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PRELIMS SAMPOORNA

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SCIENCE & TECHNOLOGY

LIFE SCIENCES & BIOTECHNOLOGY

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LIFE SCIENCES & BIOTECHNOLOGY

- Biology is the study of life, so Life Sciences is essential, the study of biology.
- The scientific method is the process by which biological information, like that of all other sciences, has been identified. This has resulted in several important biological scientific theories, including the cell theory and the theory of evolution.
- All life is built around the element carbon, and four categories of organic compounds: carbohydrates, lipids, proteins, and nucleic acids.
- One particular type of protein, enzymes, is biological catalysts, allowing biochemical reactions to proceed at the rate necessary to maintain life.

Important Disciplines in Biology

- Cytology: Study of cell structure.
- Embryology: It is the study of fertilization and development of a zygote into an embryo, larva or a miniature adult.
- Exobiology: Study of possibility of life in the outer space.
- Microbiology: It is the study of structure, life cycle and activities of micro-organisms invisible to naked eye.
- Pathology: Study of diseases, their effects, casual agents, transmission, and other activities of pathogens.

- Eugenics: Study of factors connected with impairment or improvement of a race.
- Euthenics: Study of environmental conditions that contribute to the improvement of intellect and other traits of human beings.
- Euphenics: Treatment of defective heredity through genetic engineering.
- Actinology: (i) Study of radiation affects (ii) Study of radially symmetrical animals.
- Aerobiology: Study of air borne organisms as well as structure (e,g spores) and their distribution.
- Agrobiology: Quantitative science of plant life and plant nutrition.
- Agronomy: Science of soil management of domesticated animals.
- Animal Husbandry: Raising and management of domesticated animals.
- Anthropology: Study of origin development and culture of present and past races of humans.
- Biometrics: (Biometry = Biostatistics). Statistical study of biological problems.
- Biotechnology: Technology connected with employing living beings or their products in industrial processes.
- Cardiology: Study of heart.
- Carcinology: Study of cancers or tumours.
- Dentistry: Care of teeth including cure, removal, filling and replacement.
- Dermatology: Study of skin and other body coverings.
- Ecobiology: (i) Study of adaptations in relation to habitat. (ii) Study of problems connected with existence of life in space and other planets.
- Economic Botany: Branch dealing with commercially exploited/exploitable plants/Economic Zoology animals.
- Ethnology: Science dealing with different races of mankind.
- Ethology: Study of animal behavior.
- Fishery: Catching, breeding, rearing and marketing of fish and other aquatic animals.
- Floriculture: Cultivation of plants for their flowers.
- Gastroenterology: Study of stomach, intestine and their diseases.
- Geology: Science of earth.
- Haematology: Study of blood.
- Hepatology : Study of liver.
- Horticulture: Development and management of orchards and gardens.
- Immunology: Study of immunity or resistance to disease.
- Mammology : Study of mammals.
- Molecular genetics: Molecular basis of genetics/science of inheritance and variations.
- Mycology: Study of fungi.
- Myology (Sarcology): Study of muscles.
- Neonatology: Scientific study of new born.

- Neontology : Science of present day or recent living beings.
- Nephrology: Study of kidneys.
- Neurology: Study of nervous system.
- Occupational Therapy: Treating mental and physical defects with occupation.
- Ornithology: Study of birds.
- Osteology: Study of Bones.
- Pharmacology: Study of synthesis and effects of medicine an organism.
- Physiotherapy: Treatment of body defects through massage and exercise.
- Psychiatry: Treatment of mental diseases.
- Psychology: Study of human mind and behaviour.
- Radiology: Science dealing with X-rays and other imaging techniques for medical diagnosis.
- Radiotheraphy: Treatment of diseases with X-ray and radio-active substances.
- Sericullture: Rearing silkworms of extraction of silk.
- Serology: Study of serum; interaction of antigens and antibodies in the blood.
- Therapeutics: Treatment of disease.
- Toxicology: Study of harmful effects of drugs and other substances.
- Tricology: Study of hairs.
- Urology: Science dealing with disorders of urinary tract (urinogenital tract in males).
- Venereology: Study and treatment of venereal disease.

Cells

- The cell is the structural and functional unit of all living organisms, and is sometimes called **the "building block of life."**
- Some organisms, such as **bacteria are unicellular**, consisting of a single cell. Other organisms such as humans are **multicellular.**
- Humans have an estimated 100 trillion cells. The **largest** known cell is an **Ostrich egg.**
- **Anton van Leeuwenhoek** was the first person to build a microscope and draw protozoa, such as Vorticella from rainwater, and bacteria from his mouth.
- In 1665, **Robert Hooke** discovered cells in cork, then in living plant tissue using an early microscope.
- First of all, in 1839, **Schleiden and Schwann**, states that all organisms are composed of one or more cells.
- All cells come from **pre-existing cells.**
- Vital functions of an organism occur within cells, and all cells contain the **hereditary information** necessary for regulating cell functions and for transmitting information to the next generation of cells.
- In 1953, **Watson and Crick** made their first announcement on the double-helix structure for DNA.

Anatomy of Cells

- There are two types of cells, **eukaryotic and prokaryotic**.
- **Prokaryotic cells** are **usually singletons**, while **eukaryotic cells** are usually found in **multicellular organisms**.

Comparison between Prokaryotes and Eukaryotes		
	Prokaryotes	**Eukaryotes**
Organisms	Bacteria	Protists, fungi, plants and animals
Cell size	Generally 1 to 10 mm measured lengthwise	Generally 10 to 100 mm, lengthwise
Metabolism	Anaerobic or aerobic	Anaerobic or aerobic
Organelles	None	Nucleus, mitochondria, chloroplasts, endoplasmic reticulum, Golgi apparatus, lysosomes, etc.
Cell support	External cell wall	Internal cytoskeleton
DNA	Circular DNA in single cellular compartment	Very long linear DNA contained within a membrane-bounded nucleus
RNA and protein	RNA and protein synthesized in the single compartment	RNA synthesized and processed in nucleus; proteins synthesized in cytoplasm
Transmembrane movement	No endocytosis or exocytosis	Endocytosis and exocytosis
Cell division	Chromosomes pulled apart by attachments to inner membrane	Chromosomes pulled apart by attachments to cytoskeletal components
Cellular organization	Mainly unicellular	Unicellular or multicellular, with many differentiated cell types

Subcellular Components

All cells, whether prokaryotic or eukaryotic, have a membrane, which envelopes the cell, separates its interior from its environment, regulates what moves in and out (selectively permeable), and maintains the electric potential of the cell. Inside the membrane, a salty cytoplasm takes up most of the cell volume. All cells possess DNA, the hereditary material of genes, and RNA, containing the information necessary to build various proteins such as enzymes, the cell's primary machinery. There are also other kinds of biomolecules in cells. The primary components of the cell and their functions are as follows:

- **Cell Membrane (A cell's defining boundary)**
  - The cytoplasm of a cell is surrounded by a cell membrane or plasma membrane. The plasma membrane in plants and prokaryotes is usually covered by a cell wall.
  - This membrane serves to separate and protect a cell from its surrounding environment and is made mostly from a double layer of lipids and hydrophilic phosphorus molecules. Hence, the layer is called a **phospholipid bilayer.**
  - This membrane has a variety of protein molecules that act as channels and pumps that move different molecules into and out of the cell.

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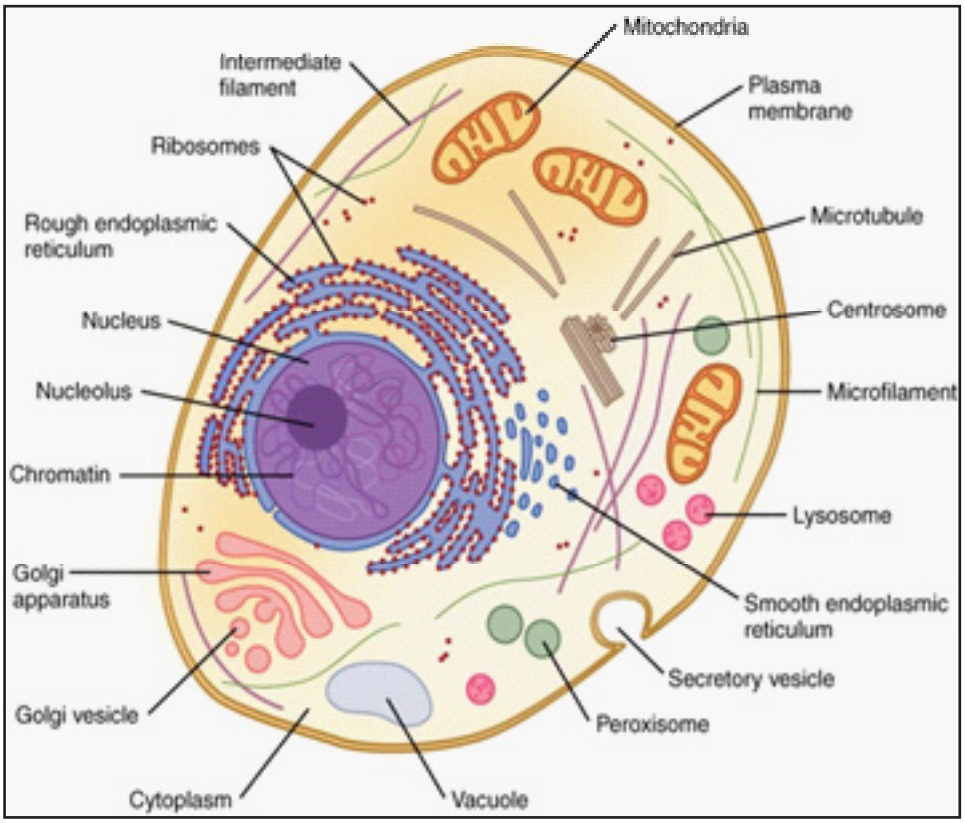
- The membrane is said to be 'semi-permeable'. Cell surface membranes also contain receptor proteins that allow cells to detect external signaling molecules such as hormones.



Cytoskeleton (A cell's scaffold)

- The cytoskeleton acts to organize and maintains the cell's shape; anchors organelles in place; helps during endocytosis, the uptake of external materials by a cell, and cytokinesis, the separation of daughter cells after cell division; and moves parts of the cell in processes of growth and mobility.
- The eukaryotic cytoskeleton is composed of microfilaments, intermediate filaments, and microtubules. There are a great number of proteins associated with them, each controlling a cell's structure by directing, bundling, and aligning filaments.
- The prokaryotic cytoskeleton is less well-developed but is involved in the maintenance of cell shape, polarity, and cytokinesis.

Genetic Material

- Within a cell, two different kinds of genetic material exist**deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).**
- Most organisms use DNA for their long-term information storage, but some viruses (e.g., retroviruses) have RNA as their genetic material.
- The biological information contained in an organism is encoded in its DNA or RNA sequence.
- RNA is also used for information transport (e.g., mRNA) and enzymatic functions (e.g., ribosomal RNA) in organisms that use DNA for the genetic code itself.
- Prokaryotic genetic material is organized in a simple circular DNA molecule (the bacterial chromosome) in the nucleoid region of the cytoplasm.
- Eukaryotic genetic material is divided into different, linear molecules called chromosomes inside a discrete nucleus, usually with additional genetic material in some organelles like mitochondria and chloroplasts.

- A human cell has genetic material in the nucleus (the nuclear genome) and the mitochondria (the mitochondrial genome). In humans, the nuclear genome is divided into 46 linear DNA molecules called chromosomes. The mitochondrial genome is a circular DNA molecule separated from the nuclear DNA. Although the mitochondrial genome is very small, it codes for some important proteins.

- **Organelles:** As the human body contains many different organs, such as the heart, lung, and kidney with different functions.Similarly, cells also have a set of **little organs**, called organelles that are specialized for carrying out one or more vital functions. Membrane-bound organelles are found **only in eukaryotes.**
- **Cell Nucleus (a cell's information center**)
  - The cell nucleus, found in a eukaryotic cell, is the **house of chromosomes** and is the place where almost all **DNA replication and RNA synthesis** occur. During processing, DNA is transcribed or copied into a special RNA, called **mRNA**. This mRNA is then transported out of the nucleus, where it is translated into a **specific protein molecule**.
  - In prokaryotes, DNA processing takes place in the cytoplasm.
- **Mitochondria and Chloroplasts(the power generators):** Mitochondria are **self-replicating organelles** that occur in various numbers, shapes, and sizes in the cytoplasm of all eukaryotic cells. As mitochondria contain their **genome** that is separate and distinct from the nuclear genome of a cell, they play a critical role in generating energy in the eukaryotic cell. **Chloroplasts**, broadly called plastids, are often involved in storage.
- **Endoplasmic Reticulum and Golgi apparatus (macromolecule managers):**
  - The endoplasmic reticulum (ER) is the **transport network for molecules** targeted for certain modifications and specific destinations, as compared to molecules that will float freely in the cytoplasm.
  - The ER has **two forms**: the **rough ER**, which has ribosomes on its surface, and the **smooth ER**, which lacks them.
  - The ER contains many **ribosomes, the protein production machine**.
  - The ribosome is a large complex composed of many molecules, only exist floating freely in the cytosol, whereas in eukaryotes they can be either free or bound to membranes.
- **Lysosomes and Peroxisomes:** The eukaryotic cell could not house such **destructive enzymes** if they were not contained in a membrane-bound system.
- **Vacuoles:** They store food and waste. Some vacuoles store extra water also they are often described as liquid filled space and are surrounded by a membrane. Some cells, most notably **Amoeba** have contractile vacuoles, which can pump water out of the cell if there is too much water

Cell Division

- The growth and the development of every organism depend exclusively on the multiplication and enlargement of its cells. The development of a multicellular organism from the unicellular zygote is achieved by cell division, growth, and differentiation.
- The division of the nucleated cells is achieved by two integral activities such as **division of the nucleus (called Karyokinesis) and the division of the cytoplasm (that is called cytokinesis)**. Usually, the Karyokinesis is followed by the Cytokinesis, but sometimes it does not follow and results in multinucleated cells.
- In animals and plants, following three types of cell division have been observed:
- **Amitosis**
  - It is the means of asexual reproduction in unicellular organisms like bacteria and protozoans. It also occurs in embryonic membranes of vertebrates.

- In Amitosis, the splitting of the nucleus is followed by cytoplasmic contraction. I
- In Amitosis, two daughter cells are formed without the occurrence of any nuclear event. It is also known as direct nuclear division.

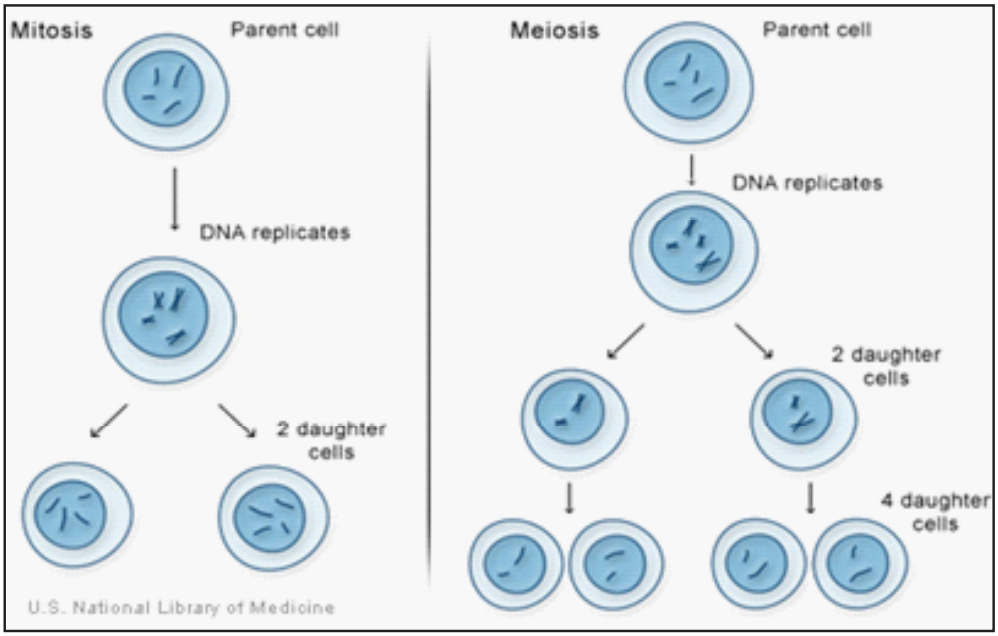
Mitosis

- It takes place as a result of mitotic division One cell divides into 2 daughter cells which are quantitatively and qualitatively identical to the mother cell. No change in the Chromosome number occurs.
- In between two successive mitotic divisions, there is a rest period called the **interphase.**
- Mitosis has 4 phases- **Prophase, Metaphase, Anaphase &Telophase**.
  - **Prophase:** Disappearance of nuclear membrane and nucleolus along with the **doubling of chromosomes.**
  - **Metaphase:** Formation of a **spindle**, chromosomes join themselves to the **equatorial plane** of the spindle.
  - **Anaphase:** Centromeres divide **longitudinally**. Sister chromatids move towards the **opposite pole**.
  - **Telophase:** Grouping of chromatids at each pole along with the formation of new nuclear membrane and nucleolus.

Meiosis

- Also called **Reproductive cell division** because it is associated with all sexual reproduction. As a result of the division in the daughter cells, chromosomes number becomes**half** to that of the mother cell.
- Each division results in 4 daughter cells in contrast to 2 daughter cells in each mitotic division.

- The division includes 2 phases i.e. **Reduction division and Equational division (Mitosis**) which also consist of the same 4 phases, i.e., **Prophase, Metaphase, Anaphase &Telophase**.
- But Prophase I (Division I) have 5 sub-stages: **Leptotene, Zygotene, Pachytene, Diplotene&Diakinesis.** The characteristics of each of the sub-stage are:



- **Leptotene:** Close association of homologous chromosomes.
- **Zygotene**: Pairing of homologous chromosomes, the phenomenon is called **Synapsis**. As a result, Bivalent Chromosomes are formed.

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- **Pachytene:**Chiasma formation and crossing over.
- **Diplotene:** Terminations of chiasma starts.
  - **Dikineses:** Disappearance of nuclear membrane and nucleolus.

- In Metaphase I spindle formation and rearrangement of chromosomes. In Anaphase I separation of homologous chromosomes. In Telophase grouping of chromosomes and formation of nuclear membrane and nucleolus. This division is followed by Division II.

Genetics

Introduction

- The science dealing with the study of the mechanism of heredity and the causes of variation in all living beings is called Genetics. The word Genetics was derived from the Greek root word 'gen' which means to grow. **The term Genetics was coined by Bateson in 1906 for the study of the physiology of heredity and variations.**Genetics is the study of two contradictory aspects of nature i.e. Heredity and Variation.
  - **Heredity:** Because of this phenomenon of heredity, **offspring of all living organisms resemble their parents in several aspects**. Hereditary exactly gives the meaning "like produces like", all living organisms tend to produce offspring like themselves.
    - Hence, heredity may be defined as the transmission of characters from one generation to other/ from parents to their offspring's via gametes in sexual reproduction or via some asexual reproductive bodies in asexual reproduction. These transferable characters are called **"hereditary characters".** Thus, heredity is the cause of similarities between the offspring's, so that the individuals of the same parents resemble each other in most of the aspects.
  - **Variation:** Though offspring receive all the characters from their parents, they are not exact copies of their parents. Differences are found even between two offspring of the same parents. The progeny differs not only among themselves but also with the parents. These differences are called variations. Thus, **variations may be defined as the visible differences between the parents and the offspring's or between the offspring of the same parents**.
- Genetics explains the mechanism and the basis for **both similarities and differences** between related individuals. Genetics also tries to explain the phenomenon of the evolution of **cytodifferentiation.**

Branches of Genetics

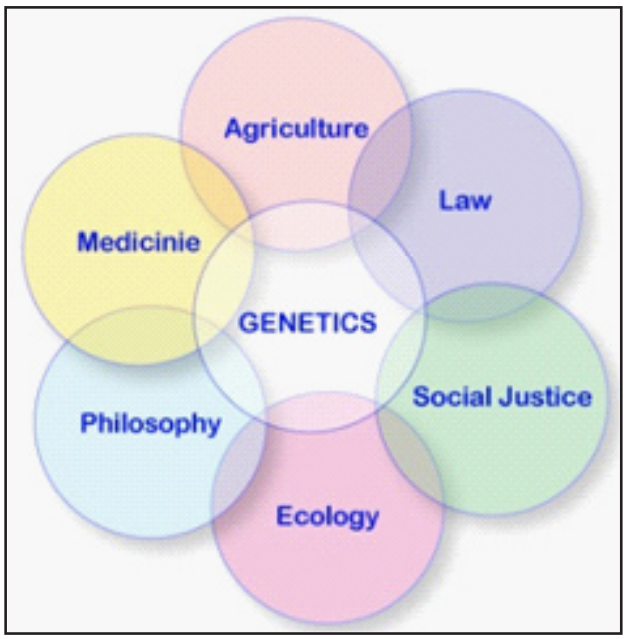
The science of genetics has proliferated into numerous distinctive sub-disciplines. The following are some of the distinctive branches of genetics:

- **Plant genetics:** The genetics of plants
- **Animal genetics:** The genetics of animals
- **Microbial genetics:** The genetics of Microorganisms (Viruses, Bacteria, unicellular plants, and animals)
- **Human genetics:** The study of heredity of human traits and human disorders and correction of human genetic disorders.
- **Viral genetics:** The genetics of viruses

- **Fungal genetics:** The genetics of Fungus
- **Drosophila genetics:** The Genetics of Fruit fly (Drosophila).
- **Mendelian Genetics:** It involves the study of heredity of quantitative (monogenic) and quantitative (polygenic) traits and the influence of the environment on their expressions.
- **Quantitative genetics:** It involves the study of heredity of quantitative traits such as height, weight, and IQ in human beings and milk production in cattle.
- **Morganian genetics:** It includes the study of recombination or crossing over in all kinds of organisms such as higher plants, animals, fungi, bacteria, and viruses. It also involves the preparation in linkage maps of chromosomes.
- **Non-Mendelian genetics:** It involves a study of the role of cytoplasm and its organelles in heredity.
- **Mutation Genetics:** They involve the study of heredity of both chromosomal changes and also gene mutation.
- **Cytogenetics:** It provides cytological explanations of different genetical principles.
- **Molecular genetics:** It includes the study of the structure and function of gene and regulation of its activity.
- **Transmission genetics:** It includes the study of the mode of gene transmission from generation to generation. The kind of studies, that Mendel performed are now included in the discipline of transmission genetics.
- **Clinical genetics:** Genetics involved in the detection of causes of diseases such as haemophilia, colour blindness, diabetes, Phenylketonuria.
- **Forward genetics and reverse genetics:** The term reverse genetics has been used in physical mapping and isolation of genes whose protein products are unknown. The term forward genetics has been used genes that are mapped based on phenotype using the technique of classical genetics.
- **Immuno-genetics:** It deals with the production of different types of antibodies. The diversity of the antibodies is found to be under the control of genetic regulation.
- **Behavioral genetics:** It involves the study of the interaction of genes with the environment to produce a particular pattern of behaviour.

Importance of Genetics

- Genetics explains a lot of things animals, plants and humans like what makes them unique, what makes them different and variable, why do they look like all the other members of their family, and why some diseases occur only in plants or animals or humans.
- The genetic information can be utilized to diagnose, treat, prevent, and cure many diseases in animals, plants, and humans. The genes can be better understood as the information, which guides and command the body to make proteins that are needed for the growth and survival of the organism. Geneticists identify and recognize the importance of these proteins for the betterment of human life with effective medicines and treatments.



- Genetic experts can trace and work out family relationships and ancestors by studying the differences in DNA. The common ailments like asthma, diabetes, etc., requires the involvement of many different genes. The identification of genetic influences and their interactions with various other factors can help in bringing great advancements in medical research.
- Scientists have decoded the genomes of humans and various other plants and animals. This decoding would help in improving the yield, selecting better traits, producing disease-resistant varieties which are the need of the hour to feed the ever-growing human population. Humans have about 24,000 different genes each made up a few hundred to a few thousand base pairs of DNA. All these genes are contained in 23 pairs of chromosomes, each of which carries thousands of different genes and millions of base pairs of DNA. When these genes are altered, there would be a direct effect on the synthesis of the corresponding proteins and consequently, this will lead to diseases.
- In recent years the advances in the field of biotechnology have created genetically engineered strains of bacteria and fungi that carry specific genes from unrelated organisms. These microbes produce useful compounds as insulin, human growth hormone, antiviral and anticancer agents.
- Finally, the information on genetic mechanisms has made us aware of some new dangers too. Some genetic experts fear there may be an accidental release of artificial pathogens from labs which may cause a great disaster. Also, some genetic experts fear that increased exposure of plant or animal products to the chemicals may bring about undesirable and haphazard outcomes. Anyways, modern genetic experts have revolutionized agriculture, horticulture, animal husbandry, philosophy, sociology, law, ecology, and many other branches of biology. Moreover, the science of genetics has helped in removing many faulty concepts of inheritance.

Mendel and his work, seven traits observed by Mendel

Introduction

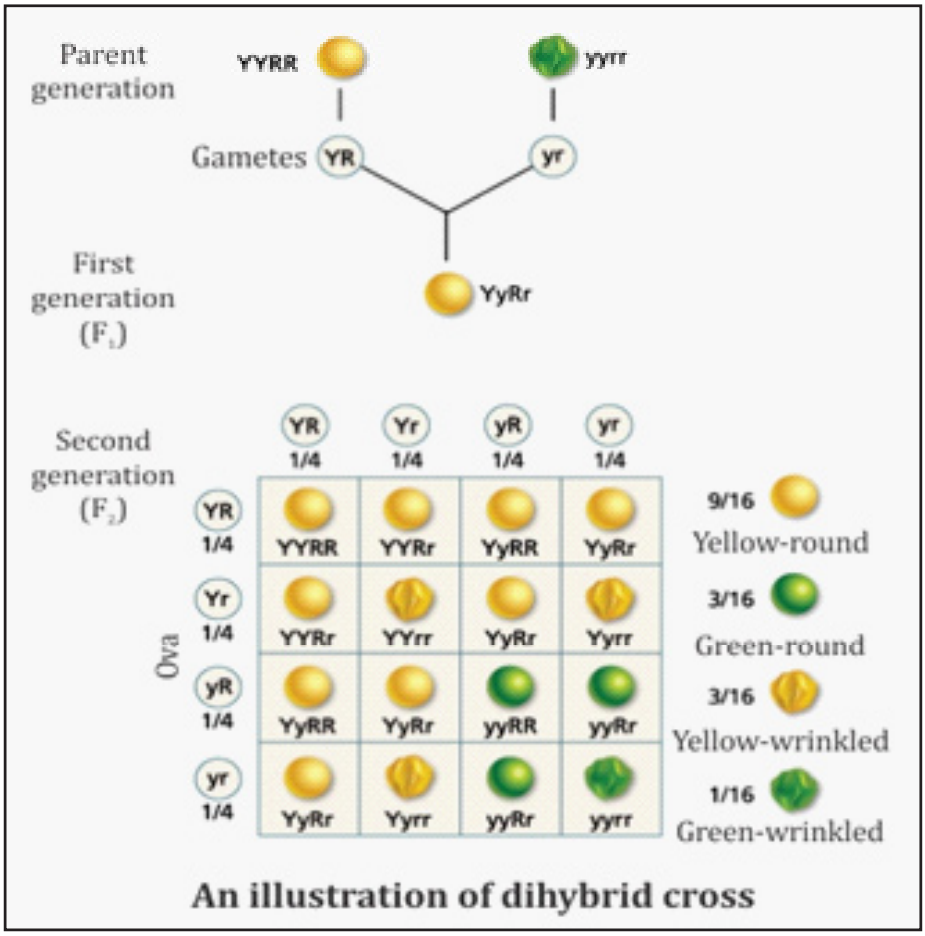
- Farmers and herders have been breeding their plants and animals selectively for thousands of years. This kind of selective breeding leads to production of more useful hybrids. Initially, they did not know the actual mechanism behind the inheritance of characters. Consequently, with the developments made in various branches of science, we finally came to know the actual mechanism behind the selective plant breeding experiments.
- The invention of better microscopes in the 1890s allowed natural scientists to realize the basic facts of cell division and sexual reproduction. The attention of genetic research was then shifted to understanding what happens behind the screen during i.e. transmission of hereditary traits from parents to children. A number of assumptions were proposed to clarify the concept heredity, but finally, it was **Johann Gregor Mendel** who set the basis for the study of genetics. His ideas have been published in 1866 but his ideas went unnoticed until 1900.
- Although Mendel experimented with **plants,** the primary principles of heredity that he discovered also apply to humans and other animals. This is because the **mechanisms of inheritance are the same for all complex life forms.**

Seven traits observed by Mendel

- Mendel selectively cross-bred over 28,000+ common pea plants for many generations and he discovered that certain characters show up in offspring without any mixing of parent characteristics. For example, the

pea flowers are either purple or white and intermediate colors do not appear in the offspring of cross-pollinated pea plants.

- Mendel observed the following seven traits that are easily recognized and these traits superficially occur only in one of two forms:
  - Flower color is purple or white
  - Flower position is axil or terminal
  - Stem length is long or short
  - Seed shape is round or wrinkled
  - Seed color is yellow or green
  - Pod shape is inflated or constricted
  - Pod color is yellow or green



An illustration of dihybrid cross

- During the 19th century, most of the genetic researchers believed in **"blending theory".** This theory states that **inherited characters blend from generation to generation**. Hence Mendel carefully selected the characters which do not show up in offspring with intermediate forms. But later it was verified that this theory was wrong.
- Another equally wrong theory known as **"pangenesis**" was proposed by **Charles Darwin**. This theory proposed that inherited **"elements"** in our bodies are altered by the things we do during our lifetime. These altered elements were thought to migrate via blood to the reproductive cells and subsequently could be inherited by the next generation.

Conclusions of Mendel's experiments

- Mendel concluded three important points from his experiments:
  - **Factors are the units that decide the inheritance of a character**. Factors remain unchanged and are transferred on to the offspring. These factors are now called **genes.**
  - An individual receives one such factor from each of the parents for each character.
  - Characters may not show up in an individual but can still are transferred to the next generation.
- It is important to note that, in Mendel's experiments, the starting parent plants were homozygous for pea seed color.
- Each parent had two identical alleles of the gene for this character. The plants of the first generation (f1) were all heterozygous.
- Offsprings have inherited two different alleles-one from each parent plant. This can be understood more clearly when we look at actual genetic makeup (genotype) and physical characteristics (phenotype).
  - Each of the offspring of the first generation gets a yellow allele from one parent and a green allele from another parent. When these plants from the first generation are breed, they have an equal chance of passing on either yellow or green alleles to each offspring.
  - Among all the seven pea plant characters experimented by Mendel, on character appears to be dominant over the other. In other words, we can say that one character masked the presence of others.
- Mendel, based on the results he obtained from his experiments formulated three laws:
  - Law of Segregation
  - Law of Independent Assortment
  - Law of Dominance

Sex Linkage in Human Beings

- In human beings, there are **46 chromosomes (23 pairs**) present in each somatic cell. In **female individuals**, there are 22 pairs of autosomes and one pair of X-chromosomes **(22 pairs + XX)** and in **male individuals,** there are 22 pairs of autosomes and one 'X' and one 'Y' chromosome **(22 pairs + XY).** Since females will produce only one type of gametes, **gametes from a male individual will determine the sex of the progeny**. In man, about fifty X-linked diseases have been reported. The most important and common X linked disease of man are:
  - Colour blindness
  - Haemophilia
  - Anhidrotic ectoderma(non-functional sweat glands)
  - Night blindness
  - Myopia (short-sightedness)
  - Juvenile glaucoma (hardening of the eye ball).
- **Turner's syndrome:**It is characterised by monosomy of XO type i.e. one X chromosome of sex chromosome (XX) is missing, the Turner's syndrome individuals are phenotypically a female and can be characterised by short stature, webbed neck, underdeveloped breasts, and small uterus.
- **Klinefelter's Syndrome:**It is characterised by trisomy (XXY) with the total number of chromosomes 47. These are male individuals who are phenotypically fairly normal but have a very low sperm count and are therefore sterile. They have female-like breast development, small testes, and sparse body hairs.
- **Colour Blindness:** It is sex-linked inheritance found more often among men than women. It is **regulated by a recessive gene**. Individuals suffering from this failure to differentiate between colours, mainly between red and green colours.
- **Down's syndrome (Mongolism):** It develops due to the trisomy of the 21st chromosome i.e. representation of the chromosome thrice instead of twice. It occurs once in every 500 to 600 childbirths. The individual is mentally retarded and there is no cure for the abnormality.

- **Haemophilia:** This is a rare hereditary blood disorder marked by a tendency towards excessive bleeding. It is a sex-linked abnormality and is entirely restricted to males.
- **Albinism:** This affects skin preventing the development of skin pigments. It happens due to an autosomal recessive gene. Individuals suffering from this abnormality are found to lack pigmentation of skin, iris, retina, choroid, and hairs. It has been proved that albinism results from failure on the part of the amino acid.

Biotechnology

Biotechnology is defined as the industrial application of living organisms and their biological processes such as biochemistry, microbiology, and genetic engineering, to make the best use of the microorganisms for the benefit of mankind.

Different types of biotechnology

- **Green Biotechnology:** It is defined as **the application of biological techniques to plants** to improve the nutritional quality, quantity, and production economics. It is done by implanting foreign genes to plant economically important species. This contains three main areas: plant tissue culture; plant genetic engineering and plant molecular marker-assisted breeding.
- **Red Biotechnology:** It is concerned with the **discovery and development of innovative drugs and treatments**. A key prerequisite was an increasing understanding of how proteins function, their roles in communication between and within cells, and the diseases caused when these proteins malfunction. This includes **Gene Therapy, Stem Cells, Genetic Testing**, etc.
- **White Biotechnology:** This field of biotechnology is **connected with the industry**. White biotech uses molds, yeasts, bacteria, and enzymes to produce goods and services or parts of products. It offers a wide range of **bio-products like detergents, vitamins, antibiotics, etc.** Most of the white biotech processes result in the saving of water, energy, chemicals, and the reduction of waste compared to traditional methods.
- **Blue Biotechnology:** It is concerned with the application of molecular biological methods **to marine and freshwater organisms**. It involves the use of these organisms, and their derivatives, for multiple purposes, the most remarkable are the identification process and development of new active ingredients from marine origin.
- **Yellow Biotechnology:** It refers to biotechnology with **insects — analogous to the green (plants) and red (animals) biotechnology**. Active ingredients or genes in insects are characterized and used for research or application in agriculture and medicine.

Applications

- **Biopharmaceuticals:** The drugs are being developed with the use of microorganisms without using any **synthetic materials and chemicals**. Large molecules of **proteins** are usually the source of biopharmaceutical drugs. They when targeted in the body attack the hidden mechanisms of the diseases and destroy them **without any side effect**(s). Now scientists are trying to develop such biopharmaceutical drugs that can be treated against diseases like hepatitis, cancer, and heart diseases.
- **Gene therapy:** It is used in delicacy and diagnoses of diseases like **cancer and Parkinson's**. The apparatus of this technique is that the fit genes are under attack in the body which **either obliterate the injured cells or replace them**. In some cases, the fit genes make corrections in the genetic information and that is how the genes start performance in the favour of the body.

- **Flowers:** There is **extra to agricultural biotechnology** than just hostility disease or civilizing food quality. There is some simply aesthetic application and an example of this is the use of gene recognition and transfer techniques **to improve the colour, smell, size, and other features of flowers.**
- **Plant and Animal Reproduction:** Enhancing plant and animal behaviour by traditional methods like cross-pollination, grafting, and cross-breeding is time-consuming. Biotech advance let for specific changes to be made **rapidly, on a molecular level through over-expression or removal of genes, or the introduction of foreign genes**.
- **Food processing** is a process by which **non-palatable and easily perishable raw materials are converted to edible and potable foods and beverages**, which have a longer shelf life. The method, by which the microbial organisms and their derivatives are used to increase the edibility and the shelf life of foods, is known as fermentation.
- **Bioremediation:** The process of **cleaning up the hazardous substances into non-toxic compounds** is called the Bioremediation process. This process is majorly used for any kind of technology clean up that uses the natural microorganisms.

Biotechnology Projects

Human Genome Project

- The "genome" of any given individual is unique; **mapping the "human genome"** involved sequencing a small number of individuals and then assembling these to get a complete sequence for each chromosome. The **finished human genome is thus a mosaic, not representing any one individual.** Itis an **international scientific research project.**

Advantages:

- It can help us understand diseases including: genotyping of specific viruses to direct appropriate treatment.
- Identification of mutations linked to different forms of cancer.
- The design of medication and a more accurate prediction of their effects.
- Advancement in forensic applied sciences.
- Biofuels and other energy applications.
- Agriculture, animal husbandry, bioprocessing; risk assessment; bio-archaeology, anthropology, and evolution.
- Commercial development of genomics research related to DNA based products, a multibillion-dollar industry.

Gene Editing

- This is a technique that allows the scientist to **edit the gene sequence and then modify it** to bring the desired changes. It helps to understand the sequence of genes and then use gene editing to cure incurable diseases like **Tay-Sachs and perhaps cystic fibrosis** through the modification of genes.
- In addition to that, gene editing can be used as a research tool to simply learn more about these diseases.

GM Mustard Issue

- **DMH-11 is a Genetically Modified (GM) mustard hybrid**. Hybrids are normally obtained by crossing 2 genetically diverse plants from the same species. The **1st-generation offspring resulting from it has higher yields** than what either of the parents is individually capable of giving.

- But there is **no natural hybridization system in mustard**, unlike in, say, cotton, maize, or tomato. This is because **its flowers contain both the female (pistil) and male (stamen) reproductive organs**, making the plant naturally self-pollinating. What scientist has done is to create a viable hybridization system in mustard using GM technology. The resulting GM mustard hybrid, it is claimed, gives 25-30% more yield than the best varieties such as 'Varuna' currently grown in the country.
- Scientists at the **Centre for Genetic Manipulation of Crop Plants (CGMCP) in Delhi University**, however, showed that this problem could be addressed by crossing Indian mustard cultivars with juncea lines of East European origin like **'Early Heera' and 'Donskaja'**. The combination of the 2 divergent gene pools enhanced the crossing options; the resultant F1 progeny were found to exhibit significant heterosis.

Terminologies associated with the biotechnology

- **DNA:** Deoxyribonucleic Acid (DNA) is a molecule that encodes the genetic instructions used in the development and functioning of all known living organisms.
- **Gene:** It is a **segment of nucleic acid** that contains the information necessary to produce a functional product, usually a protein. The genes are made up of a coding alphabet of 4 nucleotides made up of 4 bases: - **Adenine (A), Thymine (T), Guanine (G), and Cytosine (C)**.
- **Genetic Engineering:** Techniques to **alter the chemistry of genetic material** (DNA and RNA), to introduce these into host organisms and thus change the phenotype of the host organism.
- **Gene Therapy:** This is in a way, **genetic engineering of humans**, which would allow a person suffering from a disabling genetic disorder to lead a normal life.
- **Genome Resource Bank:** It is a **frozen repository of biological materials**, including sperm and embryos, tissue, blood products, and DNA. It is going to being used as a conservation tool for protecting and preserving biodiversity.
- **Bioinformatics:** It is an independent discipline that **merges the field of molecular biology and computer science**. This mainly involves the transformation of biological polymers such as nucleic acid molecules and proteins into sequences of digital symbols. The symbols and their meaning for the protein sequences have also been generated.
- **Bioremediation:** It is the **use of microorganisms for the degradation of hazardous chemicals** in soil, sediments, water, or other contaminated materials. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment.
- **Biosensors:** They are **biophysical devices that can detect the presence of specific substances e.**g. sugars, proteins, hormones, pollutants, and a variety of toxins in the environment.
- **Bioreactors:** It can be thought of as **vessels in which raw materials are biologically converted into specific products**, individual enzymes, etc., using microbial plant, animal, or human cells.
- **Bioprospecting** is an umbrella term describing the process of **discovery and commercialization of new products** based on biological resources, typically in less-developed countries. Bioprospecting often draws on indigenous knowledge about the uses and characteristics of plants and animals. In this way, **bioprospecting includes biopiracy**.
- **Biopiracy** is a situation where indigenous knowledge of nature, originating with indigenous people, is **used by others for profit, without permission** from and with little or no compensation or recognition to the indigenous people themselves.
- **Green consumerism** refers to **recycling, purchasing, and using eco-friendly products** that minimize damage to the environment. This involves decisions such as using Energy Start appliances that consume less power, buying hybrid cars that emit less carbon dioxide, using solar and wind power to generate electricity, and buying locally grown vegetables and fruits.

- **A Comprehensive Environmental Pollution Index (CEPI)**is a very useful tool to **capture the health dimensions of the environment including** air, water, and land. The CEPI is intended to act as an early warning tool and can help in categorizing the industrial clusters/areas in terms of priority of planning needs for interventions.
- **Bioregionalism** is a **political, cultural, and ecological system** or set of views based on naturally defined areas called bioregions, similar to Eco-regions. Bioregions are defined through **physical and environmental features**, including watershed boundaries and soil and terrain characteristics. Bioregionalism stresses that the determination of a bioregion is also a cultural phenomenon, and emphasizes local populations, knowledge, and solutions.
- **Bioethics:** It is the **branch of ethics, philosophy, and social commentary** that deals with the biological sciences and its impact on society.
- **Vaccine:** A preparation that contains an agent or its components, administered to stimulate an immune response that will **protect a person from illness due to that agent**. A therapeutic (treatment) vaccine is given after the disease has started and is intended to reduce or arrest the progress of the disease. A preventive (prophylactic) vaccine is intended to prevent the disease from starting. Agents used in vaccines may be whole-killed (inactive), live-attenuated (weakened), or artificially manufactured. It can be created using the recombinant DNA process.
- **Vector:** A **vehicle that carries foreign genes** into an organism and inserts them into the organism's genome. Modified viruses are used as vectors for gene therapy.
- **Virus:**A sub-microscopic particle that **can infect other organisms**. It **cannot reproduce on its own** but infects an organism's cell to use that cell's reproductive machinery to create more viruses. It usually consists of a DNA or RNA genome enclosed in a protective protein coat.
- **Stem cell:** A **fundamental cell** that has the potential to develop into any of the 210 different cell types found in the human body. **Human life begins with stem cells**, which divide again and again and branch off into special roles, like becoming liver or heart cells. They are an important resource for disease research and for the development of new ways to treat disease.
- **Amniocentesis:** A procedure used in prenatal diagnosis **to look at the chromosomes of the developing foetus**. A flexible needle is inserted into the mother's uterus through the abdomen to remove a sample of the fluid surrounding the foetus (amniotic fluid). This sample can then be analysed by karyotype to look for changes in the chromosomes. The procedure can be done after 15 weeks of pregnancy. There is a 0.5% risk of miscarriage associated with this procedure, which means one in 200 women will miscarry following this procedure.
- **Embryonic stem cells:** Cells that are **removed from the early embryo** and can become any of the 210 cell types found in the human body. Researchers are looking at the great potential stem cells have in developing new treatments for disease and injury.

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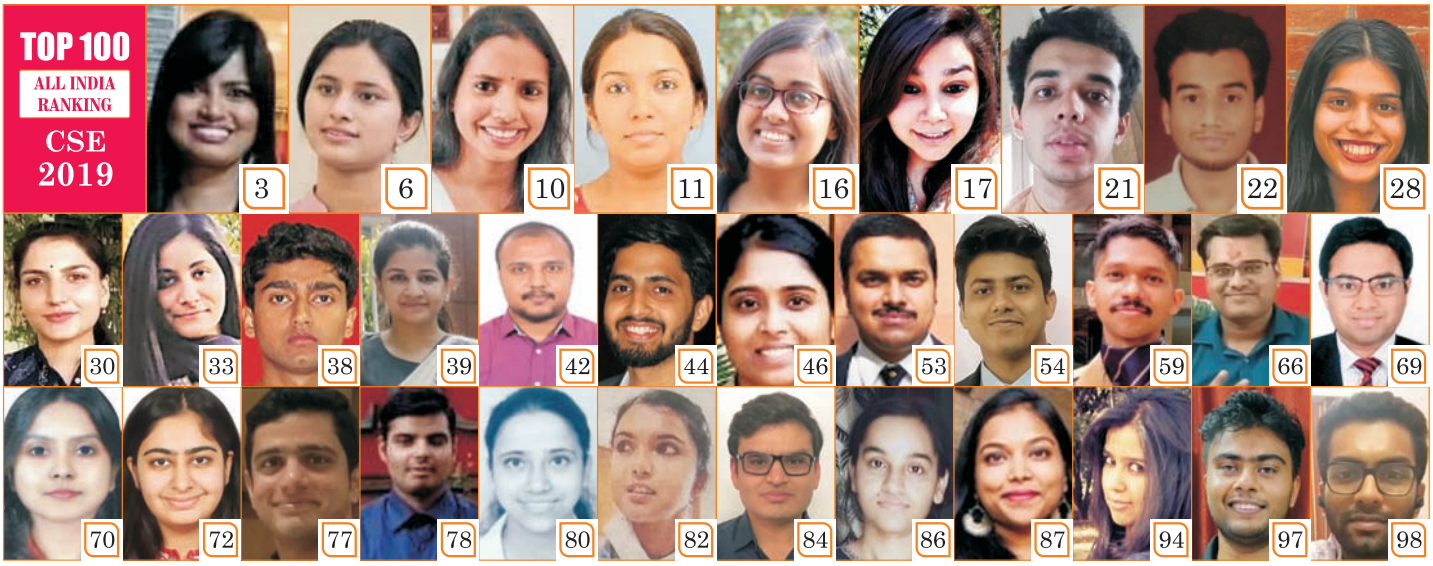

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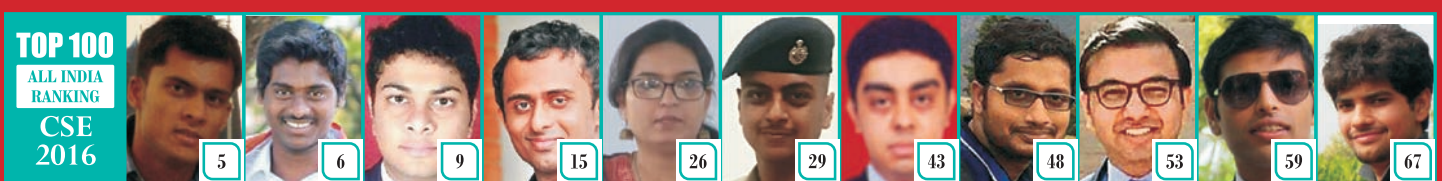

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