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Bio-diversity

- Biodiversity is the variety of life on earth. It's the variability among living organism.
- Diversity may be within species, between species and of ecosystems.

There are three types of bio-diversity -

① Genetic ② species ③ Ecosystem

① Genetic diversity occurs within a species as well as between species.

② Species diversity occurs between the populations of different species or within the populations of same species.

③ Ecosystem Diversity occurs between habitat biological communities and ecosystems.

Importance

- Biodiversity includes our resources on which our lives depend.
- Biological resources provide us food, shelter and medicines.

Threats

- Various human activities result in to habit loss and destruction of species, populations

and ecosystems.

- Each ecosystem has its own characters. A alteration in its composition may caus decline of a species. It leads to the lo biodiversity.

- Invader species adversely affect native s and disturb the entire ecosystem.

- The over-exploitation is a big threat biodiversity.

- Pollution, population and global clima affect all levels of Biodiversity.

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Chemistry of life

UNIT- II

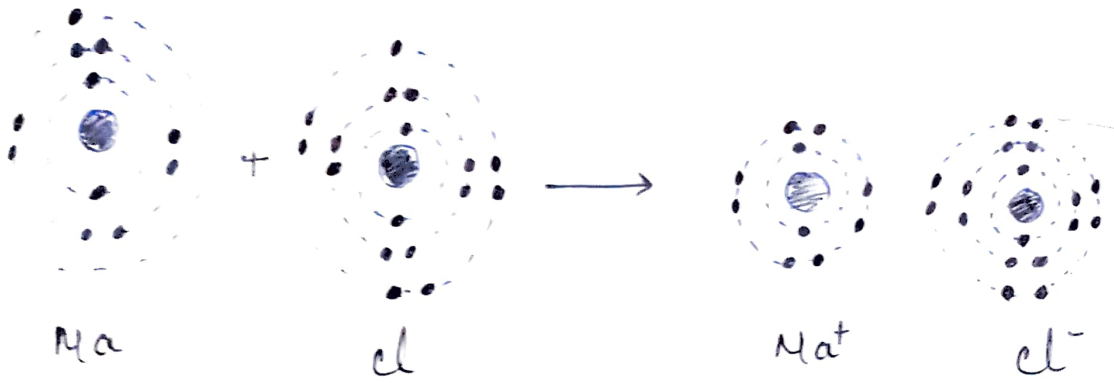
- All matter is composed of simple units called atoms.
- Each atom is composed of protons, neutrons and electrons.
- Same kind of atoms combine to form an element.
- In nature, six main elements (i.e. C, H, N, O, P, S) are important for life and make 98% of the body weight
- When two or more elements are chemically joined, they form compounds (eg. water, salt, sugar etc).
- Atoms form compounds with the help of strong attractive forces known as chemical bond.
- A chemical bond is an attraction force due to which atoms lose their individual properties and have common properties.

Types of Bonding -

① Ionic Bonding:

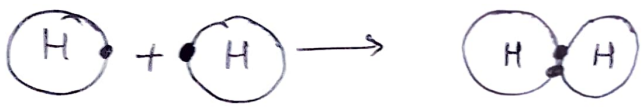
- In this type one atom donates an electron and the other atom accepts it.
- Atom that donates electron attains positive charge due to more protons and called as **Cation**
- While atom, receiving the e^-, attains negative charge due to more electrons and called as **Anion**

Ex- NaCl → Na^+, Cl^-



Covalent Bonding

- It involves sharing of electrons between two atoms.
- The number of sharing of pairs of electrons result in the formation of double and triple bonds.

Ex- 

Hydrogen gas.

Non-Covalent Bonds

- These are weak bonds, weaker than covalent bonds.
- Four types of non-covalent interactions:
  Hydrogen bonds, Ionic bonds, Vander Waals forces
  Hydrophobic interactions.
- These bonds are crucial in maintaining the shapes of nucleic acids, proteins and other biological macromolecular structures.

Ex- two strands of DNA
secondary and tertiary structure of proteins.

DR. KAMAKSHI SAXENA UNIT II

Biochemistry and Human Biology

- Biochemistry may be defined as the chemistry of living things or may be called as "life chemistry".
- It deals with the study of chemical reactions going on in the biological systems.
- These chemical reactions are called as Metabolism. It includes anabolism and catabolism.

Biomacromolecules:

- Biomacromolecules include proteins, carbohydrates, lipids, nucleic acids and other biomolecules.
- These molecules are made up of many units known as polymers, which are composed of smaller units called as Monomers.

Carbohydrates: (Saccharide - Sugar)

- These molecules are known as "hydrates of carbon" or Polyhydroxy aldehydes or Polyhydroxy Ketones. On hydrolysis they yield either Ketone or aldehyde groups.
- The carbohydrates are classified into three groups:

- These are naturally-occuring organic compounds that are soluble in non-polar organic solvents (e.g. ether, chloroform, acetone and benzene)
- Lipids are insoluble in water.
- They are esters of fatty acids including fats, waxes, steroids and oils.

Fatty Acids: They are building blocks of lipids.
- Fatty acids are composed of a chain of methylene groups with a carboxyl functional group at one end.
- The fatty acid chains are usually between 10 and 20 carbon atoms long.
- Fatty acids are of two types - saturated and unsaturated.

Triglycerides: These are energy storage molecules.
- This is a link between fatty acids and glycerol.

Steroids:
- steroids form a group of compounds which are

structurally and functionally unrelated to lipids
They are soluble in organic fat solvents.
- Some hormones belong to this group.
- A typical compound belonging to the group is cholesterol.
- A steroid contains a specific arrangement of four cycloalkane rings.

Waxes:
- Waxes are esters of long chain fatty acids with long chain of monohydric alcohols.
- They have only one ester linkage.
- Waxes form coatings on the surfaces of leaves, stems, hair, skin etc.

Proteins:
- Proteins are made up of a number of amino acids, linked together in a definite sequence by peptide bond.
- Proteins are body building organic compounds.
  ex- Hormones, Enzymes.

Nucleic Acids:
- Nucleic Acids are made up of nucleotides.
- Each nucleotide consists of a nitrogen base, a pentose sugar and phosphate molecule.
  ex - DNA, RNA

Genetic information and Protein Synthesis

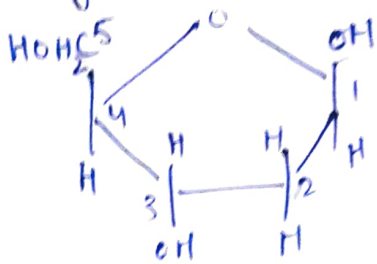
DR. KAMAKSHI SAXENA UNIT I

- In all eukaryotic organisms, the well organised nucleus contains definite number of chromosomes of distinct size and shape.
- Genetic information is found in the chromosomes.
- Chromosomes with in the nucleus remain in the form of long loosely, coiled strands called chromatin.
- A gene is the unit of information that directs the activity of the cell or organism during its lifetime.
- Chromosome contains various gene organised in linear form.
- Gene determins physical and metabolic characteristics of the cell and are responsible for the transmission of characters from one cell generation to other.
- Genes are made up of Protein and nucleic acid.
- Genes control the Synthesis of various types of RNA.
- DNA is Key molecule of living system, consisting of a repeating sequence of monomeric nucleotide arranged in linear polymeric chain.
- DNA is made up of three chemical subunits:
  - A 5-carbon Pentose sugar
  - A phosphoric acid group
  - Four nitrogenous bases - Adenine, Guanine Cytosine and Thymine

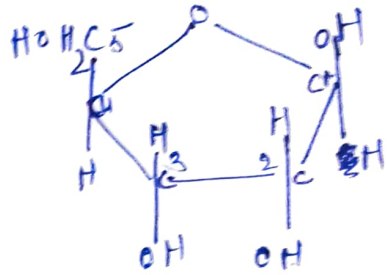
- Purine and Pyrimidine are component occur in equal amount in a molecule (Chargaff's rule).

- Pentose sugar of nucleic acid is a type of cyclic 5 carbon sugar which connect two phosphate group one at 3'c and second at 5'c, while nitrogenous base linked to C (carbon) number 1.

- In DNA, sugar is deoxyribose and in RNA sugar is ribose.



Deoxyribose (DNA) sugar

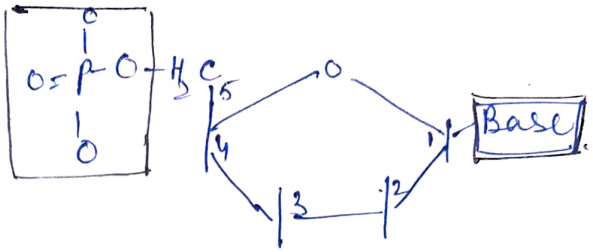


Ribose sugar (RNA).

- Phosphate group is attached to 3' carbon and 5' carbon atoms of sugar molecule. Phosphate group is responsible for the strong negative charge of nucleic acid.

- A combination of base with pentose sugar is called nucleoside.

- When a phosphate group ~~combi~~ joins a nucleoside it is called as nucleotide. It joins either at carbon no. 5 or at carbon no. 3



- A nucleotide -

- A number of nucleotide monomer units give rise to a polynucleotide chain through the formation of phosphodiester bond.

- A phosphodiester bond is formed between any two adjacent nucleotide in which 5' and 3' hydroxyls of adjacent sugar form a double esters with phosphoric acid.

- At one end of the chain 3'OH group and at the other end 5'OH is exposed, Thus each polynucleotide chain has 3' and 5' end.

(Ribose/Deoxy ribose) Sugar + nitrogenous base (A/T/G/C) → nucleoside

Sugar (Ribose/Deoxyribose) + Nitrogen base (A/C/T/G) + Phosphate Group → **Nucleotide**

- In 1953, Watson and Crick proposed double helix model of DNA.
- In Each DNA molecule there are two long anti-parallel polynucleotide chain.
- Purine of one chain pairs with pyrimidine of another chain.

  Adenine pairs with Thymine with double H bond and cytosine with Guanine with triple H bond.

  A = T, C ≡ G

Replication of DNA :-

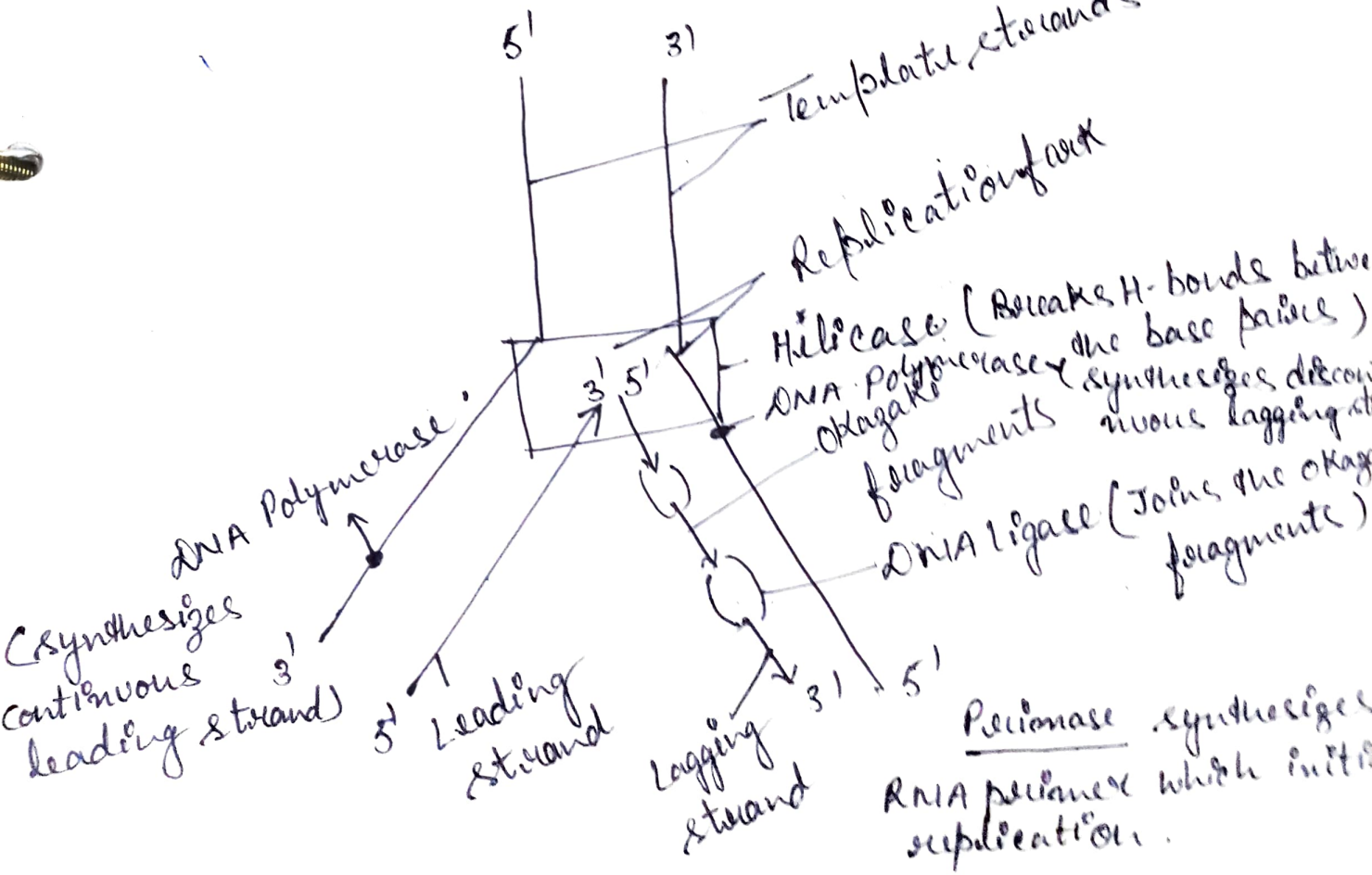
- DNA replication is the process by which a cell makes copies of its DNA.
- The process of DNA replication relies on base-pairing rules and many enzymes.

- In prokaryotes, replication starts at only one point called origin (ori) but in eukaryotes it starts at several different places at the same time.

- It begins with enzyme Helicase, it separates both the strands.

- DNA polymerase enzyme attach new DNA nucleotide one at a time on to the surface of exposed strands.

- DNA replication is semi-conservative (newly formed DNA has one old and one new strand)



- DNA polymerase always add new nucleotide in 5' → 3' direction only.
- Okazaki fragments later join together by enzyme DNA ligase.

"DNA replication is a biological process of producing two identical replicas of DNA using one original DNA molecule."

Enzymes used in DNA replication :-

Enzymes	Function in DNA replication
DNA Helicase	unwinds the DNA double helix at the replication fork
DNA Polymerase	builds a new DNA strand by adding nucleotides in the 5' to 3' direction, also performs proof-reading and error correction
DNA ligase	Joins Okazaki fragments of the lagging strand.

Three main stages of DNA replication -

Initiation - Helicase unwinds the DNA helix and two replication forks are formed at the origin of replication

Elongation - RNA Primer is added on template strand, DNA polymerase elongates a complementary polynucleotide chain. It starts from 5' to 3' end and forms a continuous leading while a discontinuous lagging strand. Pieces of lagging strand, called as Okazaki fragments are joined by DNA ligase.

Termination - Primer is removed, so replication terminates.

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Ribonucleic Acid (RNA)

- Like DNA, RNA is a nucleic acid.
- It is found in cytoplasm and nucleolus.
- RNA is a single stranded structure, consisting of an unbranched polynucleotide (poly = many, nucleotide = 1 pentose sugar + 1 nitrogen base + 1 phosphate group) chain.

Str. of RNA

- RNA has four nitrogen bases i.e. A = Adenine, C = Cytosine, G = Guanine and U = Uracil.
- The purines (A, G) and Pyrimidines (C, U) amounts are not equal.

Types of RNA

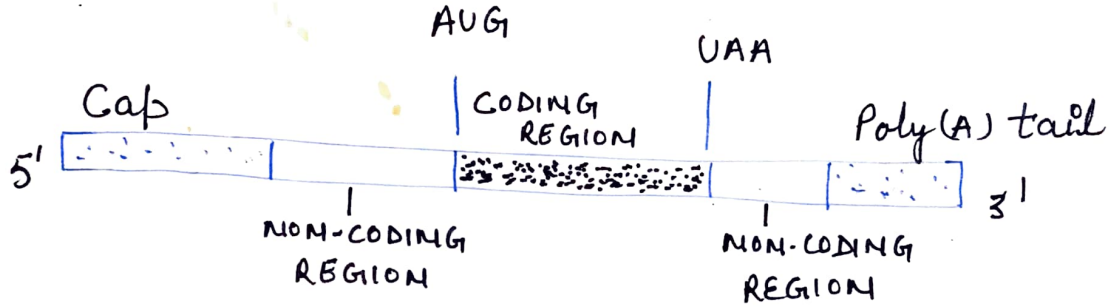
- Mainly three types of RNA are present.

i) Messenger RNA (mRNA)

- It carries the genetic information (in the form of genetic code) from DNA to the cytoplasm for protein synthesis.
- It truly represents a blueprint of DNA.

- mRNA is an exact complementary copy of DNA which is coded and translated into a protein molecule.

- It constitutes of 3-5% of the total cellular RNA.



- Structure of mRNA -

- One end is called the 5' end and the other is 3' end.

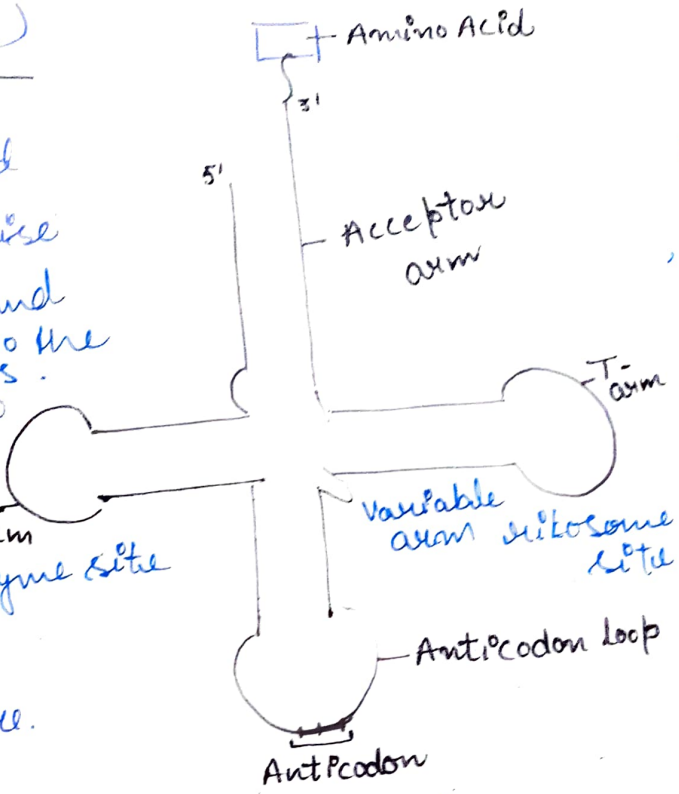
- Eukaryotic mRNA has the coding region (codes for protein) and two non-coding regions.

- Cap region is the binding site for ribosome

- At the 3' end, a poly A tail is found. All mRNAs do not carry it.

- Poly A tail consists of 100-200 nucleotides with a sequence of polyadenylic acid (pdA).

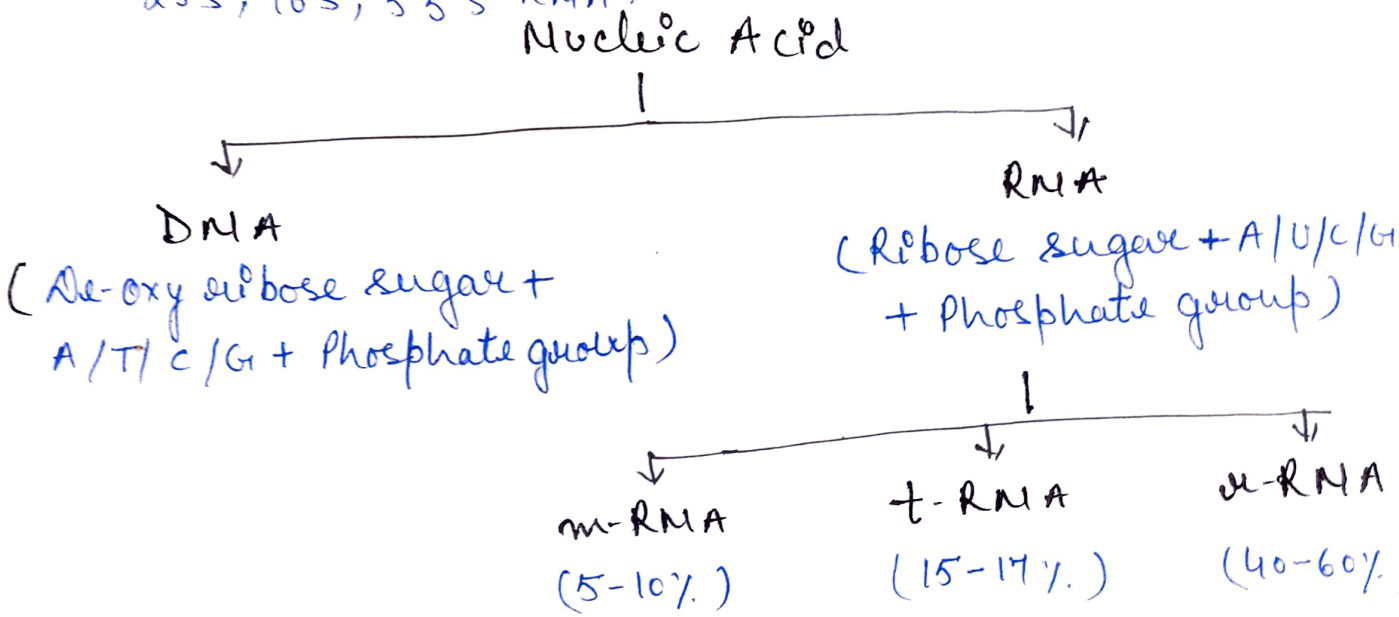
ii) tRNA (Transfer RNA)



- It is a small sized RNA which can recognise the codons on mRNA and transports amino acid to the site of protein synthesis.
- It carries the amino acids to the site of protein synthesis
- The tRNA assigns a clover leaf like structure.
- It has four arms
  a) Acceptor arm (amino acid binding site)
  b) TΨ*C arm (ribosome site)
  c) D arm (enzyme site)
  d) Anticodon arm (recognition site)
- It constitutes about 15-17% of the total cellular RNA.
- tRNA acts as an adapter molecule between a specific amino acid and the triplet (code).
- Each tRNA transports only one amino acid.
- There are 60 types of tRNA

(iii) rRNA (Ribosomal RNA)

- These are the most stable type of RNA.
- They constitute about 40% to 60% of total cellular RNA.
- It is found associated with ribosomes in cytoplasm.
- Some recent evidences suggest that few rRNAs serve to release mRNA from DNA.
- It's classified into 7 types namely - 2.8S, 18S, 5.8S, 5S, 23S, 16S, 55S RNA.



- Some non coding RNA are also present in the cell like SnRNA (small nuclear RNA) SnoRNA (Small nucleolar RNA), microRNA, SiRNA (Small interfering RNA).

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Protein Synthesis

Chemically, proteins are polymers of amino acids. Amino acids are joined by peptide bonds to form proteins.

The biosynthesis ~~is~~ of protein is under direct control of DNA. From DNA the information is transferred to mRNA and from mRNA to proteins.

$$DNA \xrightarrow{\text{Replication}} DNA$$

$$DNA \xrightarrow{\text{Transcription}} mRNA \xrightarrow{\text{Translation}} \text{Proteins}$$

—: Central Dogma of molecular biology :—

The process of protein synthesis takes place in the following steps:

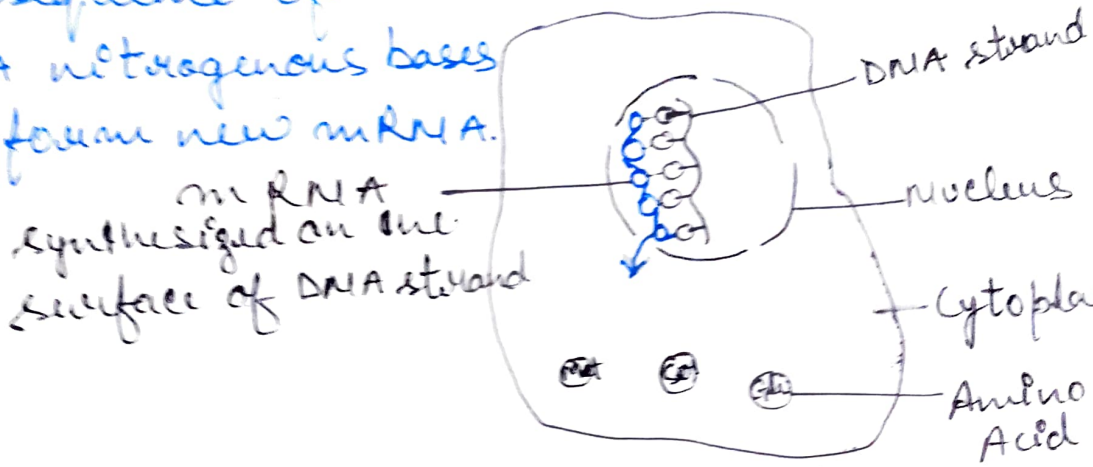
① Transcription: The synthesis of mRNA from DNA is called as transcription. It occurs in nucleus.

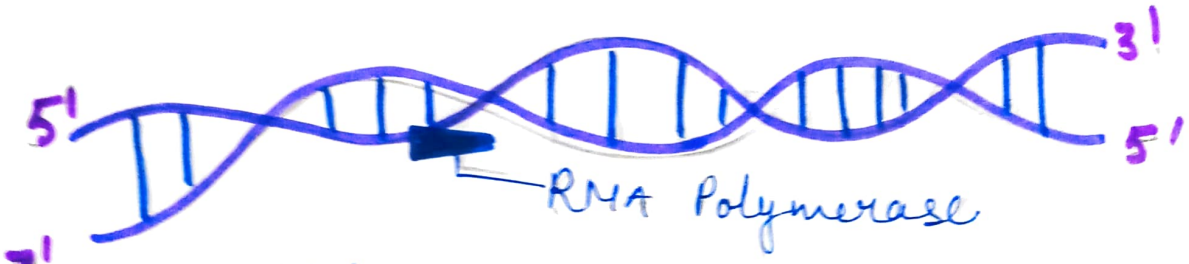
- RNA polymerase is the main enzyme involved in transcription.
- For initiation of transcription, RNA polymerase enzyme proceeds through promoter sequence or TATA Box.
- One strand of DNA serve as a template for the synthesis of mRNA and

Called as coding strand.

- Another strand is called as non-coding strand.

- The enzyme RNA polymerase reads the sequence of DNA nitrogenous bases to form new mRNA.





Initiation

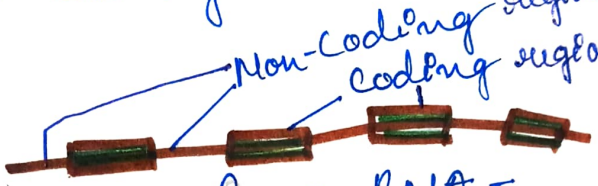
- It synthesizes mRNA in 5' ⟶ 3' direction.
- It brings new RNA nucleotides to DNA coding strand and synthesizes a complementary m-RNA strand.

- Termination of transcription is brought about by termination signals on DNA.

- As RNA polymerase enzyme reads the termination signals it unbinds itself from template strand and falls off.

Splicing

- This newly formed mRNA (Pre mRNA) has coding and non-coding sequences.

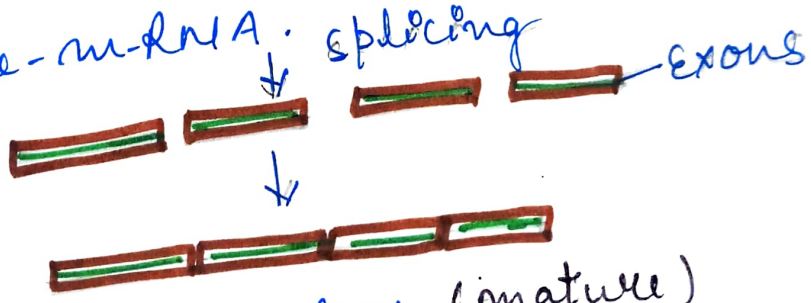


- Pre mRNA -

- Non coding sequences (introns) do not code for any protein.

- Coding sequences (exons) have codes for specific amino acid.

- Hence introns are removed from Pre-m-RNA. splicing



- Exons are joined. This mechanism is termed as Splicing of mRNA.

Small nuclear RNA and protein complex help in this process.

- mRNA leaves the nucleus and enters in cytoplasm for translation.

② Translation :- In this process the sequence of nucleotides in mRNA is translated in to the sequence of amino acids. It occurs in cytoplasm. This process is completed in three steps -

Ⓐ Initiation

- m-RNA binds to the small ribosomal unit. (mRNA ribosomal complex)
- Initiation is brought about by methionine (amino acid) which is coded by the codon AUG.
- AUG is the start codon (where translation begins)
- In Prokaryotes, initiation is brought about by formulated methionine.
- In Eukaryotes, initiation is brought about by special met tRNA.
- Amino acids are taken to the mRNA ribosomal complex by tRNA.

— Translation —

- With the help of anticodon loop, t RNA matches the correct amino acid to the m RNA codon.
- When methionine t RNA molecule is bind up over start codon, the large subunit of ribosome joins the small subunit to bind m RNA.

(6) Elongation :- After the formation of ribosomal RNA complex (60s - m RNA - f - met - t RNA), elongation of polypeptide chain takes place by regular addition of amino acids.

A specific amino acid is brought by a specific t RNA.

(C) Termination :- when the ribosome carrying (7)
peptide tRNA reaches the
termination codon (UAA, UGA, UAG) present
on mRNA, it gets dissociated.
For chain termination releasing factors
R_1 and R_2 are needed.
These factors induce enzyme peptidyl
transferase to catalyse the termination.

The main steps are as follows :-

① Transcription
② Attachment of activated amino acid with tRNA.
③ Translation
(A) Initiation (B) Elongation (C) Termination

This polypeptide chain singly or in
association with other chains take up a
secondary, tertiary or quarternary
structures.

* Protein Synthesis takes place in prokaryotes
as well as in eukaryotes.

Genetic Code :

- The instructions for the construction of proteins is written in DNA using the genetic code mea specifically the sequence of bases.
- The genetic code by which DNA stores the ge information consists of "codons" of three nucle
- With four possible bases, the three nucleotid can give $4^3 = 64$ different possibilities.
- These combinations are used to ~~specify~~ code 20 amino acids.
- The base triplets act as codons.
- 'AUG' is called as start codon, while UAA, U and UAG are called as stop codons.

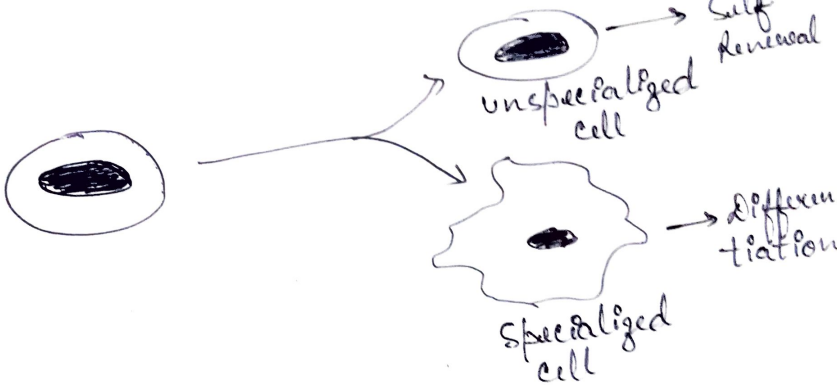
Properties -

- Genetic Code is universal among living org
- Each amino acid is coded by more than one cod Redundancy.
- No codon codes for more than one amino a ambiguous.

Stem Cell

DR. KAMAKSHI UNIT II
SAXENA

- Stem cells are unspecialized cells and have the remarkable potential to develop into many different cell types.
- Unspecialized stem cells are capable of renewing themselves through cell division.
- When a stem cell divides, one becomes unspecialized and other becomes specialized cell i.e. brain, blood, liver etc.



Properties

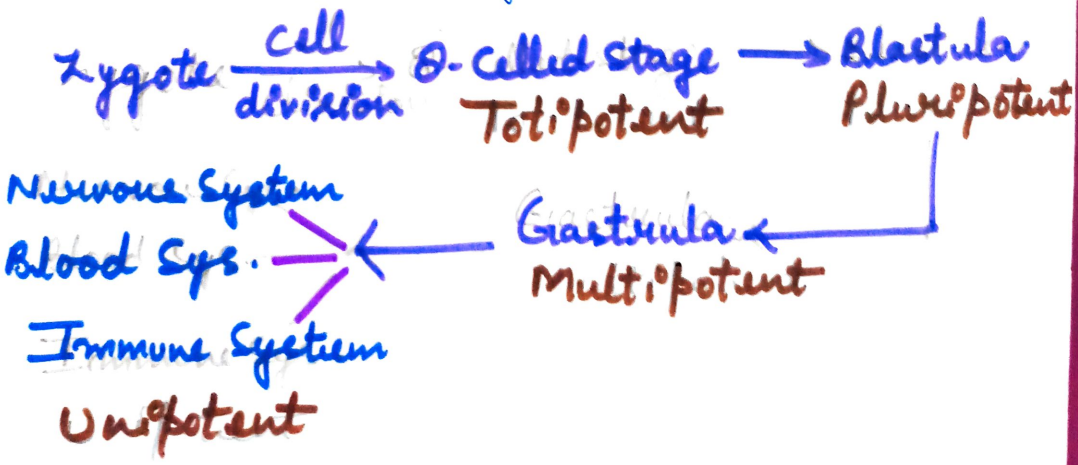
Stem cells have three unique properties.

- They have ability to replicate for a very long period. Hence they have potential of self renewal
- During cell division, one daughter cell remai unspecialized.

Classification

Based on their potency stem cells are classified as follows:

- **Unipotent** – potential to differentiate in to only one type of cell.
  ex – Brain stem cell can differentiate in to brain cell.
- **Multipotent** – potential to form many type of cells.
  ex – mesenchymal stem cells can differentiate in to many types.
- **Pluripotent** – potential to differentiate in to any type of cell except trophoectoderm.
- **Totipotent** – potential to differentiate in to all type of cells of an organism.



Types of Stem cell -

Embryonic Stem Cell :- During fertilization egg fuses with sperm to form zygote. After formation zygote undergoes series of cell division.

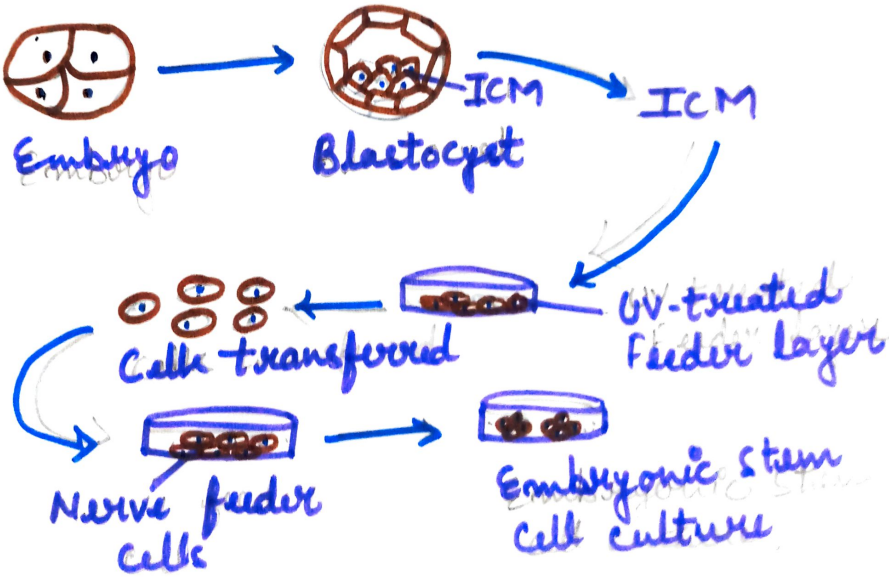
- Embryonic stem cells are pluripotent, derived from Inner cell mass of Blastocyst.
- ESC are capable to differentiate into any type of 3 germ layer (Ectoderm, Mesoderm, Endoderm).
- Due to their self renewal property ESC are used in regenerative medicines and tissue replacement after injury.

Adult Stem Cell :- After attaining adulthood, undifferentiated cells are found in the body, which repair and regenerate the body tissues.

- Adult stem cells are multipotent.
- ASC are present in various tissues and organ system (Bone marrow, liver, retina, intestine etc.)
- Their main role is tissue repair and maintenance.

Human Embryonic Stem Cell (h.E.S.C.) Isolation and culturing

- ICM (inner cell mass) from blastocyst are transferred in to a culture dish.
- culture (growing cells in the lab) dish contains culture medium.
- On the inner surface, culture dish is coated with mouse embryonic stem cells, treated with UV radiations. This layer is called as feeder layer.
- Feeder layer provides sticky surface and release growth factors in culture medium.



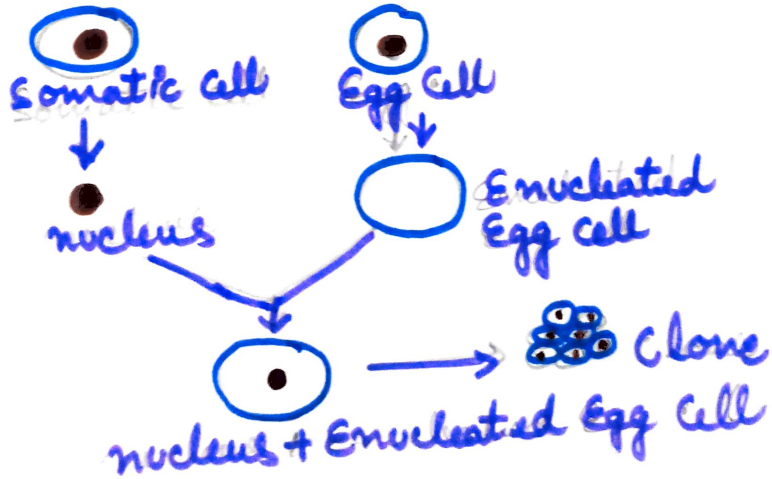
Stem cells applications

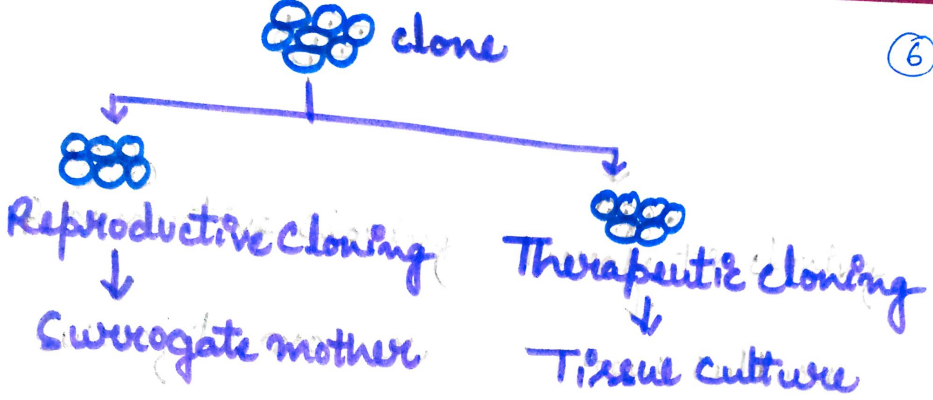
- Therapeutic cloning
- Gene Delivery
- Regenerative medicine

Therapeutic cloning :-

Somatic Cell Nuclear Transfer Technique (SCNT)

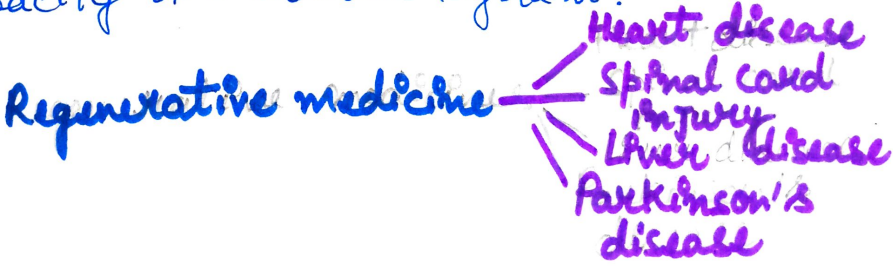
- Dolly the sheep famous for being first successful cloned mammal was produced by this process.
- This technique is used in both therapeutic and reproductive cloning.
- In this method the nucleus of a somatic (body) cell is removed and then is put into an enucleated egg cell.
- The egg divides and grow and is used as a source of stem cell.





Regenerative Medicine :-

- Regenerative medicine deals with the process of replacing or regenerative human cells.
- These can be used to replace and/or repair defective tissue and organs.
- The main focus is on those diseases which affect the systems of no regenerative capacity ex - nervous system.



Benefits of Stem cell Research for curing diseases:-

Parkinson's disease is a disorder of central nervous system, due to lack of brain chemical dopamine. Patients are injected with stem cells that increase nerve cells to release dopamine

Stem Cells

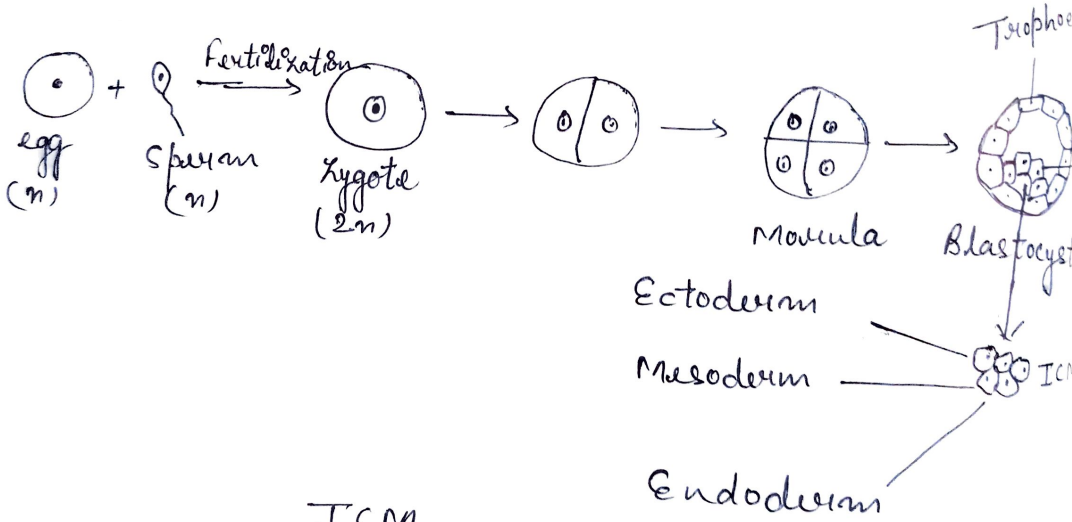
Embryonic Stem cells

Adult

Totipotent (early embryonic Stem cells) So-called stage

Pluripotent

Multipotent



ICM

Germ layers

Ectoderm
ex - Brain, Skin

Mesoderm
ex - Muscles, Blood, Bone

Endoderm
ex - Liver, glands Gut

Muscular dystrophy is a disorder of weak muscles and loss of muscle tissue. Patients are injected with healthy stem cells to get strength of muscles.

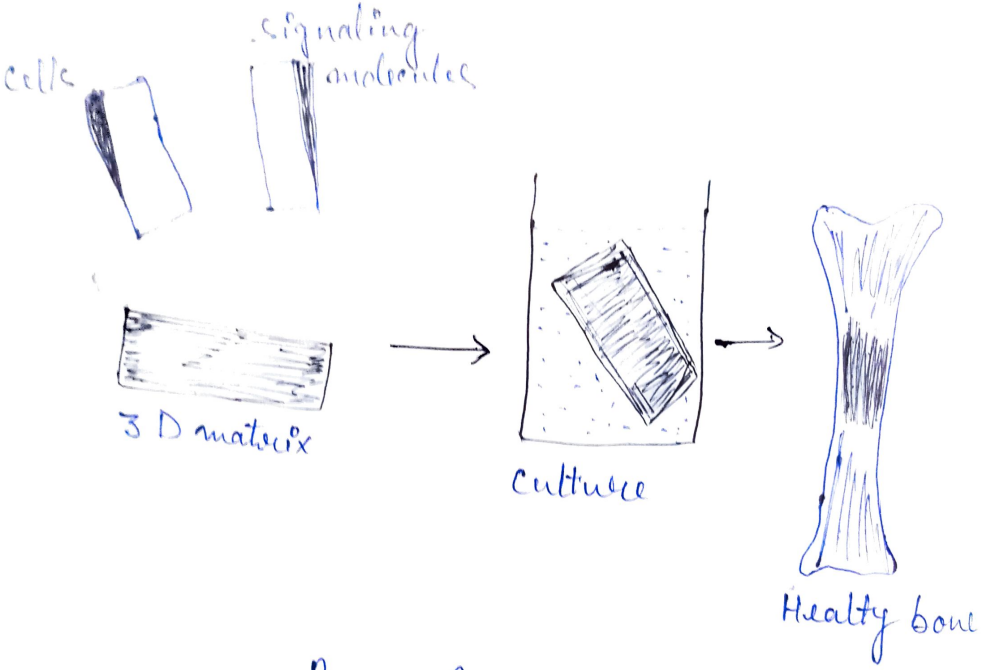
Diabetics (Type I) result from autoimmune destruction of insulin producing beta cells in the pancreas. Patients are given the injection of adult stem cells.

Polio is a viral disease that can affect nerves and can lead to partial or full paralysis. Signals from brain do not reach the muscles in the legs. Stem cells are injected to encourage new spinal neurons to grow and help new muscles to grow.

Bone Tissue Engineering

- BTE is an emerging interdisciplinary field for the development of such substitutes that can restore and maintain the functions of bone tissues.

- Due to trauma, tumor, infections, abnormal bone development and other disorders, the reconstruction of bone tissue is required.



Bone Regeneration

- To treat such problems, various types of graft materials are used such as -
  - autologous bone (from the patient)
  - allogenic bone (from a donor)
  - natural / synthetic biomaterials (metals, ceramics polymers and composites).

- Two methods are used for BTE

i) Mesenchymal cells are allowed to grow on scaffolds (that provide structure and shape) alongwith signaling molecules.

ii) When cells get attached to the scaffold, they grow in to normal, healthy bone.

iii) When bone grows, the scaffold degrades.

B-) i) Some signaling molecules i.e. BMP's bone morphogenetic proteins are added to the scaffolds.

ii) These (BMP's) promote mesenchymal cells to grow in to bone cells (osteoblasts).

iii) The scaffold induces the growth of new bone, u implanted in to the dfect.