Biyani's Think Tank

Concept based notes

Cell Biology and Plant Breeding

(B.Sc. Part-II)

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Preface

I am glad to present this book, especially designed to serve the needs of the students. The book has been written keeping in mind the general weakness in understanding the fundamental concepts of the topics. The book is self-explanatory and adopts the "Teach Yourself" style. It is based on question-answer pattern. The language of book is quite easy and understandable based on scientific approach.

Any further improvement in the contents of the book by making corrections, omission and inclusion is keen to be achieved based on suggestions from the readers for which the author shall be obliged.

I acknowledge special thanks to Mr. Rajeev Biyani, *Chairman* & Dr. Sanjay Biyani, *Director* (*Acad.*) Biyani Group of Colleges, who are the backbones and main concept provider and also have been constant source of motivation throughout this Endeavour. They played an active role in coordinating the various stages of this Endeavour and spearheaded the publishing work.

I look forward to receiving valuable suggestions from professors of various educational institutions, other faculty members and students for improvement of the quality of the book. The reader may feel free to send in their comments and suggestions to the under mentioned address.

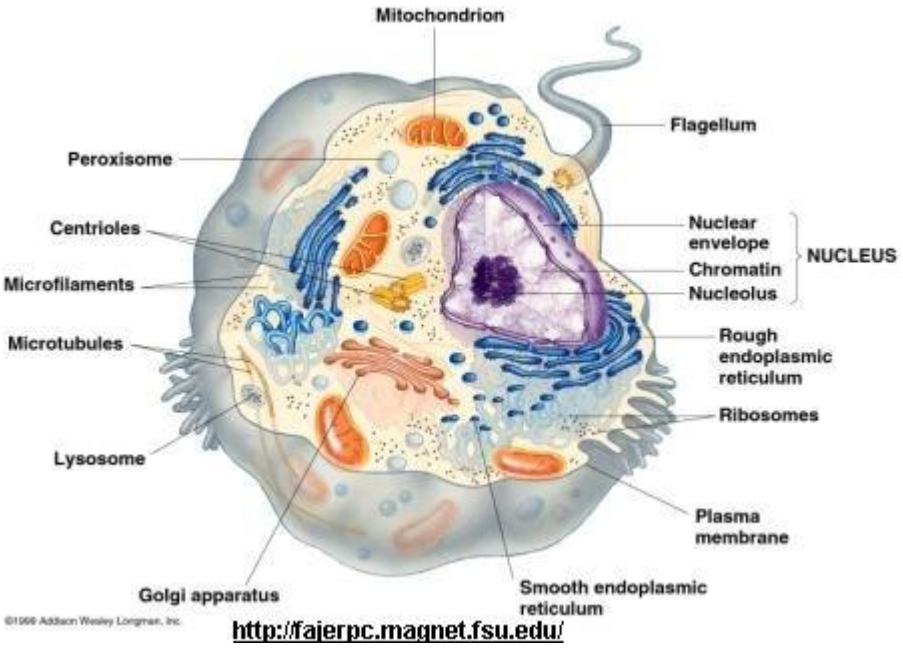
Author

Cell Biology

Q1. What is the difference between prokaryotic and eukaryotic cells ?

Ans **Prokaryotic cells:** Most primitive, earliest form of life

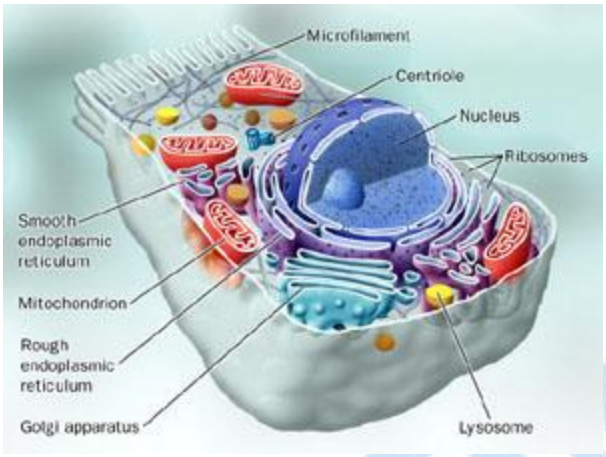
- Do not have a pre-defined nucleus
- Chromosomes are dispersed in the cytoplasm
- Contain no membrane-bound organelles
- Have circular chromosomes and lack histone proteins
- Most metabolically diverse
- Small - typically 1 - 5 micrometers in diameter
- Have a primitive cytosketetal structures or don't have a cytoskeleton at all
- Smaller (70S) ribosomes
- Don't undergo meiosis but reproduce sexually by the transfer of DNA fragments throughconjugation



Eukaryotic cells: More complex, evolved organsims

- Contain true nuclei in which chromosomes are compacted as chromatin
- Contain membrane-boundorganelles

- Have linear DNA and contain histone proteins
- Larger - typically 10-100 micrometers in diameter
- Have a complex cytosketeton
- Larger (80S) ribosom
- Reproduce sexually with the use of meiosis



Q2. Write about prokaryotic cell?

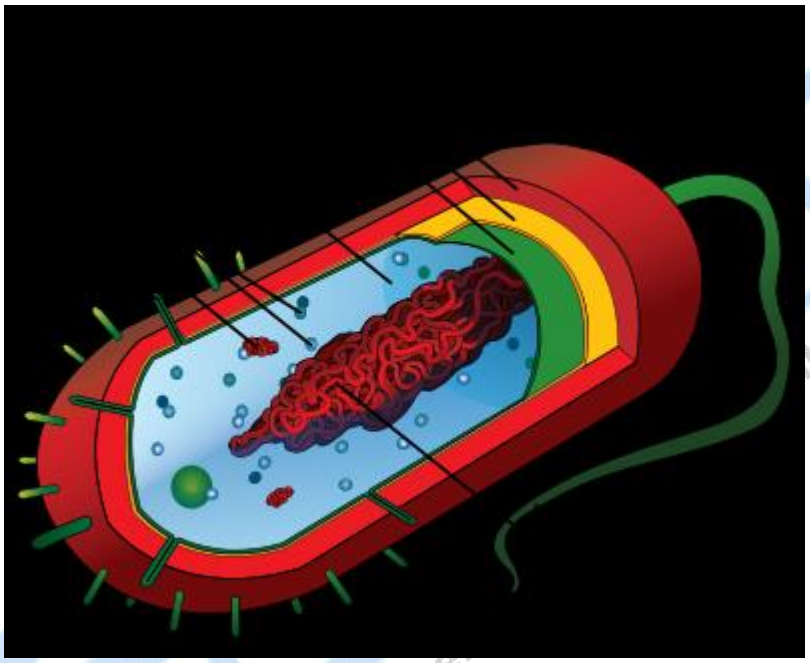
Ans The prokaryotic cell is simpler, and therefore smaller, than a eukaryote cell, lacking a nucleus and most of the other organelles of eukaryotes. There are two kinds of prokaryotes: bacteria and archaea; these share a similar structure.Nuclear material of prokaryotic cell consist of a single chromosome that is in direct contact with cytoplasm. Here, the undefined nuclear region in the cytoplasm is called nucleoid.

A prokaryotic cell has three architectural regions:

- On the outside, flagella and pili project from the cell's surface. These are structures (not present in all prokaryotes) made of proteins that facilitate movement and communication between cells;
- Enclosing the cell is the cell envelope – generally consisting of a cell wall covering a plasma membrane though some bacteria also have a further covering layer called a capsule. The envelope gives rigidity to the cell and separates the interior of the cell from its environment, serving as a protective filter. Though most prokaryotes have a cell wall, there are exceptions such as *Mycoplasma* (bacteria) and *Thermoplasma* (archaea). The cell wall consists of *peptidoglycan* in bacteria, and acts as an additional barrier against exterior forces. It also prevents the cell from expanding and finally bursting (cytolysis) from osmotic pressure

against a hypotonic environment. Some eukaryote cells (plant cells and fungi cells) also have a cell wall;

- Inside the cell is the cytoplasmic region that contains the cell genome (DNA) and ribosomes and various sorts of inclusions. A prokaryotic chromosome is usually a circular molecule (an exception is that of the bacterium *Borrelia burgdorferi*, which causes Lyme disease). Though not forming a *nucleus*, the DNA is condensed in a *nucleoid*. Prokaryotes can carry extrachromosomal DNA elements called *plasmids*, which are usually circular. Plasmids enable additional functions, such as antibiotic resistance.



Q3 Write about the organelles present in eukaryotic cell?

Ans The most noticeable feature that differentiates eukaryotes from prokaryotes is the presence of a nucleus, a double membrane-bound control center separating the genetic material, DNA (deoxyribonucleic acid), from the rest of the cell.

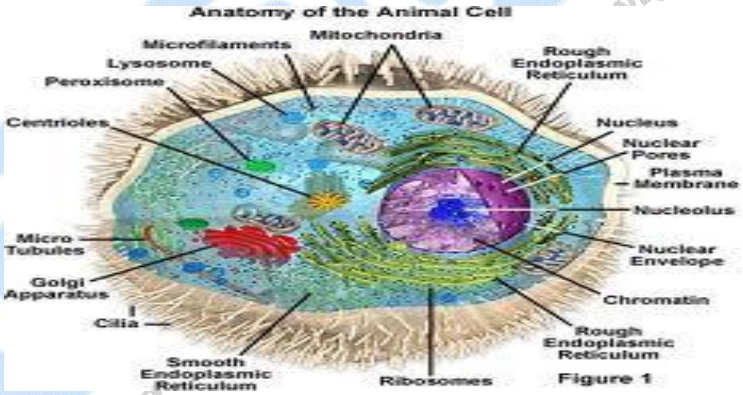
Plasma Membrane All cells have a plasma membrane, the structure separating the inside from the outside of the cell. It is a phospholipid bilayer, a double membrane composed of a unique type of lipid that spontaneously organizes into two layers. The plasma membrane controls traffic of materials into and out of the cell.

Cytoplasm The cytoplasm of eukaryotic cells, like that of prokaryotes, is a mixture of organic and inorganic materials; the fluid portion called cytosol..Eukaryotic cytosol is less viscous (not as thick) as that of prokaryotes, and is constantly in motion. The flowing movement, known as cytoplasmic streaming, allows organelles to interact with one another.

Cilia and Flagella These external appendages of the plasma membrane aid in locomotion of the cell, adhesion and movement of materials on the outside of the cell. Their internal structure consists of microtubules, and motility achieved by coordinated sliding movements of these microtubules.

Ribosomes These are the tiny cellular structures involved in making proteins under the instruction of DNA. Ribosomes are found attached to the rough endoplasmic reticulum or floating free in the cytoplasm.

Mitochondria & Chloroplasts Mitochondria are the powerhouses of the cell, where the final and most energy-productive steps of metabolism take place to generate cellular energy (ATP). Chloroplasts, possessed only by plants, are organelles containing the pigment chlorophyll. Chloroplasts harness sunlight and turn it into ATP energy. These energy-related organelles are believed to have evolved from prokaryotes that began living symbiotically within eukaryotic cells.

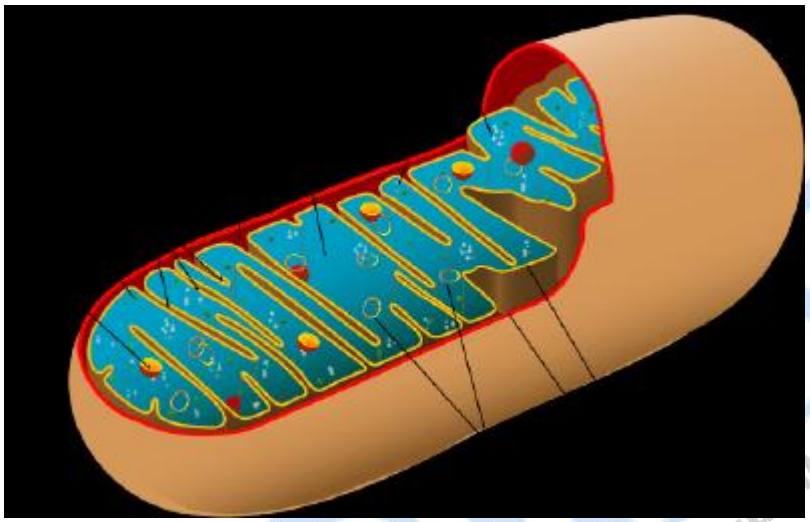


The Endomembrane System: Membrane-bound Organelles Eukaryotic cells also contain a network of internal membrane-bound structures, the organelles of the endomembrane system. These cellular organelles transport materials into, out of, and within the cell, carrying out many of the functions required for the cell to survive, thrive, grow and reproduce.

Q4. Write short notes on mitochondria?

Ans These are spherical or rod-shaped structure surrounded present in both plant and animal cells. These are surrounded by double membrane containing matrix. The

outer membrane is smooth and the inner membrane is folded into finger-like projection called cristae. Large numbers of knob-like structures are present in the inner membrane called oxysomes. The head of the oxysomes contains the enzymes of ATP synthesis. Electron transport occurs in inner membrane. ATP are synthesized and stored in mitochondria. Hence mitochondria are called as power house of cells.



Mitochondria are the powerhouse of cells.Their whole purpose is to break down the molecules in ATP (cell food) so the cell can have the energy it needs to live Mitochondria.its length is 3 to 4 micrometer & its diameter is 0.5 to 1 micrometer.Most of the cellular respiration takes place in mitochondria.

Mitochondria have tow membrane are as follows:
(i)Outer Membrane
(ii)Inner Membrane
The outer membrane & inner membrane is protect from Lipoprotein.
There is a space between the inner membrane & outer membrane called, not surprisingly, inter membrane space.

(i)Outer Membrane:
a. The outer membrane covers the mitochondria.
b.The outer membrane of cell are semipermeable or smooth which means that material can enter and leave the cell.

(ii)Inner Membrane:
a.The inner membrane of mitochondria are infolding or fingre like folding.These

folds are called Cristae.
b.The electron transport system is a series of protien imbedded on the cristae of mitochondria.

Cristae:
These cristae are important because they make more surface area where chemical reaction can take space.The molecules & some of the enzymes responsible for making ATP are located in & on the folds of these inner membrane.

Matrix:
a.The area inside the cristae is called the matrix.
b.The matrix is a fluid that has water & proteins (enzymes) all mixed together here's where the rest of the enzymes that make ATP come from.
c. The Krebs cycle occurs in the matrix while electron takes place on the cristae.

Q5. What are cells with a delimited nucleus called? What are the main elements of the nucleus?

Ans Cells with delimited nucleus are called eukaryotic cells. Organisms composed of one or more eukaryotic cells are called eukaryotes.The mains elements of the nucleus are the chromatin (made of DNA molecules), the nucleolus, the karyolymph, or nucleoplasm, and the nuclear membrane (or karyotheca).

Q6. What are heterochromatin and euchromatin?

Ans Chromatin is uncondensed nuclear DNA, the typical DNA morphology in interphase (the phase of the cell cycle in which the cells is not dividing itself). In this phase of the cell cycle chromatin can be found as heterochromatin, more condensed and dark (in electronic microscopy) portions of DNA molecules, and as euchromatin, less condensed and lighter portions of DNA molecules.

Since it is uncondensed the euchromatin is the biologically active portion of the DNA, i.e., the region that has active genes to be transcripted into RNA. The heterochromatin represents the inactive portions of the DNA molecule.

Q7. How are the concepts of chromosome, chromatin and chromatids related? In which phase of the cell cycle does DNA duplicate?

Ans. Chromatin is a set of filamentous DNA molecules dispersed in the karyoplasm forming euchromatin and heterochromatin portions. Each chromatin filament is a complete chromosome (a DNA molecule, or double helix). The chromatin of the human somatic cell is formed by 46 DNA molecules (22 homologous chromosomes and 1 pair of sex chromosomes).

In interphase the cell prepares itself for division and duplication of DNA molecules occurs. The duplication of every DNA molecule forms two

identical DNA double helix bound by a structure called centromere. In this phase each identical chromosome of these pairs is called chromatid. It is also during the interphase that the chromatids begin to condensate assuming the thicker and shorter shape typical of chromosome illustrations. So the phase of the cell cycle in which DNA duplicates is the interphase.chromosome a unique filament of chromatin as well as the condensed structure made of two identical chromatids after the DNA duplication. Rigorously the pair of identical chromatids bound in the centromere are two copies of the same chromosome and therefore they are two identical chromosomes (and not only one).

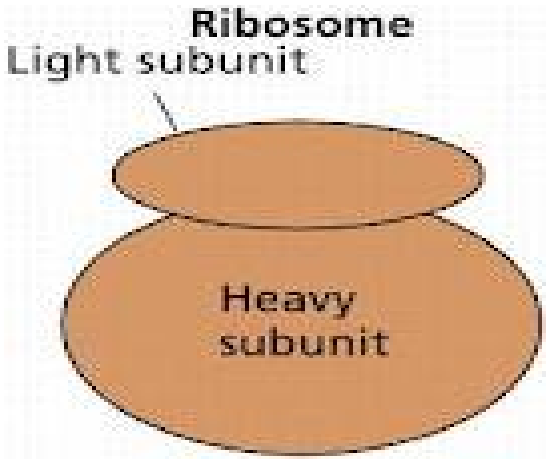
Q8. What are homologous chromosomes? Which are the human cells that do not have homologous chromosomes?

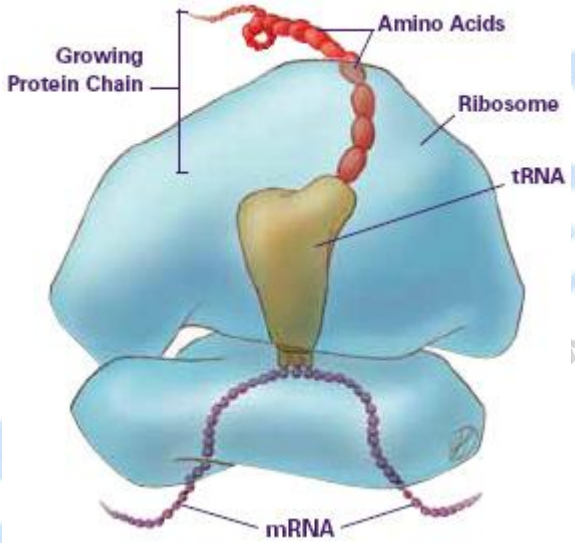
Ans. Chromosomes contain genes (genetic information in the form of nucleotide sequences) that command the protein synthesis thus regulating and controlling the activities of the cell. In the nucleus of somatic cells of diploid beings every chromosome has its correspondent homologous chromosome, both containing alleles of the same genes related to same functions. This occurs because one chromosome of one pair comes from the father and the other comes from the mother of the individual. The chromosomes that form a pair with alleles of the same genes are called homologous chromosomes. In humans, there are 22 pairs of homologous chromosomes plus the pair of sex chromosomes (the sex chromosomes are partially homologous).

The only human cells that do not have homologous chromosomes are the gametes since during meiosis the homologous chromosomes are separated.

Q9. What are Ribosomes?

Ans**.** Ribosomes are the protein-synthesizing complex of the cell and are present in all organisms from bacteria to man to green plants. Ribosomes have two subunits; the smaller subunit, 30 S for the bacterial and 40 S for the eukaryotic ribosome, containing a single ribosomal RNA and 21–33 proteins (depending on the organism), 15 of which share homology between 30 S and 40 S ribosomal subunits.1 The small ribosomal subunit is responsible for initial interactions with mRNA, and the correct positioning of the ribosome for translation start. mRNA



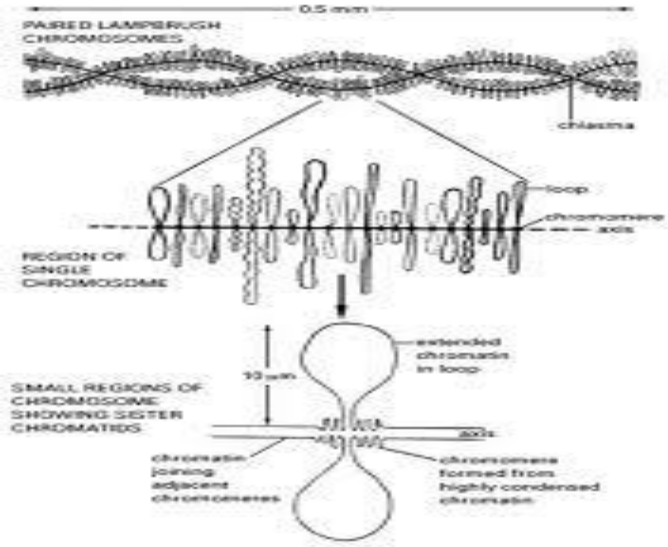


decoding and tRNA fidelity verification is carried out by the small subunit.2 The larger subunit of ribosomes, 50 S for the bacterial and 60 S for the eukaryotic ribosome, is composed of two orthree rRNAs and from 33 to 47 proteins, with 17 of these proteins conserved between 50 S and 60 S ribosomal subunits.1 The large subunit houses the peptidyl transferase reaction center and the nascent polypeptide exit tunnel.

Q.10. Write a short note on lampbrush chromosome.

Ans. A Lampbrush chromosome (first seen by Flemming in 1882) is the largest chromosome known and is found in the amphibian oocytes (immature eggs).Lampbrush chromosomes occur during the diplotene stage of meiosis I. They aremeiotic bivalents, each consisting of 2 sister chromatids. Lampbrush chromosomes are clearly visible even in the light microscope, where they are seen to be organized into a series of large chromatin loops emanating from a linear chromosomal axis. A given loop always contains the same DNA sequence, and it remains extended in the same manner as the oocyte grows. These chromosomes

are producinglarge amounts of RNA for the oocyte, and most of the genes present in the DNA loops are being actively expressed. The majority of the DNA, however, is not in loops but remains highly condensed in the chromomeres on the axis, where genes are generally not expressed. It is thought that the interphase chromosomes of all eucaryotes are similarly arranged in loops. Although these loops are normally too small and fragile to be easily observed in a light microscope, other methods can be used to infer their presence. For example, it has become possible to assess the frequency with which two loci along an interphase chromosome are paired with each other, thus revealing candidates for the sites on chromatin that form the closely apposed bases of loop structures. These experiments and others suggest that the DNA in human chromosomes is organized into loops of different lengths. A typical loop might contain between 50,000 and 200,000 nucleotide pairs of DNA, although loops of a million nucleotide pairs have also been suggested. Giant chromosomes in the lampbrush form are useful model for studying chromosome organization and gene expression during meiotic prophase



Q 11. Write short notes on polytene chromosome?

Ans. Polytene chromosomes are giant chromosomes common to many dipteran (two winged) flies. They begin as normal chromosomes, but through repeated rounds of DNA replication without any cell division (called endoreplication), they become large, banded chromosomes (see figure). For unknown reasons, the centromeric regions of the chromosomes do not endoreplicate very well. As a result, the centromeres of all the chromosomes bundle together in a mass called the chromocenter.

Polytene chromosomes are usually found in the larvae, where it is believed these many-replicated chromosomes allow for much faster larval growth than if the cells remained diploid. Simply because each cell now has many copies of each gene, it can transcribe at a much higher rate than with only two copies in diploid cells. The polytene chromosomes at the right are from the salivary glands of the fruit fly *Drosophila melanogaster*. the bands on each chromosome are like a road map, unique to each chromosome and well defined enough to allow high resolution mapping of each chromosome. The *Drosophila* Genome Project uses polytene chromosomes as a framework for the map.

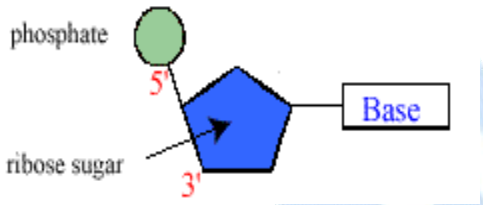
Q.12 Describe polyploidy.

Ans**.** The occurrence of related forms possessing chromosome numbers which are multiples of a basic number (n), the haploid number. Forms having 3n chromosomes are triploids; 4n, tetraploids; 5n,pentaploids, and so on. Autopolyploids are forms derived by the multiplication of chromosomes from a single diploid organism. As a result the homologous chromosomes come from the same source. These are distinguished from allopolyploids, which are forms derived from a hybrid between two diploid organisms. As a result, the homologous chromosomes come from different sources. About one-third of the species of vascular plants have originated at least partly by polyploidy, and as many more appear to have ancestries which involve ancient occurrences of polyploidy. The condition can be induced artificially with the drug colchicines and the production of polyploid individuals has become a valuable tool for plant breeding. In animals, most examples of polyploidy occur in groups which are parthenogenetic, or in species which reproduce asexually by fission.Breeding (plant), Chromosome aberration, Gene, Genetics, Plant evolution,Speciation In addition to polyploid organisms in which all of the body cells contain multiples of the basic chromosome number, most plants and animals contain particular tissues that are polyploid or polytene. Both polyploid and polytene cells contain extra copies of DNA, but they differ in the physical appearance of the chromosomes. In polytene cells the replicated copies of the DNA remain physically associated to

produce giant chromosomes that are continuously visible and have a banded pattern. The term polyploid has been applied to several types of cells: multinucleate cells; cells in which the chromosomes cyclically condense but do not undergo nuclear or cellular division (this process is termed endomitosis); and cells in which the chromosomes appear to be continually in interphase, yet the replicated chromosomes are not associated in visible polytene chromosomes.

Q 13. Give Outline for DNA nucleotide structure in terms of sugar (deoxyribose), base and phosphate?

Ans Sugar is deoxyribose which differs fro m ribose in having one less oxygen on carbon



- Phosphate is the PO_4^{-3} group.
- Bases are nitrogen based ring structures of which there are 4 different kinds.

Q14. State the names of the four bases in DNA.

Ans State means to give a specific name, value or other brief answer without explanation or calculation.Nucleosides are the combination of sugar and base only and are not required for the syllabus. You will however see the terms used in the literature.

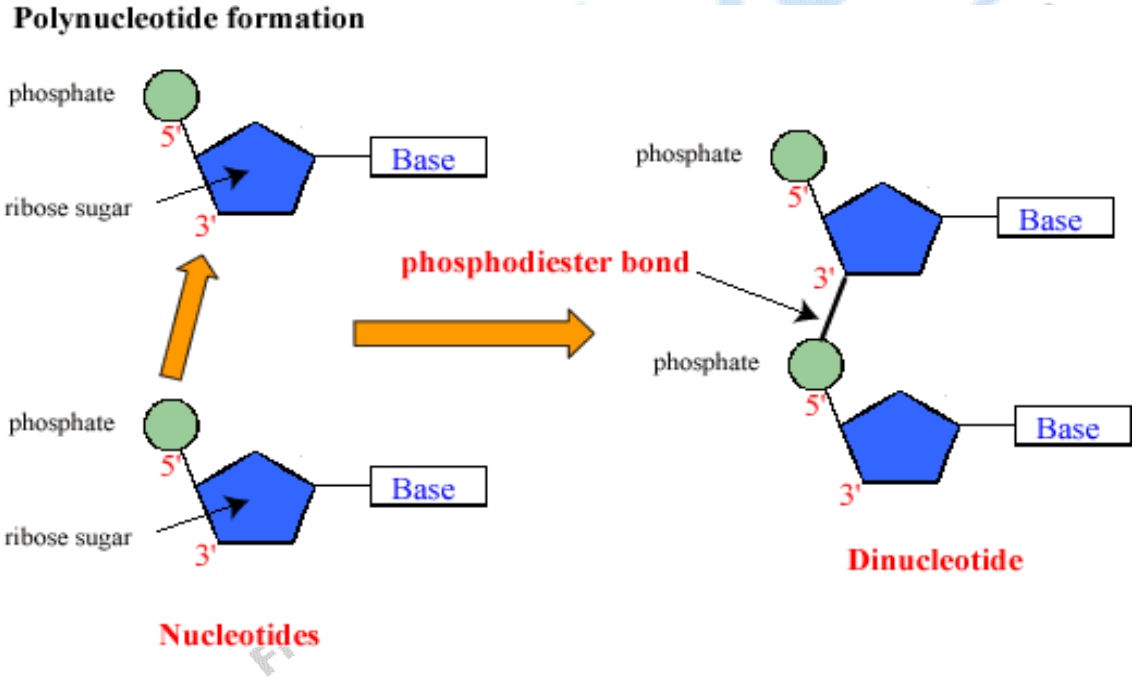
Base name	Nucleoside (s+b)	Abbreviation
Cytosine	Cytidine	C
Thymine	Thymidine	T
Adenine	Adenosine	A
Guanine	Guanosine	G

- These are the four bases which are universally found in living things.
- In 1950 Edwin Chargaff determined that within an organism there was same approx the same amount of A as T and the same amount of G=C.

- Chargaff surveyed a wide variety of organsims and found in the ratio of A:T, G:C consistently across the range of his specimens
- These ratios became known as Chargaff's ratio's and would later prove to be a significant clue to the structure of DNA.

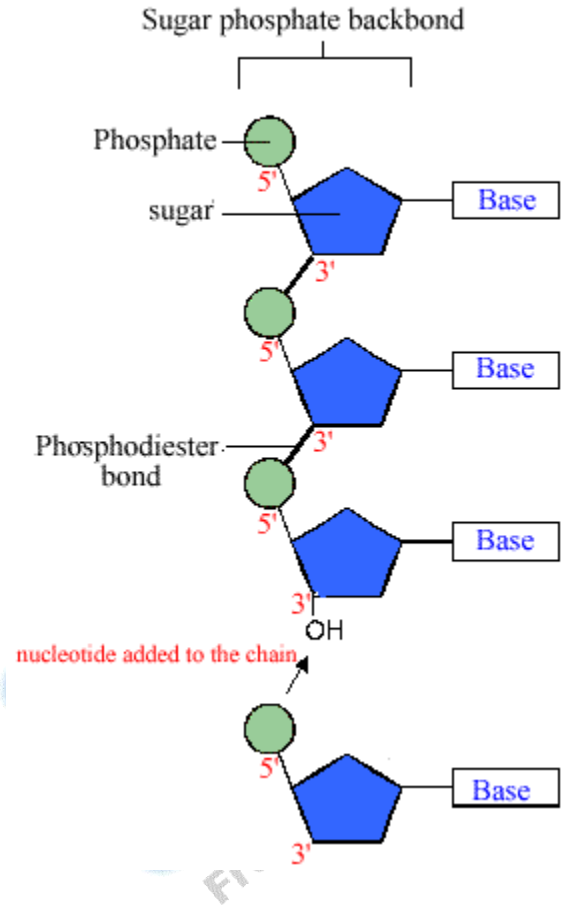
Q15 Outline how DNA nucleotides are linked together by covalent bonds into a single strand.

Ans.



DNA is composed of two polynucleotides chains.

- Nucleotides are covalently bonded between the phosphate of one nucleotide to the C3 of the second nucleotide.
- The phosphate group creates a bridge connecting C5 on one pentose with the C3 on the next pentose.
- The bond is a phosphodiester bond which indicates that there are two covalent bonds formed between the -OH and the acidic phosphate group



Polynucleotide The image is of one polynucleotide chain.

- The sugar phosphate backbone which provides the stable backbone of one of the helices.
- Covalent bonds that link the nucleotides along the backbone of the molecule.
- The bases projecting into the centre.
- At one end there is pentose with 5' (said "five prime") carbon which is free from bonding.
- At the other end there is a 3' carbon free from bonding to other nucleotides.
- Additional nucleotides are joined to the 3' end of the existing polynucleotide chain.

Q16 . Explain how a DNA double helix is formed using complementary base pairing and hydrogen bonds.

Ans. complementary means matching, is different from complimentary, which means being nice. You may recall that in 1950 Edwin Chargaff working in Columbia University USA had determined that the mass of the bases(in a DNA speciment) formed ratios of A:T and G:C. This held true when taking samples from

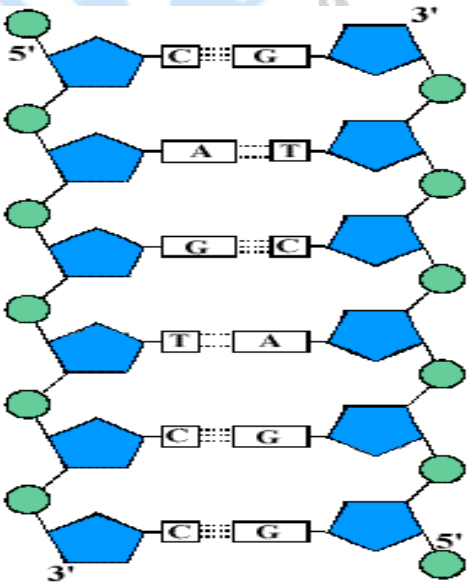
individuals within a population or when comparing species across large classification divides. In the cell of any organism the mass of Adenine seems to be about the same as the mass of Thymine. The mass of Cytosine seems to be about the same as the mass of Guanine.
Three years later the significance of *Chargaff's Rule* was realize by Watson and Crick at the Cavendish Laboratory in Cambridge, England. Watson an American geneticist and Crick an English physicist began model building DNA based on a collection of results from other researchers, including Chargaff. The model building technique uses the principles of chemistry such as molecular structure and bond angles as then developed by Linus Pauling. Together with the data from X-ray crystallography studies (the combined work of Wilkins and Franklin) they began to build DNA and part of that process involved the pairing of the bases in the centre of the helix.

Q17 Draw and label a simple diagram of the molecular structure of DNA.

Ans This image of DNA shows the arrangement of the two polynucleotide chains but not the helical shape which can be seen in the space filled model below**.**

This is image shows:

- Two polynucleotide chains.
- Two anti-parallel chains.



a) The number followed by the (') determined the carbon in deoxyribose free from bonding another nucleotide. prime to

b) two chains are in opposite directions 3' to 5' is parallel to chain. 5' to 3'

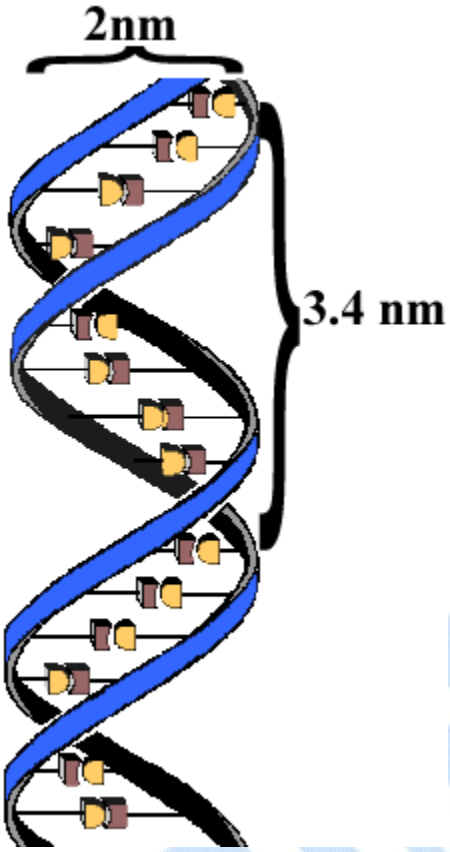
- The anti-parallel chains have a uniform distance (2nm) between the outside

  of the two sugar phosphate backbones

- Complementary base pairs: Inside the double helix bases form one strand hydrogen bond to bases on the opposite strand but always in the following way:

a) Adenine hydrogen binds to Thymine

b) Cytosine hydrogen bonds to Guanine



The three-dimensional structure of DNA was discovered in 1953 by Watson and Crick in Cambridge, using the experimental data of Wilkins and Franklin in London, for which work they won a Nobel prize. Ms Franklin however died before the award and the Nobel Prize is never awarded posthumously.

The main features of the structure are:

- DNA is double-stranded, so there are two polynucleotide stands alongside each other.
- The strands are antiparallel, i.e. they run in opposite directions thus 5' to 3' is parallel to 3' to 5'.
- The two strands are wound round each other to form a double helix (not a spiral, despite what some textbooks say).
- The two strands are joined together by hydrogen bonds between the bases.
- The bases therefore form base pairs, which are like rungs of a ladder.
- The base pairs are specific. A only binds to T (and T with A), and C only binds to G (and G with C).
  - These are called complementary base pairs (or sometimes Watson-Crick base pairs). (A-T and G-C)
  - This means that whatever the sequence of bases along one strand, the sequence of bases on the other stand must be complementary to it.

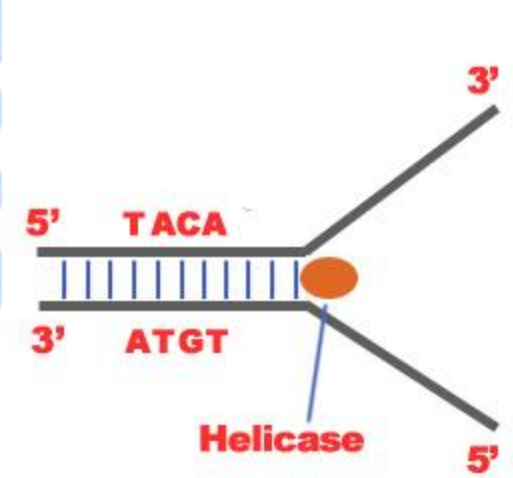
Q18. What is DNA Replication?

Ans **DNA replication** is a biological process that occurs in all living organisms and copies their DNA; it is the basis for biological inheritance. The process starts with one double-stranded DNA molecule and produces two identical copies of the molecule. Each strand of the original double-stranded DNA molecule serves as template for the production of the complementary strand. Cellular proofreading

and error toe-checking mechanisms ensure near perfect fidelity for DNA replication. In a cell, DNA replication begins at specific locations in the genome, called "origins".Unwinding of DNA at the origin, and synthesis of new strands, forms a replication fork. In addition to DNA polymerase, the enzyme that synthesizes the new DNA by adding nucleotides matched to the template strand, a number of other proteins are associated with the fork and assist in the initiation and continuation of DNA synthesis. DNA replication can also be performed *in vitro* (artificially, outside a cell). DNA polymerases, isolated from cells, and artificial DNA primers are used to initiate DNA synthesis at known sequences in a template molecule. The polymerase chain reaction (PCR), a common laboratory technique, employs such artificial synthesis in a cyclic manner to amplify a specific target DNA fragment from a pool of DNA.

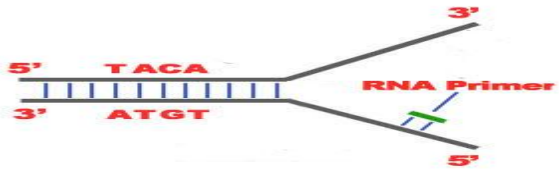
Steps of DNA Replication

1)The first major step for the **DNA Replication** to take place is the breaking of hydrogen bonds between bases of the two antiparallel strands. The unwounding of the two strands is the starting point. The splitting happens in places of the chains which are rich in A-T. That is because there are only two bonds between Adenine and Thymine (there are three hydrogen bonds between Cytosine and Guanine). **Helicase** is the enzyme that splits the two strands. The initiation point where the splitting starts is called "origin of replication".The structure that is created is known as "**Replication Fork**".

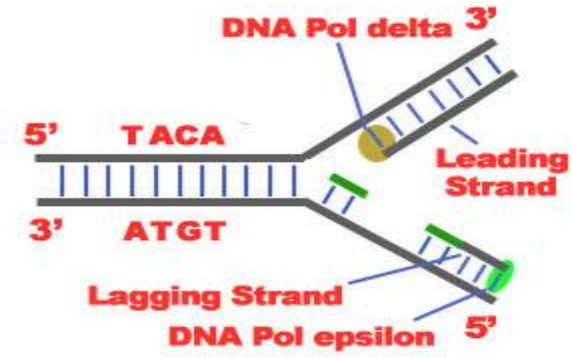


2) One of the most important **steps of DNA Replication** is the binding of **RNA Primase** in the the initiation point of the 3'-5' parent chain. **RNA Primase** can

attract RNA nucleotides which bind to the DNA nucleotides of the 3'-5' strand due to the hydrogen bonds between the bases. RNA nucleotides are the primers (starters) for the binding of DNA nucleotides

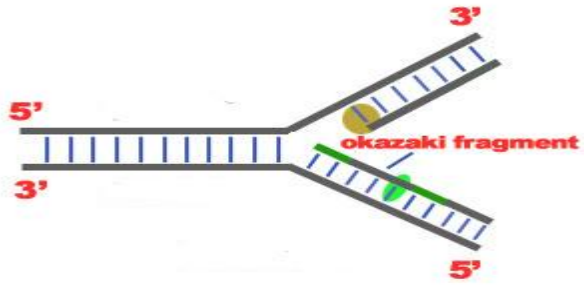


3) The **elongation** process is different for the 5'-3' and 3'-5' template. a)**5'-3' Template**: The 3'-5' proceeding daughter strand -that uses a **5'-3' template**- is called **leading strand** because **DNA Polymerase ä** can "read" the template and continuously adds nucleotides (complementary to the nucleotides of the template, for example Adenine opposite to Thymine etc).



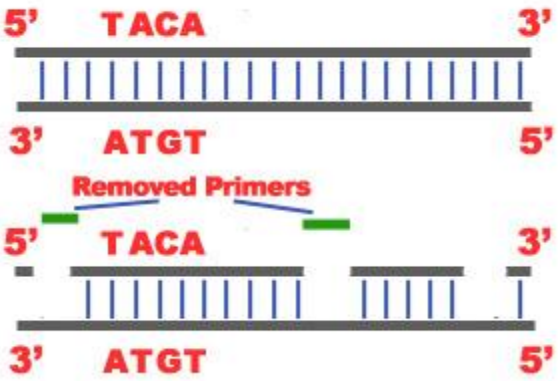
b)**3'-5'Template**: The **3'-5' template** cannot be "read" by DNA Polymerase ä. The replication of this template is complicated and the new strand is called **lagging strand**. In the lagging strand the RNA Primase adds more RNA Primers. **DNA polymerase å** reads the template and lengthens the bursts. The gap between two RNA primers is called "**Okazaki Fragments**".

The RNA Primers are necessary for DNA Polymerase å to bind Nucleotides to the 3' end of them. The daughter strand is elongated with the binding of more DNA nucleotides.



4) In the lagging strand the **DNA Pol I -exonuclease-** reads the fragments and removes the RNA Primers. The gaps are closed with the action of DNA Polymerase (adds complementary nucleotides to the gaps) and DNA Ligase (adds phosphate in the remaining gaps of the phosphate - sugar backbone).

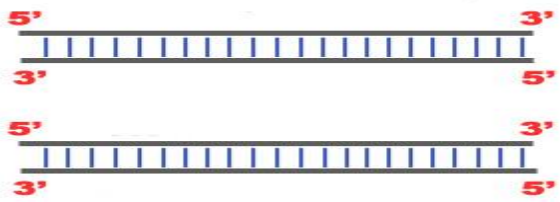
Each new double helix is consisted of one old and one new chain. This is what we call **semiconservative replication**.



5) The last **step of DNA Replication** is the **Termination**. This process happens when the DNA Polymerase reaches to an end of the strands. We can easily understand that in the last section of the lagging strand, when the RNA primer is removed, it is not possible for the DNA Polymerase to seal the gap (because there is no primer). So, the end of the parental strand where the last primer binds isn't replicated. These ends of linear (chromosomal) DNA consists of noncoding DNA that contains repeat sequences and are called **telomeres**. As a result, a part of the telomere is removed in every cycle of DNA Replication.

6) The DNA Replication is not completed before a **mechanism of repair** fixes

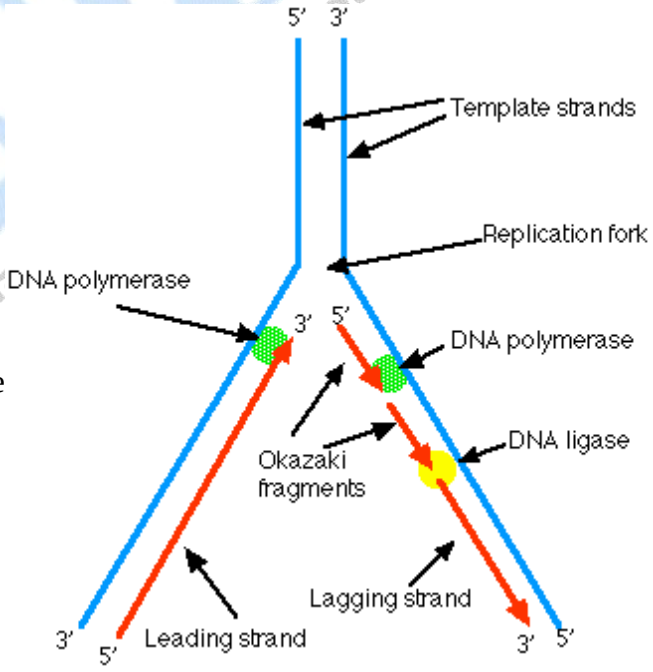
possible errors caused during the replication. Enzymes like **nucleases** remove the wrong nucleotides and the DNA Polymerase fills the gaps.



Similar processes also happen during the **steps of DNA Replication** of prokaryotes though there are some differences.

The Enzymes

A portion of the double helix is unwound by a **helicase**.



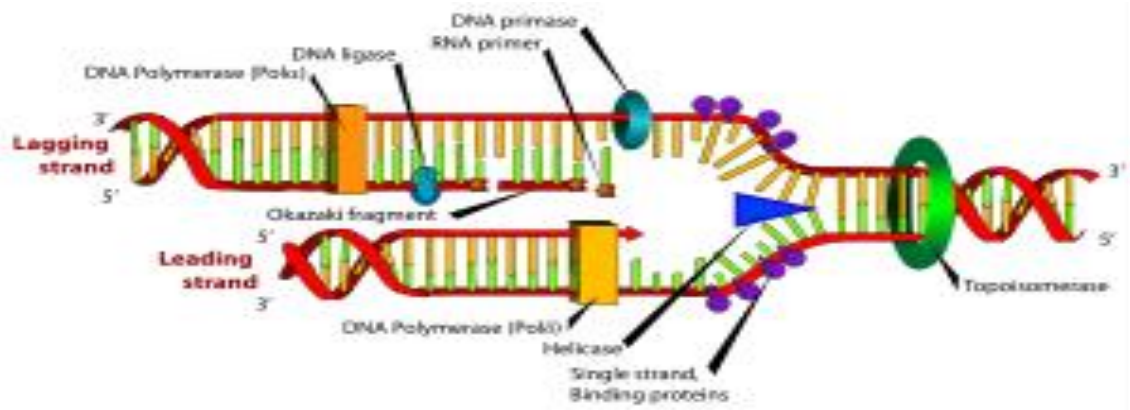
- A molecule of a **DNA polymerase** binds to one strand of the DNA and begins moving along it in the 3' to 5' direction, using it as a template for assembling a **leading strand** of nucleotides and reforming a double helix. In eukaryotes, this molecule is called DNA polymerase delta (δ).
- Because DNA synthesis can only occur 5' to 3', a molecule of a second type of DNA polymerase (epsilon, ε, in eukaryotes) binds to the other template strand as the double helix opens. This molecule must synthesize discontinuous segments of polynucleotides (called Okazaki fragments). Another enzyme, **DNA ligase I** then stitches these together into the **lagging strand**.

DNA Replication is Semiconservative

When the replication process is complete, two DNA molecules — identical to each other and identical to the original — have been produced. Each strand of the original molecule has

- remained intact as it served as the template for the synthesis of
- a complementary strand.

This mode of replication is described as semi-conservative: one-half of each new molecule of DNA is old; one-half new.



Many enzymes are involved in the DNA replication fork.The replication fork is a structure that forms within the nucleus during DNA replication. It is created by helicases, which break the hydrogen bonds holding the two DNA strands together. The resulting structure has two branching "prongs", each one made up of a single strand of DNA. These two strands serve as the template for the leading and lagging strands, which will be created as DNA polymerase matches complementary nucleotides to the templates; The templates may be properly referred to as the leading strand template and the lagging strand template.

Leading strand

The leading strand is the template strand of the DNA double helix so that the replication fork moves along it in the 3' to 5' direction. This allows the newly synthesized strand complementary to the original strand to be synthesized 5' to 3' in the same direction as the movement of the replication fork.On the leading strand, a polymerase "reads" the DNA and adds nucleotides to it continuously. This polymerase is DNA polymerase III (DNA Pol III) in prokaryotes and presumably Pol ε in eukaryotes.

Lagging strand

The lagging strand is the strand of the template DNA double helix that is oriented so that the replication fork moves along it in a 5' to 3' manner. Because of its orientation, opposite to the working orientation of DNA polymerase III, which moves on a template in a 3' to 5' manner, replication of the lagging strand is more complicated than that of the leading strand.On the lagging strand, primase "reads" the DNA and adds RNA to it in short, separated segments. In eukaryotes, primase is intrinsic to Pol α.DNA polymerase III or Pol δ lengthens the primed segments, forming Okazaki fragments. Primer removal in eukaryotes is also performed by Pol δ.In prokaryotes, DNA polymerase I "reads" the fragments, removes the RNA using its flap endonuclease domain (RNA primers are removed by 5'-3' exonuclease activity of polymerase I [weaver, 2005], and replaces the RNA nucleotides with DNA nucleotides (this is necessary because RNA and DNA use slightly different kinds of nucleotides). DNA ligase joins the fragments together

Q19 What is genetic code?

Ans The sequence of nucleotides in DNA or RNA that determines the specific amino acid sequence in the synthesis of proteins. It is the biochemical basis of heredity and nearly universal in all organisms.The rules by which the base sequences of deoxyribonucleic acid (DNA) are translated into the amino acid sequences of proteins. Each sequence of DNA that codes for a protein is transcribed or copied into messenger ribonucleic acid (mRNA). Following the rules of the code, discrete elements in the mRNA, known as codons, specify each of the 20 different amino acids that are the constituents of proteins. During translation, another class of RNAs, called transfer RNAs (tRNAs), are coupled to amino acids, bind to the mRNA, and, in a step-by-step fashion provide the amino acids that are linked together in the order called for by the mRNA sequence. The specific attachment of each amino acid to the appropriate tRNA, and the precise pairing of tRNAs via their anticodons to the correct codons in the mRNA, form the basis of the genetic code. *See also* Deoxyribonucleic acid (DNA); Protein; Ribonucleic acid (RNA). The genetic information in DNA is found in the sequence or order of four bases that are linked together to form each strand of the two-stranded DNA molecule. The bases of DNA are adenine, guanine, thymine, and cytosine, which are abbreviated as A, G, T, and C. Chemically, A and G are purines, and C and T are pyrimidines. The two strands of DNA are wound about each other in a double helix that looks like a twisted ladder. Each rung of the ladder is formed by two bases, one from each strand, that pair with each other by means of hydrogen bonds. For a good fit, a pyrimidine must pair with a purine; in DNA, A bonds with T, and G bonds with C. Ribonucleic acids such as mRNA or tRNA also comprise four bases, except that in RNA the pyrimidine uracil (U) replaces thymine. During transcription a single-stranded mRNA copy of one strand of the DNA is made.

If two bases at a time are grouped together, then only 4 × 4 or 16 different combinations are possible, a number that is insufficient to code for all 20 amino acids that are found in proteins. However, if the four bases are grouped together in threes, then there are 4 × 4 × 4 or 64 different combinations. Read sequentially without overlapping, those groups of three bases constitute a codon, the unit that codes for a single amino acid.

The 64 codons can be divided into 16 families of four (see illustration), in which each codon begins with the same two bases. With the number of codons exceeding the number of amino acids, several codons can code for the same amino acid. Thus, the code is degenerate. In eight instances, all four codons in a family specify the same amino acid. In the remaining families, the two codons that end with the pyrimidines U and C often specify one amino acid, whereas the two codons that end with the purines A and G specify another. Furthermore, three of the codons, UAA, UAG, and UGA, do not code for any amino acid but instead signal the end of the protein chain.

	U	C	A	G
U	UUU, UUC — Phe UUA, UUG — Leu	UCU, UCC, UCA, UCG — Ser	UAU, UAC — Tyr UAA, UAG — *Stop*	UGU, UGC — Cys UGA — *Stop* UGG — Trp
C	CUU, CUC, CUA, CUG — Leu	CCU, CCC, CCA, CCG — Pro	CAU, CAC — His CAA, CAG — Gln	CGU, CGC, CGA, CGG — Arg
A	AUU, AUC, AUA — Ile AUG — Met	ACU, ACC, ACA, ACG — Thr	AAU, AAC — Asn AAA, AAG — Lys	AGU, AGC — Ser AGA, AGG — Arg
G	GUU, GUC, GUA, GUG — Val	GCU, GCC, GCA, GCG — Ala	GAU, GAC — Asp GAA, GAG — Glu	GGU, GGC, GGA, GGG — Gly

phenylalanine (Phe), leucine (Leu), isoleucine (Ile), methionine (Met), valine (Val), serine (Ser), proline (Pro), threonine (Thr), alanine (Ala), tyrosine (Tyr), histidine (His), glutamine (Gln), asparagine (Asn), lysine (Lys), aspartic acid (Asp), glutamic acid (Glu), cysteine (Cys), tryptophan (Trp), arginine (Arg), and glycine (Gly)."> *Universal (standard) genetic code. Each of the 64 codons found in mRNA specifies an amino acid (indicated by the common three-letter abbreviation) or the end of the protein chain (stop). The amino acids are phenylalanine (Phe), leucine (Leu), isoleucine (Ile), methionine (Met), valine (Val), serine (Ser), proline (Pro), threonine (Thr), alanine (Ala), tyrosine (Tyr), histidine (His),*

glutamine (Gln), asparagine (Asn), lysine (Lys), aspartic acid (Asp), glutamic acid (Glu), cysteine (Cys), tryptophan (Trp), arginine (Arg), and glycine (Gly).

On the ribosome, the nucleic acid code of an mRNA is converted into an amino acid sequence with the aid of tRNAs. These RNAs are relatively small nucleic acids, varying from 75 to 93 bases in length, that are folded in three dimensions to form an L-shaped molecule to which an amino acid can be attached. At the other end of the tRNA molecule, three bases are free to pair with a codon in the mRNA. These three bases of a tRNA constitute the anticodon. Each amino acid has one or more tRNAs, and because of the degeneracy of the code, many of the tRNAs for a specific amino acid have different anticodon sequences. However, the tRNAs for one amino acid are capable of pairing their anticodons only with the codon or codons in the mRNA that specify that amino acid. The tRNAs act as interpreters of the code, providing the correct amino acid in response to each codon by virtue of precise codon-anticodon pairing. The tRNAs pair with the codons and sequentially insert their amino acids in the exact order specified by the sequence of codons in the mRNA.
The rules of the genetic code are virtually the same for all organisms, but there are some interesting exceptions. In the microorganism *Mycoplasma capricolum*, UGA is not a stop codon; instead it codes for tryptophan. This alteration in the code is also found in the mitochondria of some organisms. In addition to changes in the meanings of codons, a modified system for reading codons that requires fewer tRNAs is found in mitochondria. *See also* Gene; Gene action; Genetics.

Q20 What is cytoplasmic inheritance ?

Ans The control of genetic difference by genes carried in cytoplasmic organelles such as mitochondria or chloroplasts. Also known as extrachromosomal inheritance.

Q21 Explain Mendelian inheritance?

Ans **Mendelian inheritance** (or **Mendelian genetics** or **Mendelism**) is a scientific description of how hereditary characteristics are passed from parent organisms to their offspring; it underlies much of genetics. This theoretical framework was initially derived from the work of Gregor Johann Mendel published in 1865 and 1866 which was *re-discovered* in 1900; it was initially very controversial. When Mendel's theories were integrated with the chromosome theory of inheritance by Thomas Hunt Morgan in 1915, they became the core of classical genetics.

Mendel's Laws

Mendel discovered that when crossing white flower and purple flower plants, the result is not a blend. Rather than being a mix of the two, the offspring was purple flowered. He then conceived the idea of heredity units, which he called "factors",

one of which is a recessive characteristic and the other dominant. Mendel said that factors, later called genes, normally occur in pairs in ordinary body cells, yet segregate during the formation of sex cells. Each member of the pair becomes part of the separate sex cell. The dominant gene, such as the purple flower in Mendel's plants, will hide the recessive gene, the white flower. After Mendel self-fertilized the F1 generation and obtained the 3:1 ratio, he correctly theorized that genes can be paired in three different ways for each trait: AA, aa, and Aa. The capital "A" represents the dominant factor and lowercase "a" represents the recessive. (The last combination listed above, Aa, will occur roughly twice as often as each of the other two, as it can be made in two different ways, Aa or aA.)

Mendel stated that each individual has two factors for each trait, one from each parent. The two factors may or may not contain the same information. If the two factors are identical, the individual is called homozygous for the trait. If the two factors have different information, the individual is called heterozygous. The alternative forms of a factor are called alleles. The genotype of an individual is made up of the many alleles it possesses. An individual's physical appearance, or phenotype, is determined by its alleles as well as by its environment. An individual possesses two alleles for each trait; one allele is given by the female parent and the other by the male parent. They are passed on when an individual matures and produces gametes: egg and sperm. When gametes form, the paired alleles separate randomly so that each gamete receives a copy of one of the two alleles. The presence of an allele doesn't promise that the trait will be expressed in the individual that possesses it. In heterozygous individuals the only allele that is expressed is the dominant. The recessive allele is present but its expression is hidden.

Mendel summarized his findings in two laws; the **Law of Segregation** and the **Law of Independent Assortment**.

Law of Segregation (The "First Law")

The Law of Segregation states that every individual possesses a pair of alleles for any particular trait and that each parent passes a randomly selected copy (allele) of only one of these to its offspring. The offspring then receives its own pair of alleles for that trait. Whichever of the two alleles in the offspring is dominant determines how the offspring expresses that trait (e.g. the color of a plant, the color of an animal's fur, the color of a person's eyes).

More precisely the law states that when any individual produces gametes, the copies of a gene separate so that each gamete receives only one copy (allele). A gamete will receive one allele or the other. The direct proof of this was later found following the observation of meiosis by two independent scientists, the German botanist, Oscar Hertwig in 1876, and the Belgian zoologist, Edouard Van

Beneden in 1883. In meiosis, the paternal and maternal chromosomes get separated and the alleles with the traits of a character are segregated into two different gametes.

OR

The two coexisting alleles of an individual for each trait segregate (separate) during gamete formation so that each gamete gets only one of the two alleles. Alleles again unite at random fertilization of gametes.

Law of Independent Assortment (The "Second Law")

The Law of Independent Assortment, also known as "Inheritance Law" states that separate genes for separate traits are passed independently of one another from parents to offspring. That is, the biological selection of a particular gene in the gene pair for one trait to be passed to the offspring has nothing to do with the selection of the gene for any other trait. More precisely the law states that alleles of different genes assort independently of one another during gamete formation. While Mendel's experiments with mixing one trait always resulted in a 3:1 ratio (Fig. 1) between dominant and recessive phenotypes, his experiments with mixing two traits (dihybrid cross) showed 9:3:3:1 ratios (Fig. 2). But the 9:3:3:1 table shows that each of the two genes are independently inherited with a 3:1 phenotypic ratio. Mendel concluded that different traits are inherited independently of each other, so that there is no relation, for example, between a cat's color and tail length. This is actually only true for genes that are not linked to each other.

Independent assortment occurs during meiosis I in eukaryotic organisms, specifically metaphase I of *meiosis*, to produce a gamete with a mixture of the organism's maternal and paternal chromosomes. Along with chromosomal crossover, this process aids in increasing genetic diversity by producing novel genetic combinations.

Of the 46 chromosomes in a normal diploid human cell, half are maternally-derived (from the mother's egg) and half are paternally-derived (from the father's sperm). This occurs as sexual reproduction involves the fusion of two haploid gametes (the egg and sperm) to produce a new organism having the full complement of chromosomes. During gametogenesis—the production of new gametes by an adult—the normal complement of 46 chromosomes needs to be halved to 23 to ensure that the resulting haploid gamete can join with another gamete to produce a diploid organism. An error in the number of chromosomes, such as those caused by a diploid gamete joining with a haploid gamete, is termed aneuploidy.

In independent assortment the chromosomes that end up in a newly-formed gamete are randomly sorted from all possible combinations of maternal and paternal chromosomes. Because gametes end up with a random mix instead of a pre-defined "set" from either parent, gametes are therefore considered assorted independently. As such, the gamete can end up with any combination of paternal or maternal chromosomes. Any of the possible combinations of gametes formed from maternal and paternal chromosomes will occur with equal frequency. For human gametes, with 23 pairs of chromosomes, the number of possibilities is 2^{23} or 8,388,608 possible combinations.The gametes will normally end up with 23 chromosomes, but the origin of any particular one will be randomly selected from paternal or maternal chromosomes. This contributes to the genetic variability of progeny.

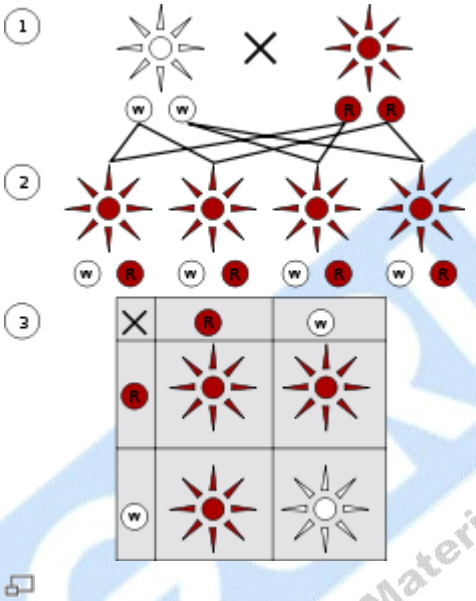


Figure 1: Dominant and recessive phenotypes.
(1) Parental generation. (2) F_1 generation. (3) F_2 generation. Dominant (red) and recessive (white) phenotype look alike in the F_1 (first) generation and show a 3:1 ratio in the F_2 (second) generation

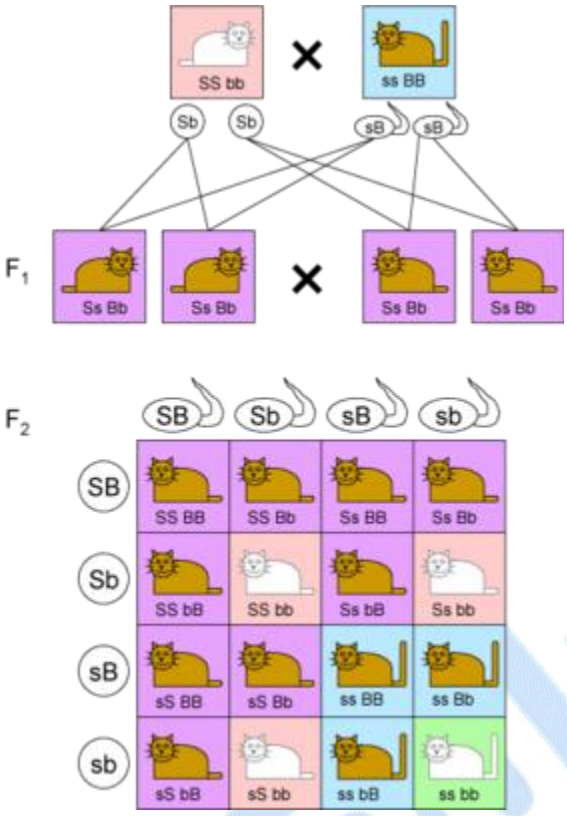


Figure 2: The phenotypes of two independent traits show a 9:3:3:1 ratio in the F_2 generation. In this example, coat color is indicated by **B** (brown, dominant) or **b** (white) while tail length is indicated by **S** (short, dominant) or **s** (long). When parents are homozygous for each trait ('*SSbb* ***and*** *ssBB*), their children in the F_1 generation are heterozygous at both loci and only show the dominant phenotypes. If the children mate with each other, in the F_2 generation all combination of coat color and tail length occur: 9 are brown/short (purple boxes), 3 are white/short (pink boxes), 3 are brown/long (blue boxes) and 1 is white/long (green box).

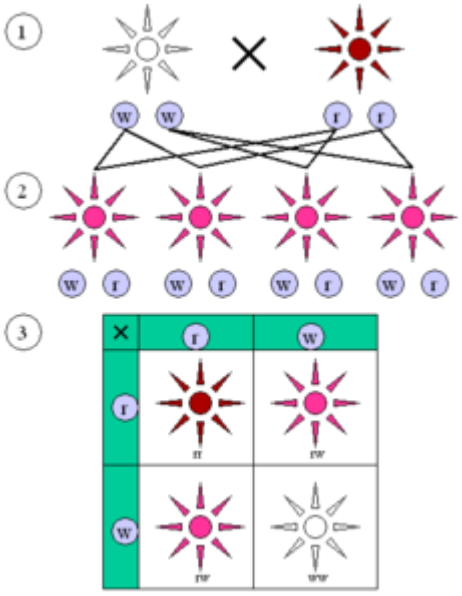


Figure 3: The color alleles of *Mirabilis jalapa* are not dominant or recessive. (1) Parental generation. (2) F_1 generation. (3) F_2 generation. The "red" and "white" allele together make a "pink" phenotype, resulting in a 1:2:1 ratio of red:pink:white in the F_2 generation.

Plant Breeding

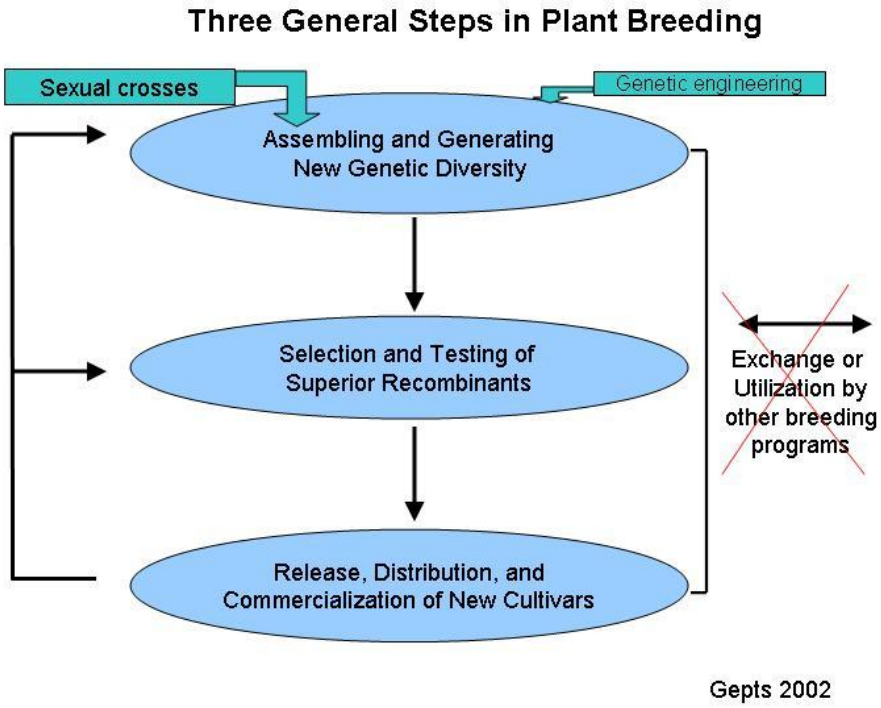
Q.1. What do you understand by plant breeding?

Ans. Plant breeding is the art and science of changing the genetics of plants in order to produce desired characteristics. Plant breeding can be accomplished through many different techniques ranging from simply selecting plants with desirable characteristics for propagation, to more complex molecular techniques.

Plant breeding has been practiced for thousands of years, since near the beginning of human civilization. It is now practiced worldwide by individuals such as gardeners and farmers, or by professional plant breeders employed by organizations such as government institutions, universities, crop-specific industry associations or research centers.

Q.2. Why plant breeding is so necessary? Discuss its objectives.

Ans. There is enormous potential for plant breeding to benefit less developed parts of the world, where food security is critical as populations continue to increase. In particular, advances in genetic technology may offer more versatile solutions than conventional systems of crop improvement. For example, scientists in Britain are pioneering important research to develop salt and drought tolerance in crop plants. This may help to alleviate the devastating effects of crop failure in arid regions such as sub-Saharan Africa. Private and public sector initiatives to share knowledge and expertise are already in place. They include commitments to provide Vitamin A enhanced rice and virus resistance in sweet potatoes free of charge to developing countries. International arrangements to recognize genetic resources as the sovereign property of individual nation states will stimulate further programmes of technology transfer and benefit sharing between industrialised and less developed regions of the world.



The constant aim of plant breeding is to improve the quality, diversity and performance of agricultural and horticultural crops. The overriding objective is to develop plants better adapted to human needs.

The major objectives of plant breeding are the following-

I. To improve a certain trait in a species or to incorporate into or delete from a species a certain trait
   a. Increased productivity
   b. Increased quality

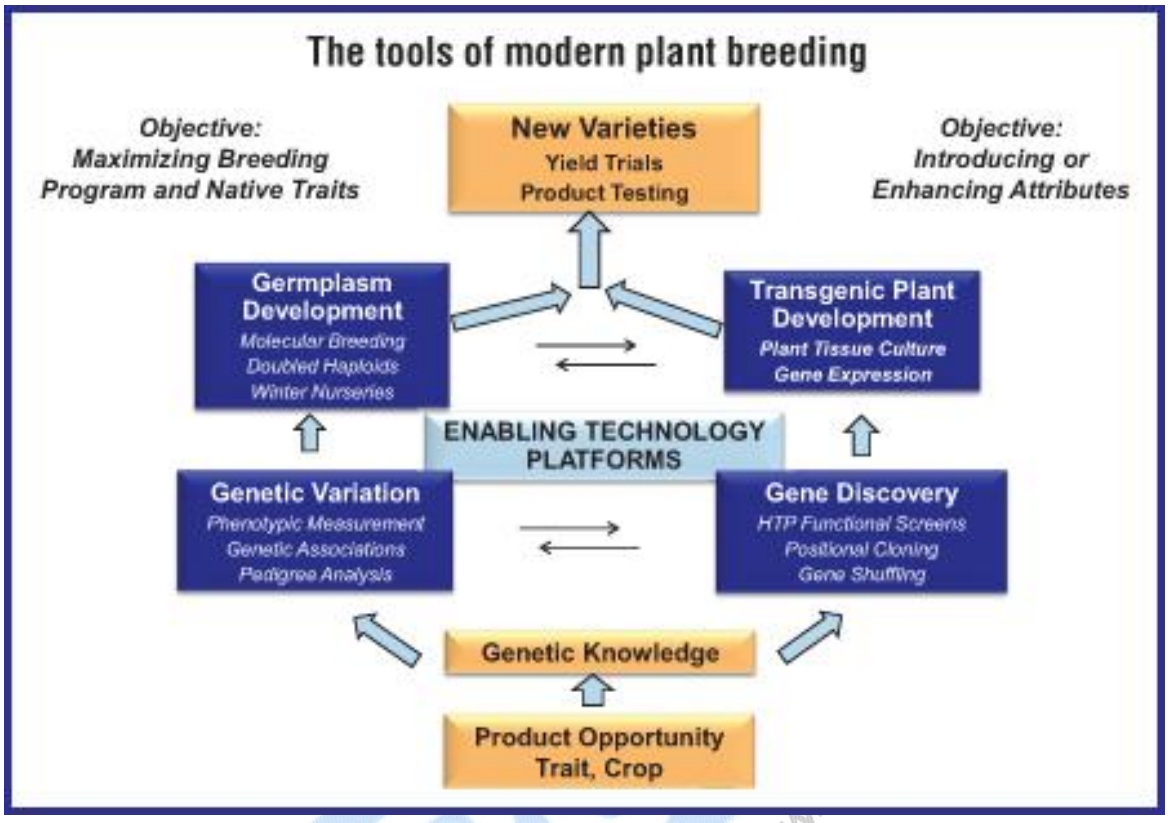
II. Ability to improve crop based on two assumptions:
   a. Genetic variations exists

III. Adapted cultivars, breeder stock, wild plants, mutations, previously crossed plants, and introductions from other parts of the world

IV. Techniques exist for getting a favorable combination of genes

Q.3. Enlist various methods of plant breeding?

Ans. The creation of each new variety is a complex, costly and skilled operation. It is also painstakingly slow – today's breeding programmes are already looking ten years ahead to the needs of farmers, consumers and the environment at the end of the next decade and beyond. Techniques vary between crop species, but the scientific principles of plant breeding remain unchanged from Mendel's first discovery that selected parent plants can be cross-pollinated to combine desired characteristics. Various breeding methods used in plant breeding are listed below.



- Plant introduction method
- Pure line selection – Selection method
- Mass selection – Selection method
- Pedigree method – Method used to handle segregating generations
- Bulk method – Method used to handle segregating generations
- Back cross method – Method used to handle segregating generations
- Single seed descent method – Modification of bulk method
- Hybridization
- Recurrent selection
- Clonal breeding
- Mutation breeding
- Composite variety production
- Synthetic variety production
- Multiline variety production

Q.4. Describe the selection method of plant breeding.

Ans. Conventional plant breeding involves crossing carefully chosen parent plants, then selecting the best plants from the resulting offspring to be grown on for further selection. For cereals, hundreds of individual crosses are carried out by

hand to create seed for the first filial (or F1) generation. The resulting F1 plants are uniform, but in the following generation several hundred thousand different plants are produced. Because of the way genes work, the new combinations produced from each cross is not revealed until the second (F2) generation. It is this enormous diversity of new gene combinations which may hold the key to a successful new variety. The plant breeder's task is to select the plants most likely to meet his breeding objectives. Seed from the best of these F2 plants is grown on in small rows or plots and the best plants again selected – this process is repeated year after year until only the very best plants remain.

There are two types of selection methods-

i. Pure line selection method
ii. Mass selection method
iii. Pure line selection method

Pure line selection is a method in which new variety is developed by selection of single best plant progeny among traditional varieties or land races. Pure line is a self pollinated descendent of a self pollinated plant. Desirable types already exist in population. Those are isolated through careful testing procedures. Another term used for this method of plant breeding is individual plant selection, as large numbers of plants are selected, but those are harvested individually, their individual progenies are grown and evaluated and then best progeny is released as a pureline variety.

Genetic basis for Pureline Selection

Pureline varieties are homozygous and homogeneous as they are genetically similar and true breeding. Such varieties possess narrow genetic base so they are more susceptible to diseases, and have poor adaptability. A pure line breeding method is normally used for self-pollinated crops, but has importance in breeding of inbred lines that are used to make hybrids in self or cross pollinated crops. Examples of Pureline

Crop	Variety	Features	Selection from and at
Cowpea	Suvita-2	Striga resistant line	Selection from landrace in Burkina Faso
Wheat	Kanred	Better in winter hardiness, rust resistance, earliness in maturity	Selected at Kansas from Crimean variety, an introduction from Russia
Oat	Columbia	Matures early, grain with high test weight.	Selected at Missouri station from Fulghum variety

Mass selection method

In mass selection seeds are collected from a large number of phenotypically similar plants available in population and are bulked to grow next generation. In the simplest manner it is the creation of mixture of different lines.

While selection easily observable characters like plant height, grain color, grain size, tillering ability, disease resistance etc. are considered. Mass selection increases frequencies of desirable genes. This type of selection method of plant breeding can be carried out multiple times as mass selected variety may contain considerable genetic variation. But, new genetic variability is not created; only the present one is used just to improve base population performance.

Genetic basis of Mass Selection

Mass selection is used in both self pollinated and cross pollinated species. In case of cross pollinated species the mass selected varieties are heterozygous and heterogeneous. In self pollinated species, these varieties are a mixture of several pure lines, means homozygous but heterogeneous.

Types of Mass Selection

It can be of two types as given below.

- Positive mass selection
- Negative mass selection

Q.5. Write a note on 'Hybridization' as a method of plant breeding.

Ans. Hybridization refers to the crossing of two individuals or plants or lines with dissimilar genotype. It is the most important among the breeding. The outcome the crossing of two individuals or plants or lines with dissimilar genotype is called as hybrid. Aims or objectives of hybridization can be enlisted as follows

- To create genetic variability
- To bring together desired qualitative characters found in different plants or plant lines into one plant or plant line i.e. to transfer desired character/s from other varieties to the considered one.
- To make F_1 useful as hybrid variety
- Improvement of one or more quantitative characters

Plant hybridization can be of two types.

- Intervarietal hybridization
- Distant hybridization

Intervarietal Hybridization

In this type of hybridization, two parents from the same species (may be from two varieties, strains or races of the same species) are crossed.

- Single Cross Hybrids
- Double Cross Hybrids
- Three-way Cross Hybrids
- Triple Cross Hybrids
- Top Cross Hybrids

Single Cross Hybrids

Results from the cross between two pure bred lines and produces an F_1 generation called an F_1 hybrid (F_1 is short for Filial 1, meaning "first offspring). The cross between two different homozygous lines produces an F_1 hybrid that is heterozygous; having two alleles, one contributed by each parent and typically one is dominant and the other recessive. The F_1 generation is also homogeneous, producing offspring that are all similar to each other.

Double Cross Hybrids

Result from the cross between two different F_1 hybrids.

Three-way Cross Hybrids

Result from the cross between one parent that is an F_1 hybrid and the other is from an inbred line.

Triple Cross Hybrids

Result from the crossing of two different three-way cross hybrids.

Top Cross Hybrids

Cross between inbred line and OPV.

Distant Hybridization *(Population hybrids)*

It includes

- Intergeneric hybridization – crossing between parents from the two different genera
- Interspecific hybridization – crossing between parents from two different species

General Procedure for Hybrid Production or Hybridization

Hybrid production or involves following main steps (i.e. steps in crossing).

- Choice of parents
- Evaluation or testing of parents
- Protection of male parent
- Emasculation
- Bagging
- Tagging
- Pollination and bagging, tagging
- Aftercare
- Harvesting

Q.5. What do you understand by inbreeding depression?

Ans. There are three main kinds of plants: inbreeding, out breeding and plants that do both.Inbreeding plants are by far the easiest to save seeds from, because they self pollinate and cross pollination is not longer remains a problem. These plants have also generally evolved to avoid inbreeding depression. Examples of plants that fall into this category are tomatoes, peas and grains. Inbreeding depression occurs when the gene pool becomes too small because too few plants of the same species were cross pollinated with one another. To avoid this problem, It is must to save seeds from a number of the same type of plant. Exactly what this number is varies from plant to plant, and indeed is the point of some disagreement between gardeners. When seeds experience inbreeding depression, they lose their vigor and and yields will decrease. In addition, some previously dormant recessive genes may express themselves resulting in undesirable traits, possibly rendering your seeds unusable. These problems may not show up for several generations after the seeds were saved. Normally the only solution for inbreeding depression is to either create a hybrid variety by cross pollinating with another type of plant from the same species, or to introduce some new pollination partners with seeds obtained from another source.

Q.6. What is Hybrid vigor? Explain.

Ans. Heterosis, or hybrid vigor, or outbreeding enhancement, is the improved or increased function of any biological quality in a hybrid offspring. The adjective derived from *heterosis* is heterotic. Heterosis is the occurrence of a superior offspring from mixing the genetic contributions of its parents. These effects can be due to Mendelian or non-Mendelian inheritance.

Q.7. How mutations affect the plant breeding objectives?

Ans. Breeding has been practiced since the early human civilization and selection was the first method of breeding, adding the criteria of suitability for man's use (e.g. larger seed, better taste, easier harvestability) to those of natural adaptation, fitness and offspring. It has been said, that the ultimate source of all heritable variation to select from are mutations. But such a statement leaves open, where the genes to start with and the genetic code came from. Recombination of genes can provide additional genetic variation, if differences exist not only between various genes, but also in form of alleles of particular genes of prospective recombinants. Such alleles derive from mutations. Using mutants in cross breeding requires no in depth knowledge about mutations, because the mutated trait is the object of desire. But when the mutant trait is not inherited as expected, the breeder may begin to think about the actual mutational event, that led to the mutant phenotype.

Induced mutations are the choice of plant researchers to induce selected mutation and thus creating desired genetic variations. With international coordination and some financial assistance by IAEA and FAO from 1964 onwards it could be convincingly demonstrated, that ionizing radiations and also certain chemicals, when handled properly, could induce many useful alterations in the genomes of crop plants. Records maintained by the Joint FAO/IAEA Division in Vienna show, that ca. 2000 crop cultivars with one or more useful traits from induced mutations (mainly from x- and gamma-rays) were released worldwide over a period of 35 years. Included in these records are some outstanding examples of cultivars (e.g. „Diamant" and „Trumpf" in barley; „IRAT 13", „Yuanfengzao" and „Calrose 76" in rice; „Lumian 1" and „NIAB 78" in cotton; „Pervenets" in sunflower; „Star Ruby" in grapefruit), which had a remarkable economic impact. Inspite of the number of induced mutants recognized as valuable crop cultivars and used successfully in cross breeding, of course „new genes" in the strict sense could not be produced . Consequently, one would expect much interest in the question, what kind of molecular alteration in the chromosomal or cytoplasmic DNA, or what kind of structural/numerical alteration in the genome happened in those successful mutant cultivars. However, so far there were not many efforts to bring into accord the destruction caused by mutagens and the good performance of so many induced mutants. The answers to this question should be very relevant for any future investment into mutation breeding and gene engineering, to give a reliable forecast of what can be expected. Some specific examples are given below

• ***Mutation induction and breeding technology for banana and plantain.***

Low geneticvariation and sterility handicap genetic improvement of banana and plantains *(Musa spp.)* by conventional breeding techniques. Shoot-tip culture and *in vitro* plant regeneration are being investigated for use in mutation induction and mutant selection.

• ***Mutation breeding to improve the tolerance to environmental stress of Azolla***.
Azolla is a small aquatic fern that lives in symbiotic relationship with the nitrogen-fixing cyanobacterium *Anabaena.* Under suitable field conditions *Azolla* can double its weight every 3-5 days. The *Azolla-Anabaena* symbiotic system provides green manure for flooded crops, particularly rice. Induced mutagenesis has produced *Azolla* variants tolerant to high salinity, toxic aluminium levels, and/or to herbicides. Tolerant plants are being investigated under field conditions to confirm that heritable changes cause the increased tolerance to environmental stress.

• ***Methods of mutation induction and breeding of tropical root and tuber crops (cassava and yam).***
Cassava and yam are among the most important staple food crops of the lowland tropics. Mutation breeding technology is being developed to increase variation in plant stature, cyanide content, disease, and pest resistance. *In vitro* techniques are used for the propagation of healthy plants and improved clones. Somatic embryogenesis is being developed for cassava and yam improvement through *in vitro* mutagenesis and later on by somatic cell manipulation. Mutant and polyploid clones are prepared for field testing in Member States.

• ***Tissue culture in cocoa as a system for more efficient mutation breeding.***
Attempts to breed cocoa for disease resistance have yielded very limited success. A major constraint is that little variation exists in currently available cultivars. Somatic embryogenesis is being developed for propagation of desirable genotypes and, through *in vitro* mutagenesis and pollen mutagenesis, is being applied for induction of virus-resistant cocoa trees in Ghana.

Q.8. How polyploidy is beneficial in plant breeding issues?

Ans. Polyploidy refers to a definite arithmetic relationship between the chromosome numbers of related organisms. It has been defined as the possession of three or more complete sets of chromosomes and has been an important feature of chromosome evolution in many eukaryotic taxa including plants, yeasts, insects, amphibians, reptiles, fishes and even the mammalian genome. Polyploidy is present to at least to some extent in most members of the plant kingdom being more common in some and rather rare in others. The fact that it is widespread many plants is also kind of exemplified by the wide variations in chromosome numbers with chromosome numbers ranging from 2n = 4 to500 in angiosperms to 2n=6 to 226 in monocots. Thousands of angiosperm species have 14 to 15 pairs of chromosomes.

Polyploidy, a prime facilitator of speciation and evolution in plants and to a lesser extent in animals is associated with intra and inter-specific hybridization. Polyploidy is an intriguing phenomenon in plants that has provided an important pathway for evolution and speciation. Polyploidy provides the opportunity for selection to sculpt a variety of new gene functions, traits, and lineages. Many important model systems, both agricultural and wild, have been used to study the consequences of recent polyploidization (e.g., cotton [*Gossypium hirsutum*],

tobacco [*Nicotiana tabacum*], wheat [*Triticum aestivum*], canola [*Brassica napus*], soybean [*Glycine max*], potato [*Solanum tuberosum*], sugarcane [*Saccharum officinarum*], cordgrass (*Spartina anglica*), and dandelion [*Taraxacum officinale*]) .the most extensive evidence for ancient polyploidy comes from analysis of the complete sequences of both rice and *Arabidopsis*.

Types of Polyploidy:

1. Autopolyploidy
   a. Autotriploidy (3x)
   b. Autotetraploidy (4x)
   c. Autopentaploidy (5x)
   d. Autohexaploidy (6x)
2. Allopolyploidy
   a. Allotetraploidy (2x1+2x2)
   b. Allohexaploidy (2x1+2x2 + 2x3)
   c. Allooctaploidy (2x1+2x2 + 2x3 + 2x4)

Use of Autopolyploid in Plant Breeding:

Following three factors should be taken in consideration as a guide for production and utilization of the autopolyploid in plant breeding:

i) Autopolyploid manifests greater vegetative growth but reduced seed production. This implies that autopolyploid induction would be more useful for vegetative parts of the plants, such as forage, or root, but not the seed.

ii) Autopolyploid produced from diploids with lower chromosome number have been relatively more successful.

iii) Performance of a diploid species in a given environment may not be correct indication regarding the performance of corresponding autotetraploid produced from it. Cross pollinated crop may be more successful as parents for autopolyploid induction than self pollinated species.

A few examples are presented below:

a) Triploid Sugar Beets: The roots of triploid sugar beet are larger in size than diploids, but they maintain the sugar content of diploids and hence yield more sugar per unit area. Triploids are highly sterile and do not produce seed. Triploid sugar beets are produced by interplanting diploidanf tetraploid.Tetraploid is used as seed parent and triploid seed is therefore harvested from tetraploid.

b) Triploid Watermelons: Seedlessness would be advantageous in watermelons. Diploid watermelons (*Citrullus lanatus*) have 22 chromosomes per somatic cell and are fully fertile, and produce large number of seeds per fruit.

Application of Allopolyploidy in Crop Improvement:

1. Bridging cross: Amphidiploids can be used as a bridge where direct cross between two species is not possible due to sterility in F1. Through this process the character from one species to a related species, generally from wild species to cultivated species. In such cases, at first an amphidiploid is made by chromosome doubling of an interspecific F1 hybrid, and then the amphidiploid is crossed with the recipient species. E.g., cotton, tobacco. In tobacco, *Nicotiana digluta* (Allohexaploid) is used as bridge in the transfer of tobacco mosaic virus resistance gene from *Nicotiana sylvestris* to *Nicotiana tabacum*.In cotton, an amphidiploid is used as a bridge for the transfer of gene from *Gossypium thurberi* to *Gossypium hirsutum.*

2. Creation of new crop species: Alloploidy sometimes helps in creation of new species as *Triticale* is the best example which is an alloploid between *Triticum aestivum* and *Secale cereale. Triticale* varities are mainly cultivated in Polland, Germany and France.*Raphanobrassica*, the triploid (AAC), was also an promising creation of new variety, which was of no use as the desired traits was not been obtained from the cross.
3. Interspecific Gene Transfer: In case of unavailability the desirable characters within the species, it is transferred from the related species. It is done in two waysas i) by alien addition or ii) by alien substitution. Such kind of gene transfer is found in wheat , tobacco, cotton and oats. In cotton, lint strength is transferred from *Gossypium thurberi* to *Gossyium hirsutum.*

4. Tracing the origin of crop species: Alloploidy study is used to identify the origin of natural alloploidy plants.
There are also certain limitations of polploidy breeding.

Limitation of Autopolyploid:

1. The larger size of autopolyploid is generally accompanied with higher water content. As a result, autopolyploid of the crop species grown for vegetative parts do not always produce more dry matter than the respective diploids. For example, tetraploid turnip (*Brassica rapa*) and cabbage (*Brassica oleracea*) outyield the diploids in fresh weight, but are comparable, or even inferior, to them in terms of dry matter production.

2. In crop species grown for seed, autopolyploids show high sterility accompanied with poor seed set.

3. Fertility in autotetraploid can be increased by hybridization and selection at the tetraploid level. But due to the complex segregation in autotetraploids, progress under selection is slow.
4. Triploid cannot be maintained except through clonal propagation.
5. New polyploids (raw polyploids) are always characterized by a few or more undesirable features, e.g., poor strength of stem in grapes, irregular fruit size in watermelon, etc.
6. Effect of autopolyploidy cannot be predicted.

Limitation of Alloploidy:

1. It is not possible to predict the effect of alloploids.
2. There may have defects in the newly synthesized alloploids.
3. It requires considerable time, labor and resources for the synthesis of alloploids through extensive breeding.
4. There are onely a small proportion of alloploids are promoising.

5. Chances of developing new species are very low.

Q.9. What do you understand by 'Green revolution'?

Ans. Green Revolution refers to a series of research, development, and technology transfer initiatives, occurring between the 1940s and the late 1970s that increased agriculture production around the world beginning most markedly in the late 1960s. The initiatives, led by Norman Borlaug, the "Father of the Green Revolution" credited with saving over a billion people from starvation, involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers. The term "Green Revolution" was first used in 1968 by former United States Agency for International Development (USAID) director William Gaud, who noted the spread of the new technologies.

Q.10. Write a note on 'Green revolution in India' giving examples of wheat and rice.

Ans. The introduction of high-yielding varieties of seeds after 1965 and the increased use of fertilizers and irrigation are known collectively as the Green Revolution, which provided the increase in production needed to make India self-sufficient in food grains, thus improving agriculture in India. Famine in India, once accepted as inevitable, has not returned since the introduction of Green Revolution crops.

Of the high-yielding seeds, wheat produced the best results. All India Radio (AIR) played a vital role in creating awareness for these methods. Along with high

yielding seeds and irrigation facilities, the enthusiasm of farmers mobilized the idea of agricultural revolution and is also credited to All India Radio. M. S. Swaminathan and his team had contributed towards the success of green revolution.

India's food-grains production has hovered around a fifth of a billion tonnes mark in recent years. More than self-sufficient, India frequently exports its surpluses. India in 55 years has emerged from famine ridden colonial times, as a famine free Republic. Its population has nearly tripled in that period. More significantly, India in 1947,lost some of its most fertile lands. But she has managed to stand up and falsify many prophesies of doom. India was the greatest success story of the Green Revolution. Although today her agriculture is at cross-roads again, the Green Revolution of the sixties gained some crucial decades for India in which to rethink her way forward. The story of how what came to be called the Green Revolution began is an exciting one. The story's moral is that hope is always buried within tragedy. Shortly after the Bengal Famine, MacArthur's victorious US army marched into Japan. In the huge occupation force was S. Cecil Salmon of the US Agricultural Research Service [ARS]. Many initiatives were being considered for rebuilding Japan. Salmon was focused on agriculture and that was how he chanced upon the legendary Norin strain of wheat that was to trigger the Revolution. Norin was a dwarf variety with little foliage and a heavy head of grain. Salmon sent this to the US for further study. In Washington State University at Pullman, a team under Orville Vogel researched the dwarf wheat. They bred many prototypes and finally created in 1959 the Gaines dwarf. It had been 13 long years of experimentation. Norman Borlaug --that icon of the Green Revolution-- picked up Gaines and crossed it with Mexico's best varieties at the International Maize and Wheat Research Centre there. He had the magic bullet -- he waited to unleash the Revolution. By the 1960's India was desperate for a breakthrough. The nation's self-confidence was at an ebb. The Chinese had delivered a military lesson. Nehru was aging. Political uncertainty loomed. Food crises were endemic. Total food production hung around about 50 million tonnes. Marginal increases were only through bringing more land area under cultivation and not through increases in productivity. Food reserves were nil. India was just about meeting its deficit with imports. Clearly a quantum leap was needed.

It was then that India discovered Borlaug and the Norin dwarf. A small field at Pusa was seeded and the results were dramatic. It was what India had been waiting for. What then followed was a display of commitment and implementation that has stood to inspire India in many other fields. It is a milestone to cherish. Though the Green Revolution was a worldwide phenomenon its most successful revolutionaries were India's political leadership, bureaucrats, scientists and of course the farmers.

Once Borlaug and India were convinced that they had a solution, the realization of what needed to be done dawned. It was a formidable task. But India had its men in place. Of the ones that are easily named are C. Subramaniam, B. P. Pal and M.S.Swaminathan. In the end however, literally millions of Indians were active parts of the Revolution.

C. Subramaniam was in 1965, the Union Minister for Agriculture. He had trudged a long road, as a Gandhi devotee, freedom fighter and as a member of India's Constituent Assembly. Most of all he was a modern mind and a man of action. Swaminathan was an entirely home-grown plant genetist of repute. He emerged as Subramaniam's able lieutenant. In 1996, Subramaniam took the politically bold decision of importing 18,000 tonnes of the dwarf wheat seeds of the Lerma Rojo 64A and Sonora 64 variety.

The induction of an agricultural technology is not a mere question of buying seeds. Conducive policies and delivery systems have to exist. Subramaniam piloted the necessary reforms. To disseminate information Krishi Vigyan Kendras, model farms and district block development offices were put in place. Seed farms were developed. To augment research the Indian Council for Agricultural Research [ICAR] was reorganised. As the dwarf variety was chemicals and fertiliser intensive new industrial units were licenced. To encourage two crops a year and monsoon-independence, irrigation canals and deep water wells were created. Policy was changed to assure guaranteed prices and markets. Food stock storages were created.

The results were not long to come. Land under active cultivation began to grow from 1.9 million hectares [mHa] in 1960 to 15.5mHa [1970], 43mHa [1980] and 64mHa [1990]. As for the Paddocks' prophesied demise of India in 1975 well, it didn't happen: India weighed in that year with over 110 million tonnes of food grains.

	1950	1960	1970	1980	1990	2000
Food grain production [mT]	50.8	82.0	108.4	129.6	176.4	201.8
Food grain import [mT]	4.8	10.4	7.5	0.8	0.3	-
Buffer stock [mT]	-	2.0	-	15.5	20.8	40.0
Population [m]	361	439	548	683	846	1000

It is also well to remember that India continued its own adaptive research on high yielding varieties [HYV]. The Revolution was not about just importing seeds. At the Indian Agricultural Research Institute [IARI], Benjamin Peary Pal developed the New Pusa 809, a hardy Indian wheat variety. A genial man who did his doctorate at Cambridge in 1933, B.P.Pal is easily the father of post-modern research in India's agriculture. He was a painter, a rose fancier and a patron of arts. He built a large team, groomed many scientists and extended the HYV research in crops other than wheat. Indian Council for Agricultural Research [ICAR] of which he was the first Director General, proceeded to synthesise and broadcast many HYV seeds like Pusa Sonara, Malavika, Kalyan Sona. Many of these are popular today in Pakistan, other SAARC countries, Afghanistan, Sudan and Syria.

Q. 11. Who is the father of green revolution in India?

Ans. M S Swaminathan is known as the "Father of the Green Revolution in India" , for his leadership and success in introducing and further developing high-yielding varieties of wheat in India. He is the founder and Chairman of the MS Swaminathan Research Foundation. Monkombu Sambasivan Swaminathan is an Indian agriculture scientist, born August 7, 1925, in Kumbakonam, Tamilnadu. He was the second of four sons of a doctor. His ancestral home is the island village of Monkompu, Alleppey District, Kerala. M S Swaminathan stated vision is to rid the world of hunger and poverty. Dr. Swaminathan is an advocate of moving India to sustainable development, especially using environmentally sustainable agriculture, sustainable food security and the preservation of biodiversity, which he calls an "evergreen revolution" In 1999, Time magazine placed him in the Time 20 list of most influential Asian people of the 20th century.

Q.12. What do you know about Norman Borlaug?

Ans. Norman Ernest Borlaug was an American agronomist, humanitarian, and Nobel laureate who has been called "the father of the Green Revolution". Borlaug was one of only six people to have won the Nobel Peace Prize, the Presidential Medal of Freedom and the Congressional Gold Medal. He was also a recipient of the Padma Vibhushan, India's second highest civilian honor. Borlaug received his Ph.D. in plant pathology and genetics from the University of Minnesota in 1942. He took up an agricultural research position in Mexico, where he developed semi-dwarf, high-yield, disease-resistant wheat varieties. During the mid-20th century, Borlaug led the introduction of these varieties combined with modern agricultural production techniques to Mexico, Pakistan, and India. As a result, Mexico became a net exporter of wheat by 1963. Between 1965 and 1970, wheat yields nearly doubled in Pakistan and India, greatly improving the food security in those nations. These collective increases in yield have been labeled the Green

Revolution, and Borlaug is often credited with saving over a billion people worldwide from starvation. He was awarded the Nobel Peace Prize in 1970 in recognition of his contributions to world peace through increasing food supply.

Q.13. Who was the Luther Burbank?

Ans. Luther Burbank was an American botanist, horticulturist and a pioneer in agricultural science.

He developed more than 800 strains and varieties of plants over his 55-year career. Burbank's varied creations included fruits, flowers, grains, grasses, and vegetables. He developed a spineless cactus (useful for cattle-feed) and the plumcot. Burbank's most successful strains and varieties include the Shasta daisy, the Fire poppy, the July Elberta peach, the Santa Rosa plum, the Flaming Gold nectarine, the Wickson plum, the Freestone peach, and the white blackberry. A natural genetic variant of the Burbank potato with russet-colored skin later became known as the Russet Burbank potato. This large, brown-skinned, white-fleshed potato has become the world's predominant potato in food processing.

Q.14. Who was Rajagopalan Krishnamurthy?

Ans. Rajagopalan Krishnamurthy is an authority on cotton research in India. He is a prolific Indian plant breeder who introduced a myriad of cotton varieties for commercial cultivation. He served in the Department of Agriculture of Tamilnadu for one decade and almost 28 years in Indian Council of Agricultural Research (ICAR). He has released as many as 6 varieties from G. Hirsutum, two from G. Barbadense and three hybrids during his tenure in ICAR Service. All of them are prominent and accepted by the farmers as well as the textile mills at Tamilnadu and elsewhere. He completed B. Sc.(Agri.) and M. Sc. (Agri.) in plant breeding and genetics from Tamilnadu Agricultural University, Coimbatore. He is also the Director of Rasi Seeds Co. Pvt. Ltd.

Multiple Choice Questions

1. To enter or leave a cell, substances must pass through

- a. a microtubule.
- b. the Golgi apparatus.
- c. a ribosome.
- d. the nucleus.
- **e. the plasma membrane.**

2. Bacterial cell are prokaryotic; in comparison to a typical eukaryotic cell they would

- **a. be smaller.**
- b. have a smaller nucleus.
- c. lack a plasma membrane.
- d. have fewer internal membranous compartments.
- e. have a greater variety of organelles.

3. You would expect a cell with an extensive Golgi apparatus to

- a. make a lot of ATP.
- **b. secrete a lot of material.**
- c. move actively.
- d. perform photosynthesis.
- e. store large quantities of food

4. Which of the following correctly matches an organelle with its function?

- a. mitochondrion . . . photosynthesis
- b. nucleus . . . cellular respiration
- c. ribosome . . . manufacture of lipids
- d. lysosome . . . movement
- **e. central vacuole . . . storage**

5. Of the following organelles, which group is involved in manufacturing substances needed by the cell?

- a. lysosome, vacuole, ribosome
- **b. ribosome, rough ER, smooth ER**
- c. vacuole, rough ER, smooth ER
- d. smooth ER, ribosome, vacuole
- e. rough ER, lysosome, vacuole

6. A cell has mitochondria, ribosomes, smooth and rough ER, and other parts. Based on this information, it could **not** be

- a. a cell from a pine tree.
- b. a grasshopper cell.
- c. a yeast (fungus) cell.
- **d. a bacterium.**
- e. Actually, it could be any of the above.

7. The electron microscope has been particularly useful in studying bacteria, because

- a. electrons can penetrate tough bacterial cell walls.
- **b. bacteria are so small.**
- c. bacteria move so quickly they are hard to photograph.
- d. with few organelles present, bacteria are distinguished by differences in individual macromolecules.
- e. their organelles are small and tightly packed together

8. Cell fractionation is the most appropriate procedure for preparing ____ for study.

- a. isolated cells which are normally found tightly attached to neighbouring cells
- b. cells without a functional cytoskeleton
- **c. isolated organelles**
- d. the basic macromolecules
- e. bone and other similar cells which are situated within a mineral framework

9. Which of the following clues would tell you whether a cell is prokaryotic or eukaryotic?

- a. the presence or absence of a rigid cell wall
- **b. whether or not the cell is partitioned by internal membranes**

- c. the presence or absence of ribosomes
- d. whether or not the cell carries out cellular metabolism
- e. whether or not the cell contains DNA

10. Sara would like to film the movement of chromosomes during cell division. Her best choice for a microscope would be a

- a. light microscope, because of its resolving power.
- b. transmission electron microscope, because of its magnifying power.
- c. scanning electron microscope, because the specimen is alive.
- d. transmission electron microscope, because of its great resolving power.
- **e. light microscope, because the specimen is alive.**

11. 1. In a cell if acidity of Lysome is lost, then loss of:
(a) Phagocytosis of invading bacteria
(b) Elevated phosphatase level
(c) Glycogen degradation
(d) No major effect
12. Bacterial genomes is prevented by its own endonucleases by-
(a) Methylation at restriction sites
(b) Immune mechanism
(c) Nuclease resistant genome
(d) Are not much effective on bacterial genome

13. The function of macrophages is to-
(a) Enzyme Secretion
(b) Engulf Cell organelles
(c) Engulf Foreign Material
(d) Kills Invading Bacteria

14. The difference which distinguish prokaryotic cell from eukaryotic is-
(a) ER (b) Mesosome
(c) Nuclear Membrane (d) Plasma membrane

15. Extra nuclear genetic material is found-
(a) Ribosome (b) ER
(c) Chloroplast (d) Centriole

16. The acrosome of the sperm is formed from the
(a) mitochondria (b) centrosome
(c) lysomome **(d) golgi bodies**

17. Holiday junction is observed during:
(a) Mitosis (b) Interphase
(c) Recombination (d) DNA Repair

18. A caretenoid less mutant plant was grown under normal sunlight then-
(a) Increased photosynthesis rate
(b) Increased chlorophyll synthesis
(c) Reduced photorespiration
(d) Increased chlorophyll oxidation and necrosis

19. A plant with purple flowers is allowed to self-pollinate. Generation after generation, it produces purple flowers. This is an example of
A) true-breeding.
B) hybridization.
C) the law of segregation.
D) polygenetics.
E) incomplete dominance

20. A cross between homozygous purple-flowered and homozygous white-flowered pea plants results in offspring with purple flowers. This demonstrates
A) the mistakes made by Mendel.
B) a dihybrid cross.
C) true-breeding.
D) dominance.
E) the blending model of genetics.

21.What was the most significant result Gregor Mendel drew from his experiments with pea plants?
A) Genes are composed of DNA.
B) There is considerable genetic variation in garden peas.
C) Traits are inherited in discrete units, and are not the results of "blending."
D) Recessive genes occur more frequently in the _elementsubscript_element than do dominant ones.
E) An organism that is homozygous for many recessive traits is at a disadvantage.

22.Alleles
A) don't affect the phenotypes until the _elementsubscript_element generation.
B) are present only in the _elementsubscript_element generation.

C) are the result of hybridization.
D) are alternative forms of a gene.
E) occur in a 3:1 ratio.

23. Mendel's law of segregation was nearly impossible for most biologists to understand until there was a general understanding of
A) meiosis. B) epistasis. C) mitosis. D) pleiotropy. E) dominance.

24. A couple who are both carriers of the gene for cystic fibrosis have two children who have cystic fibrosis. What is the probability that their next child will have cystic fibrosis?
A) 0% **B) 25%** C) 100% D) 50% E) 75%

25. A couple who are both carriers of the gene for cystic fibrosis have two children who have cystic fibrosis. What is the probability that their next child will be phenotypically normal?
A) 50% B) 0% C) 100% **D) 75%** E) 25%

26. In crossing a homozygous recessive with a heterozygote, what is the chance of getting an offspring with the homozygous recessive phenotype?
A) 0% B) 100% **C) 50%** D) 75% E) 25%

27. In snapdragons, heterozygotes have pink flowers, whereas the two homozygotes have red flowers or white flowers. When plants with red flowers are crossed with plants with white flowers, what proportion of the offspring will have pink flowers?
A) 0% **B) 100%** C) 25% D) 50% E) 75%

28.In cattle, roan coat color (mixed red and white hairs) occurs in the heterozygous (Rr) offspring of red (RR) and white (rr) homozygotes. When two roan cattle are crossed, the phenotypes of the progeny are found to be in the ratio of 1 red:2 roan:1 white. Which of the following crosses could produce the highest percentage of roan cattle?
A) white multiply roan
B) red multiply roan
C) roan multiply roan
D) red multiply white
E) All of the above crosses would give the same percentage of roan.

29.Roan color in cattle is the result of incomplete dominance between red and white color genes (Rr). How would one produce a herd of pure-breeding roan-

colored cattle?
A) cross roan with white
B) cross red with white
C) cross roan with roan
D) cross roan with red
E) It cannot be done.

30.Huntington's disease is caused by a dominant allele. If one of your parents has the disease, what is the probability that you, too, will have the disease?
A) 3/4 B) 1/4 C) 1/2 D) 1 E) 0

31.P = purple, pp = white. The offspring of a cross of two heterozygous purple-flowering plants (Pp multiply Pp) results in
A) two types of white-flowered plants: PP and Pp.
B) all white-flowered plants.
C) purple-flowered plants and white-flowered plants.
D) all pink-flowered plants.
E) all purple-flowered plants. Use the following information to answer the question below. Albinism (lack of skin pigmentation) is caused by a recessive autosomal allele. A man and woman, both normally pigmented, have an albino child together.

32.For this trait, what is the genotype of the albino child?
A) hemizygous
B) homozygous dominant
C) heterozygous
D) homozygous recessive
E) unknown, because not enough information is provided

33.The couple decides to have a second child. What is the probability that this child will be albino?
A) 3/4 B) 1/2 **C) 1/4** D) 0 E) 1

Key Term

amoeboid -- Having no definite shape to the cell, able to change shape.

amphiesma -- The outer covering of a dinoflagellate, consisting of several membrane layers.

aperture -- Small opening, for example the opening in the test of a foram.

bacteriophage -- Virus which infects and destroys a bacterial host. Some phages, however, will incorporate their DNA into that of their host, and remain dormant for an extended period. For this reason, they have become essential tools of genetic engineers.

capsid -- The protein "shell" of a free virus particle.

cell -- Fundamental structural unit of all life. The cell consists primarily of an outer plasma membrane, which separates it from the environment; the genetic material (DNA), which encodes heritable information for the maintainance of life; and the cytoplasm, a heterogeneous assemblage of ions, molecules, and fluid.

cell cycle -- Complete sequence of steps which must be performed by a cell in order to replicate itself, as seen from mitotic event to mitotic event. Most of the cycle consists of a growth period in which the cell takes on mass and replicates its DNA. Arrest of the cell cycle is an important feature in the reproduction of many organisms, including humans.

cell membrane -- The outer membrane of a cell, which separates it from the environment. Also called a plasma membrane or plasmalemma.

cell wall -- Rigid structure deposited outside the cell membrane. Plants are known for their cell walls of cellulose, as are the green algae and certain protists, while fungi have cell walls of chitin.

chloroplast -- A chlorophyll-containing plastid found in algal and green plant cells.

chromosome -- Linear piece of eukaryotic DNA, often bound by specialized proteins known as histones.

coenocytic -- Condition in which an organism consists of filamentous cells with large central vacuoles, and whose nuclei are not partitioned into separate compartments. The result is a long tube containing many nuclei, with all the cytoplasm at the periphery.

colonial -- Condition in which many unicellular organisms live together in a somewhat coordinated group. Unlike true multicellular organisms, the individual cells retain their separate identities, and usually, their own membranes and cell walls.

contractile vacuole -- In many protists, a specialized vacuole with associated channels designed to collect excess water in the cell. Microtubules periodically contract to force this excess water out of the cell, regulating the cell's osmotic balance.

cytoplasm -- All the contents of a cell, including the plasma membrane,but not including the nucleus.

cytoskeleton -- Integrated system of molecules within eukaryotic cells which provides them with shape, internal spatial organization, motility, and may assist in communication with other cells and the environment. Red blood cells, for instance, would be spherical instead of flat if it were not for their cytoskeleton.

dikaryotic -- Having two different and distinct nuclei per cell; found in the fungi. A dikaryotic individual is called a dikaryon.

diploid -- Having two different sets of chromosomes in the same nucleus of each cell. Most metazoans and plants are diploid. Compare with haploid.

double membrane -- In mitochondria and plastids, there is a two-layered membrane which surrounds the organelle. This is believed to be the result of endosymbiosis, with the outer membrane coming from the eukaryotic cell, and the inner membrane belonging to the original prokaryote which was "swallowed".

endoplasmic reticulum -- (ER) network of membranes in eukaryotic cells which helps in control of protein synthesis and cellular organization.

eukaryote -- n. An organism whose cells have cytoskeletons for support and their DNA contained in a nucleus, separated from the other contents of the cell; e.g., protists, plants, animals, and fungi; **eukaryotic**- adj.

extracellular matrix -- (ECM) Region outside of metazoan cells which includes compounds attached to the plasma membrane, as well as dissolved substances attracted to the surface charge of the cells. The ECM functions both to keep animal cells adhered together, and well as buffering them from their environment.

eyespot -- Light-sensitive organelle found in many groups of protists, and in some metazoans.

filament -- Long chain of proteins, such as found in hair, muscle, or in flagella.

fission -- Division of single-celled organisms, especially prokaryotes, in which mitosis does not occur. Also used to refer to mitosis in certain unicellular fungi.

flagellum -- n. Hair-like structure attached to a cell, used for locomotion in many protists and prokaryotes. The prokaryotic flagellum differs from the eukaryotic flagellum in that the prokaryotic flagellum is a solid unit composed primarily of the protein flagellin, while the eukaryotic flagellum is composed of several protein strands bound by a membrane, and does not contain flagellin. The eukaryotic flagellum is sometimes referred to as an undulipodium.

frustule -- The mineral "skeleton" of a diatom or other unicellular organism.

Golgi apparatus -- Eukaryotic organelle which package cell products, such as enzymes and hormones, and coordinate their transport to the outside of the cell.

haploid -- Having a single set of chromosomes in the nucleus of each cell. Mosses, and many protists and fungi, are haploid, as are some insects, bryophytes, and the gametes of all organisms. Contrast with diploid.

haptonema -- Peg-like structure unique to the Prymnesiophyta; its function is not known.

lorica -- A vase-shaped or cup-shaped outer covering. Found in many protists, including some flagellates, ciliates, chrysophytes, and choanoflagellates, as well as in some animal cells.

lysosome -- Eukaryotic organelle which carries digestive enzymes. The lyzosome fuses with a vacuolar membrane containing ingested particles, which are then acted upon by the enzymes.

mastigoneme -- Small hair-like filaments found on the "hairy" flagellum of the Chromista.

membrane -- In biology, a boundary layer inside or around a living cell or tissue.

mesokaryotic -- Nuclear condition unique to the dinoflagellates in which the chromosomes remain permanently condensed.

microtubules -- Type of filament in eukaryotic cells composed of units of the protein tubulin. Among other functions, it is the primary structural component of the eukaryotic flagellum.

microvilli -- Thin fingerlike protrusions from the surface of a cell, often used to increase absorptive capacity or to trap food particles. The "collar" of choanoflagellates is actually composed of closely spaced microvilli.

mitochondrion -- Complex organelle found in most eukaryotes; believed to be descended from free-living bacteria that established a symbiotic relationship with a primitive eukaryote. Mitochondria are the site of most of the energy production in most eukaryotes; they require oxygen to function. See: **double membrane**.

mitosis -- The process of nuclear division in eukaryotes. It is one step in cytokinesis, or cellular division. MORE ?.

MTOC -- (microtubule organizing center) MTOCs are bundles of protein tubes which may be found at the base of a eukaryotic flagellum. In animals, they also function in creating the arrays of microtubules that pull the chromosomes apart during mitosis.

multicellular -- Any organism which is composed of many cells is termed multicellular.

nanometer -- n. A unit of measure; one millionth (10^{-9}) of a meter.

nuclear membrane -- The double membrane which surrounds the eukaryotic nucleus. It has many pores in its surface which regulate the flow of large compounds into and out of the nucleus.

nucleoid -- Region in prokaryotes where the DNA is concentrated. Unlike a nucleus, it is not bound by a membrane.

nucleus -- Membrane-bound organelle which contains the DNA in the form of chromosomes. It is the site of DNA replication, and the site of RNA synthesis.

organelle -- n. A membrane-bound structure in a eukaryotic cell that partitions the cell into regions which carry out different cellular functions, e.g., mitochondria, endoplasmic reticulum, lysosomes.

plasma membrane -- Outer membrane of a cell, sometimes called the cell membrane. The term plasma membrane is used more frequently when discussing prokaryotes.

plasmid -- Circular loop of DNA in prokaryotes. Eukaryotic DNA is organized into chromosomes.

plastid -- Any of several pigmented cytoplasmic organelles found in plant cells and other organisms, having various physiological functions, such as the synthesis and storage of food.

prokaryotic -- Literally "before the nucleus", the term applies to all bacteria and archaea. Prokaryotic cells have no internal membranes or cytoskeleton. Their DNA is circular, not linear.

protoplasm -- All the contents of a cell, including the nucleus. (see: cytoplasm)

pseudopodia -- Fingerlike extensions from an amoeboid cell; literally "false feet".

repeat sequences -- The length of a nucleotide sequence that is repeated in a tandem cluster.

reticulopodia -- Long thread-like pseudopodia that branch apart and rejoin, forming a fine network. They are characteristic of forams.

ribosome -- (ribosomal RNA)

syncytic -- see Hexactinellida

test -- n. A hard shelll produced by some unicellular protists; may be made of calcium carbonate, silica, or sand grains.

theca -- General term for any stiff outer covering of a unicellular protist, and usually made up of interlocking plates. dinoflagellates and diatoms are examples of protists with thecae.

transduction -- Viral transfer of DNA to new host.

trichocyst -- Organelle in ciliates and dinoflagellates which releases long filamentous proteins when the cell is disturbed. Used as a defense against would-be predators.

ultrastructure -- The detailed structure of a specimen, such as a **cell**, **tissue**, or **organ**, that can be observed only by electron microscopy. Also called fine structure. In eggshell, ultrastructure refers to the three-dimensional arrangement of mineral crystals and organic matter. It is described in terms of calcite or aragonite mineralogy and the transition between different zones of organization within the shell. Distinct zones

of organization are called ultrastructure zones.

undulipodium -- Another term for a eukaryotic flagellum.

vacuole -- Membrane-bound fluid-filled space within a cell. In most plant cells, there is a single large vacuole filling most of the cell's volume. Some bacterial cells contain gas vacuoles.

Plant breeding

Allele -One of a pair or series of forms of a gene that are alternative in inheritance. Differing alleles can reasult in differing traits.

amino Acids-The basic building block of proteins derived from peptides and polypeptides. Amino acids form the shape and structure of cells. They play a large role both in protein development and metabolism.

Complete Dominance-A type of dominance where the dominant allele completely masks the effect of the recessive allele**.**

Dominant-An allele that determines phenotype even when heterozygous. Also the trait controlled by that allele.

Enzymes-A globular protein with an active site bound to substrate molecules which help to catalyze a reaction by holding molecules in the correct spatial conformation for the reaction to take place.

Gamete- A cell that fuses with another cell during fertilization in organisms that reproduce sexually**.**

Genome-The entirety of an organisms hereditary information encoded in DNA and RNA.

Heredity-Something that is passed on through generations genetically.

Heterozygous-A gene pair having different alleles in the two chromosome sets of the diploid individual; for example, Aa or, A1A2

Homozygous-A diploid gene pair having identical alleles in both copies; for example, AA or, aa.

Incomplete Dominance-a type of inheritance in which one allele is not completely dominant over the other allele

Phenotype-Any observable characteristic or trait of an organism

sex-linked Inheritance-The inheritance pattern of a phenotype corresponding to the sex chromosomes (usually the X chromosome in XY species).

Variation-The occurrence of differences among individuals as a result of differences in their genetic composition or the environment in which they were raised. Genetic diversity within a species.

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