



## NUCLEIC ACIDS

### DNA

- Double helix
- NOT made of amino acids

**Deoxyribose** + **phosphate** + **base** =  
**nucleotide**

## NUCLEIC ACIDS

### RNA

- Single helix
- Uracil
- tRNA, mRNA, rRNA

**Ribose** + **phosphate** + **base** =  
**nucleotide**

## NUCLEIC ACIDS STORE AND TRANSMIT HEREDITARY INFORMATION

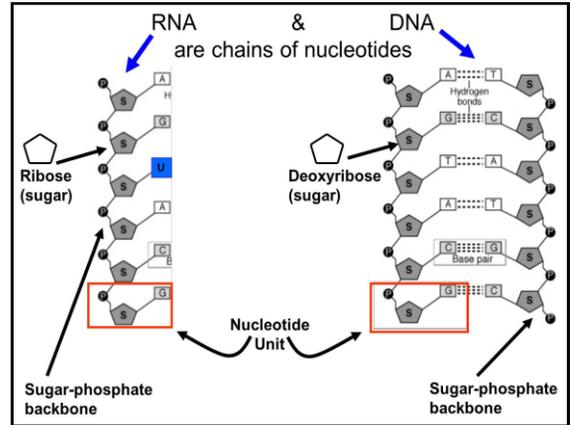
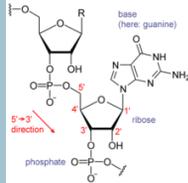
- There are two types of nucleic acids: **ribonucleic acid (RNA)** and **deoxyribonucleic acid (DNA)**.
- DNA provides direction for its own replication.
- DNA also directs RNA synthesis and, through RNA, controls protein synthesis.
- Organisms inherit DNA from their parents.

- The amino acid sequence of a polypeptide is programmed by a **gene**.
- A gene consists of regions of DNA, a polymer of **nucleic acids**.
- DNA (and thus genes) is passed by the mechanisms of inheritance.

- The flow of genetic information is from **DNA -> RNA -> protein**.
- Protein synthesis occurs in cellular structures called ribosomes.
- In eukaryotes, DNA is located in the nucleus, but most ribosomes are in the cytoplasm with mRNA as an intermediary.

**A NUCLEIC ACID STRAND IS A POLYMER OF NUCLEOTIDES**

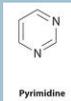
- Nucleic acids are made from repeating **nucleotide** units.
- Nucleotide components:
  - a nitrogen base
  - a pentose sugar (deoxyribose or ribose)
  - and a phosphate group.



**NITROGEN BASES: PYRIMIDINES AND PURINES**

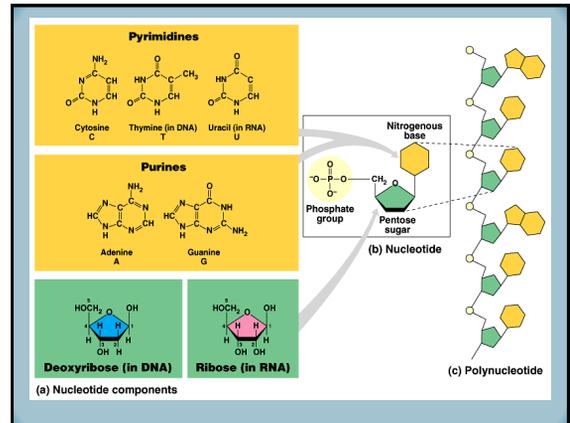
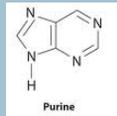
**Pyrimidines**

- Single ring
- Differ in attachments to the ring
- Cytosine (C), thymine (T), and uracil (U)



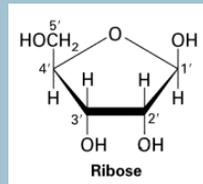
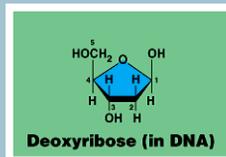
**Purines**

- Double ring
- Differ in attachments to the ring
- Adenine (A) and guanine (G).

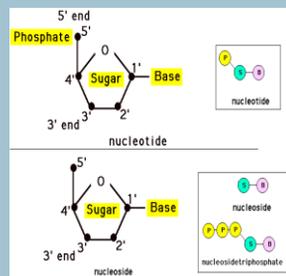


**“THE PENTOSE SUGAR”**

- In DNA this is **DEOXYRIBOSE**
- CANNOT** simply call it “sugar” on the AICE exam!

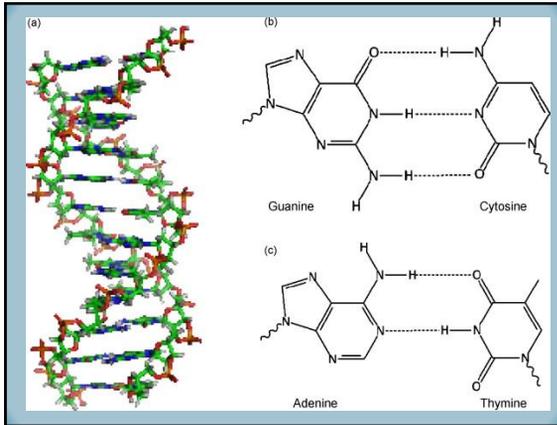


**PUTTING IT TOGETHER...**



- Nitrogen base + deoxyribose = nucleoside
- Nucleoside monophosphate = nucleoside + phosphate (nucleotide)
- Two phosphates would be a nucleoside diphosphate





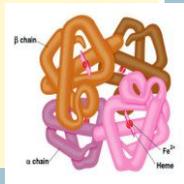
**WE CAN USE DNA AND PROTEINS AS TAPE MEASURES OF EVOLUTION**

- Because DNA molecules are passed from parents to offspring, siblings have greater similarity than do unrelated individuals of the same species.
- This argument can be extended to develop a molecular genealogy between species.
- Two species that appear to be closely-related based on fossil and molecular evidence should also be more similar in DNA and protein sequences than are more distantly related species.
- The sequence of amino acids in hemoglobin molecules differ by only one amino acid between humans and gorilla.

**Table 5.2 Polypeptide Sequence as Evidence for Evolutionary Relationships**

**Number of Amino Acid Differences in the  $\beta$  Chain of Hemoglobin, Compared to Human Hemoglobin (Total Chain Length = 146 Amino Acids)**

Species	Number of Amino Acid Differences
Human	0
Gorilla	1
Gibbon	2
Rhesus monkey	8
Mouse	27
Frog	67

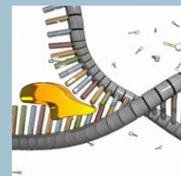
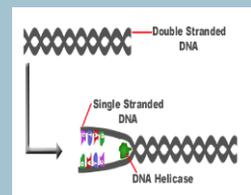


- Overview of everything: Crash Course DNA Structure and Replication <https://www.youtube.com/watch?v=8kK2zWjRVoM>

# DNA REPLICATION

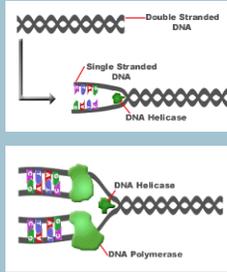
**DNA UNWINDING**

- First step in replication
- Double helix unwound by **topoisomerase**
- Double helix is “unzipped” by the enzyme **DNA helicase**
- Enzyme breaks apart the hydrogen bonds between each set of base pairs
  - A-T have 2 hydrogen bonds compared to 3 hydrogen bonds in G-C

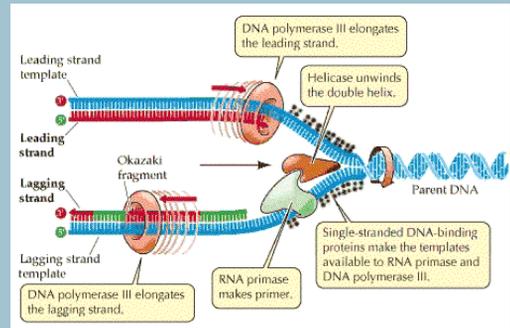


### BEGINNING TO BUILD THE NEW DNA STRANDS

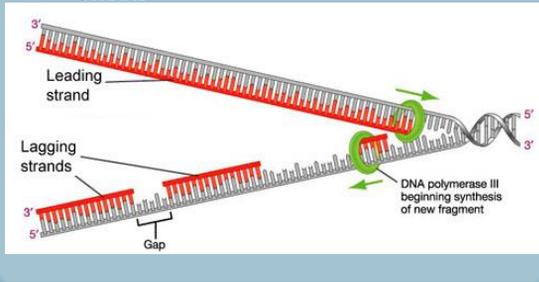
- As the DNA molecule is “unzipped,” new complementary strands are built up along each parent strand
- Creates a “replication fork”
- This process is accomplished by the enzyme **DNA polymerase**
- Attaches new nucleotides to the **free 3' end** of the deoxyribose sugar



### 3' TO 5' PRIME CHAIN READING:

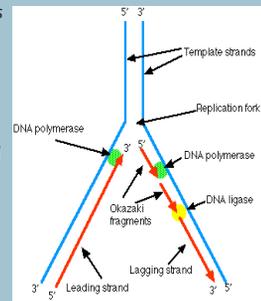


- Continuous 3' to 5' reading (5' to 3' BUILDING) is what creates the **LEADING STRAND**



### LEADING AND LAGGING STRANDS

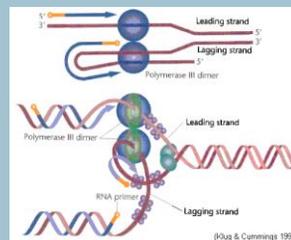
- While DNA polymerase builds DNA up in the leading strand direction...
- A slightly different type of DNA polymerase begins building in the 5' to 3' direction on the other strand
- Creates discontinuous sections of DNA called **Okazaki fragments**, marked off by **RNA primase**
- This is because DNA can only build from a 5' to 3' direction (can only attach to the 3' end)
- Referred to as the **LAGGING STRAND**



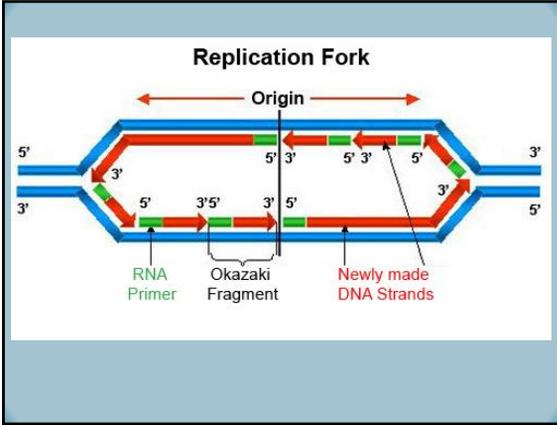
### LEADING AND LAGGING STRANDS

- <http://www.youtube.com/watch?v=mtLXpgjHLo&feature=related>

### MEMORY TRICK



- **Leading strand: LEADS** the way, moves continually in the same direction
- **Lagging strand: LAGS** behind because it is building DNA in small sections



### DNA CLEAN-UP

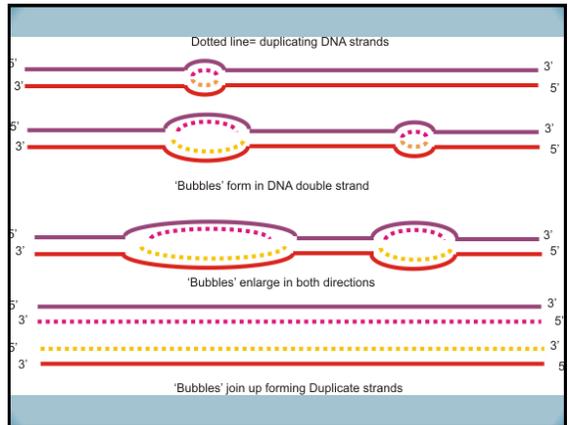
- **DNA ligase** comes in and adds in any additional phosphates needed to complete the DNA chain

This diagram shows the 'DNA CLEAN-UP' phase. It depicts a replication fork with a leading strand and a lagging strand. The lagging strand consists of Okazaki fragments. DNA polymerase (blue) is shown synthesizing the leading strand. DNA ligase (yellow) is shown joining the Okazaki fragments on the lagging strand. The main direction of replication is indicated by a black arrow at the bottom.

### SPEED OF REPLICATION

The diagram shows a replication bubble forming from multiple origins of replication. Each origin has two replication forks moving in opposite directions. The newly synthesized DNA strands are shown in purple and red, while the parent strands are in blue. The 5' and 3' orientations are marked.

- Average human chromosome is  $150 \times 10^6$  nucleotides long.
- Nucleotides are copied at about 50 BP a second
- Replicating a single DNA molecule would take a month, except...
- Multiple points of origin of replication which leads to replication bubbles



- Simulation: <http://www.johnkyrk.com/DNAreplication.html>