GROWTH , REPAIR , REGENERATION ,AGEING & DEATH

INTRODUCTION

An embryo and offsprings body gradually enlarges and assumes the form and size characterstic for the adult of its species (growth). The animals carries on the various vital processes to maintain health and keep alive. In its body, the cell organelles are constantly renewed worn out cells are healed up (repair). In certain animals, even the lost organs of the body are regrown (regeneration). Since the animals have limited life span, their body starts undergoing degenerative changes showing sign of old age (ageing). The last events of which is death.

13.1 GROWTH

(i) **Meaning and definition of growth :** Growth is an important properties of all living organisms. All organisms grow from a young stage to an adult stage. Growth is a permanent increase in dimensions of the body and its parts. It results from the addition to the body tissues. Cleavage of a zygote produces a multicellular embryo without an increase in size. This process should be regarded growth though it does not confirm to the definition of growth as it is a developmental event and growth and development go together. Moreover, cleavage increase the number of cells. In simple form growth can be defined as "The increase in size and weight of an organism due to synthesis of new protoplasm"

(ii) **Growth at different levels :**

(a) **Molecular level :** At molecular level, the growth involves synthesis of new molecules and their aggregation into organelles and storage products in the cells.

(b) **Cellular level :** At the cellular level, the growth involves.

(1) **Cell expansion (hypertrophy)** : Increase in the size of the cells due to addition of new cell material, called protoplasm.

(2) **Cell division (hyperplasia)** : Increase in the number of cells by cell division.

(3) **Cell differentiation :** Specialisation of cells for specific roles, in its broad sense, growth includes.

(4) **Matrix formation :** Addition of intercellular materials, termed apoplasmatic substances, secreted by the cells between them. The term protoplasm includes the nucleus as well as the cytoplasm and its organelles. The apoplasmatic substances include the matrix of connective tissues and intercellular fluid.

(c) **Individual level :** At individual level, the growth is the visible increase in the body, dimension, size volume and weight. Increase in weight will show that the growth has taken place. Growth result from the –

(1) Increase in the protoplasm.

(2) Addition to the apoplasmatic materials.

(3) Increase in the number of cells.

Each of these processes may occur at separate times. The growth starts in the embryonic period after laying down of the germ layers and continues for a long time in the postembryonic period. In the unicellular organism, such as bacteria and protozoans, cell division results in reproduction (not growth) of the individual and growth of the population.

Differences between Protoplasmic and Aprotoplasmic substances.

S.No.	Characters	Protoplasmic structures	Aprotoplasmic structures
(1)	Nature of structures	Living	Non-living.
(2)	Location	Intracellular	Extracellular.
(3)	Examples	Cytoplasm, cell organelles and nucleus	Matrix, fibres, minerals, etc.
(4)	Growth	Grow	Do not grow.
(5)	Division power	Can divide	Cannot divide

(iii) **Physiological condition for growth :** A variety of chemical reaction occur all the time in the living organisms. These are collectively referred to as metabolism. Metabolism has two phases building up phases or anabolism and break down phase or catabolism. Variation in the rates of the metabolic phases result in three types of growth.

(a) **Positive growth :** Anabolism normally out weighs catabolism and this brings about growth during the growing period of the organism and maintain the body thereafter. This is called positive growth.

(b) **Zero growth :** If the anabolic and catabolic processes are balanced, there is no addition to the bulk of the body and no increase in body size. This is referred to as zero growth.

(c) **Negative growth :** If catabolism occurs at a faster rate than anabolism, as happens in fasting the organism gradually becomes weak and may finally die. At this time, first the food reserves (glycogen, fat) and then body's own protein are used as sources of energy to run the body machine. This depletes the living material, causing negative growth. Due to this the reserve food and living material decrease in amount and is called degrowth.

Differences between growth and degrowth

S.No.	Characters	Growth	Degrowth
(1)	Rate of metabolism	Anabolism faster than catabolism.	Catabolism faster than anabolism.
(2)	Fate of living matter	Both protoplasmic and aprotoplasmic structures are synthesized so there is increase in the living matter.	Food reserves (fats and glycogen) are catabolised to provide the required energy so there is decrease in the living matter.

(iv) **States of growth :** Two states of growth are –

(a) **Pre-functional state of growth** : It is the early embryonic stage during which the developmental processes transform a zygote into an embryo. During this growth period the organ rudiments are established but are not functional.

(b) **Functional state of growth :** It is the late embryonic and post embryonic developmental stage during which organ rudiments become functional and organogenesis begins.

Differences between Embryonic growth and Post-embryonic growth

S.No.	Characters	Embryonic growth	Post-embryonic growth
(1)	Period of occurrence	During pre-natal (before birth) period, e.g. during blastulation and gastrulation.	During post-natal period.
(2)	Cell growth	Does not occur.	Occurs.
(3)	Nature of cells	Cells only divide so size of blastomeres becomes smaller and smaller.	Cell division occurs after the cell growth so size of cells remains nearly same.
(4)	Nature of organs	Only organ rudiments are formed but are non-functional.	Organs have been fully developed and are functional.

(v) **Biological activities of growth :** Growth of a multicellular organism is governed by two main biological activities.

(a) Cell growth (b) Cell reproduction

(a) **Cell growth :** Growth and division of a cell occur in three cyclic phases :

(1) **G_1-Phase :** It involves, pooling of amino acids and nucleotides for the synthesis of protein and nucleic acids. A newly formed cell grows by synthesizing carbohydrates, lipids, proteins, RNAs, ATP and enzymes to loosen and unfold the DNA.

(2) **S-phase :** It involves, replication of DNA, so each chromosome now consist of two sister chromatids joined at the centromere and carries a duplicate set of genes. A diploid cell ($2n$), thus, becomes tetraploid ($4n$) at the end of S-phase. Synthesis of histone protein of the chromosome.

(3) **G_2-phase :** It involves, the cell grows further, synthesizing more protein and RNAs and doubling the organelles such as centrioles, mitochondria, Golgi apparatus. The G_2 phase prepares the cell for its division.

The growth of individual cells is most essential factor of growth in all multicellular animals.

(b) **Cell reproduction :** It occurs during the M-phase of the cell cycle during which a fully formed adult cell undergoes mitosis to produce two genetically similar daughter cells which repeat the process.

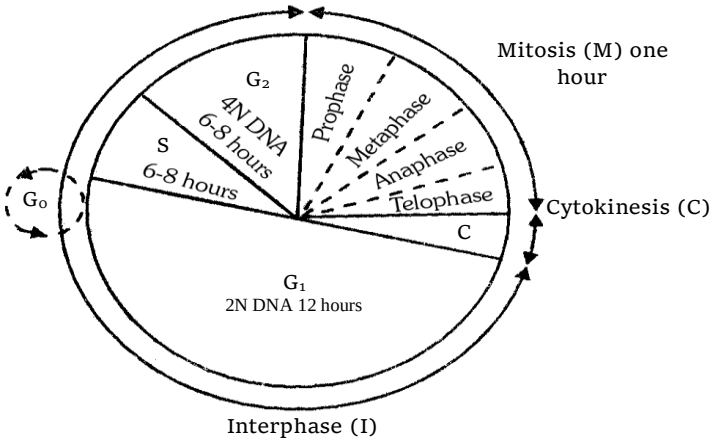


Fig : Phases of cell growth and cell division

(vi) **Strategies of growth :** Growth is accompalished by three strategies :

(a) **Cell proliferation :** The growth of a structure by cell multiplication due to cell division e.g. growth of lens.

(b) **Cell enlargement :** In this, cell do not divide but their size increase due to synthesis of more cytoplasm e.g. growth in cardiac muscles, neurons and skeletal muscles.

(c) **Growth by accretion :** In this, growth occurs due to secretion of large amount of extra-cellular materials e.g. growth of cartilage and bones.

(vii) **Types of growth :** In animals body four basic types of cellular growth are recognised.

(a) **Auxetic growth :** In some organisms growth occurs as a result of increase in the size of their cells. The number of cells remains the same. It is a rare type of growth and is found in a few nematodes (*Ascaris*) rotifers, tunicates (*Herdmania*) etc. Auxetic growth is also found in certain tissues of higher animals. Growth of a body muscle resulting from regular exercise is due to increase in size of the individual muscle fibres rather than to an increase in their number. Infant's heart has the same number of cells as the adult's heart even though it is only about 6% of its size and weight. Increase in the size of an organ due to enlargement of cells is termed hypertrophy.

(b) **Multiplicative growth :** In this, the growth occurs due to an increase in the number of cells of the body by rapid mitosis division an appreciable growth of the cells. It involves both cell growth and cell reproduction. It is found in the embryo. For example an adult human is made up of some 60 trillion (6×10^{13}) cells, while the new born baby contains only about 2 trillion (2×10^{12}) cells. In this type of growth, the average cell size remain the same or increases insignificantly. Growth of embryo, young ones and prenatal growth in mammals is of this type. Increase in the number of cells in a tissue is called hyperplasia.

(c) **Accretionary growth** : During postembryonic growth and also in the adult, all the body cells are incapable of undergoing division. The differentiated or specialized cells of organ and tissues lose the ability to divide. The undifferentiated cells (reserve cells) present at specific location in the body divide mitotically and help in growth. This kind of growth is called accretionary growth. Malpighian layer of the epidermis in vertebrate skin consist of undifferentiated cells. These cells divide to form new cells that replace the epidermal cells lost to the environment at the surface. Red bone marrow of vertebrates contains unspecialized cells, called pluripotent stem cells, which continuously produce blood cells to replace the worn out ones. Germinal epithelium of the gonads consists of undifferentiated cells. These cells, by mitotic divisions, produce new cells that give rise to the gametes. The

archaeocytes of sponges and interstitial cells of coelenterates are also reserve cells meant for replacing the other types of cells in the bodies of these animals.

(d) **Appositional growth :** It involves the addition of new layers on the previously formed layers. For example, the addition of lamellae in the formation of bone. It is characteristic mode of growth in rigid materials.

Differences between auxetic and multiplicative growth

S.No.	Characters	Auxetic growth	Multiplicative growth
(1)	Nature of growth	Body growth occurs only due to increase in size of the body cells.	Body growth occurs due to increase in number of the body
(2)	Number of cells	Number of cells remains same, but the size of cells increases.	Number of cells increases but size of cells remains nearly same.
(3)	Occurrence	Nematodes, tunicates, etc.	During embryonic period of development in most of vertebrates.

(viii) **Growth rate in animals :** Growth is the perceptible and measurable increase in the mass of living materials and can be confirmed by an increase in weight of an animal. All higher animals, including man, grow at a specific rate and rhythm. The growth rate is not uniform but is different at different periods of life, so the growth is differential.

Growth period in human may be divided into 5 stages :

(a) **Prenatal stage :** It comprises about nine months of embryonic life.

(b) **Infantile stage :** It extends from birth to 10 months of age.

(c) **Early childhood stage :** It extends from 10 months to 4 or 5 years of age.

(d) **Juvenile stage :** It extends from 4 or 5 years to about 14 years of age, i.e., upto the time of puberty.

(e) **Adolescent plus post adolescent stage :** It extends from 14 years to 20 or 22 years of age.

Maximum growth in human foetus occurs at the age of four months (growth occurs at the rate of 10 cm per month). Growth is rapid in the pre-natal and puberty period (14-18 years); it is slow in the juvenile (5-14 years) and post-adolescent (18-22 years) but is almost nil after the post-adolescent period as there is no addition of living matter in this period. The growth stops at adulthood (22-23 years).

(ix) **Growth curve :** The growth rate in an individual at different periods of life can be represented in a curve by plotting the weight of individual at different time intervals (in years) on graph paper.

(a) **Sigmoid curve** : Growth curve of higher animals, including man, is S-shaped and is called sigmoid growth curve. This growth curve proves that :

(1) First rises very slowly, showing a low rate of growth.

(2) Then rises steeply, indicating fast rate of growth.

(3) Its rise again slow down

(4) Finally it starts running horizontally, depicting stoppage of growth.

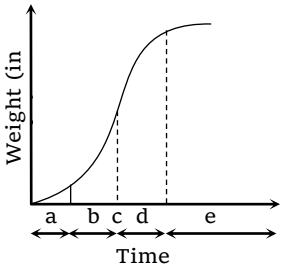


Fig : A typical sigmoid growth curve for higher animals including man (a) Lag phase, (b) Log phase (c) Inflexion point (d) Senescent

Its 4 phases are respectively called lag phase, exponential (log) phase, senescent (decelerating) phase and steady (plateau) phase. The point where the exponential growth begins to slow down is known as inflexion point.

(b) **Absolute growth :** The difference between the initial and final weight (or size) of an individual in a given period of time is called absolute growth.

(c) **Variation in steady phase :** The nature of the curve during the steady phase may vary in different species. In some cases (many invertebrates, fish and certain reptiles) the curve may continue to rise slightly till the animal dies. This is a case of positive growth. In some cnidarians, the curve flattens out showing stoppage. In many mammals including humans, the curve slowly tails off, showing degrowth or negative growth due to physical weakness caused by ageing.

(x) **Patterns of growth :** Growth patterns may be viewed from two aspects : body proportions and duration of growth.

(a) Regarding the body proportions, two patterns of growth are commonly seen in animals :

(1) **Isometric growth :** In this pattern of growth, an organ grows at the same mean rate as the rest of the body. The external form of the body does not change as the organism grows in size and the form and size remain proportional. Fish and certain insects, such as locust, show isometric growth.

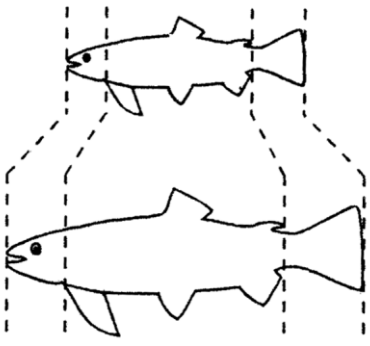


Fig : Isometric growth in a fish

(2) **Allometric growth :** In this pattern of growth, an organ grows at a rate different from that at which the body grows. The external form of the organism changes as the body grows in dimensions. This type of growth is seen in human body parts.

Differences between Isometric growth and Allometric growth

S.No.	Characters	Isometric growth	Allometric growth
(1)	Nature of growth of organs	At same mean rate.	At different rates during different periods.
(2)	Body form and size	Remain proportional.	Becomes unproportional as body parts grow at different rates.
(3)	Examples	Fish and insects (e.g. locust).	Birds and mammals.

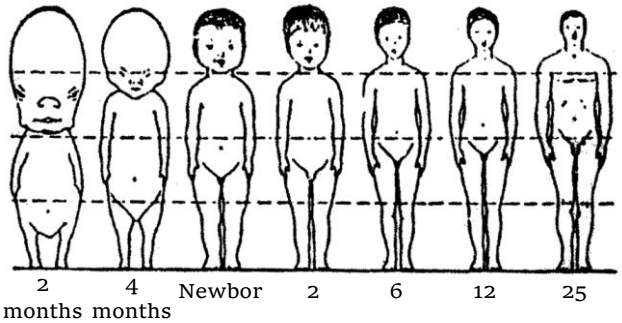
(b) Regarding duration of growth, animals show two basic patterns :

(1) **Limited (definite, determinate) growth :** Their growth stops when the size characteristic for the species is attained. Example – Insects, birds and mammals. Arthropods show discontinuous growth due to an inelastic exoskeleton. They grow in spurts for short periods after moults.

(2) **Unlimited (indefinite, indeterminate) growth :** They keep growing throughout life. Example – Non-vertebrates, fishes and reptiles.

(xi) **Differential growth of human body parts :** In human being, similar to other animals, different body organs or body parts (head, neck thorax and limbs etc.) do not grow at the same rate. The growth rate of different body parts is different.

If we keenly observe the growth of these body parts by comparing their photographs from birth for a number of years till these attain their final shape, size and weight e.g. head of a newly born human baby is proportionately larger than the rest of its body. It forms about half of the length of two month old foetus. But its growth stops early in the childhood so the head of an adult person is proportionately smaller (about one-eighth of whole body) than that of a newly born baby (about one-forth of whole body). The arms attain their proportionate size shortly after birth but legs attain their proportionate size only after 10 years of age. Reproductive organs do not grow rapidly until 12 to 14 years after the birth. These show faster growth during puberty (14–18 years). The brain and spinal cord grow rapidly in the childhood period and attain their adult size by nine years of age while thymus attains maximum size at the age of 20. In human beings, the muscles show maximum growth (from 0.8 *kg* in newly born baby to 30 *kg* in adult) while brain shows minimum growth (from 0.4 *kg* in newly born baby to 1 *kg* in adult) from birth to adulthood and show in table.



Fi total height to show the characteristic age changes in the g : Foetal and postnatal stages of a human drawn to the same form and proportions of the different parts of the body

Changes in the weights of human body parts from birth to adulthood

S.No.	Body parts	Weight in kilograms	
		New-born baby	Adult male
(1)	Muscles	0.8	30
(2)	Skeleton	0.4	10
(3)	Fat	0.8	10
(4)	Brain	0.4	1
(5)	Rest of body	0.9	19
	Total	**3.3**	**70**

(xii) **Control of growth and development :** The processes of growth and development are controlled by the information encoded in the genes (DNA). Growth, however, is the result of an interaction between DNA and environmental factors, internal (hormones, growth substances) as well as external (food, oxygen).

(xiii) **Hormonal control of human growth rate :** Throughout the developmental period from birth to adulthood, the growth is controlled by hormones secreted by endocrine glands in the blood. But different periods of growth are under different hormones e.g.

(a) Growth rate in early childhood period and juvenile period (from 10 months to 14 years) is very slow and is controlled by thymosine hormone secreted by thymus gland. It is a pinkish coloured, bilobed gland located in front of heart.

(b) During the late childhood period, growth rate becomes faster as along with thymosine, two more hormones start operating. Thyroxine hormone of thyroid gland and somatotrophic hormone (STH) or Growth hormone (GH) of anterior pituitary. Secretion of GH begins within the first year after birth and is regulated by Growth hormone releasing hormone (increases secretion of GH) and somatostatin (inhibits secretion of GH) of hypothalamus. Growth hormone also controls its own secretion by feedback signals to the hypothalamus.

(c) The growth rate reaches its peak during puberty, 14 to 18 years of age. At this time, the secretion of sex hormones (testosterone in the male; estrogens and progesterone in the female) begins, leading to the development of secondary sex organs and accessory sex characters. The person becomes full grown and sexually mature by the completion of puberty. After 18 years of age, the growth rate begins to fall and the growth almost stops at about the age of 22.

Approximate ages of sexual maturity in some mammals

S.N0.	Mammals	Age of Maturity
(1)	Human being	11-16 years
(2)	Asiatic elephant	8-16 years
(3)	White-handed gibbon	8 years
(4)	Fin whale	3 years

(5)	Rhesus monkey	2-4 years
(6)	Horse	1 year
(7)	Cat	6-15 months
(8)	Dog	6-8 months
(9)	Rabbit	6 months
(10)	House mouse	35 days

13.2 Repair and Regeneration

(i) **Definition :** It is that post-embryonic morphogenetic phenomenon which when temporarily stimulated brings about repair of the damaged cells/Tissues, or replacement or redevelopment of severed body parts or reconstruction of whole body from a small body fragment.

(ii) **Capacity for regeneration :** Among animals, power of regeneration was first discovered in *Hydra* by Trambley, in 1740. The capacity of repeated regeneration, though, present throughout the animal kingdom, but to varying degree. It is more marked in the lower animal than in the higher animals. Among invertebrates, protozoans, sponges and coelenterates, the regeneration capacity is very high. In higher animals, regenerative ability is much greater in the embryonic and larval stages than in the adult. In man, it is restricted to healing of injured tissues such as skin, muscles, bones, blood vessels and nerves; the lost organs cannot be regenerated. The skin cells and epithelial cells lining the respiratory and digestive tracts are rapidly replaced. The turn-over time for skin cells is 1–2 weeks and for intestinal cells is only 2 or 3 days. Blood corpuscles have a limited life span and are continuously replaced. Other tissues, such as liver, pancreas and thyroid, can also repair damaged parts. The cells of the central nervous system are incapable of regeneration if damaged or lost. The inability of complex animals to regenerate the lost parts is the price of their specialization.

(iii) **Types of regeneration :** Regeneration is of two main type – Reparative and Restorative.

(a) **Reparative regeneration :** In this, multicellular organism has the power only to repair certain damaged cells of the body. It is a common phenomenon observed in both invertebrates as well as the vertebrates.

Healing of a bone fracture, a skin wound, or a muscle tear are instances of reparative regeneration. This shows that fully differentiated cells retain the developmental potential. Maximum reparative regeneration is found in the liver of mammals. If a part of liver is surgically removed, then the cells of the remaining part undergo repeated mitotic divisions and original volume of the liver is maintained. Similarly, if one kidney of man is lost, the other kidney enlarges to take over the function of the missing kidney and is called compensatory regeneration.

(b) **Restorative regeneration** : In this, a multicellular organism can redevelop the severed body parts or the whole body can be formed from a body segment. It is very common in invertebrates. It may occur by epimorphosis or morphallaxis. The power of restorative regeneration varies in different groups of organisms e.g.

(1) Autotomy power in some animals, some part of the body is broken off the body on being threatened by the enemy or predator. This phenomenon of self mutilation of body is called autotomy. The lost part may be tail, limb, viscera or arm e.g.

- Crabs break of their leg on approaching the enemy.
- Lizards throw off their tail.
- *Holothurians* (Echinoderm) throw off their internal viscera (respiratory tree etc.). It is called Evisceration.
- Starfish (Echinoderm) can regenerate the whole arm.
- Autotomy is a special adaptation for escaping the danger of attack by enemy or predator.

(2) The climax of regeneration in which whole body can be developed from a body fragment is found in *Hydra* among the coelenterates; *Scypha* among the sponges and *Planaria* among flat worms.

Differences between reparative and restorative regeneration

S.No.	Reparative regeneration	Restorative regeneration
(1)	It is restricted to healing of injuries or replacement of cells.	It can replace the lost part of the body, or produce a complete organism from a fragment.
(2)	It involves minor cell proliferation and migration.	It involves large-scale cell reproduction and differentiation.
(3)	It occurs in all animals.	It is possible mainly in lower animals.
(4)	Examples : repair of a cut, replacement of skin cells, intestinal cells, blood cells etc.	Examples : regrowth of starfish's arm, wall lizard's tail, salamander's limb, etc.

(iv) **Mechanism of regeneration :** T.H. Morgan recognized two primary mechanism of regeneration in animals.

(a) **Morphallaxis :** It is the reconstruction of an entire animal from a small fragment by reorganizing the existing cells. The regenerated animal is far smaller than the original one after the completion of the process. It grows to attain the normal size. If *hydra* or *planaria* is cut transversely into two or several parts, each part develops into a complete organism. *Hydra* may arise from a fragment as small as 0.004 *mm*. Fragmentation and regeneration are usual forms of asexual reproduction in several animals.

(b) **Epimorphosis :** It replaces a lost organ of the body by proliferating new cells from the surface of the injured part. Regeneration of an appendage in an arthropod, arm in a starfish, limb in a salamander and tail in a lizard occurs in this manner. The mechanism of regeneration can be studies from limb regeneration in salamander.

Regeneration of a limb of a newt or salamander : Newt/salamander has very high power of regenerating their lost limb by the process of restorative regeneration. It involves the following steps :

(1) **Wound healing :** The epidermal cells from the edges of the cut migrate and spread over the exposed surface. This is known as wound healing.

(2) **Blastema formation :** A few days after the healing of the cut, the undifferentiated cells accumulate inside the epidermis. Due to this cellular aggregation, a stumpy outgrowth or bulge is formed. This is known as regeneration bud or blastema.

(3) **Redifferentiation and morphogenesis :** The blastema develops rudiments of digits by indentation at the free edge. These grow out into new digits.

(4) **Growth :** The regenerated limb increases till it attains the size of a normal limb.

A number of evidences have supported that the mitotically proliferating cells in a regenerating limb are derived by a regressive process called transformation or dedifferentiation of specialized or fully differentiated cells of the skin, muscles, bones, etc.

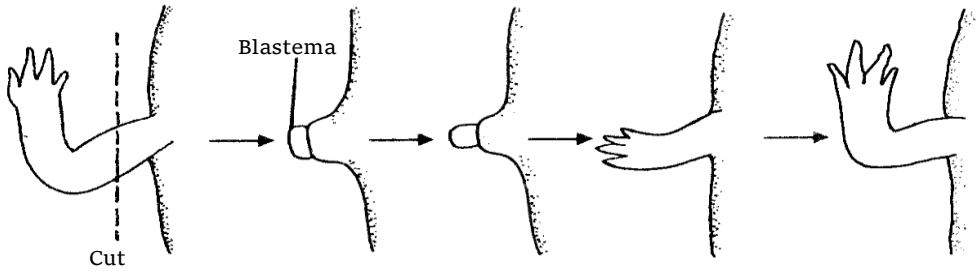


Fig : Regeneration of a limb of a newt

Differences between regeneration in Hydra and of limb in salamander.

S.No.	Characters	Regeneration in Hydra	Regeneration of limb in salamander
(1)	Extent of regeneration.	The whole body can be reconstituted from a small fragment of body by reorganizing existing body cells.	It involves redevelopment of lost body parts.
(2)	Regeneration blastema	Not formed	Formed.
(3)	Dedifferentiation	Not involved.	Dedifferentiation is involved.
(4)	Mechanism	Occurs by morphallaxis.	Occurs by epimorphosis.

Differences between Morphallaxis and Epimorphosis

S.No.	Morphallaxis	Epimorphosis
(1)	It is production of an entire animal from a small fragment.	It is regeneration of a body part by growth at the injured surface.
(2)	Regenerated animal is far smaller than the normal one.	Regenerated organ may be different from the original one.
(3)	It occurs in lower forms (Sponge, *Hydra*, *Planaria*).	It occurs in higher forms (arm of starfish, tail of lizard, limb of salamander).

(v) **Control of regeneration :** Though exact control mechanism for the regeneration of a lost limb in a salamander / newt is not known but a number of experiments have confirmed its dependency upon nerves, hormones and epithelial cover.

(a) **Epithelium :** C.S. Thornton (1960) has shown that the presence of the wound epithelium which covers the amputated surface is necessary for blastema formation. This epidermal cap acts as a stimulus for the aggregation of blastemal cells of the mesenchyme. This establishes an epithelium-mesenchymal interaction. It was reported that if the epidermal cap is placed eccentrically, an eccentric blastema is formed while if it is continually removed, blastema formation can be prevented. It was proposed that wound epithelium stimulates the secretion of certain proteinous growth factors like epidermal growth factor (EGF) and fibroblast growth factor (FGF). EGF stimulates the mitotic division of epithelial cells under the scabe of a skinned knee while FGF stimulates the mitotic division of endothelial cells to heal the injured blood vessels.

(b) **Neural trophic factor :** It has been shown that if a limb is first denervated and then amputated, or if nerves are by any means blocked from penetrating the epidermis, no regenerative blastema is formed. But if the amputated limb is denervated after the initiation of blastema formation, regenerative process continues and a new limb is formed. This confirmed that nerve supply is required for the initiation of regeneration but not for its completion. It is proposed that the neurons release some trophic factors which are essential for the regeneration of amphibian limb. Following neural trophic factors have been identified :

(1) Glial growth factor (GGF)

(2) Fibroblast growth factors (FGFs)

(3) Insulin-like growth factors (IGFs)

(4) Transferrin.

Out of these, IGFs are necessary for growth and cartilage differentiation in the regeneration blastema, while GGF and FGFs are small peptide growth factors with multiple biological functions and determine patterning growth and differentiation. Transferrin is an iron-transport protein which is necessary for mitosis in all the dividing cells.

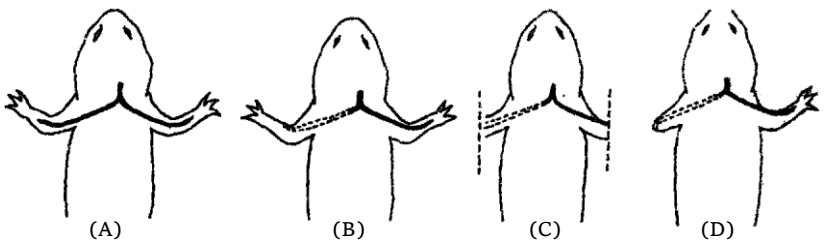


Fig : Role of intact nerve supply in the regeneration of amputated

(c) **Hormones :** Adrenal glands and pituitary gland have been found to influence the regenerative process considerably.

(vi) **Examples of regeneration in different animal groups :** The regeneration was first discovered in *Hydra* by trembley in 1740. Later, it was also found in other animal groups but to a varying degree.

Invertebrate : Power of regeneration are found in following phylum of invertebrate.

(a) **Protozoa :** Among the protozoans, very high power of regeneration was found in *Amoeba* and it was confirmed that the presence of nucleus is essential for regeneration as anucleate part finally dies.

(b) **Sponges :** Sponges have remarkable power of regeneration. Any part of the body injured or cut off is readily repaired or replaced. Small fragments of sponges grow into complete individuals.

H.V. Wilson (1907) reported that if the body of *Scypha* is dissociated into individual cells and cells are filtered through a fine silk cloth, then the individual cells by amoeboid movements aggregate into cell masses and each cell mass develops into a small functional sponge in culture medium.

(c) **Coelentrates :** Colenterates too have a remarkable power of regeneration. *Hydra* shows regeneration to an amazing degree. Trambley (1740) reported that if *Hydra* is cut transversely into two or more parts, then each fragment, as small as 0.004 mm, can grow into a complete organism. In *Hydra*, regeneration occurs by morphallaxis. *Hydra* has a unique capacity of regenerating its hypostome (oral end) again and again. This is called repetitive regeneration. It has made *Hydra* virtually immortal. In *Hydra*, the body parts usually retain their original polarity. If only the head is split into two, a peculiar two-headed *Hydra* is formed.

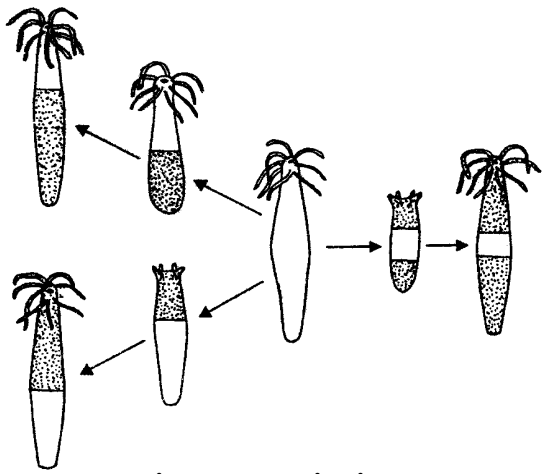
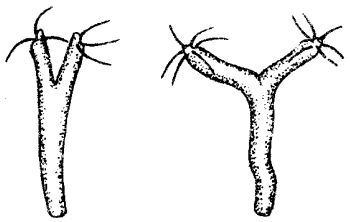


Fig : Regeneration in



(A) (B)

Fig : Hydra split part way through mouth and hypostome (A) becomes two-headed (B)

(d) **Flatworms (Platyhelminthes) :** Very high power of regeneration has been reported in *planaria* among the flat worms. Like *Hydra*, a small fragment of *Planaria* can also develop into a complete animal though of smaller size than the parental animal. Internal organs used up during starvation are also fully regenerated if food becomes available.

Power of regeneration, like the metabolic rate, is highest at the head end and progressively decreases toward the tail end. This variation is called axial gradient. A section of planaria's body grows head on its anterior side where metabolic activity is greatest and tail on its posterior side where metabolic rate is lowest. This called polarity is regeneration.

It was also found that if only the head of *Planaria* is cut into two parts, then a two-headed monster is formed. In this way, many headed *Planaria*, called heteromorph may be produced.

Recent work on regeneration suggests that certain chemicals released at the cut surface attract free cells, the neoblast from the mesenchyme. These gather to form a region of growth called blastema. The latter gives rise to the new part.

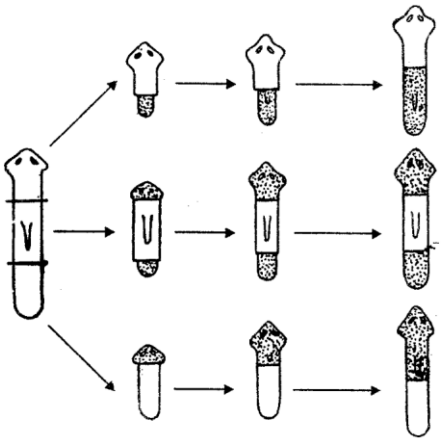


Fig : Regeneration in planaria

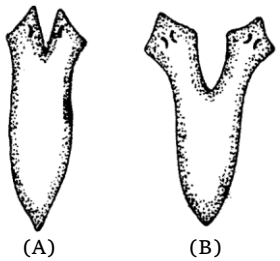


Fig : A double headed planaria results if head is split

(e) **Nematodes :** The power of regeneration is poor in nematodes. Superficial wounds are, however, healed up.

(f) **Annelids :** Annelids have less power of regeneration than the planarians. If an earthworm or other oligochaete is cut in two halves, then each half may regenerate the lost parts. But in majority of the annelids, the regeneration power is restricted and only 4 or 5 segments at either end or both ends of the body can be regenerated. Number of segments repaired is species specific e.g. in earthworm if more than fifteen anterior segments are lost, no anterior end is reformed. Among annelids, a very interesting regenerative phenomenon is found is *Eunice* (Polaloworm) in which posterior sexual part called epitoke is regenerated a number of times to increase the chances of sexual reproduction.

(g) **Arthropods :** Certain insects, crabs, lobsters and spiders can regenerate a lost leg. Crayfish regenerates any of the appendages and the eyes when removed. Regeneration is faster in the young than in the adult. The regenerated part may not always be similar to the lost one. If only a part of the eye-stalk is cut off, normal regeneration will occur, but if the entire eye-stalk is removed, an antenna-like structure replaces it. Regeneration that produces a part different from the lost part is called heteromorphosis. Among the crustaceans, prawns have a peculiar power of losing their limbs in self defence and the lost limbs are regenerated. This power of self amputation (or mutilation) is called the autotomy. It is a defensive mechanism and helps the animal to escape from the predators.

(h) **Molluscs :** Molluscs have low power of regeneration. Gastropods are capable of regenerating certain body parts only like eyes, eye stalks, the parts of head and foot. The cephalopods (e.g. cuttlefish) can also regenerate their arms only.

(i) **Echinodermates :** The power of regeneration is high in the echinoderms. Almost all the echinoderms have good power of autotomy and regeneration e.g. starfish can lose and regenerate upto 4 arms; *Holothurion* (sea cucumber) can lose its respiratory tree and visceral organs (called evisceration) in self defence. Later, these visceral organs are regenerated. Some star fishes reproduce

asexually by fragmentation in which an isolated arm with a part of central disc can develop into a complete organism by morphallactic regeneration.

Vertebrates : Many vertebrates also possess a good power of regeneration.

(1) **Fishes :** The ammocoetes larva of lamprey can regenerate the lost tail. Some fishes are known to regenerate parts of fins.

(2) **Amphibians :** The salamanders, newts and axolotl larvae are outstanding in their regenerative capacity among the vertebrates. They can regenerate a severed arm or leg. They can also regrow tail, jaws, external gills, intestine and retina. Tadpole of frog and toad can regenerate tail and hind limbs. Adult frog and toad are unable to regenerate limbs.

(3) **Reptiles :** Certain lizards can regenerate a lost tail. The wall lizard, when threatened, can sever its tail near the base, leaving the moving tail to detract the predator while it escapes, and later regenerates a new tail. The regenerated tail differs from the original one in shape, absence of vertebrae and the kind of scales covering it. This is an another case of heteromorphosis.

(4) **Birds :** Certain birds may regenerate beak.

(5) **Mammals :** Mammals are unable to regenerate any of the external parts, but can readily regenerate the liver. This organ has the maximum capacity of regeneration. Removal of over half of the liver is fully replaced. The regenerated liver resembles the original liver in volume but not in shape. Similarly, if one kidney is lost, the other enlarges and takes over the function of the missing kidney also. Such a reparative regeneration is known as compensatory hypertrophy.

From the above observation, it is evident that the power of regeneration is more in those animal groups which have simple body organisation, with less specialization and differentiation than the higher animal groups which have higher degree of specialization so less reserve cells are available for regeneration. The inability of complex animals to regenerate the lost parts is at the cost of their specilization. It is so because the lower organisms retain more of their embryonic organisation in their adult stage.

Different animal groups and their regenerative body parts.

S.No.	Animal group	Regenerated body part
	(A) Invertebrates	
(1)	**Coelenterates** (*e.g. Hydra*), **Flatworms** (*e.g. Planaria*) and **Sponges** (*e.g. Sycon*)	Fragmented body parts.
(2)	**Arthropoda** (*e.g.* Insects, Spiders, Crustaceans)	Limbs.
(3)	**Annelida** (*e.g.* Earthworm)	Body segments.
(4)	**Mollusca** (*e.g.* Snails)	Parts of the head, foot, eye, eyestalk.
(5)	**Echinodermata** (*e.g.* Starfish, Sea cucumber)	Arms.
	(B) Vertebrates	

(1)	**Pisces** (*e.g.* Fishes)	Fins.
(2)	**Amphibia** (*e.g.* Salamander)	Limbs, tail.
(3)	**Reptilia** (*e.g.* Lizards)	Tail.
(4)	**Aves**	Beak.
(5)	**Mammals** (*e.g.* Man)	Skin, body parts, kidney, liver (only reparative).

(vii) **Regeneration and embryonic development :** The process of regeneration can be described as a special kind of embryonic development because of the following similarities :

(1) In both cases, the unspecialized cells undergo repeated divisions and finally undergo differentiation to form specialized cells.

(2) Like embryogenesis, there is mass migration of cells comparable to morphogenetic movements during gastrulation.

(3) Cell differentiation occurring in the blastema leading to morphogenesis is comparable to cell interaction and cell differentiation as in developing embryo. This shows that developmental capacity is retained even in the adult organisms. The differentiated cells can undergo dedifferentiation and then redifferentiation. However, regeneration is regulated by various hormones and the nervous system of the organism, whereas in embryogenesis the regulation of development may be through some other mechanisms.

Differences between regeneration and embryonic development.

S.No.	Characters	Regeneration	Embryonic development
(1)	Occurrence	Both in larva and adult forms.	Only in embryonic stages.
(2)	Controlled by	Neural and hormonal control.	Not under neural or hormonal control.
(3)	Nature of process	Dedifferentiation of differentiated cells.	Cells are derived from zygote and undergo differentiation.

13.3 Ageing

(i) **Definition :** Ageing is the show deterioration in the structure and function of body cells tissues and organs of an animal and starts after the adulthood.

(ii) **Gerontology :** The field of developmental biology that deal with the process and problems of ageing is known as gerontology – (Gr. geron = old man; logos = discourse). The scientists involved in the science of ageing are called gerontologist.

(iii) **Life cycle and life span :** In all metazoan animals, the life cycle includes two developmental period; embryonic period (pre-natal developmental period) which extends from zygote to offspring till hatching or birth, and post embryonic period (post-natal developmental period)- which includes growth, adulthood, reproduction, ageing. Thus, the life cycle comprises five main events : birth, growth, maturity, old age and death, that follow in the sequence named. Maximum life span is the maximum number of years survived by any member of a species, while average life span is the number

of years survived by members of a population. Life expectancy is the age at which half the population still survives. The life span varies greatly in different organisms :

S.No.	Animals name	Life span
(1)	Mayfly	24 hours
(2)	Silk moth	2-3 days
(3)	Mouse	3.5 years
(4)	Rats	4.6 years
(5)	Humming bird	8 years
(6)	Rabbits	13 years
(7)	Monkeys	26 years
(8)	Dog	20-30 years
(9)	Bullfrog and Lion	30 years
(10)	Toads	36 years
(11)	Cat	35-40 years
(12)	Chimpanzee	45 years
(13)	Horses	60 years
(14)	Man	60.4 years (during 1988-95 period – WHO report)
(15)	Elephant	70 years
(16)	Turkey	118 years
(17)	Parrots	140 years
(18)	Tortoise and banyan tree	200 years
(19)	Sequoia	About 3000-4000 years (longest life span)

Maximum life span of human has been found to be about 121 years. Shirechiyo Izumi of Japan died due to pneumonia at the age of 120 years and 237 days in 1986.

Average life span of women is longer than men while the biological process of ageing is faster in human male than in human female. No organism lives for ever. (It is believed that Hydra is immortal as it does not undergo ageing). Every organism dies of old age if not killed earlier by an accident, a predator, aparasite or a disease.

(iv) **Why old age ends in a natural death :** Though it is difficult to give a categorical answer, certain factors that lead to death in old age are known. During the growth period, new cells are formed faster than the rate of death of old cells. But after the maximum growth, the metabolic rate declines and rate of formation of new cells is lower than the rate of death of body cells. So the repair of damaged cells is not complete and a slow deteriorative process starts. In human beings, it starts after the age of 30 years. But in certain cases, deterioration in structure and function of cells may start during

childhood or even during prenatal life e.g. hearing efficiency of ear and atresia in ovary. As the organism grows older,

(a) The metabolic activities gradually decline.

(b) Capacity to replace the worn out cells decreases.

(c) The power to repair the worn out tissues and organs decreases.

(d) Resistance power to diseases is lowered.

(e) Lowered adaptability.

(f) Finally, non-functioning of some vital organs like heart, brain, kidneys, lungs or liver.

So with ageing, there is an impairment of physiological functions, called senescence and ultimately leads to death.

Peak of activity : In humans, generally speaking, the peak of activity is thought to reach at about 30 years of age. Thereafter, the body shows signs of senescence, i.e., deterioration and loss of normal function. From the age of about 30 years, the human body becomes functionally less efficient by about 0.8% every year. It is a biological process.

(v) **Deterioration data of an old person :** A 75 years old man, for instance, has, as compared to a 30 years old person, about 64% less taste buds, about 44% less renal glomeruli about 20% less nerve cells in the brain, and about 37% less axons in the spinal nerves. His heart pumps 35% less blood and sends 20% and 58% less blood to the brain and the kidneys respectively. His lungs have 44% less vital capacity and provide about one-third less oxygen to the blood per minute. His kidneys have 31% lower rate of glomerular filtration. His nerve impulses are propagated at a rate about 10% slower. At the age of 30, the height starts decreasing indetectibly, it decreases by 0.3 cm. at 40, by 2 cm. at 50 and by 2.5 cm. at 70.

(vi) **Changes in ageing or symptoms of ageing :** Gerontalogist have worked out a large number of changes that accompany ageing. These are discussed below under three heads –

(a) **Changes at organ level :** During ageing, different organs and organ systems show different rates of decline e.g.

(1) **Heart :** With increasing age the efficiency of heart decreases. In a man of 70 years, the heart pumps only 65 per cent blood per minute as compared to a 30 years old man. Consequently, the blood going to the brain and kidney is reduced to 80 percent and 40 percent respectively.

(2) **Oxygen uptake by blood :** At the age of 20 blood takes about 4 litres of oxygen per minute, while in a man of 75 years, it takes only about 1.5 litres of oxygen in the same period.

(3) **Decrease of blood volume :** The production of new RBCs from the bone marrow declines and consequently the volume of blood also decreases.

(4) **Kidney :** The number of kidney tubules is found to reduce to half in the old age. As a result the volume of urine decreases. This creates lots of other urinary troubles and also causes body ache, low back and difficulty in passing urine.

(5) **Lungs :** The capacity of lungs for intake of air decreases. This leads to reduction in the oxygen supply to different tissues. Therefore, old persons suffer from breathlessness and inflammation of mucous membrane.

(6) **Digestive system :** The number of taste buds on tongue reduces to about one-third. The secretion of digestive juices also decreases with old age. This may result in indigestion. loss of appetite, dyspepsia, constipation and gas formation.

(7) **Retention of water :** The capacity of body cells to retain water also decreases with the result, the skin in old persons is dry and wrinkled.

(8) **Nerve impulse :** The rate of nerve impulse propagation reduces with age. The decline is about ten percent in man of 75 years as compared to that of 50 years old person.

(9) Increased mineral deposition in the bones which become brittle and easily fracturable.

(10) Muscle tissue degenerates due to biochemical changes in the muscle cells or neuromuscular junction. This greatly reduces the muscular strength. Without exercise, estimated muscle mass declines 22 percent for women, and 23 percent for men. It can be prevented by regular exercise.

(11) Thymus is almost microscopic by the age of 70 years. This lowers the number and functioning of T-lymphocytes which lowers the immunity against the antigens.

(12) Hair start greying or falling at the age of 40 due to reduced rate of protein synthesis.

(13) Menopause in female at an average age of 52 years.

(14) Body becomes thin, shrivelled and stooping.

(15) Decline in hearing power begins after the age of 10 years. It declines steadily upto 50 years of age after which the rate of decline is much slower. Hearing declines faster in men than in women.

(16) **Eyes :** Accommodation power of eye starts declining in the 40s; ability to distinguish fine details may begin to decline in the 70s while there is increased susceptibility of eyes to glare and more difficulty in detecting moving objects from 50 years onward. It is generalised that the human body becomes functionally less efficient from the age of 30 years onward by about 0.8% every year. So, the age of 30 years is a turning point in the process of development.

(b) **Cellular changes :** Cellular changes are of two types

Morphological changes :

(1) **Accumulation of exhaustion pigments :** The exhaustion pigment lipofuscin, yellow pigment and brown deposits are byproducts of unsaturated lipid oxidation. It is especially obvious in nerve and heart muscle cells but is present in almost all other cells of the body, though to a lesser degree. The accumulation of this pigment represents the failure of some excretory mechanism and has important implications in cellular senescence.

(2) **Appearance of lipid vacuoles :** Small lipid vacuoles appear in the cytoplasm.

(3) **Decline in cell volume :** The cells showing ageing exhibit hypertrophy or decrease in cell volume.

(4) **Nuclear pyknosis :** With advancing age, the nucleus becomes shrunken and stains deeply. Such a nucleus is called pyknotic and the degenerative process is known as nuclear pyknosis. This is caused by the condensation of the nuclear material rather than an increase in chromatin.

(5) **Hypotrophy** (decreased volume) of body cells : With the increasing age other changes associated with aging are – (i) increase in cholesterol levels, (ii) increase in blood globulin, (iii) decrease in alkaline and acid phosphatases (iv) decreases in cellular respiration.

Physiological changes :

(1) Accumulation of chromosomal aberrations and gene mutation in the nuclei with advancing age. These change the transcribed RNA which leads to the synthesis of defective proteins. These also retard the replication of DNA.

(2) Decrease in semipermeability of cell membrane due to deposition of calcium in the peripheral part of cytoplasm.

(3) Decrease in the rate of metabolism due to decreased number of mitochondria with advancing age.

(4) Decreased rate of protein synthesis is due to decrease in RER in cells.

(5) Increased inactivity of aldolase enzyme in the liver cells with advancing age.

(6) Decreased rate of cell mitosis. The non-dividing nerve cells and muscle cells start ageing earlier than the dividing cells of spleen and liver.

(7) Size of the nucleus decreases.

(8) Breakdown of cellular membrane. With advancing age, the lipids of biological membranes, that surround the cells and certain cell organelles, breakdown, forming a fatty, brown pigment called lipofuscin. The lipofuscin granules accumulate in ageing muscle and nerve cells, and interfere in their functioning.

(c) **Extracellular change :** The intercellular fibrous protein collagen forms about 40% of the total protein content of the body. It plays a significant role in the process of ageing. Collagen in young animals is permeable, flexible and soluble. As the age advances, it becomes less permeable, rigid and insoluble. On account of these changes in the surrounding collagen, it becomes progressively difficult for the diffusion of food and oxygen from the blood capillaries to the cells, and for the nitrogenous wastes and carbon dioxide to diffuse from the cells into the blood capillaries. The barrier of aged collagen between the cells and the blood results in decline of metabolic activities of ageing of the cells, and also of the animal.

(vii) **Theories of ageing :** Biological phenomena leading to ageing are not fully known. Several theories have been proposed to explain various aspects of ageing. These theories of ageing have been divided into two categories –

(a) **Programmed theories :** These theories state that ageing is due to certain "internal biological clocks" and follows a definite time table.

(b) **Damage or Error theories :** These theories state that ageing in the living organism is induced by certain external or environmental factors which cause damage to cell and organism. Several theories have been put forward to explain the process of ageing.

(1) **Environmental or Mutation theory :** It was proposed by Szilard (1959) and was supported by Curtis (1963). It states that ageing is largely due to adverse changes in the environment, especially radiations (cosmic rays, X-rays etc.) which induce gene mutations in the somatic cells by errors in DNA duplication. These mutations accumulate and result in the synthesis of defective polypeptide chains and defective proteins. Consequently, this reduces cellular efficiency and results in ageing. The view is supported by observations on ageing human cells, which produce defective enzymes. Moreover, sublethal exposure of individuals to radiation lowers their life expectancy.

(2) **Gene theory of ageing :** It states that ageing is an intrinsic phenomenon and is controlled by some genetic time table, called ageing genes, of the genome which induces ageing at specific period. The presence of a genetic time table was proposed by Pal. This theory states that ageing is the result of switching on of these ageing genes at the specific period of life span and induce the age associated symptoms, called senescence, followed by cell-death.

(3) **Environmental-cum-genetic theory :** Some biologists hold that interaction between environmental and genetic factors brings about ageing. This theory is supported by the fact that domestication, which changes the environment of animals, increases their life span.

(4) **Neurohormonal or endocrine theory :** According to this theory, ageing produces primary defects in certain centres of the central nervous system which control the functioning of the endocrine glands. Finch suggested that there is a brain-endocrine masterplan that states that biological clock operates through hormones to control the pace of ageing e.g.

(i) Level of hGH (Human Growth Hormone) decreases in about half of all adults.

(ii) In females, there is decline in level of female hormones, estrogens with age. Main source of estrogens in this period is fat tissue and not the ovaries.

(iii) In males, there is decline in the level of male hormone, testosterone, so causing decreased strength of muscles.

(iv) Level of melatonin hormone of pineal gland also falls with increasing age which may initiate changes throughout the endocrine system.

(v) There is also decreased secretion of DHEA (dehydroepiandrosterone) of adrenal glands so there is decreased synthesis of sex-hormones like testosterone and estrogens.

(5) **Immunity theory :** This theory suggests a link between ageing and disappearance of the thymus gland by late middle age in man. Thymus stimulates the proliferation of lymphocytes, increasing resistance to infection. Absence of this gland affects in two ways :

(i) It weakens the body's natural defence against foreign germs.

(ii) It increases the number of abnormal (defective or harmful) cells formed in the body itself. This destroys the tissues. The neuro-hormonal and immunity theories are collectively called pacemaker theories of ageing.

(6) **Wear-and-Tear or stress theory :** It states that the cells and tissues of the body continuously wear out due to internal and external stress factors. This coupled with the fact that the regenerative capacity progressively declines with age, causes ageing and finally death.

(7) **Cross linkage theory :** According to this theory ageing is caused by the increase of bonds between protein and nucleic acid molecules in the cell. These bonds alter the functional characteristic of these important cellular components leading to non-availability of certain functional proteins and resulting in malfunctioning of the cell.

(8) **Waste product theory :** According to this theory the accumulation of waste products are considered to poison the cell gradually, resulting in their ageing and death.

(9) **Clinker's theory :** It states that ageing is due to accumulation of metabolic wastes inside the body cells. These wastes, beyond some limit, poison the body cells and decline the metabolic rate and induce ageing.

(10) **Error catastrophy theory :** It was proposed by Orgeld (1963 A.D.). It states that errors in reading genetic code results in defective proteins which form defective enzyme leading to catastrophic damage to cells, tissues and organs, so induce senescence.

(11) **Free radical theory :** A free radical is a molecule with an unpaired and highly reactive electron. The oxygen-free radicals are formed as the by-product of normal cellular respiration. These free radicals take electrons from other molecules of a biological system so making them unstable and combine readily with other molecules. These free radicals initiate a chemical instability. These free radicals act as cross-linkers and inactivate functional molecules like DNA, RNA, enzymes, etc. and cause deterioration of functions of organisms. These free radicals are also involved in degenerative disorders, including cancer, atherosclerosis, cataract and neuro-degeneration.

(12) **Metabolic or living theory :** It states that those organisms (*e.g.* rats, mice, insects, birds, etc.) which have higher metabolic rate, mature, age and die earlier than those organisms (*e.g.* human beings) which have low metabolic rate and take years to mature and years to age.

(13) **Collagen theory :** It was proposed by F. Verzar (1964). It states that ageing is induced by changes in the collagen protein in the interstitial fluid surrounding the body cells (explained in extracellular changes in ageing).

(14) **Reconciliation of theories of ageing :** B.L. Strehler postulated that the ageing is programmed by the action of 'on-off switches' that reside in the genetic machinery. The mechanism activates first one set of genes, then another to produce special products (the enzymes, hormones, antibodies etc.) as the individual matures, ages and dies. The specific off switch prevents the key body cells found in the thymus, brain, heart and endocrine glands from dividing once the animal has attained maturity.

(15) **Integrated theory :** This theory assumes that ageing may be caused by many interacting mechanisms that occur in various cell types and at various times in the life of an individual. It seems likely that the "ageing genes" control many minor degenerations that accumulate to cause ageing. For

instance, degenerations in the control systems (immune, nervous and hormonal systems) cause ageing due to loss of adaptability to survive in changing conditions. Thus, there are too many theories to explain the phenomenon of ageing. Each theory explains a particular aspect of ageing. It is long way to formulate comprehensive theory for explaining different aspects of ageing in all kinds of cells and organisms.

13.4 Death

(i) **Definition :** Death may be defined as the permanent cessation of all the vital function in an organism.

(ii) **Characteristics :**

(a) It is the last event in the degenerative processes of ageing.

(b) Death of an organism involves the death of the body cells. But all the cells of the body do not die at the same rate *e.g.* ciliated cells lining the respiratory tract of mammals continue to beat their cilia for a long time even after animal's death. Brain cells of body are last to die.

(c) There is no natural death in the protozoans *e.g. Amoeba*.

(d) Death involves widespread cell breakdown and cell death.

(e) It usually occurs due to lack of oxygen supply to body tissues.

(iii) **Causes of death :** Causes of death are many. These can be separated into following main categories –

(a) The weakening of the body tissues and of vital organs like heart, lungs, liver, kidneys, etc. which cause physiological and metabolic disorders of permanent nature leading to death. Death, in some cases, occurs due to sudden stoppage of the circulation of blood, food and oxygen to heart and brain leading to immediate death.

(b) The immune system (A system that provide resistance against disease – causing microbes) of the body is gradually impaired with advancing age. This increases the chances of infection in old age. Many old persons die of infectious diseases.

(c) Sudden blockage in the circulation of blood to heart, lungs and brain. This causes instantaneous death.

(iv) **Brain or cerebral death :** In the presence of cardiac activity, the permanent loss of cerebral functions, manifested clinically by absence of responses to external stimuli, lack of breath, and absence of cerebral reflexes is called brain death.

(v) **The only truth of life :** The death is an inevitable reality of life, and should be gladly accepted. It is a biological necessity for the maintenance of the balance of nature. Old organisms must make room for new ones.

(vi) **Habit that influence life span :** Life-style habits can influence life span considerably. Although a healthful diet does not guarantee immortality, regular exercise and avoiding of alcohol, smoking and drugs, contentment and freedom from stress can make a person's last years more pleasant.

(vii) **Significance :** Death is an essential and inescapable biological phenomenon which helps in maintaining ecological balance or homeostasis in nature. It prevents overcrowding of the members of a specific species and justifies the 'continuity of life' on earth.

Important Tips

- The rate of growth in man from birth to 10-13 years of age (childhood) is quite slow.
- Growth at the end of childhood and during puberty is controlled by thyroxine and somatotropic hormone.
- Growth in the first 10-13 years of age is controlled by thymosin.
- Maximum growth in human foetus occurs at the age of 4^{th} month.
- Eutyly : When number of cells is constant both for entire animal and specific organs e.g. nematodes like Ascaris.
- The parts of lung affected by ageing are alveoli, pulmonary arteries and pulmonary veins.
- With increasing age, the enzyme aldolase synthesized by the mice liver cells becomes more and more inactive.
- Cell growth and cell reproduction can be studied by tissue culture methods.
- In tissue culture, cells show exponential growth.
- In mice, dogs and men, with increase in age, the liver cells exhibit increased number of chromosomal aberrations.
- Vitamins A, C and E act as anti-oxidants so can be used to neutralise the volatile and unstable oxygen-free radicals.
- Hayflick limit : Uppermost limit of cells to divide. At this limit, cells stop dividing, go quiet for a while and then die. It was discovered by Dr. Hayflick in 1960s. He stated that telomere of chromosome acts as a molecular clock so determines the life span of a cell. With each cell division, telomeres become a little shorter.
- Feedback control of secretion of GH of pituitary operates by stimulating the production of insulin-like growth factors (IGFs) secreted by the liver.
- During ageing, deterioration prevails over synthesis. In this period, there is also increase in degree of randomness, called entropy.
- Arthropods show discontinuous growth. They grow only after moulting or ecdysis.
- Growth occurs at a rate of 2 cm per month during first year after birth.
- Human embryo is about 150 μm at the time of implantation which grows to about 50 cm over the nine months of gestation period.

- According to latest world development report, Japanese have longest life span (average life expectancy is 76.3 years while that of female is 82.5 years).
- In India, male life expectancy in Kerala is 69 years while that of female is 74 years. Average life span of an Indian is 60 years.
- Name of Hydra has been derived from the mythological monster, Lema, which has seven heads.
- World Day for Elderly People : 8^{th} October.
- Geriatics : Diagnosis and treatment of diseases which affect the elderly persons.
- Maximum life span is the characteristic of a species, while life expectancy is the characteristic of a population.
- Viadimor Korenchevsky : Father of Gerontology.
- Shock (1962) : Reported Ca^{2+}-accumulation in aged cells.
- Minot (1971) : Suggested that a change in nucleo-cytoplasmic ratio acts as an important index for natural senescence and ageing.
- Cross-linking of biomolecules has a close relationship to diabetes.
- In certain cases, age-related symptoms and pathological symptoms are similar. e.g. in osteoporosis (characterized by weakening and fracture of bones especially in postmenopausal period). Similarly impairment in body temperature control may be due to ageing process or may be due to cerebrovascular disease or the dementing process, called Alzheimer's disease.
- Committing suicide by the cells (autolysis) by activating internal death programme is called apoptosis.
- H.W. Wilson (1907) : Reported morphallaxis regeneration in Scypha.
- Turnover time for skin cells is of 1-2 weeks while it is of 2-3 days for intestinal cells.
- Skin regenerates damaged portion most easily.
- Cell growth occurs during postmitotic phase and interphase.
- The correct sequence of events during regeneration are dedifferentiation, cell division, cell movement and tissue differentiation.

ASSIGNMENT

GROWTH

Basic Level

1. Degrowth is seen during

(a) Regeneration (b) Autotomy (c) Metamorphosis (d) All the above

2. Accretionary growth is due to

(a) Reserve cells (b) Meristematic cells (c) Embryonic cells (d) Differentiated cells

3. Growth curve indicates

(a) Growth rate (b) A growth parameter at various intervals

(c) Absolute growth (d) Absolute increase

4. Growth curve in animals is

(a) Delta curve (b) Alpha curve (c) Beta curve (d) Sigmoid curve

5. Which of the following glands control the growth

(a) Anterior pituitary only (b) Thyroid only

(c) Thyroid and Thymus (d) Anterior pituitary, Thyroid and Thymus

6. As compared to an adult male, the adult female has more

(a) Fat (b) Brain

(c) Connective tissue and other parts (d) Muscles

7. Growth controlling factors are

(a) Constitutional factors (b)Temperature (c) Nutritional factor (d) All the above

8. Growth is

(a) Increase in size (b) Increase in weight

(c) Synthesis of new protoplasm (d) All the above

9. When volume of body increases due to increase in the volume of cells, not in the number of cells, then it is called 'auxetic growth'. Such growth is found in

(a) Lizards (b) Men (c) Frogs (d) Nematodes

10. At cellular level, GH affects growth by controlling the production of

(a) rRNA (b) tRNA (c) mRNA (d) None of the above

11. Sexual maturity of House Mouse is attained at the age of

(a) 35 days (b) 15 days (c) 45 days (d) 75 days

12. Growth due to the increase in size of cells is called

(a) Auxetic growth (b) Accretionary

(c) Multiplicative growth (d) Differential growth

13. Which one of these is body building material

(a) Protein (b) Sugar (c) Mineral salts (d) Fat

14. Multiplicative growth is not found in

(a) Higher vertebrate (b) Crab (c) Leech (d) Tunicates

15. T-cells are found in

(a) Thymus (b) Thyroid (c) Pulmones (d) Kidneys

16. Postembryonic growth is

(a) Accretionary (b) Auxetic (c) Multiplicative (d) All the above

17. In human beings, growth stops completely at the age of

(a) 18 years (b) 22-23 years (c) 25 years (d) 20 years

18. Maximum growth in human foetus occurs at the age of

(a) Four months (b) Two months (c) Six months (d) Eight months

19. Cell growth occurs during

(a) Interphase (b) Mitotic phase

(c) Postmitotic phase (d) Interphase and postmitotic phase

20. Substances synthesised during growth are

(a) Protoplasmic (b) Apoplasmic

(c) Protoplasmic and apoplasmatic (d) Nucleic acids

21. Growth in the first 10-13 years of age is controlled by

(a) Somatotrophic hormone (b) Thyroxine

(c) Thymosin (d) Gonadotrophic hormone

22. In old age there is decrease in amount of urine output and difficulty in micturitions it is due to

(a) Increase in number of nephrons (b) Increase in glomerular filtration

(c) Decrease in number of nephrons and glomerular filtration

(d) Both (a) and (b)

23. Growth is an irreversible process seen at all organizational levels. It consists of

(a) Organ growth (b) Subcellular growth (c) Cell growth (d) All the above

24. When growth takes place only by increase in volume of existing cells it is called as

(a) Auxetic growth (b) Multiplicative growth (c) Accretionary growth (d) Differential growth

25. The following cells cannot be grown under tissue culture conditions

(a) Hela cells (b) Leucocytes (c) Kidney cells (d) Nerve cells

26. Growth in most warm blooded vertebrates is

(a) Determinate (b) Indeterminate (c) Uncontrolled (d) None of the above

27. The developing embryo shows

(a) No growth (b) Auxetic growth

(c) Accretionary growth (d) Multiplicative growth

28. The process of series of changes from larval to adult after embryonic development is called

(a) Growth (b) Ageing (c) Regeneration (d) Metamorphosis

29. Auxetic growth is characterised by

(a) Increase in cell number (b) Growth without increase in cell number

(c) Both increase in cell number and cell growth (d) Expansion in transverse direction.

30. The portion of sigmoid growth curve where it represents almost a horizontal line indicates that growth rate

(a) Slows down (lag phase) (b) Increases very fast (Exponential phase)

(c) Again slows down (Senescent phase)

(d) Reduces and becomes constant (Steady phase)

31. Growth curve shows

(a) Increase in the length of the animal with age (b) Increase in the mass of the animal with time

(c) Increase in the number of cells with age (d) Increase in the mass of the animal with temperature

32. The growth at the end of childhood and during puberty is regulated by hormone

(a) Thyroxin (b) Thymosin (c) Somatotropic hormone (d)Both (a) and (c)

33. Degrowth takes place when

(a) Anabolism is higher than catabolism (b) Catabolism is higher than anabolism

(c) Protoplasmic synthesis is more than apoplasmatic synthesis

(d) Apoplasmatic synthesis is more than protoplasmic synthesis

34. The rapid growth during adolescence is the result of the hormone

(a) GSH (b) Thyroxin

(c) Both GSH and thyroxin (d)Neither of the two

35. How many cells are present approximately in an adult man

(a) 6×10^{10} (b) 6×10^{11} (c) 6×10^{12} (d) 6×10^{13}

36. Histones are synthesised during

(a) Mitosis (b) *S* phase (c) G_1 phase (d) G_2 phase

37. Auxetic growth is one in which there is

(a) Increase in the fatty tissue only

(b) Increase in the cell volume only

(c) Increase in the cell number

(d) Increase in the volume of the body due to the decrease in the inter-cellular material

38. Growth rate in childhood is controlled by

(a) Thymosine (b) Thyroxine (c) Progesterone (d) Oestrogen

39. In animals, growth rate is

(a) Uniform (b) Linear (c) Differential (d) Slow

40. Adult females tend to have less weight than adult males due to lesser development of

(a) Muscles (b) Skeleton (c) Both muscles and skeleton (d)Fat

41. Early embryonic developmental stages constitute

(a) Functional state (b) Prefunctional state (c) Transitional growth (d) Fundamental growth

42. Growth hormone activity is

(a) Unaffected by thyroxine (b) Increased by thyroxine

(c) Decreased by thyroxine (d) None of the above

43. In human beings, which part shows the maximum increase in weight from birth to adulthood

(a) Brain (b) Fat (c) Muscles (d) Skeleton

44. In human beings, which of the following show the minimum increase in weight from birth to adulthood

(a) Brain (b) Muscle (c) Skeleton (d) Fat

45. Which of the endocrine glands promotes growth

(a) Anterior pituitary (b) Posterior pituitary (c) Adrenal gland (d) Pineal gland

46. Sexual maturity of dog is attained at the age of

(a) Two months (b) Four months (c) Five months (d) Eight months

47. Which of the following is an important property of life

(a) Photosynthesis (b) Growth (c) Cell wall (d) None of the above

48. Haemopoiesis is the example of

(a) Autotomy (b) Auxetic growth

(c) Accretionary growth (d) Multiplicative growth

49. An adult human has 6×10^{13} cells and an infant has

(a) Same number (b) 2×10^{12} (c) 15×10^{12} (d) 1×10^{3}

50. The undifferentiated cells in the adult which retain the power to divide are called

(a) Stem cells (b) Meristematic cells (c) Postmitotic cells (d) Premitotic cells

51. Diapause is

(a) Arrested development shown by insects (b)Active regeneration of *Hydra*

(c) Remarkable regeneration of urodele amphibians (d)All the above

52. The glands controlling the overall growth of man are

(a) Pituitary and thyroid (b) Liver and adrenal cortex (c)Gonads (d) All the above

53. The process in which the reserve food material is utilised and which shows negative growth is called

(a) Anabolism (b) Catabolism (c) Regeneration (d) Degrowth

54. Thyroxine is

(a) Growth inhibitor (b) Maintains basal metabolic rate

(c) Prevents sexual maturation (d) Anti FSH

55. Somatotropin hormone

(a) Promotes growth (b) Function synergistically with thyroxine

(c) Both (a) and (b) (d) Is antagonastic to FSH and LH

56. Nearly 40% of human body protein are

(a) Glycoprotein (b) Lipoprotein (c) Keratin (d) Collagen

57. Which of the organ system is last to differentiate

(a) Cardiovascular (b) Renal (c) Reproductive (d) Muscular

58. The phase of slow growth in an individual is

(a) Lag phase or preparatory phase (b) Exponential phase

(c) Stationary phase (d) Maturation

59. Thymosine hormone secreted from the thymus

(a) Enhances growth (b)Decreases growth

(c) Does not show effect (d)In the early stages it enhances and later stages it decreases

60. The human liver weighs about

(a) 5 *kg* (b) 6 *kg* (c) 1.5 *kg* (d) 3 *kg*

61. As a general rule ionizing radiation is more damaging to

(a) Mature, stable cells (b)Actively dividing cells

(c)Highly specialized cells (d)Cells in which food is stored

62. The hormone responsible for proper growth of body is secreted by

(a) Thyroid (b) Adrenals (c) Posterior pituitary (d) Anterior pituitary

63. Auxetic growth is one in which there is an increase in the volume of the body

(a) Due to increase in the intra-cellular material (b) Due to decrease in the intra-cellular material

(c) Due to increase in the inter-cellular material (d) Due to decrease in the inter-cellular material

64. The uncontrolled growth of tissue, in the parts of body is called

(a) Allergies (b) Phobia (c) Cancer (d) Acquired disease

65. There is rapid post natal development during

(a) Puberty (b) Post puberty (c) Both (a) and (b) (d) None of the above

66. Select the correct statement

(a) When some organs grow faster and others relatively slower it is called allometric growth

(b) The age menarche in human female is 45-50 years

(c) Menopausal symptoms in human female occur at the age of 10-11 year

(d) Ageing does not affect memmory in humans

67. Which one of the following is not an example of accretionary growth

(a) Increase in the size of muscles due to regular exercise

(b) Prenatal growth of the embryo

(c) Both of the above (d) None of the above

68. An example of multiplicative growth is

(a) Proliferation of germinal layer of skin (b) Prenatal growth of vertebrate embryo

(c) Growth of body cells in rotifers (d) All the above

69. Metabolic activities during growth are

(a) Only degenerative (b) Catabolic and anabolic

(c) Responsible for increase in all kinds of proteins in the body

(d) All the above

70. In postembryonic period, all cells are notable to divide. Only some cells, located at certain places will divide and promote growth. Such growth can be described as

(a) Auxentic (b) Multiple (c) Accretionary (d) None of the above

71. Embryonic development in the growth phase of man described as

(a) Infant phase (b) Adolescent phase (c) Juvenile phase (d) Prenatal period

72. During their lifecycles many plants and animals undergo periods when the metabolic activity is reduced to minimum and growth caeses. This is

(a) Epimorphosis (b) Hypertrophy (c) Dormancy (d) Heteromorphosis

Advance Level

73. Growth in living being is called

(a) Accretion (b) Intussusception (c) Aggregation (d) Interaction

74. By which age, the number of uriniferous tubules is reduced to half in man

(a) 40 years (b) 50 years (c) 70 years (d) 75 years

75. The steps involved in cellular growth is /are

(a) Cell division (b) Cell enlargement

(c) Cell differentiation and maturation (d) All the above

76. Multiplicative growth is found in

(a) Old age (b) Adulthood (c) Embryo (d) Childhood

77. Growth occurs when

(a) Anabolism is higher than catabolism (b) Catabolism is higher than anabolism

(c) Protoplasmic synthesis is more than apoplasmatic synthesis

(d) Apoplasmatic synthesis is more than protoplasmic synthesis

78. Growth at the end of childhood and during puberty is controlled by

(a) Thyroxin (b) Thymosin

(c) Somatotrophic hormone (d) Thyroxin and somatotrophic hormones

79. Absolute increase is the term which means

(a) Total growth in life time

(b) Total growth in one year

(c) Growth of a specific body organ

(d) Difference between initial weight and final weight of the body during specific time interval irrespective of other factors

80. Mitotic division in chondriocytes, osteocytes and mesenchyme cells in an adult is the example of

(a) Multiplicative growth (b)Auxetic growth

(c) Accretionary growth (d)Deaccelerating growth

81. As a person becomes old, a degenerative process initiate in the body which causes

(a) A gradual alteration in the connective tissue components only

(b) Increase in the collagen content of the connective tissues only

(c) Increase in the mucopolysaccharides content of the most of the connective tissues only

(d) (a) and (b) both are correct

82. The G_2 phase of the cell cycle is signified by the synthesis of

(a) mRNA only (b) rRNA only (c) rRNA and mRNA (d) DNA

83. Between the ages of 1 and 2 years, a baby boy's weight increases from 10 to 12 *kg* and in the same period of time the weight of a teenage boy goes up from 50 to 55 *kg*. The percentage growth rate of

(a) The teenagar is higher than that of the baby boy by 5 to 5.5%

(b) The baby boy is higher than that of the teenagar

(c) The teenagar is same as that of the baby boy (d) Both (a) and (b)

84. Allometric growth is

(a) Increase in the number of cells with growth of individual cells

(b) Growth due to multiplication of constituent cells at constant rate

(c) Difference in the rate of growth of different parts of the body

(d) Growth due to special reserve cells of the body

85. Absolute increase is

(a) Increase taken as a difference between the final and initial length of an organism for any period of time

(b) Increase taken as a difference between the final and initial age of an organism for any period of time

(c) Increase taken as a difference between the final and initial size or weight of an organism for any period of time

(d) Total increase in number of a population

86. Juvenile stage extends from

(a) Birth to 10 months of age (b) 10 months to 4 or 5 years of age

(c) 4 or 5 years to about 14 years of age (d) 14 years to 20 or 22 years of age

87. Growth abnormalities such as gigantism and dwarfism are due to

(a) Hormonal factors (b) Genetic factors (c) Deficiency of food (d) Both (a) and (b)

88. Identify the false statement

(a) Human growth phase consists of early, childhood, youth and old age

(b) The pubertal age in humans is 10-16 years

(c) A four month foetus displays maximum growth

(d) Head of human adult is 1/8 of the body

89. Growth curve of higher animals is

(a) J-shaped (b) R-shaped (c) I-shaped (d) S-shaped

90. Exponential growth of cell population is defined by the expression

(a) $P = 4n$ (b) $n = 2P$ (c) $P = 2n$ (d) $n = 4P$

91. Semilog of per minute growing bacteria is plotted against time. What will be shape of graph

(a) Ascending straight line (b)Sigmoid

(c) Hyperbolic (d)Descending straight line

92. The correct sequence of growth curve for bacteria is

(a) Lag, log, stationary and decline (b) Lag, log, decline and stationary

(c) Stationary, lag, log, decline (d) Decline, lag and log phase

93. As compared to whole body, the head of new born human baby is

(a) One-third (b) One-half (c) One-fifth (d) One-fourth

94. As compared to whole body, the head of an adult human being is

(a) One-fifth (b) One-sixth (c) One-seventh (d) One-eighth

95. The arms attain their proportionate size in human beings at

(a) Soon after birth (b) Age of two years

(c) Ten years of age (d) Fourteen years of age

96. Legs, attain their proper proportionate size in human beings at the age of

(a) Birth (b) Two years (c) Ten years (d) 18 years

97. Growth due to mitotic multiplication of reserve cells occurring in specific locations of the body is

(a) Auxetic growth (b) Multiplication growth (c) Accretionary growth (d) All the above

98. Exponential growth of cells is characteristic feature of

(a) Unicellular organisms (b)Embryo

(c) Tissue culture cells (d)Multicellular organisms

99. The usual shape of growth curve is

(a) Sigmoidal (b) Inverted bell-shaped (c) Linear (d) Zig-zag

100. The maximum growth rate occurs in

(a) Senescent phase (b) Exponential phase (c) Stationary phase (d) Lag phase

101. As compared to whole body, the head of a 2 month foetus is

(a) 1/8 (b) 1/4 (c) 1/3 (d) 1/2

102. As compared to whole body, the head of 12 year boy is

(a) 1/8 (b) 1/4 (c) 1/3 (d) 1/2

REPAIR & REGENERATION

Basic Level

103. Replacement of dead RBCs by new RBCs formed from the erythroblasts of the bone marrow by the process of erythropoeisis is an example of

(a) Growth (b) Degrowth

(c) Reparative regeneration (d)Restorative regeneration

104. Morphallaxis is reported in

(a) Porifers (b) Coelenterates and flatworms

(c) Nemarteans and some ascidians (d) All the above

105. In echinodermata, the following organs can be regenerated

(a) Arms and disc (b) Digestive system (c) Eyes (d) Pedicillaria

106. The damaged leg is not regenerated in

(a) Salamander (b) Frog's tadpole (c) Frog (d) Crab

107. Willfully seperation of body parts by an animal is called

(a) Autotomy (b) Reparative regeneration

(c)Restorative regeneration (d) Degrowth

108. Morphallaxis is

(a) Reconstruction of the whole body (b) Growth of lost limb

(c) Healing of injury (d) Regeneration with the help of blastema

109. Regeneration of a limb or tail is an example of

(a) Compensatory hypertrophy (b) Epimorphosis

(c) Morphallaxis (d) Autotomy

110. The ability of animals to regenerate the lost parts of the body was reported by

(a) Carlson (b) Trembley (c) Patten (d) Storer

111. Epimorphosis is

(a) Degeneration of old organs (b)Regeneration of lost body part

(c) Regeneration of the whole body from a small portion (d)None of the above

112. Healing of cuts and wounds is

(a) Repair (b) Regeneration (c) Dedifferentiation (d) Growth

113. Accumulation of cells and formation of a bud at the site of amputation is

(a) Morphallaxis (b) Reparative bud (c) Blastema (d) Both (a) and (b)

114. When an animal has capacity to develop whole body from a small portion the phenomenon is called

(a) Regeneration (b) Morphallaxis (c) Epimorphosis (d) Restoration

115. Factors controlling regeneration seem to be

(a) Neural (b) Hormonal

(c) Both neural and hormonal (d) Genetic

116. Restorative regeneration decreases with

(a) Increase in complexity of organisation (b) Decrease in organisational complexity

(c) Development of hormones (d) Development of nerves

117. Repetitive regeneration is found in

(a) Tadpole (b) Molluscs (c) Hydra (d) Human beings

118. Reparative regeneration occurs in

(a) Invertebrates (b) Vertebrates

(c) Both invertebrates and vertebrates (d) A few vertebrates

119. Restorative regeneration is common in

(a) Vertebrates (b) Mostly invertebrates

(c) In some vertebrate groups (d) In some invertebrate groups

120. During regeneration, modification of an organ to another is known as

(a) Morphogenesis (b) Epimorphosis (c) Morphallaxis (d) Accretionary growth

121. Regeneration of Hydra is

(a) Morphollaxis by interstitial cells (b) Epimorphosis by interstitial cells

(c) Epimorphosis by archaeocytes (d) Epimorphosis by glandular cells

122. *Hydra* is broken into pieces

(a) *Hydra* will die (b) *Hydra* will undergo sexual reproduction

(c) Some fragments will form complete *Hydra*

(d) Every fragment will grow into complete *Hydra*

123. Reparative regeneration involves

(a) Replacement of lost part (b) Growth of whole organism from a fragment

(c) Healing of injury (d) Both (a) and (b)

124. Restorative regeneration of molluscs includes the reconstitution of

(a) Damaged eyes and eye stalks (b) Part of head

(c) Part of foot (d) All the above

125. Crustaceans, spiders and insects are able to regenerate their

(a) Abdomen (b) Thorax (c) Head (d) Limbs

126. Broken arms are regenerated in

(a) Echinoderms (b) Molluscs (c) Human beings (d) Fishes

127. Salamander and Axolotl larva regenerate

(a) Limbs, eye structures and intestine (b) Jaws and external gills

(c) Both (a) and (b) (d) Trunk

128. Regeneration is possible in tadpoles for amputated

(a) Tail and hind limbs (b) Jaws and eyes (c) Intestine (d) Forelimbs

129. What is true about regeneration

(a) Beak in birds (b) Tail in lizards (c) Fish fins (d) All the above

130. Mammals can regenerate

(a) Brain (b) Liver (c) Lung (d) Urinary bladder

131. What will happen if a piece of sponge is cut into maximum possible pieces

(a) These will die (b) These will differentiate

(c) Each piece will form a sponge (d) Some pieces will develop in organs

132. Repair is effected by cell

(a) Proliferation (b) Migration (c) Both (a) and (b) (d) None of the above

133. Birds are able to regenerate their

(a) Head (b) Tail (c) Beak (d) Legs

134. Restorative regeneration of mollusc includes the reconstitution of

(a) Part of foot (b) Part of head (c) Eye and eye stalk (d) All the above

135. Regeneration was discovered in 1740 by Abraham Trembley which was published by him in 1744 in his book

(a) Fresh water polyp (b) Power of regeneration

(c) Systema naturae (d) Pflanzen familien die naturilichen

136. Hardest part of body

(a) Dentine (b) Enamel (c) Keratin (d) Chitin

137. An undifferentiated bud like structure regenerated by new cells and which continues to grow in size is called

(a) Scion (b) Blastema (c) Bud (d) Pedicel

138. Hydra is an exceptional creature as

(a) It can be dissociated into free cells which can aggregate and restore the body organisation again

(b) It is not subject to ageing

(c) It can regenerate from isolated fragments of body

(d) All the above

139. Excellent power of regeneration is shown amongst vertebrates by

(a) Man (b) Urodele amphibians (c) Urochordates (d) Fish

140. Restorative regeneration is common in

(a) Starfish (b) Sea cucumber (c) Earthworm (d) Salamander

141. Regeneration in sponges was discovered by

(a) Trembley (b) Graafian (c) Wilson (d) None of the above

142. Arthropods show

(a) Autotomy (b) Heteromorphosis (c) Repetitive regeneration (d)Both (a) and (b)

143. Which one of the following, does not exhibit autotomy

(a) Sea cucumber (b) Crab (c) Lizard (d) Hydra

144. The human body regularly loses cells in the region of

(a) Skin surface (b) Lining layer of gut (c) Red blood cells (d) All the above

145. It is said injury to brain is permanent and nerve cell cannot regenerate. The reason is

(a) Absence of nucleus

(b) Cells are very long and centriols involved in other functions

(c) They lack chromosomes

(d) Part of chromatin lies out the nucleus

146. Epimorphosis and morphollaxis was described by

(a) Wilson (b) Morgan (c) Trembley (d) Weiss

147. Characteristic of autotomy (leaving an external body organ by own) is found in

(a) Lizards (b) Snakes (c) Frogs (d) Cockroachs

148. Name the mammalian tissue which has no power of regeneration after damage/injury

(a) Central nervous tissue (b)Skin epidermis (c) Tendon (d) Smooth muscles

149. The heteromorph in Dugesia is characterised by

(a) Two distinct individuals (b) Two sexes in the same body

(c) Many heads (d) Many tails

150. The type of regeneration in which there is replacement of lost part of the body by growth and differentiation of cells from remainder piece of that part is called

(a) Restorative regeneration (b) Reparative regeneration

(c) Morphollaxis (d) Epimorphosis

151. The group of animals which are able to regenerate only the eyes, eye stalk, parts of head and foot belong to

(a) Mollusca (b) Coelenterate (c) Echinodermata (d) Arthropoda

152. In the kidney donors other left out kidney enlarges; it is

(a) Senescence (b) Dedifferentiation

(c) Blastema (d) Compensatory hypertrophy

153. Compensatory hypertrophy in man can be observed in

(a) Lobes of liver (b) Limbs of man (c) Lobes of brain (d) Kidneys

154. The cells which form blastema are called

(a) Epithems (b) Complimentary cells (c) Neoblasts (d) All the above

155. Heteromorphosis is

(a) Regeneration of a part different from the lost part (b)Increase in size of leftover kidney

(c) Regeneration of liver (d)All the above

156. In fish, regeneration is restricted to

(a) Gills (b) Eyes (c) Fins (d) None of the above

157. Autotomy can be observed in

(a) Starfish (b) Lizards (c) Birds (d) Both (a) and (b)

158. One of the following vertebrates have the least power of regeneration

(a) Fish (b) Urochordates (c) Amphibians (d) Birds

159. The proteolytic enzymes involved in vertebrates for regeneration are

(a) Hyaluronidase and lyases (b) Cathepsin and dipeptidase

(c) Deformylase and exopeptidase (d) Restriction endonucleases

160. In planarians, power of regeneration is maximum near the head and minimum near the posterior end. This variation in metabolic rate is called

(a) Dedifferentiation (b) Morphallaxis (c) Axial gradient (d) None of the above

161. Self-evisceration or complete regeneration is shown by

(a) Starfish (b) Hydra (c) Salamander (d) Holothurians

162. Select the correctly matched pair

(a) Growth curve - linear

(b) Regeneration – regrowth of lost part

(c) Morphollaxis – hormone stimulated growth

(d) Stoppage of heart beat – clinical death

163. Select the pair that does not match

(a) Clinical sign of death – brain death

(b) Regeneration of limb of salamander – epimorphosis

(c) Growth of cell without increase in number of cell – auxetic growth

(d) T- cell – produced by peyar's patches

164. Compensatory hypertrophy is referred to the phenomenone when

(a) An organ redeveloped

(b) A small piece of body produced complete animals

(c) One of the paired organs is lost and the other begins to grow in size

(d) An organ is automatically shed

Advance Level

165. If one kidney of a man is lost, the other kidney enlarges to take over the function of the missing kidney and is called

(a) Restorative regeneration (b) Reparative regeneration

(c) Autotomy (d) Compensatory hypertrophy

166. Restorative regeneration is

(a) A regular process in which the dead and worn out cells of some organs are continuously replaced by new cells

(b) Formation of a new organism from a piece of the body of the parent

(c) Healing of wounds

(d) All the above

167. The repair by cell division in the damaged tissue is

(a) Epimorphosis regeneration (b) Morphallaxis regeneration

(c) Exponential growth (d) Deaccelerating growth

168. Replacement of cells of skin takes place in

(a) 1 – 2 days (b) 2 – 8 days (c) 1 – 2 weeks (d) 2 – 3 weeks

169. Blastema formation takes place in

(a) Epimorphosis type of regeneration (b) Morphallaxis type of regeneration

(c) Exponential growth (d) Deaccelerating growth

170. The turnover time for intestinal cells is

(a) 1 – 2 days (b) 2 – 3 days (c) 3 – 5 days (d) 1 – 2 weeks

171. Which of these possesses good regenerating power

(a) Brain (b) Kidney (c) Lung (d) Liver

172. Evisceration occurs in

(a) Coelenterata (b) Annelida (c) Echinodermata (d) Chordata

173. Autotomy is recorded in

(a) Legs in crabs (b) Tail of lizards

(c) Viscera in holothurian echinoderms (d) All the above

174. During regeneration, the following takes place

(a) cell division (b) dedifferentiation (c) cell movement (d) tissue differentiation

(a) b, a, c, d (b) a, b, c, d (c) a, c, b, d (d) c, b, a, d

175. Transformation of one part of an organism into an organism is called

(a) Epimorphosis (b) Morphallaxis (c) Morphogenesis (d) Auxetic growth

176. In man RBC live on average for 120 days, some 200,000 per cc of blood being destroyed every minute. This is an example of

(a) Faulty regeneration (b) Super-regeneration

(c) Physiological regeneration (d) Epimorphic regeneration

177. One of the following is the example of physiological regeneration

(a) Periodical renewal of intestinal lining

(b) Renewal of endothelium of uterus during menstrual cycle

(c) Replacement of antlers by a stage every year

(d) All the above

AGEING & DEATH

Basic Level

178. Ageing in many mammals including man may be due to

(a) Adverse changes in the environment

(b) Interaction between hereditary factors (genes) and the environment

(c) Malnutrition and stress

(d) All the above

179. In old age bones become

(a) Elastic (b) Long

(c) Brittle and easily fracturable (d) Hollow

180. With increasing age, cell volume

(a) Increases (b) Decreases (c) Does not change (d) None of the above

181. In old age problems like indigestion, constipation and gases are caused because of

(a) Number of taste buds are decreased (b) Amount of digestive juices decreases

(c) Muscular strength reduces (d) All the above

182. Ageing is a process programmed by the action of on-off-switches was postulated by

(a) Orgel (1963) (b) Holliday (1974) (c) B.L. Strechler (d) Clinker

183. The parts of the lung affected by ageing are

(a) Alveoli (b) Pulmonary arteries (c) Pulmonary veins (d) All the above

184. The bones of old persons become brittle due to accumulation of

(a) Calcium (b) Magnesium (c) Phosphorus (d) None of the above

185. Ageing is the result of

(a) Cellular changes (b) Extracellular changes (c) Environmental changes (d)All the above

186. Ageing substances are

(a) Pigments (b) Lipofuchsin (c) Weak bones (d) Both (a) and (b)

187. In animals, chalones are substances responsible for

(a) Regeneration (b) Ageing (c) Development (d) Parthenogenesis

188. Thymus and brain are the main factors in the

(a) Stress theory (b) Gene theory (c) Pacemaker theory (d) Mutation theory

189. Which of the following protein plays an important role in ageing

(a) Elastin (b) Collagen (c) Actin (d) Myosin

190. Percentage of nerve cells deteriorated till the age of 70 years is

(a) 10 (b) 20 (c) 30 (d) 35

191. Which is called "Clock of ageing"

(a) Thymus (b) Thyroid (c) Adrenal (d) Pituitary

192. The symptoms of ageing at the organismic level include decrease in the efficiency of

(a) Heart (b) Lungs (c) Kidneys (d) All the above

193. Ageing is characterised by

(a) Decline in metabolic activity (b) Increased metabolic activity

(c) Increased anabolism (d) Increased O_2 consumption

194. During ageing, collagen present in intercellular spaces becomes

(a) Destroyed (b) Impermeable and rigid (c)More elastic (d) All the above

195. Immune system of the body is impaired in old age which

(a) Decreases memory (b) Makes skin loose and wrinkled

(c) Increases chances of infection (d) Decreases chances of infection

196. Generally decline in hearing power begins after the age of

(a) 50 years (b) 30 years (c) 40 years (d) 10 years

197. Gerantology is the branch of developmental biology which deals with the study of

(a) Cancer (b) Ageing (c) Fossils (d) Death

198. Ageing is process which takes place in

(a) Non-living (b) Dead (c) Living (d) None of the above

199. Ageing is characterised by

(a) Nuclear pyknosis (b) Changes in collagen of extracellular fluid

(c) Hypotrophy of cells (d) All the above

200. Genetic clock was propounded by

(a) V. N. Naik (b) Dr. Singh (c) B. Pal (d) None of the above

201. With the advancement of age, hair of males start thinning due to

(a) Falling of hair (b) Low ATP formation

(c) Reduced rate of protein synthesis (d) None of the above

202. Most accepted theory of ageing is

(a) Death of brain cells (b) Nonfunctioning of α-cells in pancreas

(c) Less RBC in blood (d) Nonfunctioning of thymus gland

203. Which is not connected with theory of ageing

(a) Wear and Tear (b) Neurohormonal changes (c)Epimorphosis (d) Metabolic rate

204. Ageing starts with disappearance of

(a) Spleen (b) Pituitary gland (c) Thymus gland (d) Parathyroid gland

205. Which one of the following is true during ageing

(a) Decrease in blood urea and GFR

(b) Increase in calcium content of arteries and cartilage

(c) Decrease in cholesterol content of cornea and lens

(d) Decrease in calcium content of arteries and cartilage

206. Which of the following is ageing pigment

(a) Lipofuschin (b) Viletemin (c) Both (a) and (b) (d) Bilirubin

207. Which of the following is scientifically true for death

(a) An organism dies because all its cells die (b) Organism after death can be born again

(c) Death is a natural part of life cycle

(d) Otherwise the earth will become too much crowded

208. The type of immunoglobulin present in the foetus are

(a) IgD (b) IgE (c) IgG (d) IgM

209. The theory of ageing dealing with the weakening of defence mechanism of body against invasion of foreign germs etc is called

(a) Wear and tear theory (b)Immunity

(c) Central nervous system theory (d) Environmental and genetic theory

210. Increased inactivity of the enzyme aldolase results in

(a) Regeneration (b) Fast degeneration of fats (c)Ageing (d) All the above

211. 'Clinker theory' of ageing deals with

(a) Impermeability of collagen (b) Loss of elasticity

(c) Accumulation of waste products in the cells (d) All the above

212. Where the conversion of harmful prussic acid into potassium sulphocynide takes place

(a) Spleen (b) Liver (c) Bone marrow (d) Lymph glands

213. Modified collagen fibres Sharpey's perforating fibres are related with

(a) Fixing of scales (b) Heart contraction (c) Muscle contraction (d) All the above

214. Environment genetic interactions greatly affect the process of

(a) Ageing (b) Senescence (c) Mortality (d) Youth

215. An apoplasmatic substance which plays a very important role in ageing

(a) Collagen (b) Elastin (c) Actomyosin (d) Tubulin

216. The body loses the power of defence against invasion of germs with ageing due to atrophy of

(a) Liver (b) Kidney (c) Thymus (d) Spleen

217. Increase in the life span of animals on domestication indicates that

(a) Ageing is not due to changes in the environment

(b) Environment also plays an important role in ageing

(c) Ageing is due to genetic factors and environment has no role to play

(d) Ageing is due to a combination of these factors.

Advance Level

218. According to which theory, the resistance of body decreases with the increase in age

(a) Immunity theory (b) Collagen theory (c) (a) and (b) both (d) None of the above

219. Which theory holds that accumulation of specific waste products causes ageing

(a) Waste product theory (b)Metabolic theory (c) Immunity theory (d) All the above

220. The theory of ageing holds that ageing is due to

(a) Random mutation in D.N.A. of somatic cells

(b) Increased cross-linkage of collagen & other proteins

(c) Cumulative result of damage to tissues by free radicals (d) All the above

221. Which of the following is the environmental theory of ageing

(a) The radiation affects the gene mutation resulting in the DNA transcription in somatic cells

(b) The rate of ageing and age is controlled by the ageing gene

(c) Environmental and hereditary factors control the ageing

(d) Metabolic rate affects the ageing

222. Errors are accumulated due to translation of genetic code affecting the ageing. The theory is

(a) Mutation theory (b)Error catastrophe theory

(c)Environmental theory (d)Gene theory

223. Degenerative changes occur during

(a) Metamorphosis only (b) Parthenogenesis

(c) Ageing only (d) Both in metamorphosis and ageing

224. B-cells and T-cells become less active in old age. They secrete ..... respectively

(a) Lymphocytes only (b) RBC and antibodies

(c) Antibodies and RBC (d) Antibodies and lymphocytes

225. The science of ageing is called **or** The study of degenerative changes is called

(a) Chronology (b) Odontology (c) Gynaecology (d) Gerontology

226. In old age the activity of collagen protein is badly affected. This is

(a) Permeability which becomes very slow (b) Permeability which becomes very high

(c) Diffusion which becomes very low (d) Diffusion which becomes very high

227. With advancing age in the liver cells there is increased inactivity of

(a) Lipase enzyme (b) Ptyalin enzyme (c) Rennin enzyme (d) Aldolase enzyme

228. The efficiency of heart decreases with age so heart pumps about ..... blood per minute in comparison to young age

(a) 20% (b) 40% (c) 65% (d) 85%

229. In old age memory

(a) Increases (b) Impaired

(c) Remains same as in young age (d) None of the above

230. Error catastrophe theory was propounded by

(a) B. Pal (b) Orgel (c) Strechler (d) None of the above

231. Intercellular depositions occurs during

(a) Growth (b) Repair (c) Regeneration (d) Ageing

232. Blood volume

(a) Increases with age (b) Decreases in old age

(c) Remains the same as in adulthood (d) Least in diseased man

233. Ageing is caused by disappearance of

or

Which one of the following is gradually reduced and degenerated in ageing according to immunity theory

(a) Thyroid (b) Parathyroids (c) Thymus (d) Pitutary

234. In an ageing person there is a

(a) Increase in mucopolysaccharide cement of connective tissue

(b) Gradual alteration in components of connective tissue

(c) Increasing collagen rigidity of connective tissue (d)Both (b) and (c)

235. Assertion (a) **:** Old age is not an illness. It is a continuation of the life with decreasing capacity for adaptation.

Reason (R) : Cessation of mitosis is a normal genetically programmed event.

(a) Both assertion and reason are true and the reason is the correct explanation of assertion

(b) Both assertion and reason are true but the reason is not the correct explanation of assertion

(c) Assertion is true statement but reason is false

(d) Both assertion and reason are false

236. As the age advances, there is a gradual loss of hair. This is mainly because of lowered

(a) Blood supply (b) Availability of energy

(c) Synthesis of proteins (d) Synthesis of glycogen

237. The theory of ageing holds that ageing is due to

(a) Random mutation in DNA of somatic cells

(b) Increased cross-linkage of collagen and other proteins

(c) Cumulative result of damage to tissues by free radicals (d)All the above

238. Which of the following is the cause of death

(a) Metabolic rate is affected

(b)Sudden check in blood circulation to brain and lungs

(c) Immune system does not work (d)All the above

239. Irresible breakdown of body function is

(a) Senescence (b) Death (c) Ageing (d) Both (a) and (c)

ANSWER

ASSIGNMENT (BASIC & ADVANCE LEVEL)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
c	a	b	d	d	a	d	d	d	c	a	a	a	d	a	a	b	a	d	c
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
c	c	d	a	d	a	d	d	b	d	b	d	b	c	d	b	b	a	c	c
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
b	b	c	a	a	d	b	c	b	a	a	d	d	b	c	d	c	a	d	c
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
b	d	a	c	a	a	c	b	b	c	d	c	b	d	d	c	a	d	d	c
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
d	c	b	c	c	c	d	a	d	c	a	b	d	d	a	c	c	c	a	b
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
d	a	c	d	a	c	a	a	b	b	b	a	c	b	c	a	c	c	d	c
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
a	d	c	d	d	a	c	a	d	b	c	c	c	c	a	b	b	d	b	d
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
c	d	d	d	b	b	a	a	c	d	a	d	d	c	a	c	d	d	b	c
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
d	b	d	c	d	a	a	c	a	b	d	c	d	a	b	c	d	d	c	b
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
b	c	d	a	d	d	b	c	b	b	a	d	a	b	c	a	b	c	d	c
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
c	d	c	c	b	a	c	c	b	c	c	b	a	a	a	c	b	a	a	d
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	
a	b	d	d	d	a	d	c	b	b	d	b	c	d	b	c	d	d	b	

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