INTRODUCTION

WHAT IS BIOLOGY?

The science which deals with the study of living objects and their life processes is called biology (Greek words, bios — life, logos - study). It covers all aspects of the study of living creatures like occurrence, classification, ecology, economic importance, external form, organization, internal structure, nutrition, health and other body functions, reproduction, life history, inheritance and origin. Being broad — based and multi-disciplinary, the term biology is often replaced by the term life sciences or biological sciences. Aristotle is known as the 'Father of biology'. The term biology was coined by Lamarck.

There are three major branches of biology — botany, zoology and microbiology. Botany is the branch of biology which deals with the study of different aspects of plants. Theophrastus is known as the father of Botany. Zoology is the branch of biology connected with the study of different aspects of animals. Aristotle is known as the father of Zoology. Microbiology is the branch of biology dealing with the study of different aspects of microorganisms. Leeuwenhoek is known as the father of Microbiology.

MAIN BRANCHES OF BIOLOGY

Some of the main branches of biology are briefly discussed below:

1. Taxonomy: It is the science of identification, nomenclature and classification of organisms.

2. Morphology: It is the study of external form, size, shape, colour, structure and relative position of various living organs of living beings.

3. Anatomy: It is the study of internal structure which can be observed with unaided eye after dissection.

4. Histology: It is the study of tissue organization and structure as observed through light microscope.

Contact No:9535111199/9535111188

5. Cytology: It is the study of form and structure of cells including the behaviour of nucleus and other organelles.

6. Cell Biology: It is the study of morphological, organizational, biochemical, physiological, genetic, developmental, pathological and evolutionary aspects of cell and its components.

7. Molecular Biology: It is the study of the nature, physicochemical organization, synthesis, working and interaction of bio-molecules that bring about and control various activities of the protoplasm.

8. Physiology: It is the study of different types of body functions and processes.

9. Embryology: It is the study of fertilization, growth, division and differentiation of the zygote into embryo or early development of living beings before the attainment of structure and size of the offspring.

10. Ecology: It is the study of living organisms in relation to other organisms and their environment.

11. Genetics: It is the study of inheritance of characters.or heredity and variations. Heredity is the study of expression and -transmission of traits from parents to offspring.

12. Eugenics: It is the science which deals with factors related to improvement or impairment of race, especially that of human beings.

13. Evolution: It studies the origin of life as well as new types of organisms from the previous ones by modifications involving genetic changes and adaptations.

14. Palaeontology: It deals with the study of fossils or remains and impressions of past organisms present in the rocks of different ages.

15. Exobiology: It is the branch of scientific inquiry dealing with the possibility of life in the outer space.

16. Virology: It is the study of viruses in all their aspects.

Contact No:9535111199/9535111188

Other Branches

Depending upon the group of organisms studied, biology has several branches like bacteriology (bacteria), mycology (fungi), phycology (algae), bryology (bryophytes), pteridology (pteridophytes), palynology (pollen grains), protozoology (protozoans), helminthology (worms), entomology (insects), ichthyology (fishes), herpetology (reptiles), ornithology (birds), mammology (mammals)etc.

THE CELL

Cells are the microscopic units of life. They generally cannot be seen with unaided human eye. The term 'cell' was coined by Robert Hooke. It was M.J. Schleiden who discovered that all tissues of plants are made up of cells. T.S. Schwann discovered that all tissues of animals are made up of cells. This concept was then applied to all living organisms and these findings are now referred to as the cell theory, which states that:

i) All organisms are made up of cells.
ii) The cell is the basic unit of structure and function of all organisms.
iii) All cells have their own biosynthetic machinery.
iv) All cells arise from pre-existing cells.

TYPES OF CELLS

There are main two types of cells - **prokaryotic and eukaryotic**. The terms prokaryote (Pro — before, karyon - nucleus) and eukaryote (Eu — true, karyon - nucleus) have been derived from Greek words.

Prokaryotic cells

These cells are generally confined to bacteria and blue-green algae which do not have a well organized nucleus and contain few, if any, membrane bounded

Contact No:9535111199/9535111188

organelles. The DNA is also not enclosed by a nuclear membrane. Instead it is found in the cytoplasm.

Eukaryotic Cells

These cells occur in all the organisms, namely algae (exception blue green algae). protozoans, fungi, higher animals and plants. These cells possess membrane —bounded organelles and a distinct nucleus. DNA is enclosed here in a membrane —bound nucleus.

the main differences between the Prokaryotic and eukaryotic cells are given below:

I) Eukaryotic cells have a true nucleus, bound by a double membrane. Prokaryotic Cells have no nucleus.
II) Eukaryotic DNA is linear. prokaryotic DNA is circular.
III) Eukaryotic DNA is complexed with proteins called 'histones' and is organized into chromosomes. Prokaryotic DNA is 'naked' means that it has no histones associated with it. and it is not formed into chromosomes.
IV) Both cells types have many ribosomes, but the ribosomes of the eukaryotic cells are. larger and more complex than those of the prokaryotic cell.
V) The cytoplasm of eukaryotic cells is filled with a large, complex collection of organelles, many of them enclosed in their own membrane; the prokaryotic contains no membrane-bound organelles which are independent of the plasma membrane.

CELL STRUCTURE

The various components of a cell and their structure and functions may be studied under plasma membrane, cytoplasm, cell organelles, and nucleus.

Plasma membrane

Contact No:9535111199/9535111188

The natural boundary of the cell is the cell or plasma membrane. It is thin, elastic, living organelle which imparts shape to a certain cell. It is selectively permeable and regulated the entry and exit of materials into or out of the cell. It is made up of two layers of lipid molecules with a layer of protein molecules on either side. In plants generally and in animals rarely, the cell membrane is surrounded by a thick, rigid, dead cell wall of cellulose. It protects and supports the cells. Cell membrane also forms organelles in the cytoplasm.

Cytoplasm

Cytoplasm consists of a viscid, semi-fluid, translucent, amorphous, ground substance known as the matrix. Besides a variety of biological molecules, it contains several structures in it.

Cell Organelles

Cell organelles are the organized structures with special function. These include mitochondria, endoplasmic reticulum, ribosomes, golgi apparatus, lysosomes, centrosomes, vacuoles, etc.

Endoplasmic Reticulum

Inside the cell there exists a complex tubular membrane system, which almost fills up the intracellular cavity. On the one end it is connected to the outer membrane of the nucleus and on the other to the plasma membrane. The electron microscope reveals two types of endoplasmic reticulum:

i) Tubes with smooth surface called smooth endoplasmic reticulum (SER).

ii) Tubes studded with spherical bodies (ribosomes) known as rough endoplasmic reticulum (RER).

The endoplasmic reticulum is absent in the red blood cells of mammals and embryonic cells. Its functions are: -

i) It forms the supporting skeletal framework of the cell.

ii) It provides a pathway for the distribution of nuclear material from one cell to another

iii) Certain enzymes present in it synthesize fats, steroids and cholesterol.

iv) Being highly folded or coiled, it provided increased surface for various enzymatic reactions.

Ribosomes

Ribosomes are dense, spherical and granular particles which occur freely in the matrix or remain attached to the endoplasmic reticulum. Chemically, the major constituents of ribosomes are the ribo-nucleic acid and proteins. Fats are practically absent. Ribosomes provide the surface on which protein synthesis takes place.

Mitochondria

The mitochondria are tiny bodies of varying shapes and size distributed in the cytoplasm, and each is bounded by a double membrane envelope. The inner membrane is thrown into folds and has an area several times the surface area of the outer membrane. The folds are known as cristae and are studded with small rounded bodies called oxysomes. There is a greater concentration of mitochondria in animal cells than in plant cells. Mitochondria are absent in bacteria and the red blood cells of mammals and higher animals. Mitochondria are the sites of cellular respiration. Oxidation releases energy, a portion of which is used to form ATP (Adenosine tri-phosphate). Since mitochondria synthesize the energy rich compound ATP they are also known as the 'powerhouse of the cell'.

Golgi Complex

The Golgi complex, also named Golgi bodies or the Golgi apparatus occurs in all cells with a few exceptions. Exceptions include bacteria, blue-green algae, mature sperms and red-blood cells of animals. The Golgi complex arises from the -membrane of the smooth endoplasmic reticulum, which in turn have originated from the rough endoplasmic reticulum. The main function of the Golgi body is to secrete. The synthetic products of the cell i.e. proteins,

Contact No:9535111199/9535111188

hormones and enzymes are collected by the Golgi vacuoles and secreted into the cytoplasm.

Lysosomes

Lysosomes are tiny spherical sac-like structures evenly distributed in the cytoplasm. These vesicular structures contain destructive enzymes called hydrolases. Lysosomes are absent in mature mammalian red blood cells but abundant in the white blood cells. The chief function of lysosomes is digestion. The enzymes present in the matrix of the lysosomes are rich in digestive enzymes called hydrolases. These are capably of breaking down a wide variety of flood particles. Lysosomes are known as the suicide bags of the cell.

Centrosomes and Centrioles

Just outside the nucleus of the animal there is a small clear area of cytoplasm without any granules. In this portion of the cytoplasm, which is called the centrosome, are or two tiny micro-tubular cylindrical structures develop. These are called centrioles. The centrioles are concerned with cell division. It initiates cell division in animal cells.

Plastids

Plastids are known as the kitchens of the cell. Plastids occur in most plant cells and are absent in animal cells. Cells of lower non-flowering plants like bacteria, blue-green algae and fungi contain chromataphores instead of plastids. Plastids are self-replicating i.e. they have the power to divide as they contain DNA, RNA and ribosomes. There are various types of plastids;

(i) Chloroplast: The chloroplast, containing the green pigment chlorophyll is the most widely occurring plastid. Present in green algae and higher plants each chloroplast is bounded by a double membrane. The inner content is composed of the matrix (stroma) and the grana. The matrix is a space filled with a watery proteinaceous substance, and is the site of the dark reaction during photosynthesis. The Gram, composed of disc shaped plates called Thylakoids arranged in layers is the site of the light reaction during photosynthesis.

Contact No:9535111199/9535111188

(ii) Leucoplast: There are colourless, red-shaped or spheroid plastids occurring in seeds, meristematic cells, sex-cells ground fissile 01 certain roots and stems Leucoplasts are of three types,

• Amyloplast - Stores carbohydrates in the form of starch.

• Aleuroplasts - Stores proteins.

• Elaioplasts - Stores oil or fats.

(iii) Pigments: Pigments are natural colouring agents found in plant bodies chlorophyll is the most abundant plant pigment. Other pigments include the yellow and orange carotenoids and the red and blue anthocyanins. Bio – 20

i) Lycopene: Gives red colour to ripe tomatoes and red pepper
ii) Carotene: Gives red colour to carrots
iii) Xanthophyll: Imparts red and yellow colour to followers

Nucleus

The nucleus has been described as the brain of the cell as it regulates metabolic and hereditary activities of the cell. The shape, size and number of nucleus present in a cell is variable. Some cells like mature red blood cells of mammals and the sieve tubes in plants contain no nucleus. The nucleus is composed of the following structures:

i) Nuclear Membrane: It is a selectively permeable envelope like structure around the nuclear contest which separates the nucleoplasm from the cytoplasm.

ii) Nucleoplasm: The space within the nuclear envelope is filled by a transparent semi-solid granular round substance or matrix called the nucleoplasm.

iii) The Nucleolus: It is a dense spherical granule contained within the nucleus. Its size is related to the synthetic activity of the cell. The nucleolus stores all the proteins of the ribosomes.

Contact No:9535111199/9535111188

iv) The nuclear pores: The pores help in exchange of materials between nucleoplasm and cytoplasm. RNA and ribosomes leave the nucleus through these pores.

v) Chromatin fibres: These are very fine threat-like coiled filaments uniformly distributed in the nucleoplasm. At the time of cell division, the chromatin becomes thick and ribbon like and are known as chromosomes.

Cell Inclusions

As a result of diverse metabolic activities of the cell organelles, a variety of soluble and insoluble chemical products accumulate within the cell. These are generally found stores in vacuoles or granules.

Vacuoles

These are clear spaces present in the cytoplasm enclosed by a membrane called Tonoplast. These contain fluid called cell sap in which water soluble substances are found. In animal cells, the vacuoles, if present, are small and temporary. They store gl,cogen and proteins. In plant cells, vacuoles are large and permanent. They generally contain water, anthocyanins, alkaloids, fats, sugars and proteins. Vacuoles also help in maintaining the osmotic pressure in a cell. There are various types of vacuoles, like

(a) Sap vacuoles: Store and concentrate mineral salts as well as nutrients.

(b) Contractile Vacuoles: Take part in osmoregulation and excretion.

(c) Food Vacuoles: Contain digestive enzymes with the help of which nutrients arc digested.

(d) Air Vacuoles: Present only in prokaryotes, helps in buoyancy of cells.

Differences between animal cells and plant cells

Contact No:9535111199/9535111188

ANIMAL CELL	PLANT CELL
1. Thin, flexible, living plasma membrane forms the outermost boundary.	1. Thick, rigid, dead cell wall forms the outermost boundary.
2. It may change form and move about	2. It cannot change form and position due to the presence of rigid and dead cell wall.
3. Centrosome is present in all animal cells.	3. Centrosome is absent, exception being motile cells of lower plants.
4. Nucleus lies generally in the centre of the cell.	4. Nucleus is often pushed to one side, due to the presence of large sap vacuole.
5. Many small vacuoles are present.	5. Generally, one large sap vacuole is present.
6. Plastids are rarely present.	6. Plastids are surely present.
7. Mitochondria are generally more in number.	7. Mitochondria are generally less in number.
8. Cristae in mitochondria are plate — like.	8. Cristae in mitochondria are tube — like.
9. Contractile vacuole may occur to pump out excess water.	9. Contractile vacuole is absent.
10.1t cannot synthesize all the amino acids, coenzymes and vitamins.	10.1t can synthesize all the amino acids., and coenzymes.
11. Cytokinesis occurs by a circular constriction that extends from the periphery to the centre.	11. Cytokinesis occurs by a cell plate that appears at the centre and extends peripherally.

CELL DIVISION

A unicellular organism consists of a single cell. A multi cellular organism also starts it life as a single cell and it undergoes repeated divisions. The vegetative growth of an organism takes place by an increase in the number of cells through cell divisions which follows the geometrical progression and not by increase in the volume of individual cells. The cell division is a complex dynamic and continuous process and it involves three stages:

1. DNA or genome replication

2. Nuclear division or karyokinesis

3. Cytoplasmic division or cytokinesis

On the basis of number of genomes present in the daughter cells in comparison to the dividing cell, the cell divisions are of two types: Mitosis and Meiosis.

MITOSIS

The term mitosis was first coined by W. Flemming. It occurs in somatic cells and is mainly responsible for the growth of an organism. It is a regular division of the cell in such a fashion that each of the two daughter cells receives exactly the same number of chromosomes as are contained in the parental cell.

The cell nucleus during mitosis passes through a series of uninterrupted changes which for the sake of convenience are divided into four stages or phases. These are prophase, metaphase, anaphase and telophase. Collectively these phases are known as M-phase. Prior to mitosis, the nucleus shows no sign of activity but is metabolically active. This stage of nucleus is called Interphase or preparatory phase. This phase is divided into three distinct phases on the basis of synthetic activities:

G1 Phase: During this phase the cell increases in size due to hydration. Various enzymes required for the growth of the cell and DNA synthesis are also produced.

S Phase: DNA strands are replicated during this phase. This phase is called the synthesis phase.

G2 Phase: In this phase, energy pools and proteinaceouc substances are synthesized which are required for the different movements of chromosomes during the nuclear division. It is followed by the M-phase.

The relative length of these preparatory and M-phase differ enormously in different species but are fixed for a species under a given set of conditions. The cell cycle showing the sequence of events is depicted in the figure below:

Contact No:9535111199/9535111188

M-Phase: Various events which occur during M-phase can be discussed under 4 stages:

Prophase	The chromosomes condense and become visible The centrioles form and move toward opposite ends of the cell (the poles) The nuclear membrane dissolves The mitotic spindle forms Spindle fibres from each centriole attach to each sister chromatid at the kinetochore
Metaphase	The Centrioles complete their migration to the poles The chromosomes line up in the middle of the cell ("the equator")
Anaphase	Shortest stage in the mitotic cycle. Spindles attached to kinetochores begin to shorten. This exerts a force on the sister chromatids that pulls them apart. Spindle fibres continue to shorten, pulling chromatidS to opposite poles. This ensures that each daughter cell gets identical sets of chromosomes
Telophase	The chromosomes begin to uncoil. The nuclear envelope forms Cytokinesis reaches completion, creating two daughter cells

Cytokinesis

It is the process by which a cell divides into two. In the animal cell and in lower plants, i; usually occurs by furrowing at the equatorial region. Furrow gradually deepens and ultimately divides the cell into two parts. In higher plant cells, due to the presence of rigic_' cell wall, the furrow formation does not occur but the formation of cell plate is responsible for the cytokinesis. The cell plate formation starts in the centre and extends laterally until it divides the cell into two parts.

Significance of Mitosis

Contact No:9535111199/9535111188

It is responsible for the growth of the tissues or organs due to the division of the cells. Mitosis replaces the worn out cells by new and healthy cells. It maintains the genetic integrity of the cell and ultimately of the organism as mitosis ensures equal distribution both qualitatively and quantitatively of hereditary material between the newly formed cells.

MEIOSIS

The term meiosis was first coined by Farmer and Moore and the cells in which meiosis takes place are called meiocytes. It ultimately results in the production of four haploid cells. It is a specialized division which comprises two successive divisions of nucleus (Meiosis I and Meiosis II) but a single duplication of chromosomes. Meiosis occurs in an organism when it attains maturity. Therefore, it is also known as maturation division. The interphase which precedes the onset of Meiosis I is similar to the interphase which precedes a mitotic division.

MEIOSIS - I

Meiosis I (M-I) or **heterotypic division**, the essential feature of which is to reduce th,-; chromosomal number to half is also known as reductional division. Meiosis I has been divided in to 4 stages:

Prophase I	Most of the significant processes of Meiosis occur during Prophase I • The chromosomes condense and become visible • The centrioles form and move toward the poles •The nuclear membrane begins to dissolve •The homologous pair up, forming a tetrad. Each tetrad is comprised of four chromatids - the two homologous, each with their sister chromatid. • Homologous chromosomes will swap genetic material in a process known as crossing over (abbreviated as XO). Crossing over serves to **increase genetic diversity** by creating four unique chromatids.

Contact No:9535111199/9535111188

Metaphase I	• Microtubules grow from the centrioles and attach to the centromeres. • The tetrads line up along the cell equator
Anaphase I	• The centromeres break and **homologous chromosomes** separate (note that the **sister chromatids** are still attached) Cytokinesis begins
Telophase I	• The chromosomes may decondense (depends on species) • Cytokinesis reaches completion, creating two haploid daughter cells

MEIOSIS - II

Meiosis II (M-II) or **homotypic division**, the essential feature of which is to bring about the equal separation of sister chromatids into the daughter nuclei, is also called equational division. It is very similar to mitosis and involves the following 4 stages:

Prophase II	Centrioles form and move toward the poles The nuclear membrane dissolves Spindle forms Sometimes prophase II is absent.
Metaphase II	Microtubules grow from the centrioles and attach to the centromeres The sister chromatids line up along the cell equator
Anaphase II	The centromeres break and sister chromatids separate Cytokinesis begins
Telophase II	The chromosomes may decondense (depends on species) • Cytokinesis reaches completion, creating four haploid daughter cells

Cytokinesis

Contact No:9535111199/9535111188

It is completed either by furrowing or cell plate formation. Cytokinesis may occur after the completion of M-II nuclear division. As a result of meiosis, four haploid daughter cells are formed from a single diploid cell.

Significance of Meiosis

Meiosis has great significance in sexually producing organisms. At every act of fertilization. the chromosomal number is doubled in the life cycle. Meiosis is a logical 1 necessity in bringing about a numerical reduction in chromosomal number from diploid to haploid state at the time of sporogenesis or game to genesis. Fertilization restores the diploid number. Hence, meiosis plays an important role in alteration of generations. Meiosis introduces variations in the populations produced as a result of sexual reproduction due to recombination of genetic materials.

Polyhybrid cross: It concerns the study of inheritance of more than two pairs of contrasting characters at a time.

Reciprocal cross: It concerns two crosses for the same characteristics but with reversed sexes. For example, in the first cross, A individual is female parent and B individual as male parent. In the second or reciprocal cross, individual A will be male and individual B as female.

Back cross or test cross: It is a cross between heterozygous F, hybrids and the-double recessive homozygous.

First filial (F1) generation: It actually denotes the offsprings produced in a genetic cross between two parents.

Second Filial (F2) generation: It actually denotes the offsprings produced in a genetic cross between offsprings of the first generation.

Genetic linkage: Genetic linkage is the tendency of genes that are located proximal to each other on a chromosome to be inherited together during meiosis. Genes whose loci are nearer to each other are less likely to be separated onto different chromatids during chromosomal crossover, and are therefore said to be genetically linked.

Contact No:9535111199/9535111188

Crossing over: Chromosomal crossover is the exchange of genetic material between homologous chromosomes that results in recombinant chromosomes. It is one of the final phases of genetic recombination, which occurs during prophase I of meiosis (pachytene) in a process called synapsis.

MENDELISM

Mendelism refers to laws of heredity which were discovered by Mendel in 1866. These laws of heredity provide the first ever plausible explanation for the mechanism of inheritance of traits from parents to the offspring. It is important to notice that much of the present day genetics is based upon these laws of heredity (law of segregation and law of assortment).

Mendel performed his historic experiments on garden pea plant (Pisum sativum) from 1856 to 1864. Mendel studied seven different pairs of contrasting characters in garden oea plant with respect to their mode of inheritance.

CHARACTER DOMINANT RECESSIVE

1. Seed shape Round Wrinkled

2. Seed colour Yellow Green

3. Seed coat colour Grey White .

4. Flower position Axial Terminal .

5. Pod shape Inflated Constricted

6. Pod colour Green Yellow

7. Stem length Tall Dwarf

The findings and conclusions of these experiments were published in 1865. Until the turn of 20th Century, Mendel's work on garden pea (which formed the basis of laws of heredity) remained obscured and overlooked.

In the year 1900, it was a sheer coincidence that three prominent scientists from three different countries of Europe namely, Hugo De Vries of Netherland, Carl Correns of Germany and E. Tschermak of Austria independently rediscovered

the laws of heredity earlier discovered by Mendel by conducting experiments on plants. These three biologists collectively agreed for naming the laws of heredity after Mendel and also brought these laws to the notice of the scientific world. Subsequently. Mendel's original work was republished in the year 1901. A few years later, W. Bateson and others confirmed the laws of heredity, put forth by Mendel, in relation to the mechanism oi inheritance in animals.

MONOHYBRID CROSS

Monohybrid cross involves the inheritance of a single pair of contrasting characters. In this regard, Mendel considered the length of the stem (contrasting pair viz., tall plant and dwarf plant). He cross-pollinated a pure tall plant with a pure dwarf plant. Seeds obtained from this cross were sown again to obtain the plants. These first generation plants were termed first filial generation (F1 generation). These F, plants were self pollinated. The seeds, thus, obtained were collected and in turn were sown again to get next generation of plants. Mendel called these plants as second filial generation (F-, generation).

Mendel explained the above results by assuming that when the two factors for alternative expression of a trait come together as a result of fertilization, then only one (dominant one) factor expresses itself. The other factor is recessive and remains hidden. On the basis of this behaviour, tallness is described as the dominant character and the dwarfness as the recessive one. Correlated with this phenomenon, Mendel coined the law of dominance.

The factors or determiners never get contaminated with each other. Actually when the gametes are formed these so called factors get segregated so that each gamete gets one of the two alternative factors. Evidently, it means that factor for tallness (T) and factor for dwarfness (t) are, indeed, separate entities. Thus, a gamete can have either factor T or factor t at a time. When F1 hybrids (Tt) are self-pollinated, the two entities separate out into T and t and independently produce tall (TT) and dwarf (tt) plants. Based upon these facts, Mendel formulated a law known as the law of segregation or law of purity of gametes or the law of unit characters. This is Mendel's first law of inheritance.

LAW OF SEGREGATION T

Contact No:9535111199/9535111188

he law of segregation states that when a pair of contrasting factors or genes or allelomorphs are brought together in a heterozygote hybrid, the two members of the allelic pair remain together without being contaminated and when gametes are formed from the hybrid, the two separate out from each other and only one enters each gamete. In simple words, this law states that during the formation of gametes, the two factors or genes controlling each character separate out due to the segregation of homologous chromosomes so that each gamete receives only one factor or gene of each character. Since, the gametes possess one factor or gene of each character, the gametes are always pure. Therefore, this law of segregation is also called the law of purity of gametes.

The results of a monohybrid cross very well illustrate the phenomenon of purity of gametes or law of segregation.

DIHYBRID CROSS

Dihybrid cross involves the inheritance of two pairs of contrasting characters simultaneously. In this regard, Mendel studied the inheritance of round and wrinkled characters of seed coat along with the yellow and green colours of seeds of the pea plant. He crossed a pea plant having round seeds and yellow cotyledons with a pea plant having wrinkled seeds and green cotyledons to obtain F, generation. In the F1 generation, round seeds with yellow cotyledons were produced. Fl plants were grown from these seeds and were self pollinated to obtain four kinds of plants in F2 generation. Nine plants possessed the two dominant traits i.e. round seeds and yellow cotyledons: three plants had one dominant (round seeds) and one recessive trait (green cotyledons): three other plants possessed another dominant (yellow cotyledon) and recessive (wrinkled seeds) traits while one plant had both the recessive (wrinkled seeds and green cotyledons) traits. Thus, in F2 generation four types of plants are formed with a ratio of 9:3:3:1.

DIHYBRID CROSS BETWEEN PEA PLANTS WITH YELLOW ROUND SEEDS AND GREEN WRINKLED SEEDS

The above results by assuming that the two characters (round shape and yellow colour of the seed) of pea plant were dominant over wrinkled shape of the seed

Contact No:9535111199/9535111188

and green colour of the cotyledons. Thus, all the F1 offsprings were round and yellow. In F2 generation, all the four characters got assorted independently of each other. Mendel held that cotyledon colour trait was independent of the seed shape. Therefore, at the time of gamete formation, factors or genes for round or wrinkled character of seed coat assorted out independently of the yellow or green colour of the cotyledon. This is known as law of independent assortment or Mendel's second law of inheritance.

LAW OF INDEPENDENT ASSORTMENT

The law of independent assortment states that if the inheritance of more than one pair of characters (two pairs or more) is studied simultaneously, the factors or genes for each pair of characters assort out independently of the other pairs. In simple words, the law states that the factors or genes of each character are segregated into the gametes independently of the factors or genes of any other character.

It is necessary to mention that N./lenders second law (law of independent assortment) does not have a universal application. It has been found that only those allelomorphs assort independently during meiosis which are present in different homologous pairs. However, if the allelomorphs for different characters happen to present on the same homologous pair of chromosomes, then these allelomorphs are passed on to the same gamete rather than to two different gametes. The results of a dihybrid cross very well illustrate the Mendel's second law of inheritance. Besides these two laws, a third law i.e. the law of dominance was also discussed by Mendel.

LAW OF DOMINANCE

For any given trait, there is a pair of genes. For instance, in pea plant genes for tallness are TT and for dwarfness tt. Tall character in this case is dominant and the dwarf character is recessive. According to the law of dominance, when two homozygouc individuals, with one or more set of contrasting characters are crossed the characters that appear in the F1 hybrids are dominant characters and those which do not appeal are recessive characters.

Contact No:9535111199/9535111188

This law has direct practical relevance. For instance, harmful recessive characters are unable to cause any harm to their possessors (hybrids) in the presence of normal. dominant characters. Troublesome diseases in human beings like diabetes and haemophilia are some examples of the expression of recessive characters.

INCOMPLETE DOMINANCE

After Mendel's discovery of dominance, several cases have come to light wherein the F1 hybrids do not resemble either of the parents. Instead a blending of the characters of thr, two parents is expressed in a way that the hybrids are midway between the two parents. This phenomenon is termed as Incomplete dominance or blending inheritance, Evidently, the two allelomorphs of a pair are not related as dominant and recessive. Actually, both have equal capacity to express resulting in the blending of their expressions.

A good example of incomplete dominance is offered by the four O'clock plant (Mirabilis jalapa). In this case, when plants with red flowers (RR) are made to cross with plant possessing white flowers (rr), the hybrid F1 plants have pink flowers (Rr). When these F1 plants having pink flowers are self-crossed, they bear red, pink and white flowers in a definite ratio of 1:2:1 in F2 generation.

SIGNIFICANCE OF MENDEL'S LAWS

Mendel's laws have proved to be of immense significance to man in improving the breeds of commercially important animals and plants. For instance, the application of Mendel's laws has helped in improving the varieties of poultry and the products obtained from them. Efficient breeds of horses and dogs have also been obtained by cross breeding experiments. Similarly, Eugenics (the science of human welfare) is based on these laws.

Much more important use of Mendel's laws has been in the field of agriculture. A number of new varieties of crops have been developed at a considerably

Contact No:9535111199/9535111188

faster rate. These new varieties of crops provide more yield. Also such crop plants are resistant to insect pests and fungal and viral diseases etc. This extra vigour, vitality, productivity, size, enhanced capacity to resist diseases and overall better adaptability to the environment of the hybrids is termed as heterosls. individual can receive blood only from individuals of groups B or 0 (with B being preferable), and can donate blood to individuals with type B or AB. Blood group 0 individuals do not have either A or B antigens on the surface of their RBCs, but their blood serum contains IgM anti-A and anti-B antibodies against the A and B blood group antigens. Therefore, a group 0 individual can receive blood only from a group 0 individual, but can donate blood to individuals of any ABO blood group (i.e., A, B, 0 or AB). If a patient in a hospital situation were to need a blood transfusion in an emergency, and if the time taken to process the recipient's blood would cause a detrimental delay, 0 Negative blood can be issued. They are known as universal donors.

Rh BLOOD GROUP SYSTEM

The Rh (Rhesus) blood group system (including the Rh factor) is one of thirty current human blood group systems. Clinically, it is the most important blood group system after ABO. At present, the Rh blood group system consists of 50 defined blood-group antigens, among which the five antigens D, C, c, E, and e are the most important. The commonly used terms Rh factor, Rh positive and Rh negative refer to the D antigen only. Besides its role in blood transfusion, the Rh blood group system—specifically, the D antigen—is used to determine the risk of haemolytic disease of the newborn (or erythroblastosis fetalis) as prevention is key.

Rh factor An individual either has, or does not have, the "Rhesus facto(on the surface of their red blood cells. This term strictly refers only to the most immunogenic D antigen of the Rh blood group system, or the Rh- blood group system. The status is usually indicated by Rh positive (Rh+ does have the D antigen) or Rh negative (Rh- does not have the D antigen) suffix to the ABO blood type. In contrast to the ABO blood group, immunization against Rh can generally only occur through blood transfusion or placental exposure during pregnancy in women.

Contact No:9535111199/9535111188

Haemolytic disease of the newborn The haemolytic condition occurs when there is an incompatibility between the blood types of the mother and the foetus. There is also potential incompatibility if the mother is Rh negative and the father is positive. When any incompatibility is detected, the mother receives an injection at 28 weeks gestation and at birth to avoid the development of antibodies toward the foetus. These terms do not indicate which specific antigen-antibody incompatibility is implicated. The disorder in the foetus _ due to Rh 7: incompatibility is known as erythroblastosis fetalis.

Symptoms and signs in the foetus: Enlarged liver, spleen, or heart and fluid build up in the foetus' abdomen seen via ultrasound.

Symptoms and signs in the newborn:

• Anaemia that creates the newborn's pallor (pale appearance).

• Jaundice or yellow discoloration of the newborn's skin, sclera or mucous membrane. This may be evident right after birth or after 24-48 hours after birth. This is caused by bilirubin (one of the end products of red blood cell destruction).

• Enlargement of the newborn's liver and spleen.

• The newborn may have severe oedema of the entire body.

• Dyspnoea or difficulty breathing.

Genetic Inheritance Patterns (Multiple Alleles) The term multiple allele is a condition where more than two genes occupy the same locus, on the same pair of homologous chromosomes. Each of these genes expresses a totally different character. The inheritance of A B 0 blood groups in man is an example of multiple alleles.

ABC blood types are inherited through genes on chromosome 9, and they do not change as a result of environmental influences during life. An individual's ABO type determined by the inheritance of 1 of 3 alleles (A, B, or 0) from each parent.M; possible outcomes are shown below:

Contact No:9535111199/9535111188

Both A and B alleles are dominant over 0. As a result, individuals who have an AO genotype will have an A phenotype. People who are type 0 have 00 genotypes. In other words, they inherited a recessive 0 allele from both parents. The A and B alleles are co-dominant, i.e. they are both expressed. Therefore, if an A is inherited from one parent and a B from the other, the phenotype will be AB. Agglutination tests will show that these individuals have the characteristics of both type A and type B blood. ABO Blood type antigens are not only found on the surface of red cells. They are also normally secreted by some people in their body fluids, including saliva, tears, and urine. Whether someone is able to secrete them is genetically controlled. Police agencies now routinely use this so-called secretor system data to identify potential victims and criminals when blood samples are not available.

GENETIC DISORDER

A genetic disorder is an illness caused by abnormalities in genes or chromosomes, especially a condition that is present from before birth. Most genetic disorders are quite rare and affect one person in every several thousands or millions. A genetic disorder may or may not be a heritable disorder. Some genetic disorders are passed down from the parents' genes. but others are always or almost always caused by new mutations or changes to the DNA. Genetic disorders rarely have effective treatments, though gene therapy is being tested as a possible treatment for some genetic diseases.

Single gene disorder A single gene disorder is the result of a single mutated gene. Over 4000 human diseases are caused by single gene defects. Single gene disorders can be passed on to subsequent generations in several ways. Genomic imprinting and uniparental disomy, however. may affect inheritance patterns. The divisions between recessive and dominant types are not "hard and fast", although the divisions between autosomal and X-linked types are (since the latter types are distinguished purely based on thr.7 chromosomal location of the gene). For example, achondroplasia is typically considered a dominant disorder, but children with two genes for achondroplasia have a severe skeletal disorder of which achondroplasics could be viewed as carriers.

Contact No:9535111199/9535111188

Sickle-cell anaemia is also considered a recessive condition, but heterozygous carriers have increased resistance to malaria in early childhood, which could be described as a related dominant condition. When a couple where one partner or both are sufferers or carriers of a single gene disorder and wish to have a child, they can do so through in vitro fertilization, which means they can then have a pre-implantation genetic diagno to check whether the embryo has the genetic disorder.

Autosomal dominant Only one mutated copy of the gene will be necessary for a person to be affected by an autosomal dominant disorder. Each affected person usually has one affected parer: The chance a child will inherit the mutated gene is 50%. Autosomal dominant conditions sometimes have reduced penetrance, which means although only one mutated copy is needed. not all individuals who inherit that mutation go on to develop the disease. Examples of this type of disorder are Huntington's disease, neurofibromatosis type 1, neurofibromatosis type 2, etc. Birth defects are also called congenital anomalies.

Autosomal recessive Two copies of the gene must be mutated for a person to be affected by an autosomal recessive disorder. An affected person usually has unaffected parents who each carry a single copy of the mutated gene (and are referred to as carriers). Two unaffected people who each carry one copy of the mutated gene have a 25% chance with each pregnancy of having a child affected by the disorder. Examples of this type of disorder are cystic fibrosis. sickle-cell disease. Tay-Sachs disease, spinal muscular atrophy, and Roberts syndrome.

X-linked dominant X-linked dominant disorders are caused by mutations in genes on the X chromosome. Only a few disorders have this inheritance pattern, with a prime example being X-linked hypophosphatemic rickets. Males and females are both affected in these disorders, with males typically being more severely affected than females. Some X-linked dominant conditions, such as Rett syndrome is usually fatal in males either in utero or shortly after birth, and is therefore predominantly seen in females.

Contact No:9535111199/9535111188

Exceptions to this finding are extremely rare cases in which boys with Klinefelter syndrome (47,XXY) also inherit an X-linked dominant condition and exhibit symptoms more similar to those of a female in terms of disease severity. The chance of passing on an X-linked dominant disorder differs between men and women. The sons of a man with an X-linked dominant disorder will all be unaffected (since they receive their father's Y chromosome), and his daughters will all inherit the condition.

X-linked recessive X-linked recessive conditions are also caused by mutations in genes on the X chromosome. Males are more frequently affected than females, and the chance of passing on the disorder differs between men and women. The sons of a man with an X-linked recessive disorder will not be affected, and his daughters will carry one copy of the mutated gene. A woman who is a carrier of an X-linked recessive disorder (XRXr) has a 50% chance of having sons who are affected and a 50% chance of having daughters who carry one copy of the mutated gene and are therefore carriers. X-linked recessive conditions include the serious diseases haemophilia A, muscular dystrophy etc. X-linked recessive conditions can sometimes manifest in females due to skewed X-inactivation or monosomy X (Turner syndrome).

Y-linked Y-linked disorders are caused by mutations on the Y chromosome. Because males inherit a Y chromosome from their fathers, every son of an affected father will be affected. Because females only inherit an X chromosome from their fathers, and never a Y chromosome, female offspring of affected fathers are never affected.

Since the Y chromosome is relatively small and contains very few genes, relatively few Y-linked disorders occur. Often, the symptoms include infertility, which may be circumvented with the help of some fertility treatments. Examples are male infertility.

Multi factorial and polygenic (complex) disorders Genetic disorders may also be complex, multi factorial, or polygenic, meaning they are likely associated with the effects of multiple genes in combination with lifestyles and

environmental factors. Multi factorial disorders include heart disease and diabetes. Although complex disorders often cluster in families, they do not have a clear-cut pattern of inheritance. This makes it difficult to determine a person's risk of inheriting or passing on these disorders. Complex disorders are also difficult to study and treat because the specific factors that cause most of these disorders have not yet been identified.

On a pedigree, polygenic diseases do tend to "run in families", but the inheritance does not fit simple patterns as with Mendelian diseases. But this does not mean that the genes cannot eventually be located and studied. There is also a strong environmental component to many of them (e.g., blood pressure). The important disorders include asthma, autoimmune diseases such as multiple sclerosis. cancers, diabetes, heart disease, hypertension, mental retardation, mood disorder, obesity, and infertility.

Haemophilia Haemophilia is also called 'bleeders disease'. Like colour blindness, haemophilia is a well-known disorder which is sex-linked. It is a recessive condition. In a patient of haemophilia, blood clotting is deficient because of lack of the necessary substrate, thromboplastin. TWo types of sex-linked haemophilia are _ haemophilia A and Haemophilia B. Haemophilia A is characterised by lack of anti haemophilia globulin (factor VIII). Four -fifths of the cases of haemophilia are of this type. Haemophilia - B or Christmas disease results from a defect in plasma thromboplastin component (PTC or Factor IX). This is milder form of the condition.

Sickle Cell Anaemia It is a genetic disease that results in abnormal haemoglobin molecules. When these release their oxygen load in the tissues, they become insoluble, leading to mis-shaped red blood cells. These sickle shaped red cells are rigid and cause blood vessel blockage, pain, strokes and other tissue damages.

Thalassemia It is a genetic disease that results in the production of an abnormal ratio of haemoglobin subunits. It results in anaemia.

CHROMOSOMES

Contact No:9535111199/9535111188

The term chromosome has been derived from two Greek words chroma meaning colour and soma meaning body. Such darkly stained rod-like structures were first called chromosomes by Waldeyer. Chromosomes are made up of chromatin material which is the most important and permanent constituent of the cell nucleus. During nuclear division, the chromatin gradually condenses resulting in the shortening of the elongated chromonemal threads. The chromosomes range in size from 0.1 p to 30 p in length and from 0.2 p to 2 lu in diameter. However, their size varies from specie to species so much so that even various chromosomes in the same cell have different sizes.

Each chromosome consists of two parallel and identical structures called chromatids attached to each other at a point called centromere. The centromere is the term used to a definite clear and non-stainable point on each chromosome. Its position varies in different chromosomes. Depending upon the location of centromere in a chromosome, four types of chromosomes have been recognized:

Telocentric (Rod-shaped): Centromere is at the proximal end. Acrocentric (J-shaped): Centromere is very near the proximal end.

Sub-metacentric (L-shaped): Centromere divides the chromosome into two unequal arms.

Metacentric (V-shaped): Centromere divides the chromosomes into two equal arms. The chromosomes are composed of about 40% DNA, 50% histones and other basic proteins, 8.5% acidic proteins, and 1.5% RNA.

CHROMOSOMAL ABERRATIONS

Chromosomal aberrations are disruptions in the normal chromosomal content of a cell and are a major cause of genetic conditions in humans, such as Down syndrome, although mosi aberrations have little to no effect. Some chromosome abnormalities do not cause disease in carriers, such as translocations, or chromosomal inversions, although they may lead to a higher chance of bearing a child with a chromosome disorder. Abnormal numbers of chromosomes or chromosome sets, called aneuploidy, may be lethal or may give rise to genetic

Contact No:9535111199/9535111188

disorders. Genetic counselling is offered for families that may carry a chromosome rearrangement. The gain or loss of DNA from chromosomes can lead to a variety of genetic disorders. Human examples include: • Cri du chat, which is caused by the deletion of part of the short arm of chromosome 5. "Cri du chat" means "cry of the car in French; the condition was so-named because affected babies make high-pitched cries that sound like those of a cat. Affected individuals have wide-set eyes, a small head and jaw, moderate to severe mental health issues, and are very short.

• Down syndrome. the most common trisomy, usually caused by an extra copy of chromosome 21 (trisomy 21). Characteristics include decreased muscle tone, stockier build, asymmetrical skull, slanting eyes and mild to moderate developmental disability.

• Edwards syndrome, or trisomy-18, the second-most-common trisomy. Symptoms include motor retardation, developmental disability and numerous congenital

anomalies causing serious health problems. Ninety percent of those affected die in infancy. They have characteristic clenched hands and overlapping fingers.

• Klinefelter syndrome (XXY). Men with Klinefelter syndrome are usually sterile, and tend to be taller and have longer arms and legs than their peers. Boys with the syndrome are often shy and quiet, and have a higher incidence of speech delay and dyslexia. Without testosterone treatment, some may develop gynecomastia during puberty.

• Patau Syndrome, also called D-Syndrome or trisomy-13. Symptoms are somewhat similar to those of trisomy-18, without the characteristic folded hand.

• Triple-X syndrome (XXX). XXX girls tend to be tall and thin and have a higher incidence of dysle.xia.

• Turner syndrome (X instead of XX or XY). In Turner syndrome, female sexual characteristics are present but underdeveloped. Females with Turner syndrome often have a short stature, low hairline, abnormal eye features and bone development and a "caved-in" appearance to the chest. XYY syndrome.

Contact No:9535111199/9535111188

XYY boys are usually taller than their siblings. Like XXY boys and XXX girls, they are more likely to have learning difficulties.

GENE

The term gene was first coined by Wilhelm Johannsen to indivisible and unidentified conceptual unit of heredity. A gene is commonly conceived as the smallest portion of a chromosome which occupies a definite locus and is responsible for a specific phenotypic character or trait. Here, gene is regarded as a unit of function. Any variation or modification in the gene is recognizable by an observable heritable change or mutation. The gene, therefore. is also referred to the smallest chromosomal segment in which mutation could occur. In fact, this ability to mutate has proved a major tool for the identification of genes. A gene has also been considered the smallest chromosomal ur; capable of undergoing recombination by crossing over. The three concepts of genes i.e. as a unit of function, unit of transmission and unit of mutation are not the same or equivalent to one another. A definite sequence of nucleotides repeated within the length of DNA constitutes classical gene or modern operon. Hence, gene is a section of polynucleotide chain (DNA) divisible both by mutation and recombination and is concerned with a specific unitary function.

According to Benzer, three units of gene have been distinguished as follow:

Recon: It is the smallest unit of DNA capable of undergoing crossing over and recombination. A recon may be as small as one nucleotide pair in DNA.

Muton: It is the smallest unit of DNA which is capable of undergoing mutation and in its smallest expression represents a change in a pair of nucleotides.

Cistron: It is the unit of function. Cistron is that smallest unit of DNA that codes for a polypeptide chain or for the synthesis of m-RNA, t-RNA or r-RNA required for the synthesis of such a polypeptide chain. In other words, cistron is that DNA segment which is bounded by a start and a stop signal and contains enough information for the synthesis of a complete polypeptide chain.

KINDS OF GENES

Contact No:9535111199/9535111188

French scientists Jacob and Monad proposed three kinds of genes:

1. Structural genes (A. B, C etc.) These genes produce rn-HNA which in turn govern protein synthesis by the ribosornes in the cytoplasm.

2. Operator genes -or operons (0): Such genes act as switches to stimulate the synthesis of m-RNA by the structural genes. In majority of cases, a single operon governs the activities of a cluster of nearby structural genes.

3. Regulatory gene (R): The switching off and on of the operator is controlled by regulatory genes. The signal from the regulator to the operator is made by a substance called repressor produced by the regulator. Repressor turns the operator genes off and the system remains in the switch off condition.

GENE EXPRESSION

In all organisms, there are two major steps separating a protein-coding gene from its protein: First, the DNA on which the gene resides must be transcribed from DNA to messenger RNA (mRNA); and, second, it must be translated from mRNA to protein. RNA-coding genes must still go through the first step, but are not translated into protein. The process of producing a biologically functional molecule of either RNA or protein is called gene expression, and the resulting molecule itself is called a gene product.

GENETIC CODE

The genetic code is the set of chemical symbols by which a gene is translated into a functional protein. Each gene consists of a specific sequence of nucleotides encoded in a DNA (or sometimes RNA in some viruses) strand; a correspondence between nucleotides, the basic building blocks of genetic material, and amino acids, the basic building blocks of proteins, must be established for genes to be successfully translated into functional proteins. Sets of three nucleotides, known as codons, each correspond to a specific amino acid or to a signal; three codons are known as "stop codons" and, instead of specifying a new amino acid, alert the translation machinery that the end of the aene has been reached. There are 64 possible codons (four possible nucleotides at each of three positions. hence 43 possible codons) and only 20 standard

Contact No:9535111199/9535111188

amino acids; hence the code is redundant and multiple codons can specify the same amino acid.

Properties of Genetic Code

1. The code is triplet.

2. The code is non-overlapping.

3. The code is commaless.

4. The code is degenerate

5. The code is universal

TRANSCRIPTION

The process of genetic transcription produces a single-stranded RNA molecule known as messenger RNA, whose nucleotide sequence is complementary to the DNA from which it was transcribed. The DNA strand whose sequence matches that of the RNA is known as the coding strand and the strand from which the RNA was synthesized is the template strand. Transcription is performed by an enzyme called an RNA polymerase, which reads the template strand in the 3' to 5' direction and synthesizes the RNA from 5' to 3'. To initiate transcription, the polymerase first recognizes and binds a promoter region of the gene. Thus a major mechanism of gene regulation is the blocking or sequestering of the promoter region, either by tight binding by repressor molecules that physically block the polymerase, or by organizing the DNA so that the promoter region is not accessible.

In prokaryotes, transcription occurs in the cytoplasm; for very long transcripts, translation may begin at the 5' end of the RNA while the 3' end is still being transcribed. In eukaryotes, transcription necessarily occurs in the nucleus, where the cell's DNA is sequestered; the RNA molecule produced by the polymerase is known as the primary transcript and must undergo post-transcriptional modifications before being exported to the cytoplasm for translation. The splicing of introns present within the transcribed region is a modification unique to eukaryotes; alternative splicing mechanisms can result

in mature transcripts from the same gene having different sequences and thus coding for different proteins. This is a major form of regulation in eukaryotic cells.

TRANSLATION

Translation is the process by which a mature mRNA molecule is used as a template for synthesizing a new protein. Translation is carried out by ribosomes, large complexes of RNA and protein responsible for carrying out the chemical reactions to add new amino acids to a growing polypeptide chain by the formation of peptide bonds. The genetic code is read three nucleotides at a time, in units called codons, via interactions with specialized RNA molecules called transfer RNA (tRNA). Each tRNA has three unpaired bases known as the anticodon that are complementary to the codon it reads; the tRNA is also covalently attached to the amino acid specified by the complementary codon. When the tRNA binds to its complementary codon in an mRNA strand, the ribosome ligates its amino acid cargo to the new polypeptide chain, which is synthesized from amino terminus to carboxyl terminus. During and after its synthesis, the new protein must fold to its active three-dimensional structure before it can carry out its cellular function.

DNA REPLICATION AND INHERITANCE

The growth, development, and reproduction of organisms rely on cell division, or the process by which a single cell divides into two usually identical daughter cells. This requires first making a duplicate copy of every gene in the genome in a process called DNA replication. The copies are made by specialized enzymes known as DNA polymerases, which "read" one strand of the double-helical DNA, known as the template strand. and synthesize a new complementary strand. Because the DNA dcuble helix is held together by base pairing, the sequence of one strand completely specifies the sequence of its complement; hence only one strand needs to be read by the enzyme to produce a faithful copy. The process of DNA replication is semi - conservative; that is, the copy of the genome inherited by each daughter cell contains one original and one newly synthesized strand of DNA.

After DNA replication is complete, the cell must physically separate the two copies of the genome and divide into two distinct membrane-bound cells. In prokaryotes - bacteria and archaea - this usually occurs via a relatively simple process called binary fission, in which each circular genome attaches to the cell membrane and is separated into the daughter cells as the membrane invaginates to split the cytoplasm into two membrane-bound portions. Binary fission is extremely fast compared to the rates of cell division in eukaryotes. Eukaryotic cell division is a more complex process known as the cell cycle; DNA replication occurs during a phase of this cycle known as S phase, whereas the process of segregating chromosomes and splitting the cytoplasm occurs during M phase. In many single-celled eukaryotes such as yeast, reproduction by budding is common, which results in asymmetrical portions of cytoplasm in the two daughter cells.

MOLECULAR INHERITANCE

The duplication and transmission of genetic material from one generation of cells to the next is the basis for molecular inheritance, and the link between the classical and molecular pictures of genes. Organisms inherit the characteristics of their parents because the cells of the offspring contain copies of the genes in their parents' cells. In asexually reproducing organisms, the offspring will be a genetic copy or clone of the parent organism. In sexually reproducing organisms, a specialized form of cell division called meiosis produces cells called gametes or germ cells that are haploid, or contain only one copy of each gene. The gametes produced by females are called eggs or ova, and those produced by males are called sperm. Two gametes fuse to form a fertilized egg, a single cell that once again has a diploid number of genes—each with one c.,-Tly from the mother and one copy from the father During the process of meiotic cell division, an event called genetic recombination or crossing-over can sometimes occur, in which a length of DNA on one chromatid is swapped with a length of DNA on the corresponding sister chromatid. This has no effect if the alleles on the chromatids are the same, but results in reassortment of otherwise linked alleles if they are different. The Mendelian principle of independent assortment asserts that each of a parent's two genes for each trait will sort

Contact No:9535111199/9535111188

independently into gametes; which allele an organism inherits for one trait is unrelated to which allele R inherits for another trait. This is in fact only true for genes that do not reside on the same chromosome, or are located very far from one another on the same chromosome. The closer two genes lie on the same chromosome, the more closely they will be associated in gametes and the more often they will appear together; genes that are very close are essentially never separated because it is extremely unlikely that a crossover point will occur between them. This is known as genetic linkage.

TISSUE

Tissue is a cellular organizational level intermediate between cells and a complete organism. A tissue is an ensemble of similar cells from the same origin that together carry out a specific function. Organs are then formed by the functional grouping together of multiple tissues. The study of tissue is known as histology or, in connection with disease, histopathology.

ANIMAL TISSUES

Animal tissues can be grouped into four basic 'types: epithelial, connective, muscle, and nervous. While all animals can generally be considered to contain the four tissue types, the manifestation of these tissues can differ depending on the type of organism. For example, the origin of the cells comprising a particular tissue type may differ developmentally for different classifications of animals.

EPITHELIAL TISSUE

The epithelial tissues are formed by cells that cover the organ surfaces such as the surface of the skin, the airways, the reproductive tract, and the inner lining of the digestive tract.

The cells in epithelium are very densely packed together like bricks in a wall, leaving very little intercellular space. The cells can form continuous sheets which are attached to each other at many locations by tight junctions and desmosomes. Cell junctions are especially abundant in epithelial tissues. They consist of protein complexes and provide contact between neighbouring cells,

between a cell and the extracellular matrix, or they build up the paracellular barrier of epithelia and control the paracellular transport. All epithelial cells rest on a basement membrane, which acts as scaffolding, on which epithelium can grow and regenerate after injuries. Epithelial tissue is innervated, but avascular. This epithelial tissue must be nourished by substances diffusing from the blood vessels in the underlying tissue, but they don't have their own blood supply. The basement membrane acts as a selectively permeable membrane that determines which substances will be able to enter the epithelium. Types of epithelium I. Tissues are generally classified by the morphology of their cells, and the number of layers they are composed of. Epithelial tissue that is only one cell thick is known as simple epithelium. If it is two or more cells thick, it is known as stratified epithelium, which is a subtype of compound epithelium.

SIMPLE EPITHELIUM

Simple epithelium is one cell thick, that is, every cell is in direct contact with the underlying basement membrane. It is generally found where absorption and filtration occur. The thinness of the epithelial barrier facilitates these processes. Simple epithelial tissues are generally classified by the shape of their cells. The four major classes of simple epithelium are

(1) simple squamous;

(2) simple cuboidai;

(3) simple columnar;

(4) pseudostratified.

Squamous epithelium: Cells are extremely thin and flattened with clear cytoplasm. A single round or oval-shaped nucleus is present in the centre of the cells. Simple squamous epithelium is found lining areas where passive diffusion of gases occur. E.g. walls of capillaries, linings of the pericardial, pleural, and peritoneal cavities, as well as the linings of the alveoli of the lungs.

Contact No:9535111199/9535111188

Cuboidal epithelium: Cells of the epithelium are as long as broad in shape and appear cube-like. It is found in some parts of kidney, tubules, ducts of salivary glands, thyroid gland, covering of ovary etc.

Columnar epithelium: Cells of this epithelium are much longer than broad and hence look like a column. Their nuclei are situated in the centre when these cells are not secretary and at the base when they are doing the function of secretion. It is found in tilt., linings of alimentary canal, uterus and uterine tubes (fallopian tubes). Its main function is secretion and absorption. In the intestinal mucosa, it has got large number of microvilli thus giving it a brush-border appearance.

Pseudostratified epithelium: Cells of this epithelium are tall column-like arranged in a single layer but appears as if multi-layered due to different positions of their nuclei. It is found in male urethra, larger excretory ducts of many glands etc.

COMPOUND EPITHELIUM

(i) Transitional epithelium: It is seen in the regions which are subjected to different pressures as in the pelvis. of kidney, urinary passage, urinary bladder etc.

(ii) Stratified epithelium: Cells of this epithelium are arranged in many layers one above the other. It is of the following types: a) Squamous epithelium: It is seen on the moist surface of buccal cavity. pharynx and the oesophagus. The top layer of cells may be keratinised (skin) or may be non-keratinised (vagina, oesophagus).

b) Cuboidal epithelium: The outermost layer of cells is cube-like in appearance. It is found in the mammary glands, the ducts of sweat and larger salivary and pancreatic ducts.

According to the functions. epithelial tissues are of the following types:

Ciliated epithelium: This epithelium (usually cuboidal or columnar in shape) possesses thin, delicate, hair-like projections of their cells cytoplasm called cilia

Contact No:9535111199/9535111188

on their outer free surface. It is found in kidney tubules, trachea, oviduct etc. This epithelium helps in the movement of substances. In animals like paramecium the cilia are locomotary organelles.

Glandular epithelium: The cells of this epithelium are columnar in shape. Some of these cells become modified to serrate mucus. These unicellular gland cells are called goblet cells. It is seen in the intestine and other parts of the alimentary canals.

Sensory epithelium: The cells of this epithelium have nerve endings so that they can perceive various sensations. It is found in the nasal passage, taste bunds. epidermis of earthworms, retina of eyes etc.

Absorptive epithelium: The columnar cells of this epithelium have got villi and microvilli so that surface area of the cells is increased that help in better absorption. It is found in the linings of alimentary canals.

Functions of epithelial tissues The primary functions of epithelial tissues are:

(1) to protect the tissues that lie beneath it from radiation, desiccation, toxins, invasion by pathogens, and physical trauma;

(2) the regulation and exchange of chemicals between the underlying tissues and a body cavity;

(3) the secretion of hormones into the blood vascular system, and/or the secretion of sweat, mucus, enzymes, and other products that are delivered by ducts glandular epithelium;

(4) The intestinal epithelial cells with their microvilli help in the absorption of digested food materials. It is done by columnar cells. The epithelial cells that are supplied with nerve endings as in the retina of the eye, olfactory epithelium etc. help to receive various stimuli from the atmosphere and convey them to the brain. (6) In the region of kidney, tubules and sweat glands, the epithelial cells produce substances that are not needed and so are removed out of the body

Contact No:9535111199/9535111188

(5) Embryological development In general, there are epithelial tissues deriving from all of the embryological germ layers:

• from ectoderm (e.g., the epidermis);

• from endoderm (e.g., the lining of the gastrointestinal tract);

• from mesoderm (e.g., the inner linings of body cavities).

However, it is important to note that pathologists do not consider endothelium and mesothelium (both derived from mesoderm) to be true epithelium. This is because such tissues present very different pathology. For that reason, pathologists label cancers in endothelium and mesothelium as sarcomas, whereas true epithelial cancers are called carcinomas.

Epithelium lines both the outside (skin) and the inside cavities and lumen of bodies. The outermost layer of our skin is composed of dead stratified squamous, keratinized epithelial cells.

Tissues that line the inside of the mouth, the oesophagus and part of the rectum are composed of non-keratinized stratified squamous epithelium. Other surfaces that separate body cavities from the outside environment are lined by simple squamous, columnar, or pseudostratified epithelial cells. Other epithelial cells line the insides of the lungs, the gastrointestinal tract, the reproductive and urinary tracts, and make up the exocrine and endocrine glands. The outer surface of the cornea is covered with fast-growing, easily-regenerated epithelial cells. Endothelium (the inner lining of blood vessels, the heart, and lymphatic vessels) is a specialized form of epithelium. Another type, mesothelium, forms the walls of the pericardium, pleurae, and peritoneum.

CONNECTIVE TISSUE (Or Supporting tissue)

Connective tissue is a kind of biological tissue that supports, connects, or separates different types of tissues and organs of the body. All Connective tissues have three main components: cells, fibres, and extracellular matrix. all

immersed in the body fluids. Fibroblasts are the cells responsible for the production of some Connective tissue.

I collagen, is present in many forms of connective tissue, and makes up about 25% of the total protein content of the mammalian body.

Connective tissue can be broadly subdivided into connective tissue proper. special connective tissue, and series of other, less classifiable types of connective tissues. Connective tissue proper consists of loose connective tissue and dense connective tissue (which is further subdivided into dense regular and dense irregular connective tissues.)

Special connective tissue consists of areolar connective tissue, adipose tissue, cartilage, bone, and blood.

Other kinds of connective tissues include fibrous, elastic, and lymphoid connective tissues.

1. Areolar connective tissue: This tissue lies just below the epidermis of the skin on many hollow visceral organs and on the walls of arteries and veins. It consists of a matrix which is glycoprotein (protein and carbohydrate) in nature and is not dense. Imbedded in the matrix are present mainly these types of cells.

i) **Fibroblast:** They are large, fiat, spindle shaped, branching cells with long protoplasmic processes and an oval nucleus in the centre.

ii) **Macrophages:** They are large and wandering cells with a central nucleus. They are phagocytic in nature i.e. ingesting bacteria, cell debris and foreign bodies. During inflammation they may show amoeboid movements.

iii) **Mast Cells:** They are usually found near the blood vessels. They produce histamines and heparin, an anticoagulant). These cells are usually stimulated by different chemicals called allergens.

2. Adipose Connective tissue:

It is a specialised form of areolar tissue in which there are mainly present fat cells or adipocytes besides other cells. Collagen fibres and elastic fibres are also

Contact No:9535111199/9535111188

present. They function to store fat and re found underneath the dermis of skin, around kidneys and in mesenteries and bone marrow. The adipose tissue mainly synthesizes, stores and metabolises the fat. It serves as a heat insulating layer underneath the skin. It also acts as a shock absorbing cushion around kidneys and eyeballs.

3. White, fibrous tissue: it provides a great tensile strength to the tissues. It is seen in the joints of skull bones that makes them immovable.

4. Tendon: It is very thick, dense and strong connective tissue mainly composed of while collagenous fibres. Tendons help to join a muscle to a bone.

5. Ligament: It is also a dense fibrous connective tissue but yellow elastic fibres are also present in between the white collagenous fibres ligaments help to join one bone to another bone at the joints and also hold them in position.

6. Cartilage: A cartilage is a flexible and tough connective tissue having the ground substance or matrix, the cells called chondrocytes and the fibres. The cartilage is covered by a tough sheet of connective tissue called perichondrium. Depending upon the structure, cartilage is of the following three types:

i) Hyaline cartilage: It is homogenous translucent, crystal like cartilage and is quite flexible. Hyaline cartilage is present in the articular surfaces of bones, nasal septum, trachea, bronchus, front end of ribs etc.

ii) Fibrous Cartilage: The matrix of this cartilage is mainly constituted by the white collagenous fibres and cells. It is present in the regions of intervertebral discs, pubic symphysis etc.

iii) Elastic Cartilage: The matrix of this cartilage has more of yellow elastic fibres, which is present in all directions. It is present in the regions of pinna, external auditory, meatus, epiglottis etc.

7. Bone: Bone or osseous tissue is composed of an organic matrix with heavy deposition of inorganic salts. The matrix is made up of a protein called ossein and the inorganic salts are of calcium, phosphorus, magnesium, sodium, potassium, etc_ mainly it is calcium phosphate. About 65% of the dry weight of

Contact No:9535111199/9535111188

a bone constitutes these salts. In the matrix bone cells called osteolytes, osteoblasts and osteoclasts are present in concentric rings called lamellae. All the lamellae are arranged around a haversian canal (a characteristic of mammalian bone). These haversian canals are longitudinal and are transversely connected by Volkmanns' canals. On the outside, bone is surrounded by periosteum though which blood vessels and nerve. fibres enter in it; and an internal living in the endosteum. In long bones inside the endosteum, bone marrow is present. It is of two types:

(i) Yellow marrow having mainly adipose tissues and blood vessels.

(ii) Red marrow is found at the extremities and manufactures red blood cells. It is found only in mammals. Two types of bones are distinguished:

i) Spongy bone: it is found at the ends of long bones, in sides of round are.; irregular bones.

ii) Dense or compact bone: It is comparatively hard and compact and found in the shaft of long bones. and outer layers of round and irregular bones.

8. Blood: Discussed in the chapter — (Circulatory system) Functions of connective tissue

• Storage of energy

• Protection of organs

• Provision of structural framework for the body

• Connection of body tissues

• Connection of .epithelial tissues to muscle tissues

MUSCULAR TISSUE (Or Contractile Tissue)

Muscle tissue is a soft tissue that composes muscles.

Types of Muscle cells Muscle cells (myocytes) are elongated and classified as either striated muscle cells or smooth muscle cells depending on the presence or absence, respectively, of organized, regularly repeated arrangements of

myofibrillar contractile proteins called myofilaments. Striated muscle is further classified as either skeletal or cardiac muscle. Thus, muscle tissue can be described as being one of three different types: • Skeletal muscle or "voluntary muscle" is anchored by tendons to bone and is used to effect skeletal movement such as locomotion and in maintaining posture. Though this postural control is generally maintained as an unconscious reflex, the muscles responsible react to conscious control like non-postural muscles. An average adult male is made up of 42% of skeletal muscle and an average adui: female is made up of 36% (as a percentage of body mass). It also has striations unlike smooth muscle.

• Smooth muscles are called as non-striated muscles as these muscles do not-contain any striations when observed under a microscope. These are also known as involuntary muscles as these muscles are not under our control. The brain does not control its actions voluntarily. Smooth muscles are responsible for the movement of muscular actions of internal organs such as movement of food and wastes along the digestive tract. The other movement is the contraction or dilation of the pupil of the eyes and other countless involuntary movements of the sense and internal organs except the heart.

• Cardiac muscles are also known as heart muscles as these muscles are specially confined to the region of the heart. Cardiac muscles are involved in the rhythmic beating and contractions of the heart, which are not under our consciousness, therefore cardiac muscles are also known as involuntary muscles. Cardiac muscles are different from the skeletal muscles in having lateral connection between the muscle fibres. They are under the control of Autonomic Nervous System and are not under self control.

Cardiac and skeletal muscles are striated in that they contain sarcomeres and are packed into highly regular arrangements of bundles; smooth muscle has neither. While skeletal muscles are arranged in regular, parallel bundles, cardiac muscle connects at branching, irregular angles (called intercalated discs). Striated muscle contracts and relaxes in short, intense bursts, whereas smooth muscle sustains longer or even near-permanent contractions.

NERVOUS TISSUE

Contact No:9535111199/9535111188

Nervous tissue is the main component of the nervous system - the brain, spinal cord, and nerves-which regulates and controls body functions. It is composed of neurons, which transmit impulses, and the neuroglia cells, which assist propagation of the nerve impulse as well as provide nutrients to the neuron.

Nervous tissue is made of nerve cells that come in many varieties, all of which are distinctly characteristic by the axon's or long stem like part of the cell that sends action potential signals to the next cell.

The important functions of the nervous system are sensory input, integration, control of muscles and glands, homeostasis, and mental activity. All living cells have the ability to react to stimuli. Nervous tissue is specialized to react to stimuli and to conduct impulses to various organs in the body which bring about a response to the stimulus. Nerve tissues are all made up of specialized nerve cells called neurons. Neurons are easily stimulated and transmit impulses very rapidly. A nerve is made up of many nerve cell fibres (neurons) bound together by connective tissue. A sheath of dense connective tissue, the epineurium surrounds the nerve. This sheath penetrates the nerve to form the perineurium which surrounds bundles of nerve fibres. Blood vessels of various sizes can be seen in the epineurium. The endoneurium, which consists of a thin layer of loose connective tissue. surrounds the individual nerve fibres. The cell body is enclosed by a cell (plasma) membrane and has a central nucleus. Granules called Nissl bodies are found in the cytoplasm of the cell body. Within the cell body, extremely fine neurofibrils extend from the dendrites into the axon. The axon is surrounded by the myelin sheath, which forms a whitish, non-cellular, fatty layer around the axon. Outside the myelin sheath is a cellular layer called the neurilemma or sheath of Schwann cells. The myelin sheath together with the neurilemma is also known as the medullary sheath. This medullary sheath is interrupted at intervals by the nodes of Ranvier.

Nerve cells are functionally made to each other at a junction known as a synapse, where the terminal branches of an axon and the dendrites of another neuron lie close to each other but normally without direct contact. Information is transmitted across the gap by chemical secretions called neurotransmitters. It causes activation in the post-synaptic cell. All cells possess the ability to

Contact No:9535111199/9535111188

respond to stimuli. The messages carried by the nervous system are electrical signals called impulses.

Classification of neurons Neurons are grouped structurally according to the number of processes extending from their cell body. Three major neuron groups make up this classification: multipolar, bipolar and unipolar neurons.

Multipolar Neurons: These are the most common neuron type in humans (more than 99% of neurons belong to this class) and the major neuron type in the CNS.

Bipolar Neurons: Bipolar neurons are spindle-shaped, with a dendrite at one end and an axon's at the other. An example can be found in the light-sensitive retina of the eye. They also grow rapidly.

Unipolar Neurons: Sensory neurons have only a single process or fibre which divides close to the cell body into two main branches (axon and dendrite). This type of nerve fibre is present only in embryonic stage in human beings.

The immune system is a system of biological structures and processes within an organism that protects against disease. To function properly, an immune system must detect a wide variety of agents. from viruses to parasitic worms, and distinguish them from the organism's own healthy tissue. Pathogens can rapidly evolve and adapt to avoid detection and neutralization by the immune system. As a result, multiple defence mechanisms have also evolved to recognize and neutralize pathogens..Even simple unicellular organisms such as bacteria possess a rudimentary immune system, in the form of enzymes that protect against bacteriophage infections.

Other basic immune mechanisms evolved in ancient eukaryotes and remain in their modern descendants, such as plants and insects. These mechanisms include phagocytosis, antimicrobial peptides called defensins, and the complement system. Jawed vertebrates, including humans, have even more sophisticated defence mechanisms, including the ability to adapt over time to recognize specific pathogens more efficiently.

Contact No:9535111199/9535111188

Adaptive (or acquired) immunity creates immunological memory after an initial response to a specific pathogen, leading to an enhanced response to subsequent encounters with that same pathogen. This process of acquired immunity is the basis of vaccination.

Immunology covers the study of all aspects of the immune system.

COMPONENTS OF THE IMMUNE SYSTEM

Innate immune system Adaptive immune system Response is non-specific Pathogen and antigen specific response Exposure leads to immediate maximal response Lag time between exposure and maximal response No immunological memory Exposure leads to immunological memory Found in nearly all forms of life Found only in jawed vertebrates

Both innate and adaptive immunity depend on the ability of the immune system to distinguish between self and non-self molecules. In immunology, self molecules are those components of an organism's body that can be distinguished from foreign substances by the immune system. Conversely, non-self molecules are those recognized as foreign molecules.

Innate immune system Microorganisms or toxins that successfully enter an organism encounter the cells and mechanisms of the innate immune system. The frInate response is usually triggered when microbes are identified by pattern recognition receptors, which recognize components that are conserved among broad groups of microorganisms, or when damaged, injured or stressed cells send out alarm signals, many of which (but not all) are recognized by the same receptors as those that recognize pathogens. Innate immune defences are non-specific, meaning these systems respond to pathogens in a generic way. This system does not confer long-lasting immunity against a pathogen. The innate immune system is the dominant system of host defence in most organisms.

Adaptive immune system The adaptive immune system evolved in early vertebrates and allows for a stronger immune response as well as immunological memory, where each pathogen is "remembered" by a signature

Contact No:9535111199/9535111188

antigen. The adaptive immune response is antigen-specific and requires the recognition of specific "non-self" antigens during a process called antigen presentation. Antigen specificity allows for the generation of responses that are tailored to specific pathogens or pathogen-infected cells. The ability to mount these tailored responses is maintained in the body by "memory cells". Should a pathogen infect the body more than once, these specific memory cells are used to quickly eliminate it.

Lymphocytes

The cells of the adaptive immune system are special types of leukocytes, called lymphocytes. B cells and T cells are the major types of lymphocytes and are derived from hematopoietic stem cells in the bone marrow. B cells are involved in the humoral immune response, whereas T cells are involved in cell-mediated immune response. Both B cells and T cells carry receptor molecules that recognize specific targets. T cells recognize a "non-self" target, such as a pathogen, only after antigens (small fragments of the pathogen) have been processed and presented in combination with a "self' receptor called a major histocompatibility complex (MHC) molecule. There are two major subtypes of T cells: the killer T cell and the helper T cell. In contrast, the B cell antigen-specific receptor is an antibody molecule on the B cell surface, and recognizes whole pathogens without any need for antigen processing. Each lineage of B cell expresses a different antibody, so the complete set of B cell antigen receptors represent all the antibodies that the body can manufacture. Bio – 61

Killer T cells Killer T cells are a sub-group of T cells that kill cells that are infected with viruses (and other pathogens), or are otherwise damaged or dysfunctional. As with B cells, each type of T cell recognizes a different antigen. Killer T cells are activated when their T cell receptor (TCR) binds to this specific antigen in a complex with the MHC Class I receptor of another cell. Recognition of this MHC antigen complex is aided by a co-receptor on the T cell, called CD8. The T cell then travels throughout the body in search of cells where the MHC I receptors bear this antigen. When an activated T cell contacts such cells, it releases cytotoxins, such as perforin, which form pores in the target cell's plasma membrane, allowing ions, water and toxins to enter. The

Contact No:9535111199/9535111188

entry of another toxin called granulysin (a protease) induces the target cell to undergo apoptosis. T cell killing of host cells is particularly important in preventing the replication of viruses. T cell activation is tightly controlled and generally requires a very strong MHC/antigen activation signal, or additional activation signals provided by "helper" T cells.

Helper T cells Helper T cells regulate both the innate and adaptive immune responses and help determine which immune responses the body makes to a particular pathogen. These cells have no cytotoxic activity and do not kill infected cells or clear pathogens directly. They instead control the immune response by directing other cells to perform these tasks.

Helper T cells express T cell receptors (TCR) that recognize antigen bound to Class II MHC molecules. The MHC antigen complex is also recognized by the helper cell's CD4 co-receptor, which recruits molecules inside the T cell that are responsible for the cell's activation. Helper T cells have a weaker association with the MHC antigen complex than observed for killer T cells, meaning many receptors (around 200-300) on the helper T cell must be bound by an MHC antigen in order to activate the helper cell, while killer T cells can be activated by engagement of a single MHC antigen molecule. Helper T cell activation also requires longer duration of engagement with an antigen-presenting cell. The activation of a resting helper T cell causes it to release cytokines that influence the activity of many cell types. Cytokine signals produced by helper I cells enhance the microbicidal function of macrophages and the activity of killer T cells. In addition, helper T cell activation causes an upregulation of molecules expressed on the T cell's surface, such as CD40 ligand (also called CD154), which provide extra stimulatory signals typically required to activate antibody-producing B cells.

B lymphocytes and antibodies A 'B cell' identifies pathogens when antibodies on its surface bind to a specific foreign antigen. This antigen/antibody complex is taken up by the B cell and processed by proteolysis into peptides. The B cell then displays these antigenic peptides on its surface MHC class 11 molecules. This combination of MHC and antigen attracts a matching helper T cell, which releases lymphokines and activates the B cell. As the activated B cell then

Contact No:9535111199/9535111188

begins to divide, its offspring (plasma cells) secrete millions of copies of the antibody that reco6nizes this antigen. These antibodies circulate in blood plasma and lymph, bind to pathogens expressing the antigen and mark them for destruction by complement activation or for uptake and destruction by phagocytes. Antibodies can also neutralize challenges directly, by binding to bacterial toxins or by interfering with the receptors that are used by viruses and bacteria to infect cells.

Immunological memory

When B cells and T cells are activated and begin to replicate, some of their offspring become long-lived memory cells. Throughout the lifetime of an animal, these memory cells remember each specific pathogen encountered and can mount a strong response if the pathogen is detected again. This is "adaptive" because it occurs during the lifetime of an individual as an adaptation to infection with that pathogen and prepares the immune system for future challenges. Immunological memory can be in the form of either passive short-term memory or active long-term memory.

Disorders of human immunity The immune system is a remarkably effective structure that incorporates specificity, inducibility and adaptation. Failures of host defence do occur, however, and fall into three broad categories: immune-deficiencies, autoimmunity, and hypersensitivities.

Immuno-deficiencies immuno-deficiencies occur when one or more of the components of the immune system are inactive. The ability of the immune system to respond to pathogens is diminished in both the young and the elderly, with immune responses beginning to decline at around 50 years of age due to immune senescence. In developed Countries, obesity, alcoholism, and drug use are common causes of poor immune function. However, malnutrition is the most common cause of immunodeficiency in developing countries. Diets lacking sufficient protein are associated with impaired cell-mediated immunity, complement activity, phagocyte function, IgA antibody concentrations, and cytokine production. Additionally, the loss of the thymus at an early age

Contact No:9535111199/9535111188

through genetic mutation or surgical removal results in severe immunodeficiency and a high susceptibility to infection.

Immuno-deficiencies can also be inherited or 'acquired'. Chronic granulomatous disease, where phagocytes have a reduced ability to destroy pathogens, is an example of an inherited, or congenital, immunodeficiency. AIDS and some types of cancer cause acquired immunodeficiency.

Autoimmunity

Overactive immune responses comprise the other end of immune dysfunction, particularly the autoimrnune disorders. Here, the immune system fails to properly distinguish between self and non-self, and attacks part of the body. Under normal circumstances, many T cells and antibodies react with "self" peptides. One of the functions of specialized cells (located in the thymus and bone marrow) is to present young lymphocytes with self antigens produced throughout the body and to eliminate those cells that recognize self-antigens, preventing autoimmunity.

Hypersensitivity Hypersensitivity is an immune response that damages the body's own tissues. They are divided into four classes (Type I — IV) based on the mechanisms involved and the time course of the hypersensitive reaction. Type I hypersensitivity is an immediate or anaphylactic reaction, often associated with allergy. Symptoms can range from mild discomfort to death. Type I hypersensitivity is mediated by IgE, which triggers degranulation of mast cells and basophils when cross-linked by antigen. Type II hypersensitivity occurs when antibodies bind to antigens on the patient's own eel's, marking them for destruction. This is also called antibody-dependent (or cytotoxic) hypersensitivity, and is mediated by IgG and IgM antibodies. Immune complexes .(aggregations of antigens, complement proteins, and IgG and IgM antibodies) deposited in various tissues trigger Type III hypersensitivity reactions. Type IV hypersensitivity (also known as cell-mediated or delayed type hypersensitivity) usually takes between two and three days to develop. Type IV reactions are involved in many autoimrnune and infectious diseases,

but may also involve contact dermatitis (poison ivy). These reactions are mediated by T cells, monocytes, and macrophages.

NUTRITION

All living organisms need raw materials to build up most of their own body molecules. and they require energy to operate the metabolic reactions that sustain life. The materials which provide the two primary requirements of life, namely raw materials and energy, are called nutrients. Nutrients are supplied to the body by taking food. The sum total of the processes by which the living organisms obtain food and utilize it for use in various biological activities such as growth, maintenance and for meeting their energy needs is termed as nutrition.

A nutritionally adequate diet must also contain essential nutrients, i.e., the substances an animal cannot synthesize for itself from any raw material and must take in food in prefabricated form. These include essential amino acids, essential fatty acids. vitamins and minerals.

The organisms have evolved three different types of nutrition: autotrophic, heterotrophic and symbiotic.

Autotrophic or Holophytic nutrition: Preparation of organic food from the inorganic materials in the organism's own body is called 'autotrophic nutrition'. It is of 2 types.

A. Photoautotrophic Nutrition- All green plants and certain bacteria have evolved a mechanism to directly use the energy of sunlight for preparing organic food in their own body from simple inorganic molecules. They take carbon dioxide and water from environment and transform these into glucose and oxygen with the help of sun's energy trapped by chlorophyll. This process of making organic food with the help of sunlight is called photosynthesis. The organisms capable of photosynthesis are termed phototrophs. They retain glucose to prepare other organic materials from it, and release oxygen as a by product. 6002 + 6H20 -4 C61-11206 + 602

B. Chemoautrophic Nutrition- Some bacteria have developed a technique to capture energy released during oxidation of inorganic chemical substances and prepare organic food with its help. They are known as chemotrophs. The process of preparing organic food with the help of energy from chemical reactions is known as chemosynthesis. Since both phototrophs and chemotrophs do not take organic molecules produced by other organisms, they are called autotrophs or 'self-nourishing'.

II. Heterotrophic Nutrition- Animals, fungi, some protists (amoeba) and many bacteria lack chlorophyll and cannot utilise sun energy. They use chemical bond energy of organic molecules synthesised by other organisms in building their own organic molecules. Taking organic food synthesised by autotrophs is termed heterotrophic nutrition. Heterotrophs get organic molecules by taking plants or animals (living or dead) or their products, and obtain energy by "burning" these molecules in their body. Thus, the heterotrophs also get energy from the sunlight but indirectly through the plants. Heterotrophic Nutrition is of 4 kinds:

A. Saprophytic Nutrition — Bacteria and fungi flourish on dead, decaying organic matter of both and animal origin. They secrete digestive enzymes onto this matter. The enzymes hydrolyze the organic matter into simple soluble products that are then absorbed. This method of taking up food from nonliving source is known as saprophytic nutrition.

B. Holotrophic

Nutrition — Majority of invertebrates and vertebrates take plants, animals or their products through the mouth and break up the large organic molecules into smaller ones in their own body with the help of digestive enzymes. The simple molecules are then absorbed into the cells and utilised. This mode of taking food or fluid organic food via mouth is called holotrophic nutrition. Depending upon the food habits, holozoic animals are mainly classified into three categories:

Herbivores — These eat only algae or plant materials. e.g.- cow, rabbit, horse, deer etc.

Contact No:9535111199/9535111188

Carnivores — These are flesh eating animals. e.g. — lion, tiger etc. Some carnivores eat up individuals of their own species and their feeding habit is called cannibalism. e.g. bed bug.

Omnivores — They eat both plants and other animals as food. e.g. — sparrow, man, rat, crow, etc. Sanguivores suck blood of other animals. E.g. leeches, mosquitoes, vampires

Coprophages feed on animal dung.

C. Mixotrophic Nutrition — Euglena carries on autotrophic and saprophytic nutrition at the same time. This is called mixotrophic nutrition. D. Parasitic Nutrition — Parasites live on liquid food material obtained from the body of the host and their mode of nutrition is termed as parasitic nutrition.

YAJIRAM & RAVI III. Symbiotic Feeding Two different species of organisms living in association and" deriving nutrition from each other are relationship is called symbiotic nutrition. Some animals, such as certain sponges, have unicellular green algae, the zoochlorellae, in their cells. These algae supply carbohydrates to host and, in return. utilize ammonia given off by the host for protein synthesis.

DIGESTIVE SYSTEM

The human digestive system is a complex series of organs and glands that processes food. It is a complex process that consists of breaking down large organic masses into smaller particles that the body can use as fuel. The breakdown of the nutrients requires the coordination of several enzymes secreted from specialized cells within the mouth, stomach, intestines, and liver.

The ceeran major organs or Transverse colon structures that i Aso:2.nd rig coordinate digestion Desoandaig colon —within the human body Cecurn include the mouth, Appemcbc oesophagus, stomach, small and large intestine, and liver.

Most of the digestive organs (like the stomach and intestines) are tube-like and contain the food as it makes its way through the body. The digestive system is essentially a long, twisting tube that runs from the mouth to the anus, plus a few other organs (like the liver and pancreas) that produce or store digestive chemicals.

The Digestive Process The start of the process - the mouth: The digestive process begins in the mouth. In the human body, the mouth (oral cavity) is a specialized organ for receiving food and breaking up large organic masses. In the mouth, food is changed mechanically by biting and chewing. Humans have four kinds of teeth: incisors are chisel-shaped teeth in the front of the mouth for biting; canines are pointed teeth for tearing; and premolars and molars are flattened, ridged teeth for grinding, pounding, and crushing food.

Total number of teeth in a man is 32. Dental formula of an adult man is 2123/2123. In man. 20 teeth are diphyodont i.e. grow twice in life. Milk dentition formula of a man is 2102/2102.

In the mouth, food is moistened by saliva, a sticky fluid that binds food particles together into a soft mass. Three pairs of salivary glands—the parotid glands, the submaxillary glands, and the sublingual glands—secrete saliva into the mouth. The saliva contains an enzyme called amylase, which digests starch molecules into smaller molecules of the disaccharide maltose. (Mumps is a viral disease causing painful inflammation of parotid glands.)

During chewing, the tongue moves food about and manipulates it into a mass called a bolus. The bolus is pushed back into the pharynx (throat) and is forced through the opening to the oesophagus.

On the way to the stomach:

The oesophagus - After being chewed and swallowed, the food enters the oesophagus. The oesophagus is a thick-walled muscular tube located behind the windpipe that extends through the neck and chest to the stomach. It uses rhythmic, wave-like muscle movements (called peristalsis) to force food from

Contact No:9535111199/9535111188

the throat into the stomach. This muscle movement gives us the ability to eat or drink even when we're upside-down.

In the stomach - The oesophagus joins the stomach at a point just below the-diaphragm. A valve like ring of muscle called the cardiac sphincter surrounds thy: opening to the stomach. The sphincter relaxes as the bolus passes through and then quickly closes.

The stomach is a Wge, sack-like organ that churns the food and bathes it in a very strong acid (gastric acid). Food in the stomach that is partly digested and mixed with stomach acids is called chyme. The stomach stores food and prepares it for further digestion. In addition, the stomach plays a role in protein digestion. Gastric glands contain four types of gland cells —mucous cells, chief (or peptic or zymogen) cells, oxyntic (or parietal) cells, and Argentaffin cells. The chief cells secrete pepsinogen. Pepsinogen is converted to the enzyme pepsin in the presence of hydrochloric acid. Hydrochloric acid is secreted by parietal cells in the stomach lining. The pepsin then digests large proteins into smaller proteins called peptides. To protect the stomach lining from the acid, a third type of cell secretes mucous that lines the stomach cavity. An overabundance of acid due to mucus failure may lead to an ulcer.

In the small intestine — The soupy mixture called chyme spurts from the stomach through a sphincter into the small intestine. An adult's small intestine is about 23 feet long and is divided into three sections: the first 10 to 12 inches form the duodenum; the next 10 feet form the jejunum; and the final 12 feet form the ileum. The inner surface of the small intestine contains numerous fingerlike projections called villi. Each villus has projections of cells called microvilli to increase the surface area.

Food first enters the duodenum, the first part of the small intestine. It then enters the jejunum and then the ileum (the final part of the small intestine). Most chemical digestion takes place in the duodenum. In this region, enzymes digest nutrients into simpler forms that can be absorbed. Intestinal enzymes are supplemented by enzymes from the pancreas, a large, glandular organ lying

Contact No:9535111199/9535111188

near the stomach. In addition, bile enters the small intestine from the gall bladder to assist in fat digestion.

The enzymes functioning in carbohydrate digestion include amylase (for starch), maltase (for maltose), sucrase (for sucrose) and lactase (for lactose). For fats, the principal enzyme is lipase. Before this enzyme can act, the large globules of fat must be broken into smaller droplets by bile. Bile is a mixture of salts, pigments, and cholesterol that is produced by the liver and stored in the gall bladder, a sac-like structure underneath the liver. Cystic duct conducts bile from liver to gall bladder. (Surgical removal of gall bladder called cholecystectomy.)

Protein digestion is accomplished by several enzymes, including two pancreatic enzymes: trypsin and chymotrypsin. Peptides are broken into smaller peptides, and peptidases reduce the enzymes to amino acids. Nucleases digest nucleic acids into nucleotides in the small intestine also.

Most absorption in the small intestine occurs in the jejunum. The products of digestion enter cells of the villi, move across the cells, and enter blood vessels called capillaries. Diffusion accounts for the movement of many nutrients, but active transport is responsible for the movement of glucose and amino acids. The products of fat digestion pass as small droplets of fat into lacteals, which are branches of the lymphatic system.

Absorption is completed in the final part of the small intestine, the ileum. Substances that have not been digested or absorbed then pass into the large intestine.

In the large intestine - After passing through the small intestine, food passes into the large intestine. The small intestine joins the large intestine in the lower right abdomen of the body. The two organs meet at a blind sac called the caecum and a small finger-like process called the appendix. Evolutionary biologists believe the caecum and appendix are vestiges of larger organs that may have been functional in human ancestors. The large intestine is also known as the colon. It is divided into ascending, transverse, and descending portions, each about one foot in length.

Contact No:9535111199/9535111188

In the large intestine, some of the water and electrolytes (chemicals like sodium) are removed from the food. Many microbes (bacteria like Bacteroides, Lactobacillus acidophilus, Escherichia coli, and Klebsiella) in the large intestine help in the digestion process. The first part of the large intestine is called the caecum (the appendix is connected to the caecum). Food then travels upward in the ascending colon. The food travels across the abdomen in the transverse colon, goes back down the other side of the body in the descending colon, and then through the sigmoid colon. The intestinal matter remaining after water has been reclaimed is known as faeces. Faeces consist of non-digested food (such as cellulose), billions of mostly harmless bacteria, bile pigments, and other materials.

The end of the process - The faeces are stored in the rectum and passed out through the anus to complete the digestion process.

Liver

The liver is the largest gland located above stomach under the diaphragm. The liver has an important function in processing the products of human digestion. For example, cells of the liver remove excess glucose from the bloodstream and convert the glucose to a polymer called glycogen for storage.

The liver also functions in amino acid metabolism. In a process called deamination, it converts some amino acids to compounds that can be used in energy metabolism. In doing so, the liver removes the amino groups from amino acids and uses the amino groups to produce urea. Urea is removed from the body in the urine. Fats are processed into two-carbon units that can enter the Krebs cycle for energy metabolism. The liver also stores vitamins and minerals, forms many blood proteins, synthesizes cholesterol, and produces bile for fat digestion.

NUTRITIONAL REQUIREMENTS

CARBOHYDRATES

Contact No:9535111199/9535111188

A carbohydrate is an organic compound that consists only of carbon, hydrogen, and oxygen, usually with a hydrogen:oxygen atom ratio of 2:1. Body uses carbohydrates tr) make glucose which is the fuel that gives energy and helps keep everything going. Body can use glucose immediately or store it in liver and muscles for when it is needed.

Sources of carbohydrates: Fruits; Vegetables; Breads, cereals, and other grains; Milk and milk products; Foods containing added sugars (e.g., cakes, cookies, and sugar sweetened beverages).

The carbohydrates (saccharides) are divided into four chemical groupings. monosaccharides, disaccharides, oligosaccharides, and polysaccharides. In general, the monosaccharides and disaccharides, which are smaller (lower molecular weight) carbohydrates, are commonly referred to as sugars. 1. Monosaccharides are the simplest carbohydrates which cannot be hydrolysed to smaller molecules as they are formed of only one sugar molecule. E.g. — glucose (Blood sugar/Grape sugar), galactose, fructose (Fruit sugar). 2. Oligosaccharides can be hydrolysed to yield 2 to 6 monosaccharide molecules as they are formed of 2 to 6 monosaccharide molecules by dispelling water molecules. Disaccharides (maltose (malt sugar), sucrose (Cane sugar), lactose (milk sugar)) are the most common oligosaccharides. 3. Polysaccharides are formed of very large number of monosaccharide molecules interlinked by glycosidic bonds. They may be homopolysaccharides (e.g. starch, cellulose, glycogen) or heteropolysaccharides (e.g. heparin, chitin).

Polysaccharides serve for the storage of energy (e.g., starch and glycogen), and as structural components (e.g., cellulose in plants and chitin in arthropods). Carbohydrates perform numerous roles in living organisms. They form the major fuel in the cells to provide energy for life processes. One gram of food carbohydrate on oxidation in the cells produces 4 kcal of energy. This is known as physiological fuel value of carbohydrates. Carbohydrates form a better fuel than proteins and fats because their molecules have relatively more oxygen and therefore need less molecular oxygen for oxidation than those of proteins and fats. Glucose is the most common fuel carbohydrate. Other carbohydrates

Contact No:9535111199/9535111188

change by enzymatic action into glucose fof use as fuel. Glucose is completely oxidised to carbon dioxide and water for releasing energy.

Carbohydrates form storage products for later use. If in excess, glucose is converted into glycogen by the process of glycogenesis and stored in the muscle and liver cells. It may also change into fat and stored in liver, adipose tissue and mesenteries. This change is termed lipogenesis. In case the food provides inadequate glucose, reserve glycogen is converted into glucose for use in energy production. This conversion is known as glycogenolysis. Our body generally expends liver glycogen first, and then draws on muscles glycogen and fat.

The 5-carbon monosaccharide ribose is an important component of coenzymes (e.g., nicotinamide adenine dinucleotide (NAD)), ribonucleic acids (RNAs) and energy carriers such as ATP. The related pentose sugar deoxyribose is a component of DNA. The RNA and DNA are, in turn, components of ribosomes and chromosomes respectively.

Heteropolysaccharides consist of modified monosaccharide units. They from certain very important substances-

(a) anti-coagulant heparin that prevents the clotting of blood in the intact blood vessels.

(b) blood group substances, such as A,B, and Rh antigens of erythrocytes, that are responsible for major immunological reactions of blood.

(c) lubricant hyaluronic acid present in the synovial fluid of the joints, cerebrospinal fluid and vitreous humpur.

(d) protective coats, such as glycocalyx, that covers the intestinal epithelium and mucus which covers all mucous membranes.

(e) luteinizing hormone that causes ovulation, formation of corpus luteum and secretion of female sex hormone.

There are three main types of polysaccharides - storage, structural and bacterial. Polysaccharides may act as food stores in plants in the form of starch, or food

stores in humans and other animals in the form of glycogen. Polysaccharides also have structural roles in the plant cell wall in the form of cellulose or pectin, and the tough outer skeleton of insects in the form of chitin.

1. Storage polysaccharides a. Glycogen - a polysaccharide that humans and animals store in the liver and muscles.

b. Starch - these are glucose polymers made up of Amylose and Amylopectin. Amylose molecule chains are linear (long but no branches) while Amylopectin molecules are long and branch out - some Amylopectin molecules are made of several thousand glucose units. Starches are not water soluble. Humans and animals digest them by hydrolysis - our bodies have amylases which break them down. Rich sources of starches for humans include potatoes, rice and wheat.

2. Structural polysaccharides a. Cellulose - The structural constituents of plants are made mainly from cellulose. Wood is mostly made of cellulose, while paper and cotton are almost pure cellulose. Lignin, derived from wood, is a key component in the secondary walls of plant cells. Some animals, such as termites. can digest cellulose because their gut has a type of bacteria that has an enzyme which breaks down cellulose - humans cannot digest cellulose.

Chitin - Microorganisms, such as bacteria and fungi secrete chitinases, which over time can break down chitin. The bacteria and fungi convert the decomposed chitin into simple sugars and ammonia. Chitin is the main. component of fungi cell walls, the exoskeletons (hard outer shell/skin) of arthropods, such as crabs, lobsters, ants, beetles, and butterflies.

3. Bacterial polysaccharides These are polysaccharides that are found in bacteria, especially in bacterial capsules. Pathogenic (illness causing) bacteria often produce a thick layer of mucous-like polysaccharide which cloaks the bacteria from the host's immune system. In other words, if the bacteria were in a human, that human's immune system would less likely attack the bacteria because the polysaccharide layer masks its pathogenic properties. E. co/i, which can sometimes cause disease,

Contact No:9535111199/9535111188

produces hundreds of different polysaccharides. Daily Requirement: An adult man of average weight and doing moderate work needsabout 500 gms of carbohydrates daily. Carbohydrates from more than half of our total diet, but form only 1% of our total weight. This shows that they are primary fuel foods and are rapdly oxidised to supply energy for body activities.

PROTEINS

Proteins, building blocks of life, are compounds of carbon, oxygen, hydrogen and nitrogen. In addition, majority of proteins contain sulphur. Each protein is made up of numerous monomers,_the amino acids, which are joined together by peptide bonds. Every cell in the human body contains protein. It is a major part of the skin, muscles, organs, and glands. Protein is also found in all body fluids, except bile and urine. Proteins perform a vast array of functions within living organisms, including catalyzing metabolic reactions, replicating DNA, responding to stimuli, and transporting molecules from one location to another. The body needs proteins to repair and maintain itself. Protein is also important for growth and development during childhood, adolescence, and pregnancy.
Proteins differ from one another primarily in their sequence of amino acids, which is dictated by the nucleotide sequence of their genes, and which usually results in folding of the protein into a specific three-dimensional structure that determines its activity.

Sources of proteins

Animal sources: meats, milk, fish, and eggs;
Plant sources: soya beans, legumes, nut butters, and some grains (such as wheat germ).

Types of Proteins
On the basis of their chemical nature, proteins are divided into three categories:
a. Simple Proteins on hydrolysis yield only amino acids. E.g.- albumins (egg albumin), globulins and glutelins (glutenin in wheat).

b. Conjugated proteins on hydrolysis yield amino acids along with other organic or inorganic components (non-protein part). This non-protein part of the conjugated protein is known as the prosthetic group.

Contact No:9535111199/9535111188

c. Derived proteins are formed by the partial hydrolysis of simple proteins. E.g. metaproteins, peptones, proteoses, etc.

Functions of Proteins

The principal role of the proteins is to build the tissues. The proteins with this function are called structural proteins. They are essential for growth, repair and reproduction.
Their need increases during pregnancy and lactation. Their deficiency may retard physical growth and mental ability, and cause anaemia and breakdown of tissues, and deficiency diseases such as kwashiokar in school-going children and marasmus in infants.

Most enzymes and some coenzymes are proteins. They catalyse all metabolic reactions in the cells and digestive tract. Many hormones are of proteinacious nature and they regulate metabolism. Carrier proteins are special protein molecules that transport materials across the membranes of cells and their organelles.

Blood proteins immunoglobulins form antibodies to defend the body against foreign materials entering it. Plasma protein fibrinogen brings about clotting of blood to stop bleeding from injury. Plasma proteins globulins carry hormones thyroxine and insulin bound to them. Haemoglobin (nonprotein heme + protein globin) of erythrocytes carries oxygen and carbon dioxide in respiration.

The proteins rhodopsin and iodopsin of rod cells and con cells respectively present inthe retina provide vision. Contractability of the proteins myosin and action of muscle fibres provides movements.
Proteins are used as a source of energy when carbohydrates and lipids are exhausted. The proteins so utilized are structural and functional proteins of the cells as there is little storage of proteins as such in the body. Hence protein respiration leads to breakdown of tissues and finally death. The physiological fuel value of proteins is 4kcal per gram.

Types of Amino acids

Nutritionally the amino acids are of two types- essential and non-essential amino acids. Eight amino acids cannot be synthesized in the adult human body and must be taken in the diet. They are called essential amino acids. They include isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. A ninth amino acid is essential for infants. Other non-essential amino acids may be synthesised in the body from some amino acids or carbohydrate metabolites. These include alanine, asparagine, as partic acid and glutamic acid. Arginine and histidine are considered semi-indispensable amino acids. Animal proteins contain all the essential amino acids, and are known as the “first class proteins".

Daily Requirement

About 70-100 grams of protein are needed daily. Since the proteins are constantly degraded and replaced, there is a continued necessity for a certain minimum of protein in the diet, even for adults whose growth has stopped.

FATS

Some fat is essential in everyone's diet. Fats provide a source of concentrated energy as well as the fat-soluble vitamins A, D, E and K. Fat transports these vital nutrients around the body.

Fat is also needed for hormone metabolism, healthy skin and hair, tissue repair, protecting the internal organs and to prevent excessive loss of body heat. Fats may be either solid or liquid at room temperature, depending on their structure and composition. Although the words "oils", "tats", and "lipids" are all used to refer to fats, "oils" is usually used to refer to fats that are liquids at normal room temperature, while "fats" is usually used to refer to fats that are solids at normal room temperature. "Lipids" is used to refer to both liquid and solid fats, along with other related substances, usually in a medical or biochemical context.
Fats or lipids are broken down in the body by enzymes called lipases produced in the pancreas.

All fats are derivatives of fatty acids and glycerol. The molecules are called triglycerides, which are triesters of glycerol (an ester being the molecule formed from the reaction of the carboxylic acid and an organic alcohol).

Types of Fat

There are two maintypes of fat: saturated and unsaturated. In saturated tats, carbon-carbon atoms are connected by single bonds. Each carbon atom in the chain is saturated with hydrogen, meaning they are bonded to as many hydrogens as possible. Sources of saturated fats are mainly products of animal origin (Meat, butter, cream, cheese, eggs, full fat milk). These are solid at room temperature.

Saturated fat raises cholesterol levels and increases risk of many chronic diseases, such as heart disease, stroke and certain cancers.

Unsaturated fats are derived from fatty acids containing double bonds within carbon chain. Monounsaturated fatty acids contain single double bond. Polyunsaturated fatty acids are fatty acids with more than one double bond. Unsaturated fats can be converted to saturated ones by the process of hydrogenation. They are liquid at room temperature. Their sources are products of plant origin. Unsaturated fats contain essential fatty acids that cannot be manufactured by the body. Omega-3 and omega-6 essential fatty acids play an important role in the functions of the body that promote health and wellbeing. In particular, studies have shown that omega-3 fatty acids protect against heart disease. Oily fish is the best source of omega-3.

There are two ways the double bond may be arranged: the isomer with both parts of the chain on the same side of the double bond (the cis-isomer), or the isomer with the pans of the chain on opposite sides of the double bond (the trans-isomer). Most trans-isomer fats (commonly called trans fats) are commercially produced by partial hydrogenation of unsaturated tats. Trans fatty acids are rare in nature. The cis-isomer introduces a kink into the molecule that prevents the fats from stacking efficiently as in the case of fats with saturated chains. This decreases intermolecular forces between the fat molecules, making it more difficult for unsaturated cis-fats to freeze; they are typically liquid at room temperature. Trans fats may still stack like saturated fats, and are not as susceptible to metabolisation as other fats. Trans fats may significantly increase the risk of coronary heart disease.

Functions of Fats

Fats play a vital role in maintaining healthy skin and hair, insulating body organs againstshock, maintaining body temperature, and promoting healthy cell function. Fats also serve as energy stores for the body, containing about 9

calories per gram of fat. They are broken down in the body to release glycerol and free fatty acids. The glycerol can be converted to glucose by the liver and thus used as a source of energy.

Fat also serves as a useful buffer towards a host of diseases. When a particular substance, whether chemical or biotic—reaches unsafe levels in the bloodstream, the body can effectively dilute—or at least maintain equilibrium ol—the offending substances by storing it in new fat tissue. This helps to protect vital organs, until such time as the offending substances can be metabolized and/or removed from the body by such means as excretion, urination, accidental or intentional bloodletting, sebum excretion, and hair growth.

VITAMINS

Vitamins are organ'|c compounds regularly required in minute quantities in the diet for normal metabolism, health and growth. Most of the vitamins are obtained from the diet because these cannot be synthesized in the body. A sufficiently varied and balanced diet provides all vitamins in proper amounts. Some vitamins (A, D and B12) maybe stored in the body, chiefly liver. Others must be supplied constantly because they are excreted in the urine if present in excess amount in the diet.

Method of preparing food may result in loss of vitamins. Refined flour and canned foods are usually deficient in vitamins unless they are fortified. The heat of cooking destroys certain vitamins and“ some are lost with water drained off after cooking. Fresh fruits and vegetables are useful as they retain their vitamins.

Symbiotic bacteria'i.e. Escherichia coli bacteria residing in colon part of the large intestine synthesizes certain B-complex vitamins like B1, B2, 8,2 and also, ‘vitamin K.

Importance of Vitamins

They are not sources of energy. They regulate the various metabolic processes. They mostly act as the constituents of coenzymes in the cells. Each vitamin must be present in a certain minimum amount for proper functioning of the body. Lack or shortage ol vitamins leads to malfunctioning of the body known as avitaminosis. Vitamins are divided into two groups: fat-soluble vitamins

which include vitamins A, D, E and K; and water-soluble vitamins that include vitamins B complex and C.

1. Water-soluble Vitamins

a. Vitamin B Complex — It consists of 8 different components. which help in synthesis of coenzymes (non-protein part of enzymes). i. B, (Thiamine) Sources- yeast, wheat germ, peanuts, beans, liver, pulses Daily requirements- About 1.5 mg.

Function- It plays a role in aerobic carbohydrate metabolism and prOlnOf-2° appetite. It forms part of a coenzyme for oxidative decarboxylation oz c keto acids, such as pyruvate and ci-ketoglutarate, and synthesis and metabolism of pentose. It is also needed for nerve impulse transmission.

Deficiency symptoms- Beriberi characterised by loss of appetite andweight, retarded growth, degeneration of nerves and muscle atrophy. Wernicke Korsakoff syndrome, characterised by loss of memory and to- and-fro motion of eye-ball, occurs in chronic alcoholic persons as alcohol.

Sources- yeast, liver, milk, yeast, curd, pulses, green' leafy vegetables, eggs. Daily requirements- About 2 mg. Function- Needed for cellular respiration and growth; forms part of coenzymes for hydrogen transfer in electron transport system in mitochondria; maintains normal healthy skin and oral mucosa.

Deficiency symptoms- Cheilosis characterised by sores on the lips; inflammation of the eyes; skin diseases Destroyed by- Light B3 (Pentothenic Acid) Sources- yeast, peas, liver, eggs, kidney, pulses . Daily requirements- About 5-10 mg Function- lt forms part of coenzyme needed in cell respiration, necessary for normal nerves and skin. Deficiency symptoms- Abnormal functioning of adrenal glands, nen/ edegeneration, dermatitis, gastrointestinal disorders B6 (Pyridixine) Sources meat, milk, liver, banana, eggs, yeast. Daily requirements- About 2 mg. Function~ lt forms part of coenzymes for amino acid synthesis and glycogen synthesis; helps in normal nerve function and RBCs formation. Deficiency symptoms» Skin lesions, disturbance of central nervous system, anaemia. Extreme Excess- Unstable gait, numb feet, and poor coordination Destroyed by- Cooking, oral contraceptives B4 (Niacin) Sources- yeast, wheat germ, peanuts, pulses, meat Daily requirements About 20 mg

Contact No:9535111199/9535111188

Function

It forms part of coenzymes which serve as hydrogen acceptors and donors for many enzymes called dehydrogenate. Deficiency symptoms- Pellagra characterised by skin inflammation, diarrhoea and nervous disorder. It is mostly seen in people whose staple diet is maize as it is deficient in essential amino acid tryptophan, which is required for formation of niacin. Extreme Excess- Flushing of face and hands, and liver damage Destroyed by- Cooking.

Folic Acid

Sources- green leafy vegetables, banana, orange, liver, yeast. Daily requirements About 0.5 mg Function- lt forms part of coenzymes for protein and nuclei_c acid metabolism, essential for growth and formation of RBCs.
Deficiency symptoms- Macrocytic anaemia, failure of RBCs to mature; sprue (ulceration of mouth, inflammation of bowel, inability to absorb, especially fats, diarrhoea) Extreme Excess- May mask deficiency of vitamin B12 Destroyed by- Cooking B1 (Biotin) Sources— fresh fruits and vegetables, liver, milk, eggs, whole grain cereals, yeast, pulses Function- lt forms parl of coenzyme for fatty acid synthesis and for the conversion of pyruvate to oxaloacetate by addition of CO2 Deficiency symptoms- Scaly and itchy skin, muscle pain, weakness Destroyed by- Prolonged use of antibiotics and sulpha drugs, taking raw egg white in large quantities. Egg white contains a protein avidin, which forms tight complex with biotin and prevents its absorption. B‘;

(Cyanocobalamin)
Function-

It forms part of coenzyme for nucleic acid metabolism, essential for formation of RBCs, and myelin formationDeficiency symptoms- Pernicious anaemia, malformed RBCs Destroyed by- Grilling or excessive heat Vitamin B12 is synthesised by colon bacteria. Absorption of vitamin B,2 from the intestine requires the action of a gastric enzyme, Castle's intrinsic factor. Lack of this enzyme causes vitamin B12 deficiency. Vitamin C (Ascorbic Acid) Sources- green leafy vegetables, citrus fruits, peppers, tomatoes Daily requirements- About 50 mg - Function- helps in collagen (inorganic part of bones) formation; maintains integrity of capillary walls; maintains normal growth of bones and teeth; takes part in cellular oxidation and reduction; reduces the risk of cancer and coronary heart disease by acting as a strong anti-oxidant; plays role in maturation of RBCs

Contact No:9535111199/9535111188

Deficiency symptoms- Scurvy characterised by bleeding gums and swollen joints, decreased resistance to common cold. Extreme Excess- Gastrointestinal upset Destroyed by~ Heat and light.

Lipid-

Soluble Vitamins Excesses of fat-soluble vitamins are not excreted but are deposited in bodv fat. Therefore, their overdoses may accumulate to toxic levels.

a. Vitamin A (Retinol)

Sources- Yellow or green vegetables and fruits, egg yolk, whole milk, cod liver oil, shark liver oil, butter, ghee. Vitamin A is formed in the liver from B-carotene, an orange-yellow pigment that occurs in carrots, spinach, maize and papaya. Daily Requirement- About 2 mg Function- essential for formation of visual pigments rhodopsin of rod cells and iodopsin of cone cells for eyesight; growth and maintenance of normal epithelia of eye, mucous membranes and glands; prevents keratinisation; essential for the maintenance of proper immune system to fight various infections, so is called 'anti-infection vitamin'. Deficiency Symptoms- Night blindness; severe deficiency leads to xerophthalmia, a blindness caused by a film of keratin over the cornea; blockade of the ducts of all glands, leading to atrophy of the glands; retarded growth Extreme Excess- Headache, irritability, vomiting, hair loss, blurred vision, bone and liver damage

Destroyed by- Strong light

b. Vitamin D (Calciferol) Sources- Fish liver oil, egg yolk, milk, liver. It is formed in the skin from a cholesterol derivative by the action of UV rays of sunlight.

Daily Requirement- About 0.01 mg

Function- Facilitates absorption of calcium and phosphorous by intestine and their retention in the body and deposition in bones and teeth Deficiency Symptoms- Rickets in children (soft, yielding, deformed bones, bowed eggs), osteomalacia in adults (weak bones liable to easy fracture)

Extreme Excess- Brain, cardiovascular and kidney damage Destroyed by- Oral contraceptives

c. Vitamin E (Tocoferol) Sources- Green leafy vegetables, whole cereal grains, vegetable oils Daily Requirement- About 15 mg Function- Prevents breakage of RBCs; acts as a natural anti-oxidant, preventing oxidation of certain materials; may have some role in the mitochondria! electron transport system, maintains normal membrane structure; required for maintaining the health of germinal epithelium of testes in males, so is called as 'anti-sterility vitamin' Deficiency

Symptoms- Destruction of RBCs; In animals, vitamin E deficiency causes sterility in males; death of embryos and muscle degeneration
Destroyed by- Heat d. Vitamin K (Phylloquinone) Sources- Green leafy vegetables (spinach, coriander leaves. radish tops). soybean oil. liver Daily Requirement- About 0.07- 0.14 mg Function- Promotes synthesis of prothrombin in the liver for normal clotting of blood Deficiency Symptoms- Faulty blood clotting, haemorrhage Extreme Excess- Liver damage and anaemia Destroyed by- Prolonged use of antibiotics and sulpha drugs.

MINERALS

Minerals are classified as major and trace. This classification is based on how much of the mineral is needed. We consume 0.1 gm of each major mineral and 0.01 gm of eac'-- trace mineral per day.
Major Minerals (Macro elements)

MINERAL SOURCE FUNCTION

Calcium Dairy products, eggs, green vegetables Formation of bone, teeth. blood clots; keeping muscles and nerve activity normal Chlorine Table salt, sea food, chlorinated water pH balance of body fluid, tissues. production of gastric acid Magnesium Dairy products, cereals, green leafy vegetables, seafood Helping in release of energy; as catalyst:* muscle relaxation Phosphorus Meat, fish, eggs, dairy products Formation of bone, teeth, cell membranes; keeping muscle and nerve activity normal, part of many compounds such as ATP, ADP, AMP, DNA, RNA Potassium Most fruits and vegetables, cereals Normal muscle and nerve activity.

Sodium

Table salt, processed foods Sulphur Most meats, dairy products, eggs pH balance, Normal muscle and nerve activity Part of many proteins and vitamins; part of skin, hair and Nails Trace Minerals (Micro elements)

MINERAL SOURCE FUNCTION

Chromium Meats and animal proteins (except fish), whole grains, most other foods Promotion of insulin action Copper Seafood, nuts, legumes Promotion of iron utilization in haemoglobin Fluorine Fish, tea, drinking water Prevention of tooth decay Iodine Iodized salt, seafood Part of the thyroid hormones Iron Meat, eggs, legumes, cereals Part of Haemoglobin Manganese Liver, nuts, legumes, cereals Part of several enzymes and synthesis of Haemoglobin Zinc

Oysters, milk, eggs, whole grains Component of more than 80 enzyme systems. wound and burn healing. protein synthesis, immune reactions, general growth 1

Balanced Diet A diet is said to be balanced when various nutritional materials i.e. proteins. carbohydrates, fats, minerals, vitamins, roughage and water are present in sufficient amount and proper proportion. Various constituents of balanced diet provide energy, growth. repair, replacement of cells, and physiological regulation. Our food should contain the various nutrients in such proportions as can satisfy all the needs of our body. It has been discovered that of our energy requirement. We obtain about 50% from carbohydrates, 35% from fats and 1 5% from proteins. Thus, we daily require about 400 — 5—ams of carbohydrates, 60 — 70 gms of fats and 65 — 75 gms of proteins.

Pharynx Pharynx is a junction for the food and air passages.

Trachea (Wind Pipe) After passing through the pharynx, air passes into the windpipe, or trachea. The trachea has a framework of smooth muscle with about 16 to 20 open rings of C- shaped cartilages. These rings give rigidity to the trachea and ensure that it remains open. The opening to the trachea is a slit-like structure called the glottis. A thin flap of tissue called the epiglottis folds over the opening during swallowing and prevents food from entering the trachea.

At the upper end of the trachea, several folds of cartilage form the larynx, or voice box. In the larynx, flap-like pairs of tissues called vocal cords vibrate when a person exhales and produce sounds. In women and children, the vocal cords are usually short and the voice is high pitched. In men, the vocal cords are usually longer and voice is correspondingly lower.

At its lower end, the trachea branches into two large bronchi. These tubes also have smooth muscle and cartilage rings. The bronchi branch into smaller bronchioles, forming a bronchial "tree.' The bronchioles terminate in the air sacs known as alveoli.

Lungs Human lungs are composed of approximately 300 million alveoli, which are cup-shaped sacs surrounded by a capillary network. Red blood cells pass through the capillaries in single file, and oxygen from each alveolus enters the red blood cells and binds to the haemoglobin. In addition, carbon dioxide contained in the plasma and red blood cells leaves the capillaries and enters the alveoli when a breath is taken. Most carbon dioxide reaches the alveoli as bicarbonate ions, and about 25 percent of it is bound loosely to haemoglobin.

Lungs are protected from the external injury by sternum or breast bone in the front. vertebral column on the back and ribs on the sides which altogether form a bony box and protect the lungs.

When a person inhales, the rib muscles and diaphragm contract thereby increasing the volume of the chest cavity. This increase leads to reduced air pressure in the chest cavity, and air rushes into the alveoli, forcing them to expand and fill. The lungs passively obtain air from the environment by this process.

During exhalation, the. rib muscles and diaphragm relax, the chest cavity area diminishes, and the internal air pressure increases. The compressed air forces the alveoli to close, and air flows out. The nerve activity that controls breathing arises from impulses transported by nerve fibres passing into the chest cavity and terminating at the rib muscles and diaphragm. These impulses are regulated by the amount of carbon dioxide in the blood: A high carbon-dioxide concentration leads to an increased number of nerve impulses and a higher breathing rate.

Breathing In mammals, the diaphragm divides the body cavity into the abdominal cavity, which contains the viscera (e.g., stomach and intestines) and the thoracic cavity, which contains the heart and lungs. The inner surface of the thoracic cavity and the outer surface of the lungs are lined with pleural membranes which adhere to each other. If air is introduced between them, the adhesion is broken and the natural elasticity of the lung causes it to collapse. This can occur from trauma. And it is sometimes induced deliberately to allow the lung to rest. In either case re-inflation occurs as the air is gradually absorbed by the tissues. Because of this adhesion, any action that increases the volume of the thoracic cavity causes the lungs to expand, drawing air into them.

• During inspiration (inhaling), o The external intercostal muscles contract, lifting the ribs up and out. o The diaphragm contracts drawing it down.

• During expiration (exhaling), these processes are reversed and the natural elasticity of the lungs returns them to their normal volume. At rest, we breath 15-18 times a minute exchanging about 500 ml of air.

• In more vigorous expiration, o The internal intercostal muscles draw the ribs down and inward O The wall of the abdomen contracts pushing the stomach and liver upward.

Under these conditions, an average adult male can flush his lungs with about 4 litres of air at each breath. This is called the vital capacity. Even with maximum expiration, about 1200 ml of residual air remain.

Important Lung Volumes Tidal air: The air that normally goes in and out of lungs during breathing (500 ml). The air normally inspired and expired in one

Contact No:9535111199/9535111188

breath is called tidal air. Inspiratory reserve volume: This is also called complemental air. The amount of air we can inspire over and above the tidal air by deepest possible Inspiration (3100 ml). Expiratory reserve volume: This is also called supplemental air. The amount of air we -can expire over and above the tidal air by most forceful expiration (1200 ml). Vital capacity: The capacity of lungs to expire maximum volume of air after a deep inspiration. The largest quantity of air that can be expired after maximal inspiratory effort. Vital capacity is equal to the sum of the tidal, complemental and supplemental air (500 + 3100 + 1200 = 4800 ml)

Residual air: The volume of air that remains in the lungs after the most forceful expiration (1200 ml). Residual air mostly occurs in alveoli.
Total lung capacity: TLC is the sum of the vital capacity (VC) and residual volume (RV) i.e. TLC = VC + RV.4800 ml + 1200 ml = 6000 ml.
Dead air space: A part of the inspired air left in the trachea and bronchial tree (about 150 ml) where no gaseous exchange occurs.
Minute volume: The amount of air moved in and out of the lungs during one minute. It is equal to the tidal volume against the member of breaths per minute (500 ml X 12 = 6000 ml).

RESPIRATRY QUOTIENT (RQ)
RQ is the ratio of carbon dioxide output to oxygen usage during respiration: RQ Volume of CO2 formed Volume of 02 utilized
RQ is determined by Ganong's respirometer. Substance RQ Carbohydrates 1 Proteins 0.80 Fats 0.70

DISEASES OF THE LUNGS
Pneumonia Pneumonia is an infection of the alveoli. It can be caused by many kinds of both bacteria (e.g., Streptococcus pneumoniae) and viruses. Tissue fluids accumulate in the alveoli reducing the surface area exposed to air. If enough alveoli are affected, the patient may need supplemental oxygen.
Asthma In asthma, periodic constriction of the bronchi and bronchioles makes it more difficult to breathe in and, especially, out. Attacks of asthma can be triggered by airborne irritants such as chemical fumes and cigarette smoke and airborne particles to which the patient is allergic.
Emphysema In this disorder, the delicate walls of the alveoli break down, reducing the gas-exchange area of the lungs. The condition develops slowly and is seldom a direct cause of death. However, the gradual loss of gas-exchange

Contact No:9535111199/9535111188

area forces the heart to pump ever-larger volumes of blood to the lungs in order to satisfy the body's needs. The added strain can lead to heart failure.

The immediate cause of emphysema seems to be the release of proteolytic enzymes as part of the inflammatory process that follows irritation of the lungs. Most people avoid this kind of damage during infections, etc. by producing an enzyme inhibitor (a serpin) called alpha-1 antitrypsin. Those rare people who inherit two defective genes for alpha-1 antitrypsin are particularly susceptible to developing emphysema.

Chronic Bronchitis Any irritant reaching the bronchi and bronchioles will stimulate an increased secretion of mucus. In chronic bronchitis the air passages become clogged with mucus, and this leads to a persistent cough. Chronic bronchitis is usually associated with cigarette smoking.

Chronic Obstructive Pulmonary Disease (COPD) Irritation of the lungs can lead to asthma, emphysema, and chronic bronchitis. And, in fact, many people develop two or three of these together. This constellation is known as chronic obstructive pulmonary disease (COPD). The causes of COPD are cigarette smoke (often) and cystic fibrosis (rare).

Cystic fibrosis is a genetic disorder caused by inheriting two defective genes for the cystic fibrosis transmembrane conductance regulator (CFTR), a transmembrane protein needed for the transport of Cl- and HCO3- ions through the plasma membrane of epithelial cells. Defective secretion of HCO3- lowers the pH of the fluid in the lungs making it more hospitable to colonization by inhaled bacteria. The resulting inflammation leads to the accumulation of mucus which plugs the airways and hampers the ability of ciliated cells to move it up out of the lungs. All of this damages the airways — interfering with breathing and causing a persistent cough.

Lung Cancer Lung cancer, like all cancer, is an uncontrolled proliferation of cells. There are several forms of lung cancer, but the most common (and most rapidly increasing) types are those involving the epithelial cells lining the bronchi and bronchioles.

Medical Terminology

Apnea absence of breathing Eupnea Normal breathing Hypopnea decreased breathing rate Hyperpnea increased breathing rate --, 1 Dyspnea Painful breathing Orthopnea inability to breathe in a horizontal position. The human circulatory system functions to transport blood and oxygen from the lungs to the various tissues of the body. The heart pumps the blood throughout the body.

Contact No:9535111199/9535111188

The lymphatic system is an extension of the human circulatory system that includes cell-mediated and antibody-mediated immune systems. The components of the human circulatory system include the heart, blood, red and white blood cells, platelets, and the lymphatic system.

HEART

The human heart is about the size of a clenched fist and is built with the muscles situated in the rib cage between the lungs.

Chambers of the Heart It contains four chambers: two atria (or auricles) and two ventricles. Auricles are divided as right and left auricles by a thin membrane know as intra auricular membrane. Similarly ventricles are divided into right and left ventricles by a thick membrane called as intraventricular membrane. Auricles and ventricles are separated by a auriculo-ventricular membrane. Pace-makers namely sino-auricular node (SA node) and auriculo-ventricular node (AV node) are present which stimulate the functioning of the heart. Structure of the Heart (View from the front, which means the right side of the heart is on the left of the diagram &vice-versa)

Blood Vessels Blood vessels are thin pipe like structures which supply the blood to the heart and receive impure blood from body parts. Blood vessels are mainly of two types namely arteries and veins.

Arteries supply oxygenated blood from the left ventricle to all parts of the body. These arteries divide into arterioles and end as capillaries in the cells. Pulmonary artery supplies deoxygenated blood from right ventricle to lungs. The largest artery in the body is aorta.

Veins collect deoxygenated blood from all parts of the body. They start as capillaries. then to veinlets and to larger veins finally. Pulmonary vein brings oxygenated blood from lungs to left auricle. Capillaries are the smallest blood vessels in the body and have no muscular wall.

Physiology of blood circulation Oxygen-poor blood i.e. deoxygenated blood enters the right atrium through a major vein called the vena cava. The blood passes through the tricuspid valve into the right ventricle. Next, the blood is pumped through the pulmonary artery to the lungs for gas exchange. Oxygen-rich i.e oxygenated blood returns to the left atrium via the pulmonary vein. The oxygen-rich blood flows through the bicuspid (mitral) valve into the left

Contact No:9535111199/9535111188

ventricle. from which it is pumped through a major artery, the aorta. Two valves called semilunar valves are found in the pulmonary artery and aorta.

The ventricles contract about 70 times per minute, which represents a person's pulse rate. Blood pressure. in contrast, is the pressure exerted against the walls of the arteries. Blood pressure is measured by noting the height to which a column of mercury can be pushed by the blood pressing against the arterial walls. A normal blood pressure is a height of 120 millimeters of mercury during heart contraction (systole) and a of 80 millimeters of mercury during heart relaxation (diastole). Normal blood pressure is usually expressed as 120/80. Coronary arteries supply the heart muscle with blood. The heart is controlled by nerves that originate on the right side in the upper region of the atrium at the sinoatrial node. This node is called the pacemaker. It generates nerve impulses that spread to the atrioventricular node where the impulses are amplified and spread to other regions of the heart by nerves called Purkinje fibres.
BLOOD Blood is a fluid connective tissue which is red in colour due to the presence of haemoglobin. Our body contains 5-6 litres of blood. It is the medium of transport in the body. The main components of the blood are plasma and blood cells. Plasma constitutes 55% of the blood and blood cells constitute 45% of the blood.

The fluid portion of the blood, the plasma, is a straw-colour liquid composed primarily of water. All the important nutrients, the hormones, and the clotting proteins as well as the waste products are transported in the plasma. Red blood cells and white blood cells are also suspended in the plasma. Plasma from which the clotting proteins have been removed is serum.

Blood Cells float in plasma and are of three types. They are red blood cells, white bloc.... cells and blood platelets.

RED BLOOD CELLS (RBCS)
Red blood cells are also called as erythrocytes. These are round in shape and disk-shaped cells with constriction in the middle and are produced in the bone marrow. Red blood cells have no nucleus, and their cytoplasm is filled with a pigment called as haemoglobin.

Haemoglobin is a red-pigmented protein that binds loosely to oxygen atoms and carbon dioxide molecules. It is the mechanism of transport of these substances. (Much carbon dioxide is also transported as bicarbonate ions.) Haemoglobin

also binds to carbon monoxide. Unfortunately, this binding is irreversible, so it often leads to carbon-monoxide poisoning.

A red blood cell circulates for about 120 days and is then destroyed in the spleen, an organ located near the stomach and composed primarily of lymph node tissue. When the red blood cell is destroyed, its iron component is preserved for reuse in the liver. The thrombocytes, they serve as the starting material for blood clotting. The platelets adhere to damaged blood vessel walls, and thromboplastin is liberated from the injured tissue. Thromboplastin, in turn, activates other clotting factors in the blood. Along with calcium ions and other factors, thromboplastin converts the blood protein prothrombin into thrombin..Thrombin then catalyzes the conversion of its blood protein fibrinogen into a protein called fibrin, which forms a patchwork mesh at the injury site. As blood cells are trapped in the mesh, a blood clot forms. The life span is 3 -10 days.

Function of Blood The blood performs the following functions in our body:
(1) Transport of gases: oxygen transportation from lungs to various body parts. CO2 transportation from various body parts to lungs.
(2) Transport of food substances
(3) Transport of excretory wastes
(4) Transport of hormones
(5) Maintenance of water balance of body
(6) Maintenance of PH of body fluids
(7) Maintenance of body temperature by thermoregulation and heat dispersion.
(8) To prevent haemorrhage by formation of blood clot.
(9) Defence of the body from microbes and pathogens by phagocytosis by WBC and antibodies found in the plasma. Antibodies are specialised proteins which destroy specific antigens.
(10) **Turgidity:** It helps in insemination (by the flood turgidity in male genital organ)
(11) **Sexual selection:** Helps in genetic counselling as Rh factor and M.N.O.P. factor etc. during premarital counselling.

LYMPHATIC SYSTEM
The lymphatic system is an extension of the circulatory system consisting of a fluid known as lymph, capillaries called lymphatic vessels, and structures called lymph nodes. Lymph is a watery fluid derived from plasma that has seeped out of the blood system capillaries and mingled with the cells. Rather than returning

to the heart through the blood veins, this lymph enters a series of one-way lymphatic vessels that return the fluid to the circulatory system. Along the way, the ducts pass through hundreds of tiny, capsule-like bodies called lymph nodes. Located in the neck, armpits, and groin, the lymph nodes contain cells that filter the lymph and phagocytize foreign particles.
The spleen is composed primarily of lymph node tissue. Lying close to the stomach, the spleen is also the site where red blood cells are destroyed. The spleen serves as a reserve blood supply for the body.

The lymph nodes are also the primary sites of the white blood cells called lymphocytes. The body has two kinds of lymphocytes: B-lymphocytes and T-lymphocytes. Both of these cells can be stimulated by microorganisms or other foreign materials called antigens in the blood. Antigens are picked up by phagocytes and lymph and delivered to the lymph nodes. Here, the lymphocytes are stimulated through a process called the immune response.

Certain antigens, primarily those of fungi and protozoa, stimulate the T-lymphocytes. After stimulation, these lymphocytes leave the lymph nodes, enter the circulation, and proceed to the site where the antigens of microorganisms were detected. The T-lymphocytes interact with the microorganisms cell to cell and destroy them. This process is called cell-mediated immunity.

B-lymphocytes are stimulated primarily by bacteria, viruses, and dissolved materials. Or stimulation, the B-lymphocytes revert to large antibody-producing cells called plasma cells. The plasma cells synthesize proteins called antibodies, which are released into the circulation. The antibodies flow to the antigen site and destroy the microorganisms by chemically reacting with them in a highly specific manner. The reaction encourages phagocytosis, neutralizes many microbial toxins, eliminates the ability of microorganisms to move, and causes them to bind together in iarge masses. This process is called antibody-mediated immunity. After the microorganisms have been removed, the antibodies remain in the bloodstream and provide lifelong protection to the body. Thus, the body becomes immune to specific disease microorganisms.

IMPORTANT CONCEPTS

Cardiac Cycle The sequence of events that occur during one heart beat is called cardiac cycle. The contraction phase is called systole and the relaxation phase is called diastole.

Duration of cardiac cycle:

1. Atrial systole 0.1 sec.
2. Atrial diastole 0.7 sec.
3. Ventricular systole 0.3 sec.
4. Ventricular disable 0.4 sec.

In a normal resting man, the rate of heart beat is 72/minutes. One heart beat (cardiac cycle) lasts 60/72 = 0.8 second. In abnormal conditions when the SA node fails, the AV node generates the impulse (nodal rhythm). It is capable of initiating impulse of contraction at the rate of about 45 times per minute. The rate of heart beat varies a great deal among different animals. In general, larger the animal, slower is the heart rate.

Regulation of Heart beat -Heart beat rate is under the control of autonomous nervous system i.e. sympathetic and parasympathetic nervous systems. Sympathetic Nerves are accelerator nerves, increase heart beat by secreting adrenaline (epinephrine), whereas J stimulation of parasympathetic nervous system (vagus supply) decrease the rate of heart beat secreting acetylcholine. High levels of potassium and sodium ions decrease heart rate and strength of contraction. An excess of calcium ions increase heart rate. Increased body temperature during fever increases heart rate. Strong emotions such as fear, anger and anxiety increase heart rate, resulting in increased blood pressure. Mental status such as depression and grief decrease heart rate. The heart beat is somewhat faster in females. The heart beat is fastest at birth, moderately fast in youth, average in adulthood and below average in old age.

Electrocardiogram (ECG) Electrocardiogram is the process of recording of the electrical changes that accompany the cardiac cycle. ECG is the instrument used to record potential differences of heart muscles. A normal ECG consists of a P wave (spread of impulse from SA node), ORS wave (spread of impulse through ventricles) and T wave (Ventricular repolarisation). ORS is related to ventricular systole (contraction). ECG is valuable in diagnosing abnormal cardiac rhythms and conduction pattern and abnormalities in heart for heart block, heart attack and coronary thrombosis.

Heart Sounds The instrument used to bear heart sound is stethoscope (PCG - Phonocardiogram). First sound is 'Iubb' a long and booming sound, created by the closure of atria-ventricular values (tricuspid and bicuspid) at the beginning of ventricular systole. Second is 'dupp' a short and sharp sound, created by the

closing of semilunar values towards the end of ventricular systole. Heart sound gives valuable information about the working of values.
The heart murmur is due to defective valve.

Cardiac Output
Cardiac output is the amount of blood ejected from the left ventricle into aorta per minute.
Cardiac Output = Stroke volume (ventricular systole/minute)
= 70 ml X 72 / minute
= 5040 ml/minute
= about 5 litres/minute
Of the blood pumped out (cardiac output) each minute by heart, distribution to different parts are: _ '
10% to heart muscles
15% to brain
25% to digestive system -
20% to kidneys
30% to other organs.

Heart Attack
The blood flows to myocardium through coronary circulation. Most heart problems result from faulty coronary circulation. lf a reduced oxygen supply weakens the cells but does not actually kill them, the condition is called ischaemia. Angina pectoris meaning ‘chest pain‘ is ischaemia ol the myocardium. A much more serious problem is myocardial infarction commonly called a ‘coronary’ or ‘heart attack‘. lnfarctiori means death of an area of tissue because of an interrupted blood supply. Frequently myocardial infarction is due to thrombosis (formation of thrombus) in right coronary artery.

Pulse Pulse is the alternate expansion and elastic recoil of an artery with each systole. Pulse is strongest in the arteries closes to heart. Pulse can. be detected in superficial arteries like radial artery of wrist and temporal artery. Normal pulse rate ranges 70 - 90 per minute and is same as the heart rate.
Tachycardia The term applied to a rapid heart or pulse rate (> 100/minute)
Bradycardia The term indicates a slow heart or pulse rate (< 50/minute)

Disorders of the Blood and Circulatory System
Anaemia: Anaemia is a disease characterized by the oxygen transport capacity of the cause el low red cell count or some abnormality of the red blood cells or

the 53'O pi. Cr (D haemoglobin. Iron deficiency Anaemia is the most common anaemia: it occurs when the dietary intake or absorption oi iron is insufficient. and haemoglobin. which contains iron, cannot be formed.

Pernicious anaemia is an autoimmune disease wherein the body lacks intrinsic factor, required to absorb Vitamin B12 from food. Vitamin B12 is needed for the production of haemoglobin. "

Aplastic anaemia iscaused by the inability of the bone marrow to produce blood cells. Pure red celi aplasia is caused by the inability of the bone marrow to produce only red blood cells.
Haemolysis is the general term used for excessive breakdown of red blood cells. Haemolysis can also lead to anaemia. Polycythemias (erythrocytoses): They are diseases characterized by a surplus of red blood cells. The increased viscosity oi the blood can also cause a number of symptoms. Haemolytic transfusion reaction is the destruction of donated RBCs after a transfusion. mediated by host antibodies, often as a result of a blood type mismatch.

Arteriosclerosis: This refers to a hardening of the arteries. The wall of the blood vesseis thicken when muscle tissue in the walls slowly become more fibrous and less eiastic -tar: larger amounts of tat. especially cholesterol, are deposited in the surface oioleocssei. The major artery. aorta is frequently involved. It may take a serious turn if a srn. the material that clogs the vessels loosens. breaks of f and flows along coco‘ stream. Such a particle is called embolus and this condition is, therefore. ref; rr-ed to as embolism.

Varicose Veins: These are veins that have lost their elasticity and as a result appear in the legs as swollen. tortuous blue veins. They can cause considerable physical discomfort. Both dull and stabbing pains may be tell and the entire limb may becomes vollen. Such veins are often seen in middle - aged and older persons. Some younger m during the course of pregnancy.a oerscn under conditions of rest consistently has blood pressure that exceeds 145.90 mmHg. he is said to have high blocs‘ pressure. it is caused by an increase in the resistance ollered to the flow of the btooc‘ by the small vessels of the circulavcv dizziness, flushness of face and fatigue. lt can lead to degenerative changes in the heart. '
Hypotension: When the systolic arterial pressure is consistently below 100 mm/Hg, low blood pressure is said to occur. A moderately low blood pressure

Contact No:9535111199/9535111188

is considered conducive to a longer lite. ln a few extreme cases, weakness, dizziness and faintness may give indication of reduced circulation to the brain.

Heart attack or coronary thrombosis: This is often the result ol muscle damagecaused by interference with the blood supply. ll one of the coronary arteries that supply the heart muscle with blood is clogged, the blood supply of a portion ol the heart is shut off. As a result the tissue in the affected area clogged, the smallerbranches of the other artery, over a period of several days, begin to take up the workot the blocked artery. Ll the second artery can carry the load for both, the patient lives. ll it cannot, he dies. The typical symptoms are: crushing pain felt in the region beneath sternum, pain continuous or intermittent; pain may be noted initially in the arms, neck or left shoulder.

Often, it radiates to the left arm. Pain is accompanied by extreme sweating and shortness of breath.

Angina Pectoris: The heart, being a very active muscle, requires a continuous and adequate supply of oxygen from the blood. Lack of oxygen in the blood may cause inadequate supply of oxygen to the heart muscle. Under such circumstances. a person with a certain degree of exertion may suffer from pain in the chest or below collar bones.

Such a pain is referred to as angina pectoris. Persons over 40 years ot age generally suffer from it.

Filariasis: The lymphatic system is also subject to diseases of its own. ln elephantiasis (filariasis) for example a thread like parasite (Wuchereria Bancrolti) renders the lymphatic tissue incapable of draining of f the fluids that collect in the tissue spaces. This result in swollen water logged lower limbs and coarsencd skin.

EXCFIETORY SYSTEM

Osmoregulation and excretion help in maintaining chemical and fluid homeostasis i.e. nearly uniform and beneficial physiological state in the body.

Waste materials excreted in animals are of various kinds: nitrogenous substances, carbon dioxide, pigments, spices, drugs, and excess of water, inorganic salts, vitamins and hormones. Of these. nitrogenous waste materials form the principal excretory product. These materials are formed from breakdown of proteins and nucleic acids, as by product of metabolic reactions occurring in the animal body. They become toxic if allowed to accumulate in the body. Therefore, these materials must be removed from the body for healthy

life. The elimination of nitrogenous waste products from the animal body to regulate the composition of the body fluids and tissues is called excretion.

Organs concerned with removal of waste products of metabolism from the ahimal body constitute excretory system. Osmoregulation is a process that regulates the body's salt and water content. It maintains the composition of the body fluids at a steady state for efficient metabolism in the cells. lt involves water (solvent) movement which follows solutes by osmosis.

Usmosis is a type of diffusion where the movement of water occurs from a dilute solution (hypotonic) to a strong solution (hypertonlc) across a semi permeable membrane. Both excretion and osmoregulation are conducted by kidney.
The principal nitrogenous waste product varies in different animals. In human beings. the main waste eliminated by kidney is urea. So. they are called ureotolic organisms. Fish and amphibians excrete waste in the form artimonia. so are called ammoniotelic animals. Reptiles and birds, which excrete waste in the form of uric acid, are called uricotelic organisms. Certain molluscs and echinoderms excrete excess of amino acids as such without any change. They are called aminotelic animals, and their mode of excretion is termed aminotelism.

Besides kidney. some other organs. such as lungs, liver, intestine and skin, also remove certain metabolic wastes besides their normal functions. Liver helps in elimination of bile pigment and many toxic drugs, Lungs help in removal of carbon dioxide. The sweat glands cf skin help in eiiminazicn ex-toss cl salt and water.

HUMAN SYSTEM

Human. urinary system consists of a pair of kidneys, a pair of ureters, a urinary bladder and urethra. red. slightly flattened, bean-shaped orgart. They are placed against the back wall of the nary abdominal cavity just I .1-i below the diaphragm, on either side of the Zreihro. backbone. The lower two pairs of ribs protect them. A kidney is composed of numerous microscopic coiled tubules called nephrons, or uriniferous tubules. The nephrons are held 'together by connective tissue, all enveloped by a firm capsule of white fibrous tissue. Outside the capsule is a layer of fat, the adipose capsule, followed by a fibrous membrane. the renal fascia. The fibrous capsule. adipose capsule and renal

Contact No:9535111199/9535111188

fascia are protective coats of the kidney. On the medial side, each kidney has a conc,ivlty called as hilius. or helium.

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From the helium of each kidney emerges a slender, whitish tube, the ureter. Within the kidney, the ureter is expanded to form the renal pelvis. The wail of ureters consists of transitional epithelium surrounded by a layer of muscle fibres followed by a layer of fibrous connective tissue. The ureters run downward along the muscles of the back a short distance from the median line. At the lower end of the abdomen, they bend inward and open into the urinary bladder through its hind wall.

Urinary Bladder Urinary Bladder is a median pear-shaped sac situated in the lower or pelvic region of the abdominal cavity within the front body wall. It has thick. muscular. distensible wall lined by transitional epithelium that allows expansion. The bladder receives the ureters through the lower part of its back "dorsal) wall. The lower cart or neck of the bladder leads into the urethra. The neck of the bladder is rciec by two rings of muscle fibres called sphincters, which generally remain contracted to keep the bladder closed. Both the sphincters must relax to let urine pass out from the bladder. Bladder can hold about 700-800 ml of urine. The urge to discharge the stored urine can be suppressed for a short time by the external sphincter. The cerebral cortex directs the sphincters to relax and the contraction of bladder muscles squirts urine out.

Urethra The urethra starts from the lower part or neck of the urinary bladder and leads to the exterior. Muscular urethral sphincters keep the urethra closed except during the act of passing out urine.

Nephron

Nephron is the structural and functional unit of kidney. A kidney contains about a million nephrons, each approximately 3cm2 in area. There is, thus. an enormous surface area for the exchange of materials in a kidney.

A nephron is a long tubule differentiated into four regions having different anatomic,' features and physiological role: Bowman's Capsule, proximal convoluted tubule (PG-I loop of Henle, and distal convoluted tubule (DCT). The latter opens into one of the - collecting ducts.

Blood Supply A kidney receives the blood by a renal artery that arises from the dorsal aorta. In the kidney, the renal artery divides and sub-divides to ser-: an

afferent arteriole into each Bowman's Capsule. Here, the afferent arteriole forms a globular bunch of about 50 parallel capillaries called the glomerulus. The giomeruiar capillaries rejoin to form an efferent arteriole by which a reduced .inlaene of blood leaves the glomerulus.

Bowman's Capsule is a large. double-walled cup. It lies in the renal cortex and forms the beginning of the nephron. It contains a glomerulus in it. Inner wall of the Bowman's Capsule is in close contact with the glomerular capillaries; its outer wall is continuous with the rest of the nephron. The space between the two walls of the Bowman's capsule is continuous with the lumen of the next part of the nephron. The Bowman's capsule and the glomerulus together form a globular body called renal corpuscle. or Maipighian body.

The separation of small molecules and ions from large molecules and cells in the blood is termed ultrafilration. The filtered out fluid is known as glomerular filtrate or ultrafiltrate.

The ultrafiltrate conatins sodium, potassium and chloride ions, glucose, amino acids, along with urea, uric acid. creatinine, ketone bodies, and a large amount of water. The blood is left with only corpuscles, and plasma proteins.

2. **Tubular Reabsorption —** From the Bowman's capsule, the glomerular filterate passes into the tubule and flows through it to the collecting duct. During this course, its composition, osmotic pressure and pH change due to selective reabsorption of materials from it and secretion of more waste materials into it.

i. **Proximal Convoluted Tubule —** The cells lining the PCT are well adapted for reabsorption of materials from the filtrate. They have abundant mitochondria and bear numerous microvilli on the free side. Mitochondria power the active transport of nutrient molecules back into the blood. Microvilli increase the surface for reabsorption. The cells absorb entire glucose, amino acids, most of the inorganic ions (Na"-, K', CF), much of the water as well as some urea from the filtrate.

ii. **Loop of Henle** — The first wide part of the descending limb is impermeable to ions, urea and water. It merely transfers the nearly isotonic filtrate from the PCT to the narrow region of the descending limb, which is freely permeable to water. Water is drawn out of the filtrate by osmosis. The exit of water makes the filtrate hypertonic by the time it reaches the turn of the loop to enter the ascending limb, which is impermeable to water along its entire length but permeable to inorganic ions. After passing the ascending limb, the filtrate

becomes hypotonic to plasma due to loss of inorganic ions, and passes into the DCT.

iii. **DCT, Collecting Tubule and Collecting Duct** — When the level of plasma water falls, the posterior pituitary lobe releases the antidiuretic hormone (ADH) which increases the permeability of the DCT, collecting tubule and collecting duct to water. Water is reabsorbed from the filtrate by osmosis, and a reduced amount of concentrated urine is produced. When the level of plasma water becomes normal, ADH is not secreted, permeability of the DCT, collecting tubule and collecting duct to water decreases, less water is reabsorbed, and abundant dilute urine is produced. The DCT, collecting tubule and collecting duct actively reabsorb sodium from the filtrate under the influence of the adrenal hormone aldosterone which makes their walls permeable to ions. The reabsorption of sodium brings about the uptake of an osmotically

ZEMI VAJIRAM & RAVI

equivalent amount of water: Lack of aldosterone makes the DCT, collecting tubule and the collecting duct impermeable to ions. Bicarbonate ions are also reabsorbed in DCT.

3. Tubular Secretion — Creatinine and foreign substances (pigments, drugs including penicillin) are actively secreted into the filtrate in the PCT from the interstitial fluid. Hydrogen ions and ammonia are also secreted into the PCT. Potassium, hydrogen, NH4+ and HCO3" ions are secreted by active transport, into the filtrate in the DCT. Urea enters the filtrate by diffusion in the thin region of the ascending limb of Henle's loop: This process helPi' the body to get rid of toxic substances and also helps in maintaining blood pH or acid-base balance.

URINE

The glomerular filtrate reaching the end of the collecting duct, after being modified by reabsorption of certain substances and addition of others, is called final urine. The volume of urine is far less than the volume of the glomerular filtrate, and its composition is quite different from that of the glomerular filtrate due to loss and gain of many substances in the nephron. An adult man normally

Contact No:9535111199/9535111188

passes about 1 to 1.8 litres of urine within 24 hours. Certain substances such as tea, coffee and alcohol increase urine output. These are said to be diuretic.

Urine is a transparent, yellowish fluid, its shade depending on its concentration. Its colour is due to a pigment urochrome derived from the breakdown of haemoglobin from the worn-out RBCs. Its pH, depending on the diet, ranges from 5 to 8. Urine is produced and drained continuously by the nephrons into the renal pelvis from where it is carried down the ureters by peristaltic waves into the body of the urinary bladder. The bladder serves to store the urine temporarily and also to pass it out at suitable intervals. The process of passing out urine from the urinary bladder is called urination or micturition.

MUSCULAR - SKELETAL SYSTEM
SKELETAL SYSTEM

Human endoskeleton includes elements made of living skeletal connective tissues called cartilages and bones. Osteology is the study of bones and chondrology is the study of cartilages. Endoskeleton is mesodermal in origin. Animals possess two forms of movements: locomotion and movement of body parts. In higher animals, movement and locomotion depend on the association of skeletal muscles with skeletal system. The scientific study of body movements is known as Kinesiology.

Human skeleton Human newborns have over 270 bones some of which fuse together into a longitudinal axis, the axial skeleton, to which the appendicular skeleton is attached. The total number of bones in adult human is 206. The axial skeleton of adult man consists of 80 bones. The appendicular skeleton of adult man consists of 126 bones.

Axial skeleton The axial skeleton (80 bones) is formed by the vertebral column (26), the rib cage (12 pairs of ribs and the sternum), and the skull (22 bones and 7 associated bones). The upright posture of humans is maintained by the axial skeleton, which transmits the weight from the head, the trunk, and the upper extremities down to the lower extremities at the hip joints.

The number of bones in the skull of man is 28 (cranium bones 8, facial bones 14 and ear ossicles (malleus, incus and stapes) 3 X 2 = 6). Stapes in the ear is the smallest bone in the human body. The bone common to cranium and face is frontal. Number of bones present in the human cranium is 8. The skull bones fit together by sutures Sinuses are air spaces within skull bones. The only movable bone in the skull of man is mandible.

The number of bones in the vertebral column is 26. Vertebral column gives support to the trunk, provides places for the attachment of the ribs and bones of

pelvis. Vertebral column permits movements and protects the spinal cord. There are 12 pairs of ribs. The first seven pairs of ribs are known as 'true ribs' the only one to reach the sternum directly. Pairs 8, 9 and 10 are 'false ribs' they are attached indirectly to sternum by means of cartilages. Last two pairs (11 and 12) fall for short of the sterum and are known as 'floating ribs'. Sternum or breast bone of man consists of three portions: manubrium, body of sternum and Xiphoid process. Clavicles or collar bones articulate with the manubrium of the sternum. The sternum is a favoured site for obtaining samples of haemopoietic (blood forming) tisse*F4fig• , of•suspected blood diseases.

Appendicular skeleton The appendicuiar skeleton (126 bohes) is formed by the pectoral girdles (4), the upper limbs (60), the pelvic girdle (2), and the lower limbs (60). Their functions are to make locomotion possible and to protect the major organs of locomotion, digestion, excretion, and reproduction.

The appendicular skeleton is divided into six major regions: 1) Pectoral Girdles (4 bones) - Left and right Clavicle (2) and Scapula (2). The Cavity in pectoral girdle is called glenoid cavity.
2) Arm and Forearm (6 bones) - Left and right Humerus (2) (Arm), Ulna (2) and Radius (2) (Fore Arm). •
3) Hands (54 bones) - Left and right Carpal (16) (wrist), Metacarpal (10), Proximal phalanges (10), Middle phalanges (8), distal phalanges (10).
4) Pelvis (2 bones) — Left and right innominate bones consisting of ilium, ischium and pubis. The Cavity in pelvic girdle is called acetabulum.
5) Thigh and leg (8 bones) - Femur (2) (thigh), Tibia (2), Patella (2) (knee cap), and Fibula (2) (leg). Femur is the longest bone in the body.
6) Feet and ankles (52 bones) - Tarsals (14) (ankle), Metatarsals (10), Proximal phalanges (10), middle phalanges (8), distal phalanges (10).
The appendicular skeleton of 126 bones and the axial skeleton of 80 bones together form the complete skeleton of 206 bones in the human body. Unlike the axial skeleton, the appendicular skeleton is unfused. This allows for a much greater range of motion.

Function of Skelton
1. Support: The skeleton provides definite shape to the body and gives support to various body organs.
2. Facilitation of movement: The skeleton provides site for attachment of muscular tendons and it aids in locomotion.

Contact No:9535111199/9535111188

3. Haemopoiesis: Formation of blood cells in the bone marrow by a process called haemopoiesis.
4. Protection: Protection of the brain by skull, and of heart and lungs by the bones of the thorax.