• **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.
Organisms store information about the structure of their proteins in macromolecules called NUCLEIC ACIDS.

Nucleic acids are used by all organisms to store hereditary information that determines structural and functional characteristics.
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
- a phosphate group
- a nitrogenous base

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

The large number of hydrogen bonds between DNA strands account for its structural stability.
The phosphate group of one nucleotide is linked to the sugar of another via a PHOSPHODIESTER BOND.

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

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 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

Overall direction of replication

Leading strand
Origin of replication
Leading strand
Lagging strand

OVERVIEW

Leading strand

DNA pol III

Replication fork

Primase

Primer

DNA pol III

Lagging strand

DNA pol I

DNA ligase

Parental DNA

3' to 5'
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 synthesized 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

Leading strand

3'

5'

Primer

DNA polymerase

Okazaki fragment

Primase

Helicase

Lagging strand

5'

3'
A SUMMARY OF DNA REPLICATION

1. Helicases unwind the parental double helix.
2. Single-strand binding proteins stabilize the unwound parental DNA.
3. The leading strand is synthesized continuously in the 5' → 3' direction by DNA polymerase.
4. The lagging strand is synthesized discontinuously. Primase synthesizes a short RNA primer, which is extended by DNA polymerase to form an Okazaki fragment.
5. After the RNA primer is replaced by DNA (by another DNA polymerase, not shown), DNA ligase joins the Okazaki fragment to the growing strand.

Overall direction of 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