CH 4 – DNA

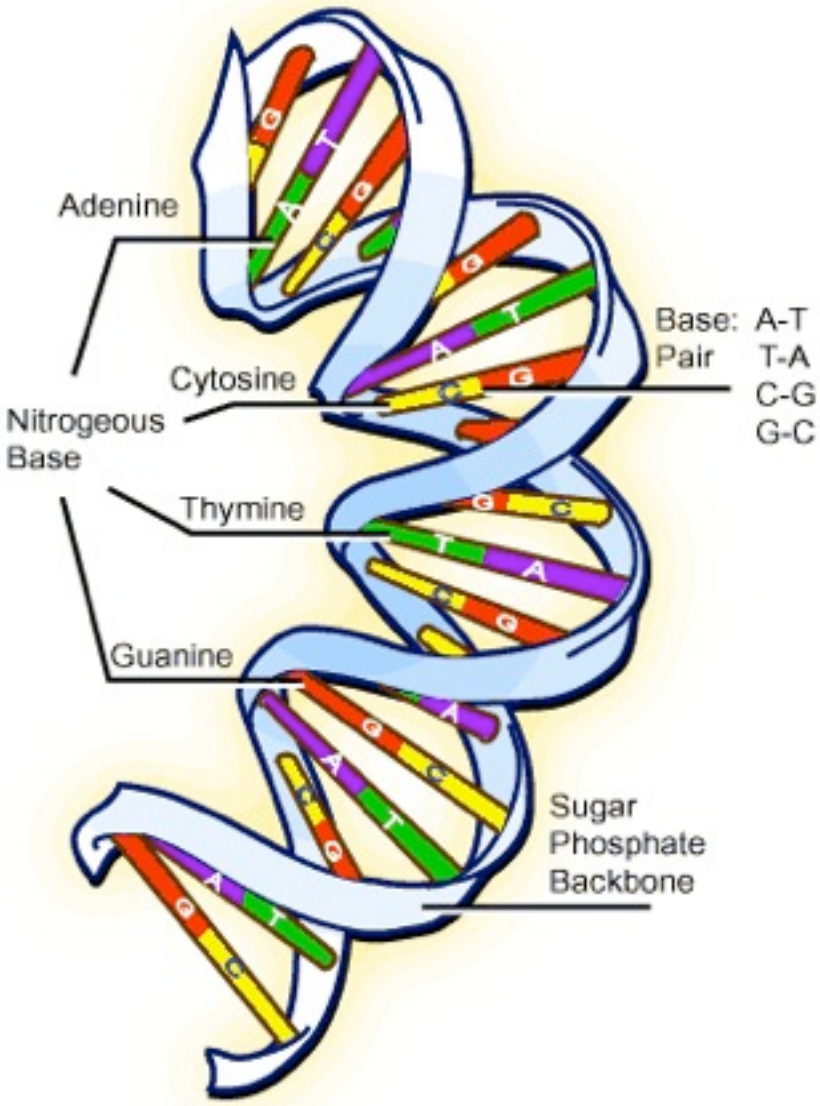
- **DNA** is the **hereditary substance** that is found in the nucleus of cells

- **DNA** = **deoxyribonucleic acid**

  » its structure was determined in the 1950's (not too long ago).

  » scientists were already investigating DNA over 130 years ago.

NUCLEIC ACIDS



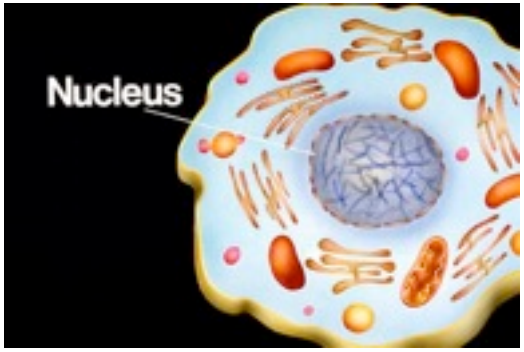
Organisms store <u>information about the structure of their proteins</u> in macromolecules called **NUCLEIC ACIDS**.

Nucleic acids are used by all organisms to store <u>hereditary information</u> that determines structural and functional characteristics.

NUCLEIC ACIDS

- There are **TWO types of nucleic acids** in living organisms:
  - » **DNA (deoxyribonucleic acid) –** the instructions for creating an organism are stored in digital code along coiled chains of DNA
  - » **RNA (ribonucleic acid) –** reads the information in DNA and transports it to the protein-building apparatus of the cell

DNA and RNA is found in the nucleus of cells!!!!

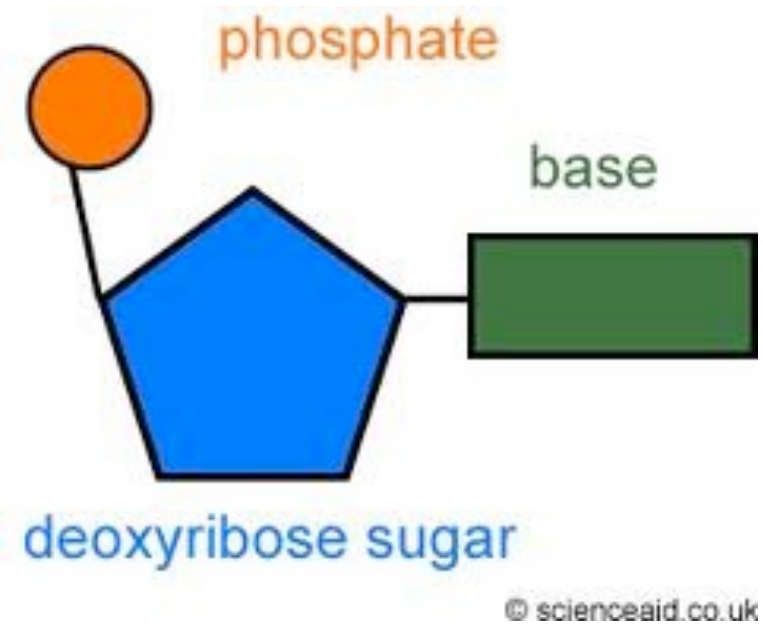


Chemical composition of DNA

DNA is made up of sub-units called NUCLEOTIDES. Nucleic acids are nucleotide polymers.

Each **nucleotide** is made up of:

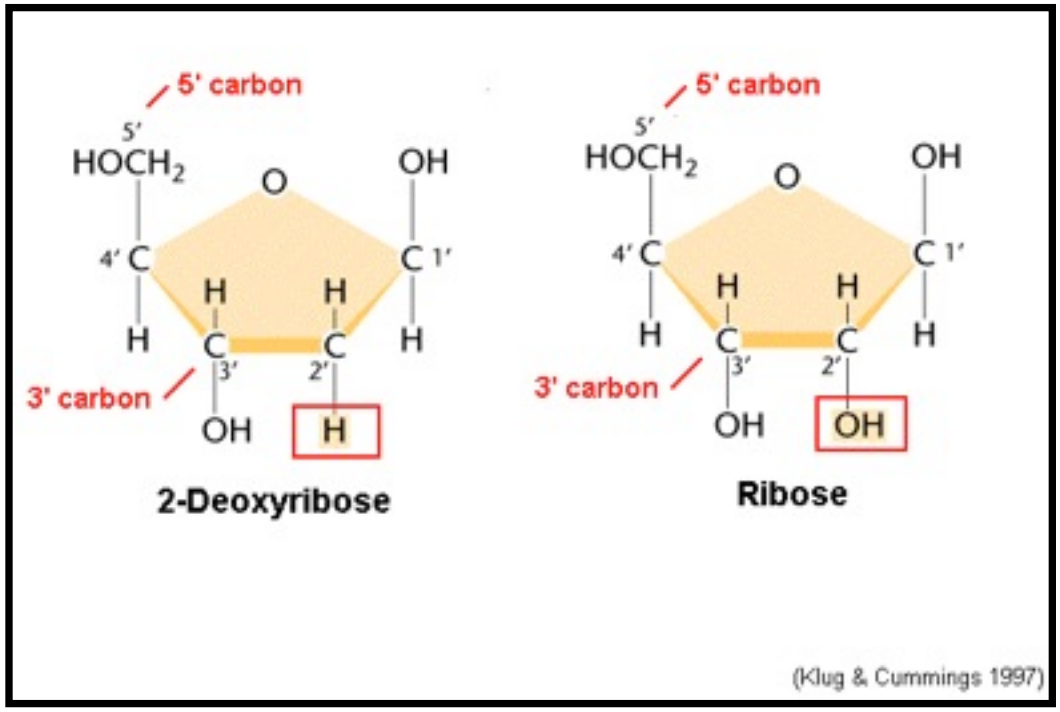
- **A 5 carbon sugar**
- **a phosphate group**
- **a nitrogenous base**



In a **NUCLEIC ACID CHAIN**, the phosphate group of one nucleotide is linked to the sugar of another nucleotide by a **PHOSPHODIESTER BOND**.

NUCLEIC ACIDS

- **DNA** contains the sugar **DEOXYRIBOSE** whereas **RNA** contains the sugar **RIBOSE**.



The only difference between these two sugars is the **lack of oxygen at carbon 2 in deoxyribose** – this accounts for its name.

Chemical composition of DNA

Each **nucleotide** is made up of:

- **A 5 carbon sugar**
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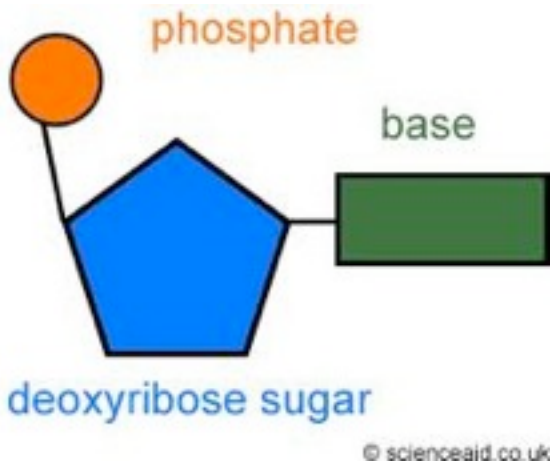
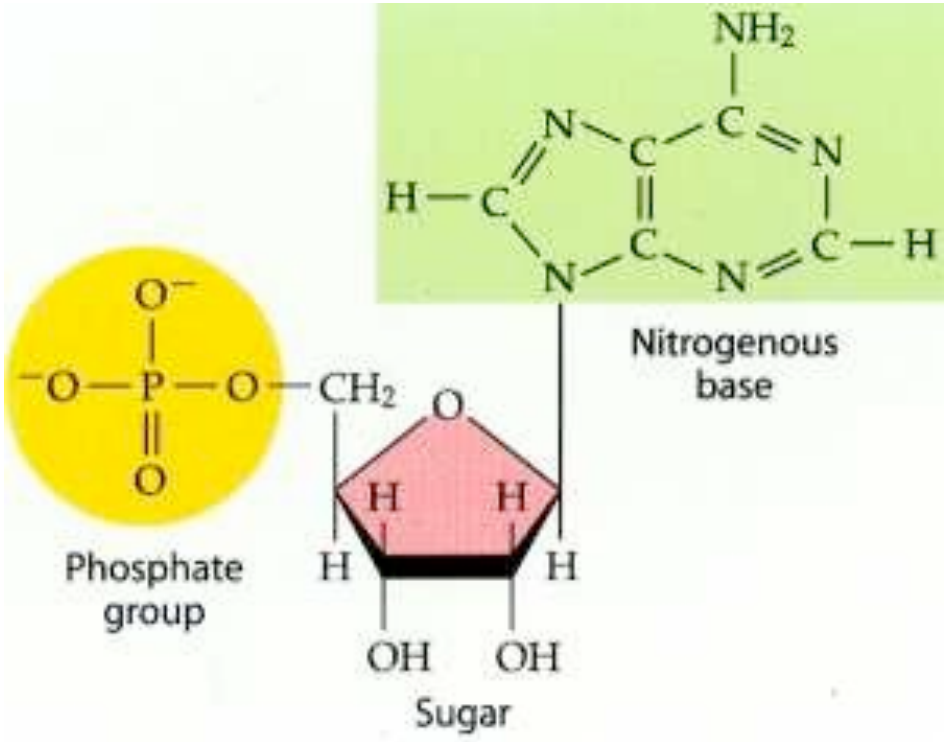


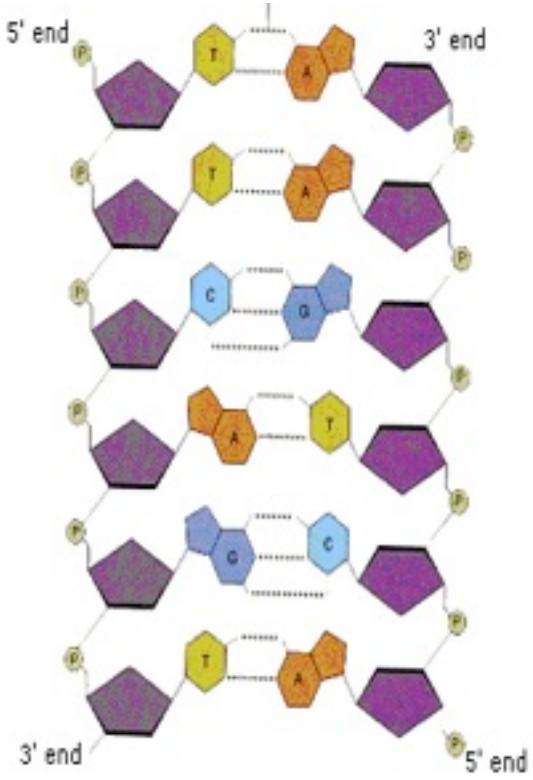


DNA is **slightly acidic** and composed of large amounts of **phosphorus** and **nitrogen**. The phosphate group is negatively charged.

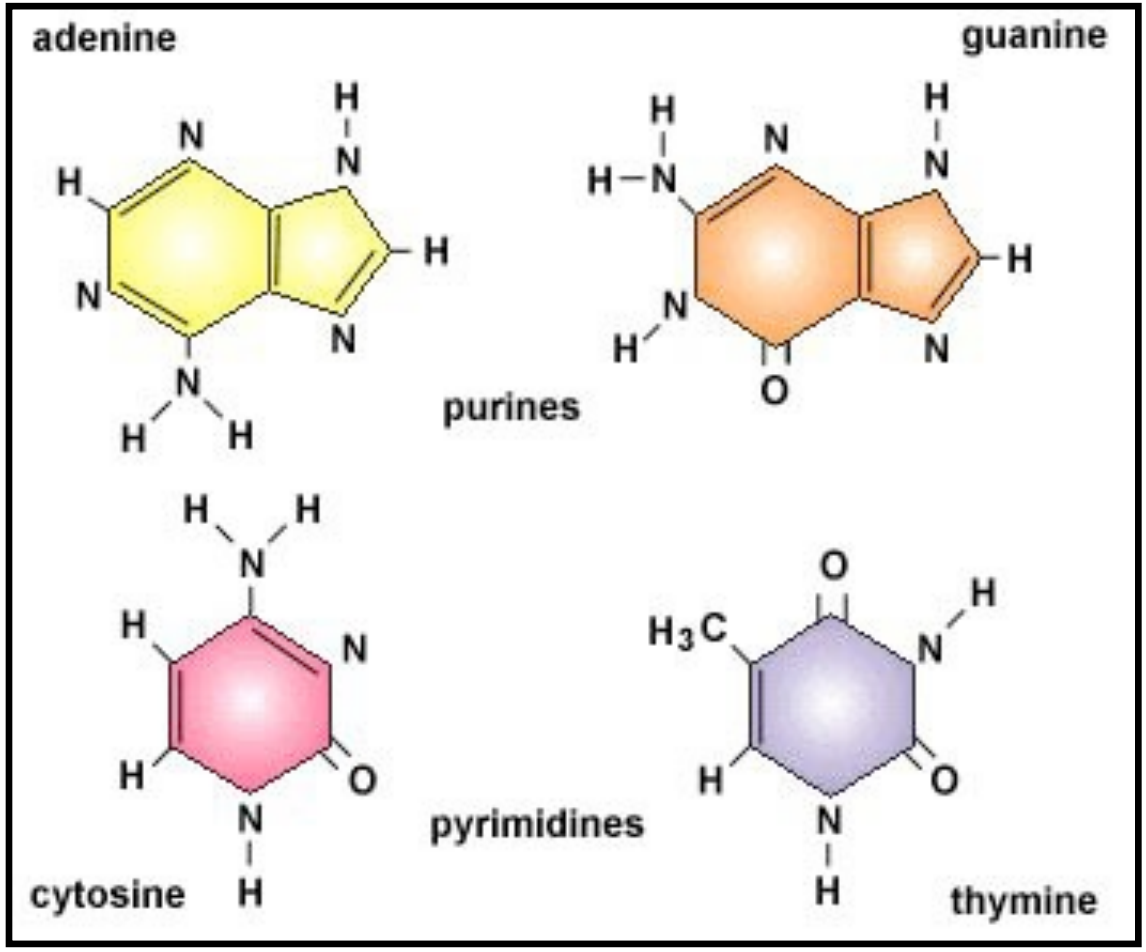
DNA

- There are **4 types of nitrogenous bases** in DNA. The **source of variation** in DNA is found in these bases:

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



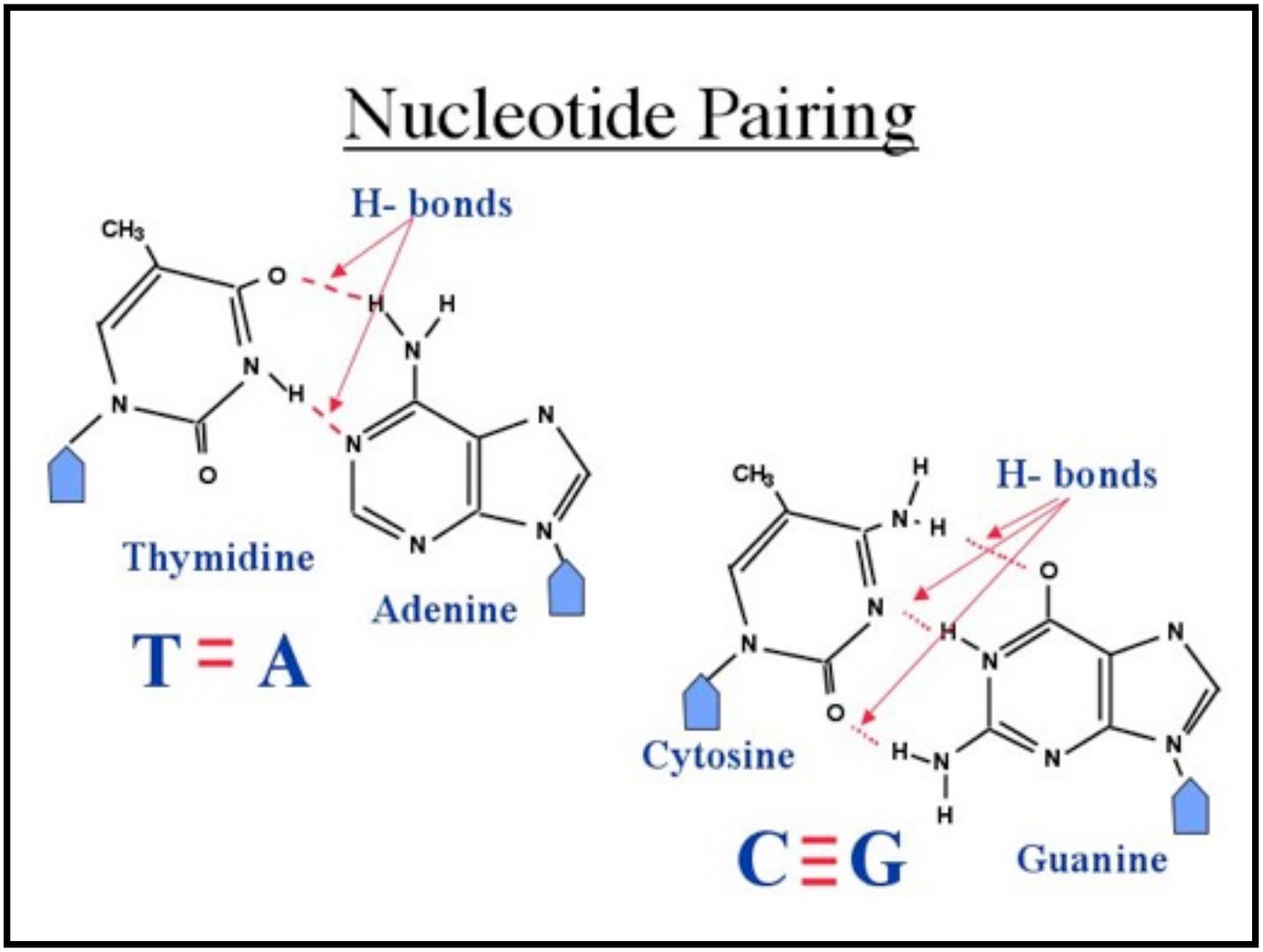
NUCLEIC ACIDS



Purines have a double-ringed structure.

Pyrimidines have a single-ringed structure.

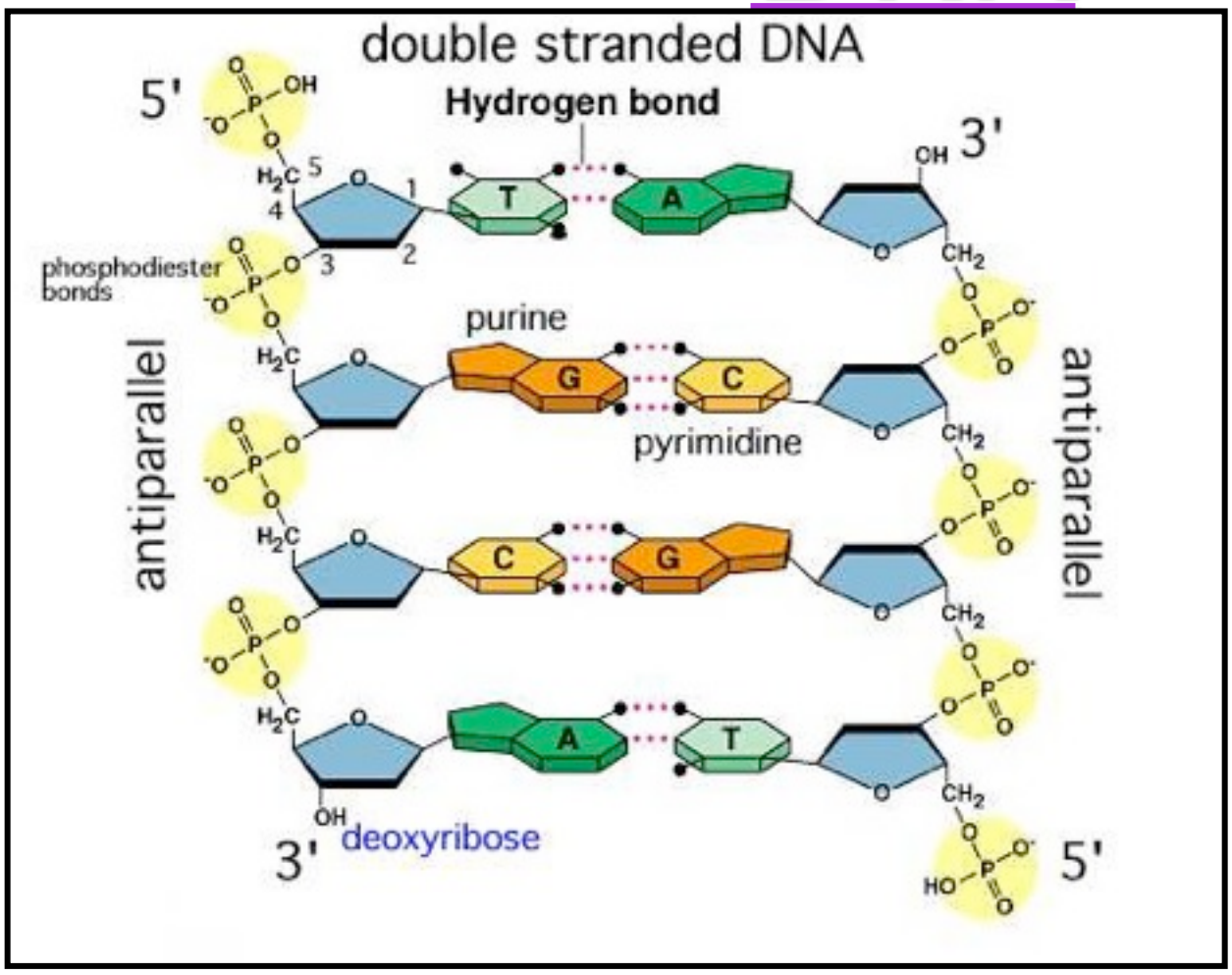
NUCLEIC ACIDS



Complimentary base pairing causes the diameter of the DNA helix to remain constant ie: 2nm.

The large number of hydrogen bonds between DNA strands account for its structural stability.

DNA



The phosphate group of one nucleotide is linked to the sugar of another via a **PHOSPHODIESTER BOND**.

The end that terminates in a **PHOSPHATE GROUP** is labelled the **5' end**.

The end that terminates in a **HYDROXYL GROUP** is labelled the **3' end**.

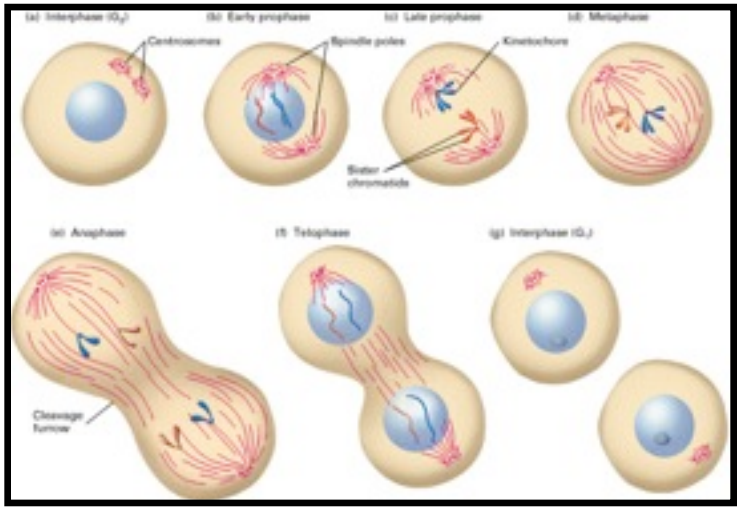
The bond that links the sugar to its nitrogenous base is referred to as a **GLYCOSYL BOND**.

Complimentary strands are said to be **ANTIPARALLEL.**

DNA REPLICATION

- **Mitosis** is the division of the nucleus of a eukaryotic cell into two daughter nuclei with identical sets of chromosomes (DNA).

  » following mitosis, the cytoplasm divides as well via **cytokinesis** in order to create two daughter cells.



Cell division is important for:

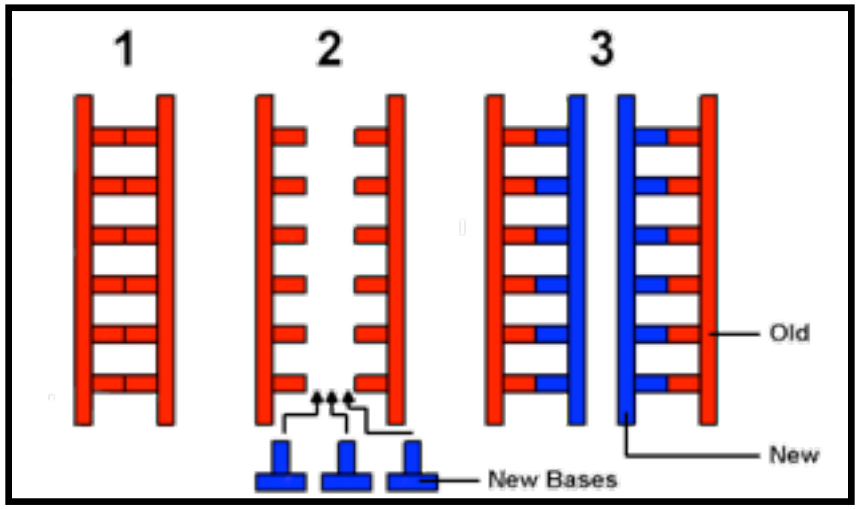
- Growth of tissues during embryonic dev.

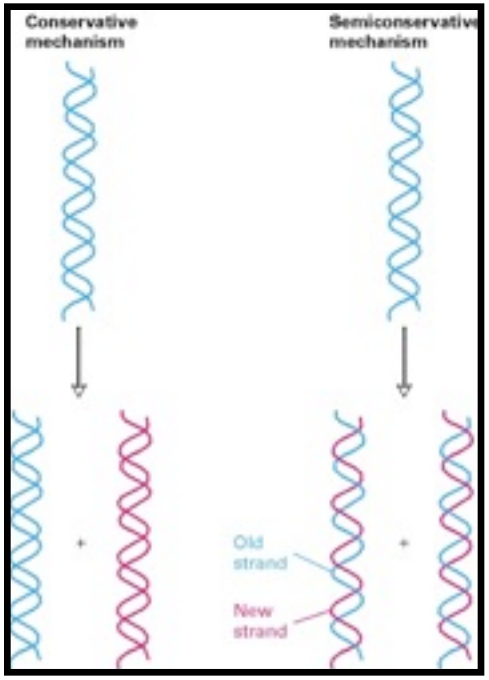
- tissue regeneration (ie: daily replacement of skin cells)

- repair of damaged tissue

DNA REPLICATION

- DNA replication is said to be **SEMI-CONSERVATIVE**:
  - » **each new DNA molecule is composed of one parent strand and one newly synthesized strand**





DNA REPLICATION

- **STEP ONE: Separating the DNA Strands**

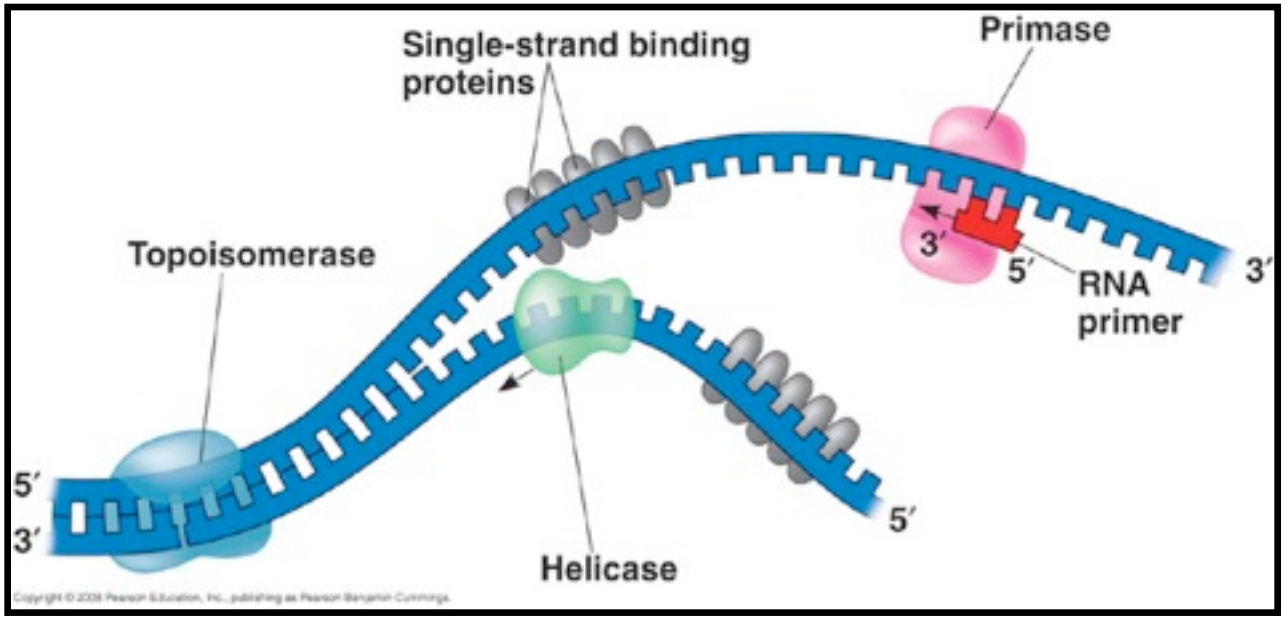
- The double helix structure is unwound, with the enzyme **DNA GYRASE** relieving any tension caused by the unwinding.

- The enzyme **DNA HELICASE** unwinds the double-helical DNA by breaking the hydrogen bonds between the complementary base pairs.

DNA REPLICATION

- **STEP ONE: Separating the DNA Strands**

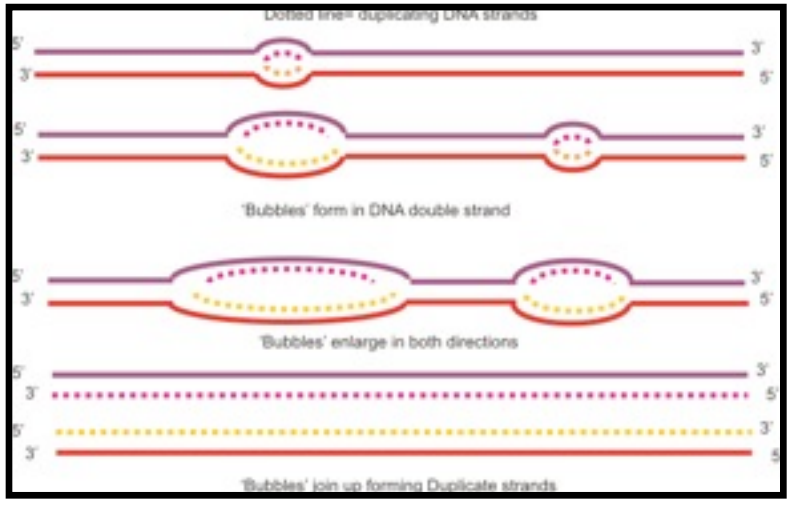
- Next, **SINGLE-STRANDED BINDING PROTEINS (SSBs)** bind to the exposed DNA single strands and block hydrogen bonding.



DNA REPLICATION

Replication begins in two directions from the origin as a region of the DNA is unwound (always in the 5` to 3` direction).

New complementary strands are built as soon as an area of DNA has been unwound.



The **replication fork** is the junction where DNA strands are still joined. DNA replication proceeds toward the direction of the fork on one strand and away on the other strand.

DNA REPLICATION

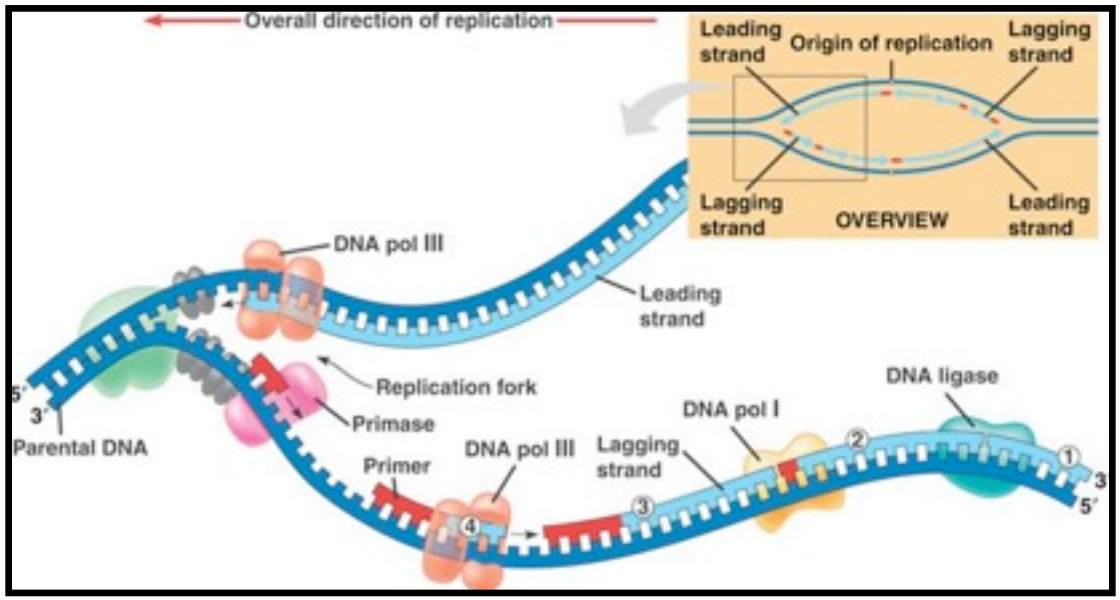
- **STEP TWO: BUILDING THE COMPLIMENTARY STRANDS**

- In prokaryotes, **DNA POLYMERASE I,II** and **II** are the 3 enzymes known to function in replication and repair – in eukaryotes there are 5 different POLYMERASES at work.

- **DNA POLYMERASE III** = the enzyme that builds the complimentary strand **(always in the 5` to 3`direction)** using the template strand as a guide.

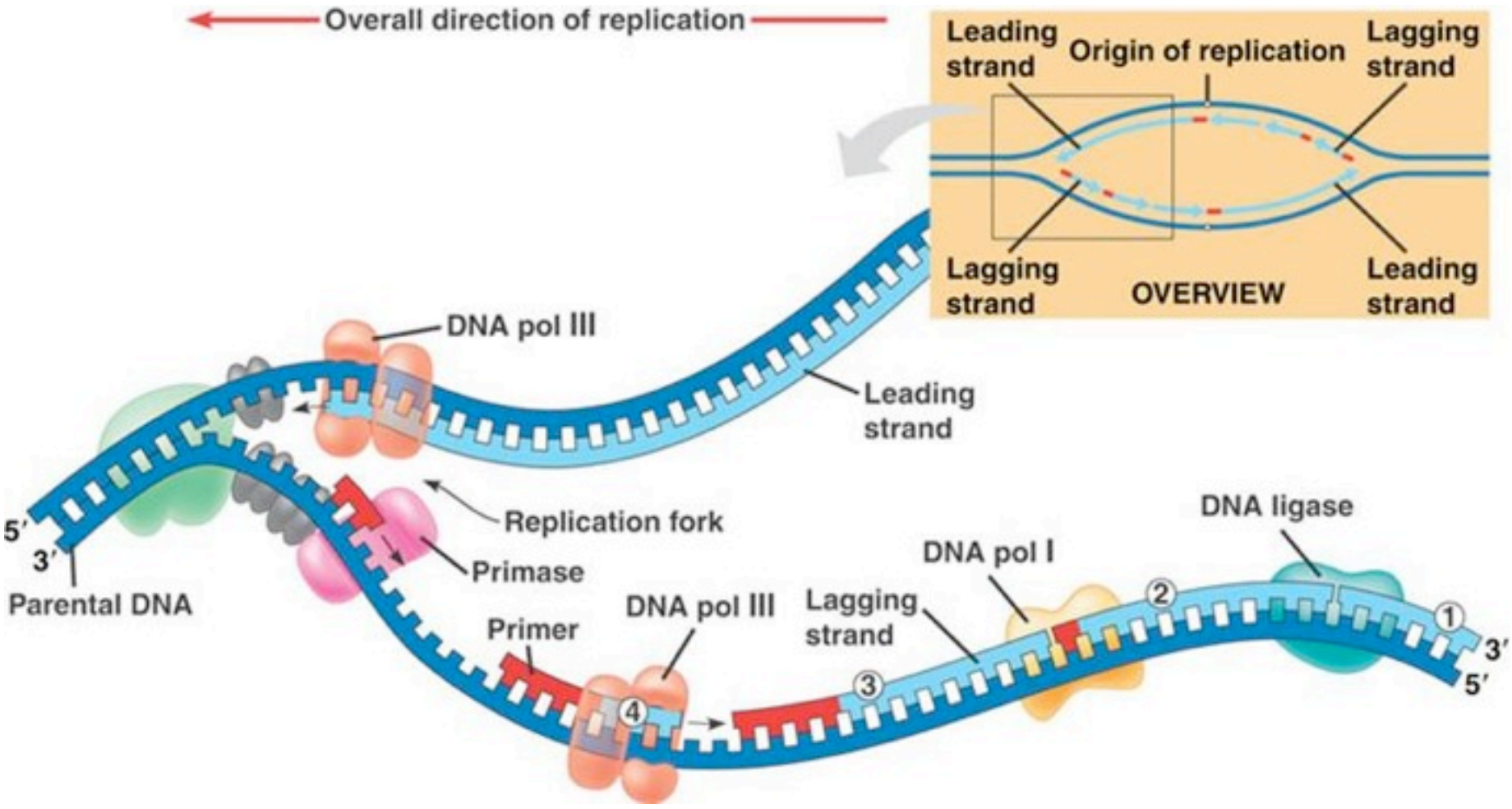
DNA REPLICATION

- First, **DNA POLYMERASE III** needs the enzyme **PRIMASE** to synthesize and lay down an RNA PRIMER.
  - » an RNA primer is a sequence of 10 to 60 RNA bases that is annealed to a region of single-stranded DNA for the purpose of initiating DNA replication



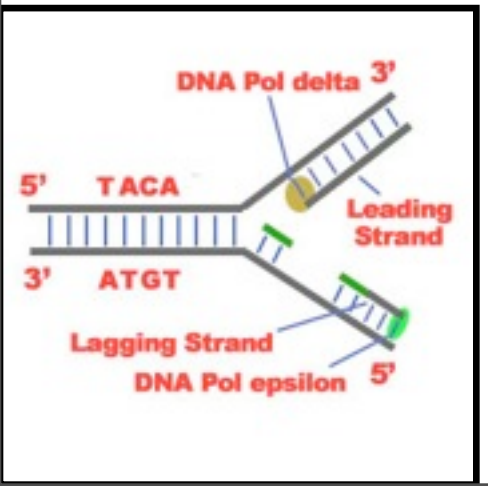
Once a primer is in place, **DNA POLYMERASE III** can start elongation by adding complementary bases to the growing complementary strand.

DNA REPLICATION



DNA REPLICATION

- Since DNA is always synthesized in the 5`to 3`direction, and the template strands run antiparallel, only one strand is able to be built continuously.
  - » LEADING STRAND = the new strand of DNA that is synthesizes continuously and **uses the 3`to 5`** template as its guide.
  - » LAGGING STRAND = the new strand of DNA that is sytnesized in short fragments, called **OKAZAKI FRAGMENTS**, which are later joined together.

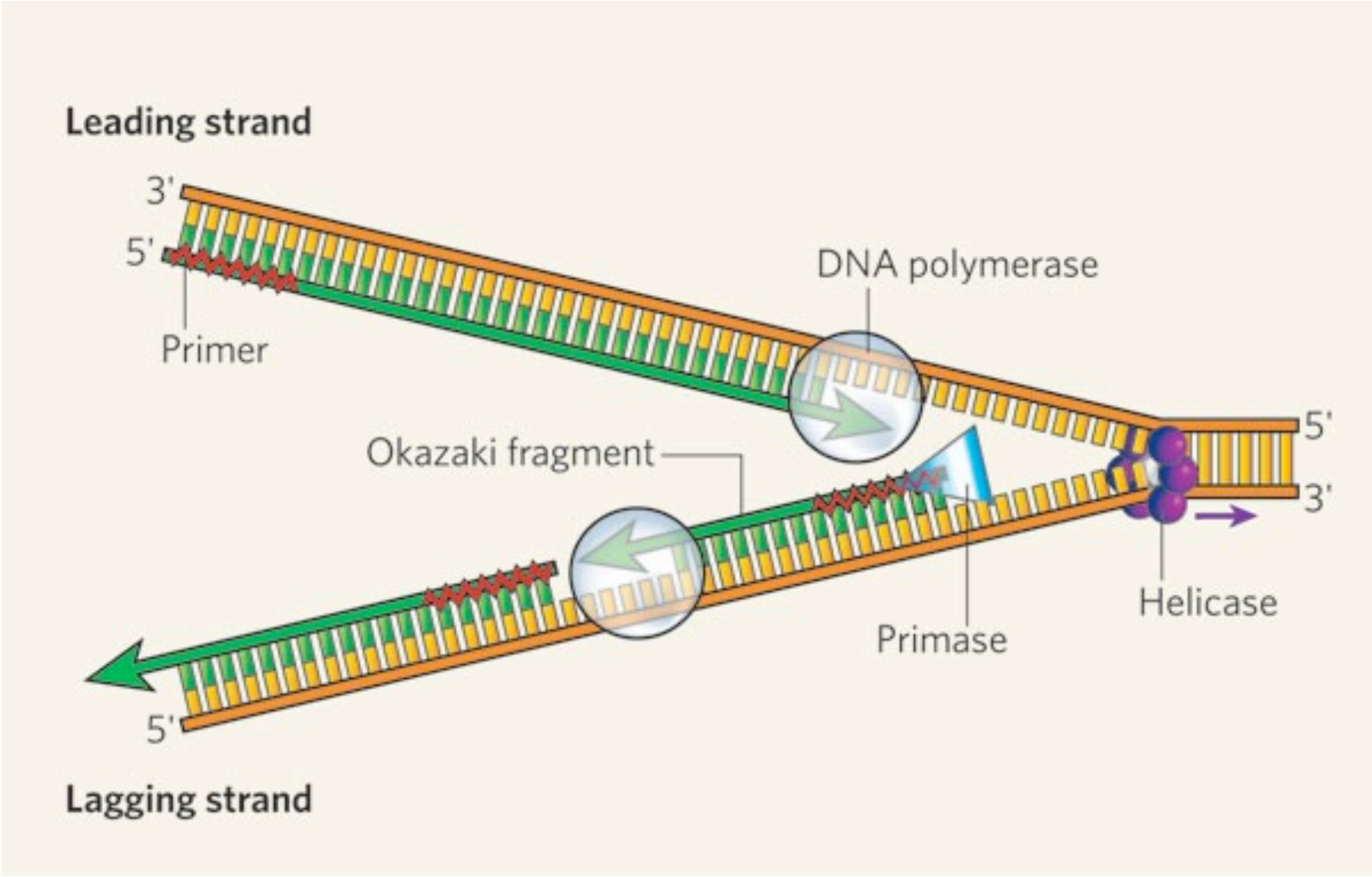


DNA REPLICATION

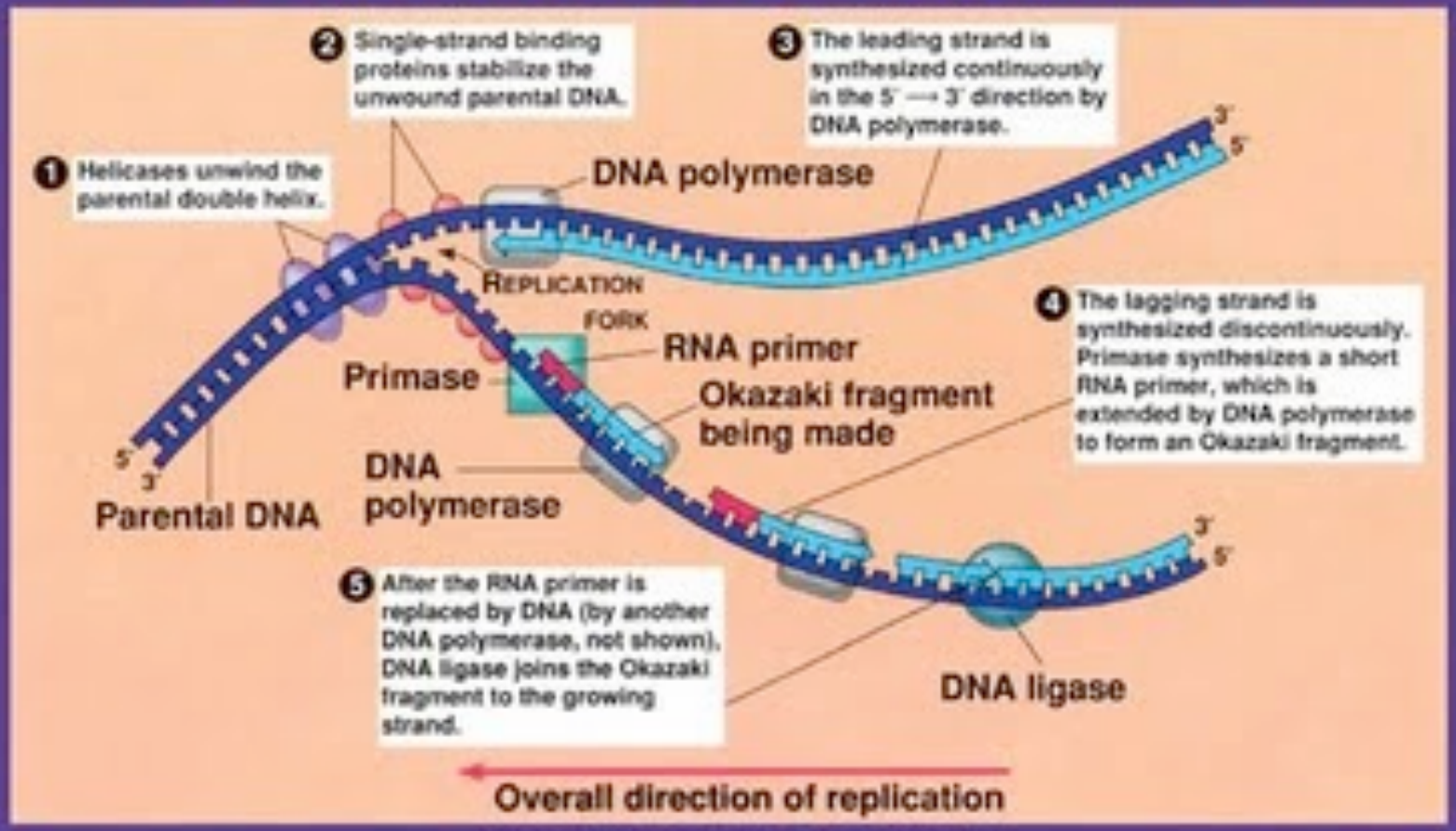
- **DNA POLYMERASE I** is an enzyme that removes the RNA primers following the synthesis of the okazaki fragments.

- **DNA LIGASE** then joins DNA fragments together by catalyzing the formation of a bond between the 3`hydroxyl group and a 5`phosphate group on the phosphate-sugar backbone.

DNA REPLICATION



A SUMMARY OF DNA REPLICATION



DNA REPLICATION

- lets take a look at some animations!

- http://www.youtube.com/watch?v=teV62zrm2P0

- http://www.youtube.com/watch?v=-mtLXpgjHL0&feature=related