64 mRNA codons

Genetic code is the rule that describes how a sequence of nucleotides (3 nucleotides) correspond to specific amino acids

2. Transfer RNA (tRNA) = form of RNA that are single strands of RNA that temporarily carry a specific amino acids on one end.
    - Anticodon = a 3 nucleotide sequence on a tRNA that is complementary to a mRNA codon
3. Ribosomal RNA (rRNA) = form of FNA that are part of the structure of ribosomes

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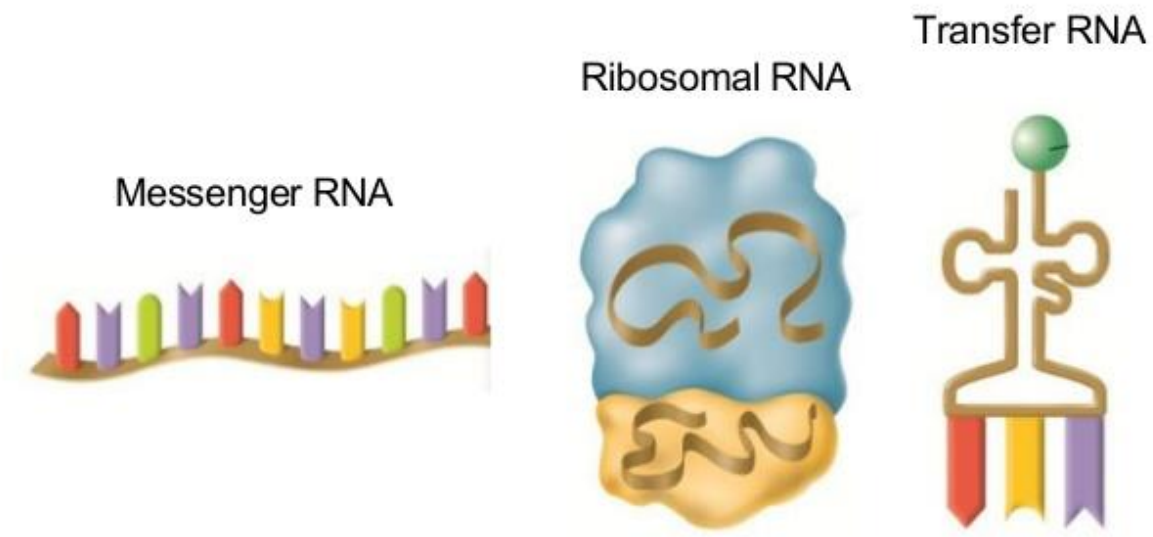
## Types of RNA

The three main types of RNA are:




Evidence 22: Why do you think a disposable copy of the DNA code is necessary for protein synthesis?

Evidence 23: Identify the starting and ending materials for transcription and translation.

Evidence 24: In which part of the process of translation and transcription, and in what location, is DNA involved?

Evidence 25: How does the genetic information get from the nucleus into the cytoplasm?

Evidence 26: Why is the ability to produce multiple RNA transcripts at the same time useful in maintaining homeostasis in a cell?

Mutation = a change in the nucleotide base sequence of a gene or DNA molecule

Mutations that move an entire gene to a new location are called gene rearrangements

A change in a genes position often disrupt the genes function because it is exposed to new regulatory controls in the new location

- Ex moving to France and can't speak French

Mutations that change a gene are called gene alterations

1. Point mutation – a single nucleotide changes
2. Insertion mutation – a sizeable length of DNA is inserted into a gene
3. Deletion mutation – segments of a gene are lost often during meiosis

Because the genetic message is read as a series of triplet nucleotides, insertions and deletions of one or two nucleotides can upset the triplet groupings

A mutation that causes a gene to be read in the wrong three nucleotide sequence is called a frameshift mutation


Effects of changes brought about by mutations

1. Beneficial
    a. Food
2. Harmful
    a. disease
3. neutral

Evidence 27: How are genes, proteins, and cell processes related?