PREFACE

With its grounding in the "guiding pillars of Access, Equity, Equality, Affordability and Accountability," the New Education Policy (NEP 2020) envisions flexible curricular structures and creative combinations for studies across disciplines. Accordingly, the UGC has revised the CBCS with a new Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) to further empower the flexible choice based credit system with a multidisciplinary approach and multiple/ lateral entry-exit options. It is held that this entire exercise shall leverage the potential of higher education in three-fold ways - learner's personal enlightenment; her/his constructive public engagement; productive social contribution. Cumulatively therefore, all academic endeavours taken up under the NEP 2020 framework are aimed at synergising individual attainments towards the enhancement of our national goals.

In this epochal moment of a paradigmatic transformation in the higher education scenario, the role of an Open University is crucial, not just in terms of improving the Gross Enrolment Ratio (GER) but also in upholding the qualitative parameters. It is time to acknowledge that the implementation of the National Higher Education Qualifications Framework (NHEQF), National Credit Framework (NCrF) and its syncing with the National Skills Qualification Framework (NSQF) are best optimised in the arena of Open and Distance Learning that is truly seamless in its horizons. As one of the largest Open Universities in Eastern India that has been accredited with 'A' grade by NAAC in 2021, has ranked second among Open Universities in the NIRF in 2024, and attained the much required UGC 12B status, Netaji Subhas Open University is committed to both quantity and quality in its mission to spread higher education. It was therefore imperative upon us to embrace NEP 2020, bring in dynamic revisions to our Undergraduate syllabi, and formulate these Self Learning Materials anew. Our new offering is synchronised with the CCFUP in integrating domain specific knowledge with multidisciplinary fields, honing of skills that are relevant to each domain, enhancement of abilities, and of course deep-diving into Indian Knowledge Systems.

Self Learning Materials (SLM's) are the mainstay of Student Support Services (SSS) of an Open University. It is with a futuristic thought that we now offer our learners the choice of print or e-slm's. From our mandate of offering quality higher education in the mother tongue, and from the logistic viewpoint of balancing scholastic needs, we strive to bring out learning materials in Bengali and English. All our faculty members are constantly engaged in this academic exercise that combines subject specific academic research with educational pedagogy. We are privileged in that the expertise of academics across institutions on a national level also comes together to augment our own faculty strength in developing these learning materials. We look forward to proactive feedback from all stakeholders whose participatory zeal in the teaching-learning process based on these study materials will enable us to only get better. On the whole it has been a very challenging task, and I congratulate everyone in the preparation of these SLM's.

I wish the venture all success.

Professor Indrajit Lahiri
Authorised Vice-Chancellor
Netaji Subhas Open University (NSOU)

Netaji Subhas open University

Four Year Undergraduate Degree Programme

Under National Higher Education Qualifications Framework (NHEQF) & Curriculum and Credit Framework for Undergraduate Programmes

Bachelor of Science (Honours)

Subject : Honours in Zoology (HZO)

Course Type : SEC-04

Course Title : Insect Biology, Disease and Health and Nutrition

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UNIT I ❑ Insect - General features and basic classification; General morphology - head, eyes, mouth parts, legs and their adaptations

Structure / Content

I.I Objective

From this unit you will learn about insects and their classification and morphology.Insects are most numerous & successful creatures on Earth. Their species richness or diversity surpasses any other group of organisms. In the animal kingdom more than 85 per cent of the species belongs to insect group.Total number of insects described so far is more than 9 lakhs approximately.

I.II Introduction

The earth is literally crawling with insects, otherwise known as members of the class Insecta or Hexapoda under the phylum Arthropoda. It would be hard to get through the day without a close encounter with a six-legged species. Insects are so prolific that added together they outnumber all other life forms combined. Insects can be found on land, in

the air, and in the sea. Insect diversity is astonishing. From the minute flea (smallest insect) to the majestic monarch butterfly (largest insect), there are around a millions of different species. Insects are the most ancient group of animals. The first insects probably originated before the Devonian period (400 – 360 million years ago) and by the Carboniferous period (360 - 285 million years ago) .In spite of their vast differences, all insects have certain characters in common which are :

I.III General Characters of Insects

1. Insect body is divided into three general region, head, thorax and the abdomen.
2. Thorax is divided into three segments, anterior most the prothorax, middle the mesothorax and the posterior metathorax.
3. These three thoracic segments bears three pairs of jointed legs (that's why insects are also known as Hexapoda) , one pair on each thoracic segments.
4. Head bears a pair of compound eyes (in some cases simple eye or ocelli may also be present) and a pair of antennae.
5. Both meso and metathorax also bears one or two pairs of wings.
6. Abdomen is the largest part of insect body and it is often large and bulbous.
7. Abdomen contains important internal structures such as the digestive system and reproductive organs etc.
8. Insect body is covered by an exoskeleton made up of chitin (a nitrogenous carbohydrate) commonly known as cuticle.
9. Insect head is made up of fused six segments of which segment two bears antennae, segment four bears mandibles, five bears maxillae and six bears labium. Segments one and three do nt contain any appendages.
10. Head also bears a presegmental acron which bears the compound eye.
11. Abdomen is made up of eleven segments which do not bear any appendages.
12. Insects respires through tracheae.
13. Excretion in insects occurs through malphigian tubules which are present in the gut of insects.

14. Development in most of the insects are indirect that is trough larval or nymphal stages.

15. Insects have circulatory system which is of open type i.e. blood flows through body cavity or haemocoel and the insect blood is green and it never helps in respiration.

I.IV Basic classification of Insecta

The traditional taxonomy provides the most convenient and authentic classification based on the overall similarities, most visible characters between species. It is pivotal in species recognition (with identification keys) and management of biological collections. At the beginning, classification work was restricted to just taxonomic details of the organism without considering the degree of relatedness between species. Later in 1950s, the phylogenetic classification cropped up to take care of the evolutionary history of the organism. The different schools, (part of conventional taxonomy) that differ in their concepts of phylogenetic classification butstill converge on the basis of morphological similarities between species. Following are basis for insect taxonomy:-

A. Conventional or Evolutionary Taxonomy

Evolutionary taxonomy, originated in early twentieth century, attempts to classify the organisms based on phylogenetic relationships coupled with degree of evolutionary changes. It takes taxon into consideration rather than a species. The characters differ in information content regarding phylogeny and hence have different weights. In this taxonomy characters like wing venation , genetilia , mouth parts etc are considered to be most important. Evolutionary taxonomists see two types of taxa viz., monophyletic and paraphyletic taxa arising from the processes of speciation through cladogenesis and anagenesis, respectively. evolutionary taxonomists believe that classifications should highlight only genealogical taxa, and those taxa can be either monophyletic or paraphyletic .

B. Phenetics or Numerical Taxonomy

Phenetic taxonomy determines the relationships of organisms through a measure of similarity, considering plesiomorphies (ancestral traits) and apomorphies (derived traits) to be equally informative. It aims at natural classification using numeric algorithms like cluster analysis rather than using subjective evaluation of properties. A priori every character is given equal weight.

C. Cladistics or Phylogenetic Taxonomy

In cladistics, taxonomy is mainly based on common ancestry and hence, believes in cladogenesis, where two taxa originated in the same branching event have a common ancestor that is not shared by any other taxon. Thus, cladistics represents only monophyletic taxa in their taxonomy.

D. Cladoendesis- a new approach to taxonomy

The term cladoendesis was introduced by N. J. Kluge in early twenty-first century, meaning "branch coupling" that pays more attention on the connection between apomorphies of each taxon and characteristics of higher taxa, so that the characters of all the taxa are, from the very beginning, considered to be interrelated within a certain hierarchy . It is a method of phylogenetic analysis opposed to various matrix methods. The phylogenetic trees are not built each time as new ones but reconstructed based on the previous results where each character of each taxon is compared with its ancestral condition in the ground plan of the higher taxon .Cladoendesis enables understanding of nature and evolution of metamorphosis in insects.

Classification of insects up to orders

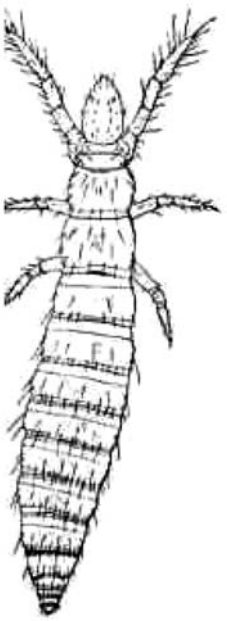
Class Insecta or Hexapoda are divided into two sub classes which are Apterygota and Pterygota. Apterygota insects are also known as Ametabola and similarly Pterygota insects are also known as Metabola. Metabolus insects are of two types Hemimetabolus (partial metamorphosis) and holometabolus (total metamorphosis) insects.

Sub class I :- Apterygota or Ametabola

These insects are primitively wingless , without metamorphosis. Head is prognathous type. Abdominal appendages may be present. Ectognathous mouthparts, with mandibles attached at one point. There is no metamorphosis . This subclass is divided into four Orders.

Order-I-Protura

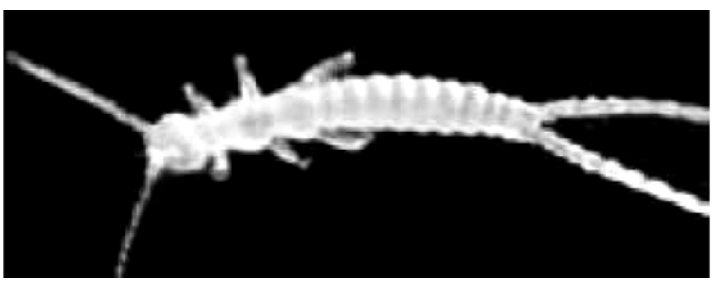
These insects are also known as Telson tail insect and have world wide distribution. This order have 90 tto 98 species. Insects are minute with white body. Head is of Prognathus type and eyes are absent.Wings and antennae are also absent. Prothorax is reduced and tarsus is one segmented. Abdomen is 11 segmented. Telson is present but without cerci. Normally these insects live in dark and damp places.



Example- *Acerantomon* sp.

Order-II- Diplura

These insects are also known as double tail insects. These are herbivorous and predaceous insect and lives in dark and damp places. These insects are worldwide in distribution distribution and have more than 400 species. Head is prognathus type and eyes are absent. Antennae are present and are of monoliform type. Mouth parts are mandibulate type. Wings are also absent. Tarsus is one or two segmented. Cerci are also present and it is very long. These insect is about 1-2 mm in size.

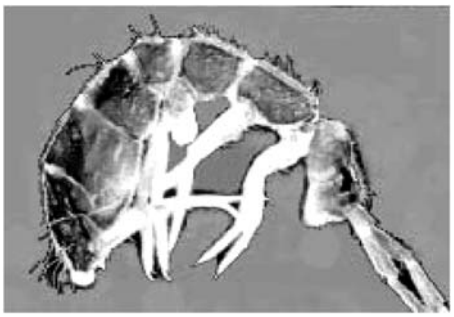


Example-*Campodea* sp, *Japyx* sp.

Order-III- Collembola

These insects are also known as Spring tail. These insects are minute soft bodied insect with 11-2 mm in size. Insects are dull whitish in colour. Head is prognathous type.

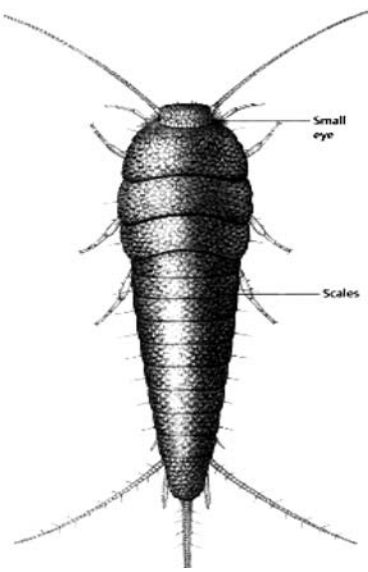
Presence of Compound eyes with 8 facets. Ocelli absent. Antennae 4-6 segmented and filiform. Maxilla and labium reduced. One-segmented tarsus is fused with tibia. Abdomen is 5-segmented segmented with a telson, which is modified to form form a springing organ. The Furcula is a forked springing organ on the 2nd and 3rd abdominal segments. These insects can jump about 3 inches high with the help of furcula. Cerci is absent. Their food consists of decaying matter in damp soil.They are found in decaying matter, in damp places, in debris etc.



Example- *Sensiphorula sp, Coloburella sp*

Order-IV-*Thysanura*

These insects are also known as bristle tail insects. The order includes about 350 species. Insects have soft elongated bodies covered with silvery scales. Prognathous head with compound eyes and with or without ocelli. Antennae long, multi-segmented, filiform. Mouthparts biting and chewing type. Tarsi 2—4 segmented. Cerci long and multi-



Example-*Lepisma sp.*

segmented, filiform, usually three. They are primitively wingless insects. They are found in a variety of habitats, usually in damp and dark places. Silverfish are found on the walls in houses, behind the pictures and books. They are omnivorous and prefer starchy material.

Sub class II- Pterygota or Metabola

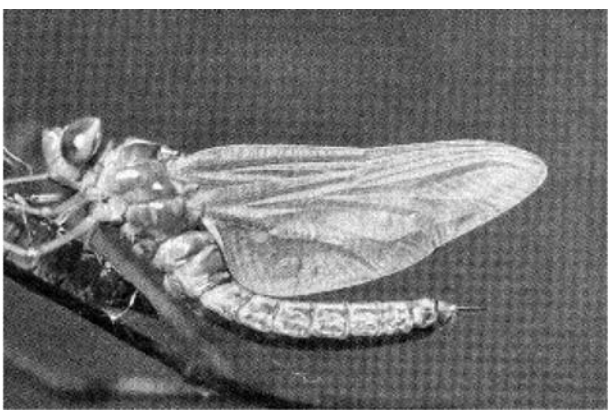
These insects are winged or secondarily wingless , with prognathous or hypognathous head. Mouthparts are of endognathous type. Metamorphosis occurs and it is either incomplete without a pupal stage or complete with a pupal stage. These insects are again subdivided into two major divisions which are-

Division I : Exopterygota or Hemimetabola

The most important characters of these group of insects are (i) wings develop externally during the larval growth and (ii) there is no pupal stage. Nymphs possess compound eyes and have similar habits and habitats as the adults. This Division is again classified into 16 orders which are :

Order-I- Ephimeroptera

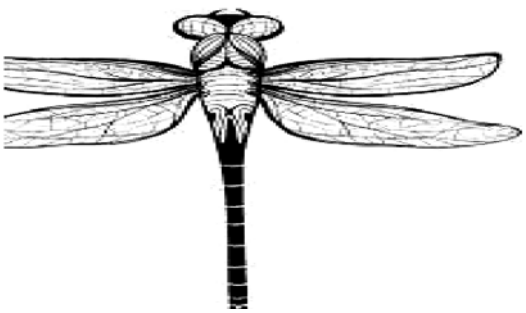
These insects are small, light-coloured, coloured, soft-bodies, light greenish or yellowish in color and commonly known as May flies. Head is prognathous type and compound eyes are well-developed. Ocelli are also present and, number are three. Short, setiform antennae is present.. Mouthparts biting and chewing type by vestigial. Weak clinging type of legs, with 5-jointed jointed tarsi. Tip of abdomen with two or three long cerci. Larvae are aquatic and called “Naiad”, having abdominal gills, chewing mouthparts. Larvae are mostly herbivorous but sometimes carnivorous also.Adults are found in swarms, particularly particularly in the morning and evening, near water bodies.



Example-*Rhithrogena sp.*

Order-II-Odonata

These insects are also known as dragonflies and damselflies. these are medium to large-large-sized insects, with well-sclerotized, hard bodies, hypognathous head, large compound eyes and 3 ocelli. Antennae are short, 33-segmented, aristate type. Mouthparts are strong biting and chewing type. Wing venation is net-like, with large number of cross veins. Larvae are aquatic and called Naiads and are predaceous on small insects and other organisms. These insects are strong fliers.



Example- *Petalura sp ,Uropetala sp.*

Order-III-Orthoptera

These are medium to large sized insects, having long, jumping hind legs. Fore wings thick and leathery in texture and cover the larger and known as tegmina, membranous hind wings which are used for flying. Fore wings are used as balancers during flight. They have large compound eyes and 2 3 ocelli. Mouth parts are strong biting and chewing type. In crickets, particularly in mole-crickets, mole rickets, fore legs are modified for digging and hind legs for jumping. These insects are commonly known as grasshoppers, mole crickets , locust and crickets.

Example- *Locusta sp., Schizodactylus sp, Gryllotalpa sp*

Order-IV-Dictyoptera

These insectss are commonly known as cockroaches and praying mantis. Medium to large insects, with forewings leathery or chitinous, tegmen—like like and hind wings large and membranous used for flying. Head is hypognathous, with strong mandibulate mouth parts. Eggs are laid in a protective ootheca. Antennae very long and setaceous, generally longer than body. These insects are found in dark and damp places and are omnivorous and scavengers in habit.

Example- *Periplaneta sp., Blatta sp.*

Order- V- Phasmida

These insects ts are commonly known as stick insect and leaf insects and ghost insects. These insects are cryptically coloured, brown or green phytophagous in habits. Fore wings are leathery while hind wings membranous. Mouthparts are biting and chewing type. All legs are similar with small coxae and used for slow walking on plants. Head having long filiform antennae and small compound eyes. Male genitalia and ovipositor concealed. Leaf insects are superb mimics of the broad-leaved broad leaved plants. Their wings are flattened, green and venation mimicking leaf-venation. Legs also got flattened leaf-like.

Example-*Exstatosoma sp., Phyllium sp*

Order-VI-Plecoptera

These insects are commonly known as stone flies and salmon flies. These are medium to large insects, having about 1500-1700 species. Head is prognathous, with small to

moderate compound eyes. Ocelli present or absent. Antennae long, either filiform or setaceous. Mouthparts are mandibulate but weak. Wings are transparent,, the hind wing a little broader, while resting they are folded over the abdomen. Tarsi 22-3 segmented. Tip of abdomen with two long filiform cerci but without an ovipositor. Males can produce drumming sound with a disc-like percussion on 9th abdominal segment. segment. Adults are herbivorous or predaceous found resting on vegetation by the side of water sources. Nymphs are aquatic, predaceous, found in the rapidly flowing streams.

Example-*Perlesta sp.*

Order-VII-Isoptera

These insects are commonly known as white ant or termites. These are small (2-33 mm long) soft soft-bodied social insects having caste system. The castes are queen, which is physogastric (having enormously enlarged abdomen), males which are apterous in the nest and alate during nuptial flight; workers having broad, chewing type of mandibles; soldiers having long, pointed dagger-like dagger like mandibles for defence and in some colonies thereare nasutes which bear a long pointed snout for secretion of a highly corrosive fluid that can be used to defend the colony or to make galleries through hard rocks. They are photophobous and live in underground nests called “termatoria” and always move through galleries. Compound eyes are small or sometimes absent; ocelli also either two or absent. Head is prognathous and antennae moniliform. Mouthparts are mandibulate type. Abdomen is broadly attached to the thorax. Legs are short adapted for slow-walking slow walking and tarsi 44-jointed. Wings when present are of equal size.

Example-*Odontotermis sp, Kalotermis sp*

Order-VIII-Zoraptera

This order contain only one genus named Zorotypus and there are about 20 species.These These insects are small, pale, soft bodied insects resembling termites, with large hypognathous head. Antennae are moniliform, 99-segmented and the size of the segments increases gradually from base to the apex. Mouthparts biting and chewing type. They are mostly withoutt eyes and Ocelli but some species have eyes. Legs are short and adapted for slow walking, with 2-segmented segmented tarsi. Cerci are short. They are gregarious insects but do not have caste system. They feed on fungus and some are predaceous on mites. Zorapterans are found in decaying wood orunder the bark or in humus.

Example- Zorotypus sp.

Order-IX-Embioptera

These insects are also known as web-spinners. spinners. These are small slender-bodied insects, with a large prognathous head. Compound eyes are large in malee but smaller in female. Ocelli are absent. Antennae are filiform type and mouth parts are mandibulate type. Females are wingless but males are winged, with membranous, transparent or sometimes cloudy equal-sized wings. Legs short, adapted for crawling.

Fore leg with first segment of tarsus enlarged containing silk-gland. gland. Thorax elongated, almost equal to abdomen. Cerci 2-segmented, asymmetrical in male. These are gregarious insects, which live under bark, in rocks or in debris, in silken tunnels. These insects are nocturnal and totally phytophagous in habit, feeding mostly on fungus.

Example- *Andesembia sp, Microembia sp.*

Order-X-Dermaptera

These insects are commonly known as earwig. The insects have narrow, elongated bodies with prognathous head and generally dark coloration. They have prognathous head, with well-developed well developed compound eyes (sometimes eyes are absent). Ocelli absent. Antennae are long and filiform and mouthparts strong mandibulate.Forewings are reduced to short leathery tegmina under unde which large membranous, fan-like hind wings are kept folded . Legs are strong for and tarsi are 3-segmented.Abdomen is 11-segmented, at the tip of which cerci are modified in the form of forceps, which are used for defence. Ovipositor is reduced.These reduced.These insects are nocturnal and prefer moist dark places, sometimes attracted to light in the night. They are predaceous in tropics and herbivores in temperate area.

Example- *Euborelia sp.*

Order-XI-Psocoptera

These insects are commonly known as book lice. These insects are small, fragile, light-coloured coloured and wingless. They have large hypognathous head and depressed

body. They have large compound eyes and 3 ocelli. Antennae are long and filiform. Mouth parts are manbibulate, manbibulate, used for feeding on debris, book-glue or cereals. Book lice are wingless but bark lice are winged, having membranous wings, fore wing being larger than hind wings. Wings are held tent-like over the abdomen while at rest. Legs are slim, hind femora aare enlarged and tarsal segments are1-3 segmented. Abdomen is 10-segmented and cerci absent. Adults can make ticking sound by striking venter against the loose wood or paper. That is why sometimes they are called “death watch”. Psocopterans lay very large egg which measures about one-third of their body size.

Example-*Psocus sp.*

Order-XII-Mallophaga

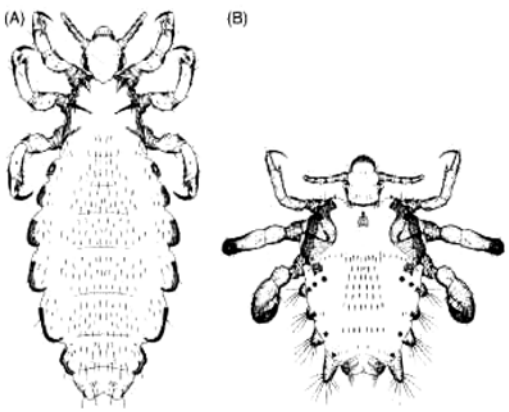
These insects are commonly known as bird lice because these insects are ectoparasites of bird .About 2000-2100 species are present in this order. These insects possess

Example-*Phthiraptera sp*

dorsoventrally flattened body with a tough integument. Head is large and distinct, with short filiform antennae and strong biting and chewing mouthparts. Compound eyes reduced and ocelli absent. Legs are short and adapted for clinging; tarsi 1-2 segmented, claws two and curved. Abdominal segments 8—10 and cerci absent. Eggs are glued to the feather base. These insects generally feed on feathers, hairs, skin, scales and on dried blood around wounds.

Order-XIII-Anopleura

These insects are commonly known as human lice. There are about 400 species in this order.All insects in this order are ecto-parasites of human and other mammals. These are small grey or pale insects with dorso-ventrally flattened bodies, with small head. Eyes are rudimentary and ocelli absent. Antennae 3-5 segmented and filiform. Mouthparts are modifies for sucking. Legs are short and stout and joined on the side of the thorax. Tarsi 1-segmented. Claw single, long, curved and adapted for clinging on to the hair. They are secondarily wingless. Abdomen is 9-segmented and contains no cerci. They live on mammals at constant body temperatures and transmit diseases such as relapsing fever, epidemic typhus and trench fever.



Example- *Pediculas humanus capitis (human head louse), Pediculas humanus corporis (human body louse), Pthyrus pubis (human pubic louse).*

Order-XIV-Thysanoptera

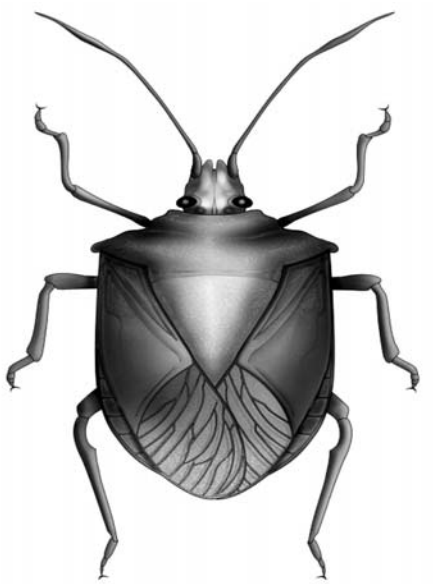
These insects are commonly known as thrips and this order contains about 2500-2600 species. These insects have long narrow wings, whose margins are fringed with long hairs. head hypognathous with prominent compound eyes and short antennae containing 6-10 segments. Mouthparts are rasping and sucking type. Legsshort, with one or two

tarsal segments and claws reduced but aerolium enlarged. Cerci are absent. Thrips live in a variety of habitats, viz. in cracks and crevices, under leaf sheaths or in flower petals or in grasses. Some species are aquatic. Most of the species feed on plant tissues by rasping the epidermis and therefore pests of agriculture, some are scavengers and others predators of small insects such as aphids and mites. They lay eggs inside the plant tissues. Some species serve as vectors of bacterial and viral plant diseases.

Example- *Aeolothrips sp, Thrips sp.*

Order-XV-Heteroptera

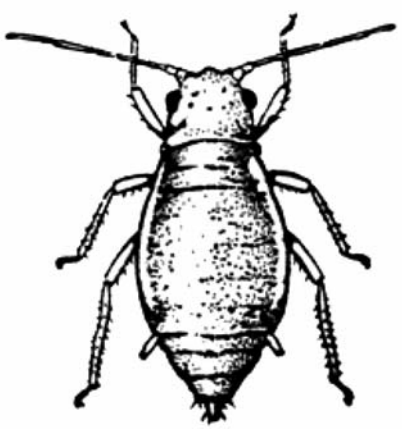
These insects are commonly known as bugs. This is one of the largest order in class insecta. Compound eyes are large and ocelli may be present or absent. Antennae 2-10 segmented, filiform or aristate. Mouthparts are piercing and sucking type segmented proboscis. There is a large, triangular scutellum on thorax. Cerci are absent. Fore wing is half thick, parchment like and hind wing is membranous.



Example- *Rhodnius sp., Cimex sp., Lohita sp.*

Order-XVI-Homoptera

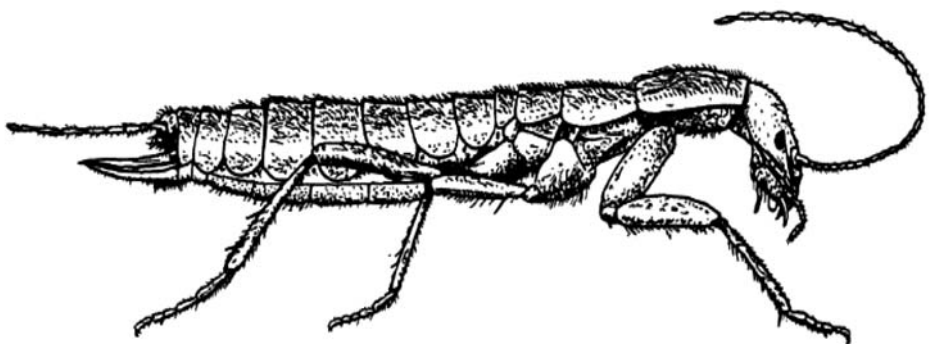
These insects are commonly known as aphids ,cicadas and scale insects. Previously both Heteroptera and Homoptera are included under single order the Hemiptera. The only difference in between heteroptera and homoptera is that in case of homopteran insects both pairs of wing are membranous but in case of heteroptera only the hind wing is membranous. These insects are noxious pest of agriculture.



Example- *Aphis sp*

Order-XVII-Grylloblattodea

There are only 6 species in this order and these insects shows very primitive characters. These insects can be found beyond 6000 ft altitude. These are wingless insects, without eyes and ocelli but sometimes reduced eyes may be present. Antennae are long and filiform and mouthparts mandibulate. All legs are similar with 5-segmented tarsi. There is one pair of long, 8-segmented, filiform cerci. Female possesses long ovipositor. Head is prognathous and body dorsoventrally flattened.



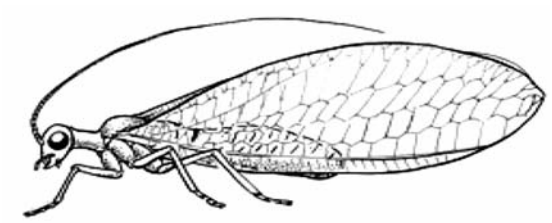
Example- *Grylloblatta sp.*

Division II : Endopterygota or Holometabola

These insects have complete metamorphosis i.e. larval stages are morphologically completely different from that of their adult. Larva are variously known as caterpillar ,maggot ,grub etc. Not only that during metamorphosis there is a pupal stage. Wings developed internally inside the pupal case. There are 9 orders in this division which are :

Order-I-Neuroptera

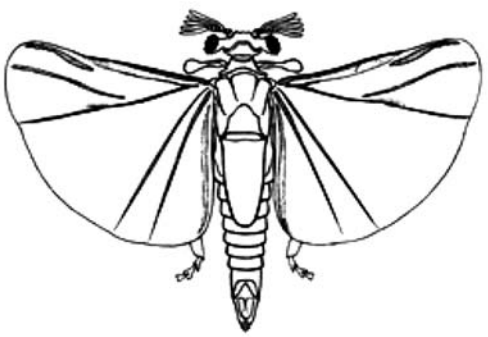
These insects are commonly known as ant lion and lace wings. Neuroptera have two pairs of similar size membranous wings with a complex, net-like pattern of veins. They are rather fragile insects. Adults have chewing mouthparts, but some larval mouthparts are modified for piercing and sucking. They are considered beneficial because they feed on other insects. Immature antlions are called "doodlebugs." They form pits in dry, dusty soil.



Example- *Chrysoperla sp ,Chrysopa sp*

Order-II-Strepsiptera

These insects are commonly known as stylopoids. These insects (only female insect) lives as parasites on insects and therefore the size of these insects are very small. There are about 400 species in this order. The hind pair of wing is twisted while the fore pair of wing is small enough and functions like haltere as in Diptera. Female insects do not have any wing , antennae and legs .Reproduction by means of parthenogenesis and males do not have any role in reproduction.



Example- *Stylops sp*

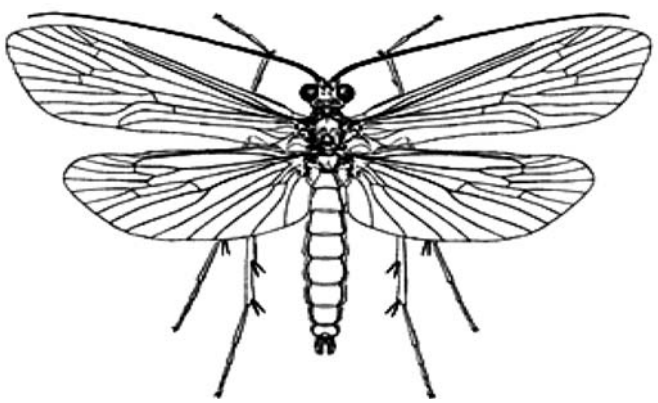
Order-III-Siphonoptera

These insects are commonly known as flea. These are dark bodied insects and are of 1-10 mm in size.These are wingless insect. Hins leg is adapted for jumping. Mouth parts is adapted for piercing and sucking.There are rows of bristles present on the head. These insects transmit pathogens that cause disease in humans and other animals. There are almost 325 species in this order.

Example-*Xenopsilla sp.*

Order-IV-Trichoptera

These insects are commonly known as caddish flies and almost 14500 species described so far. These are dull coloured insects with a size of 2-40 mm. Two pairs of membranous wings are present and it is covered with hairs. Mouthparts is reduced and long filliform antenna is present. Larval forms are aquatic. Adult insects are predominantly found near the water body and are nocturnal.

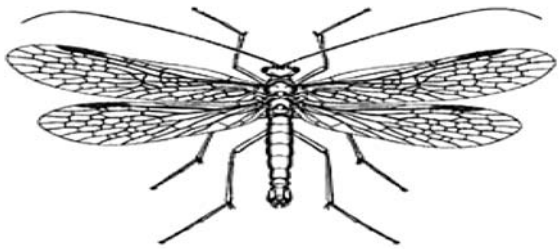


Example-*Nyctiophylax sp*

Order-V-Mecoptera

These are commonly known as scorpion flies and almost 85-125 species present in this order. The body of the insects are soft , elongated and cylindrical. Head is

opisthognathus type with chewing mouth parts. Two pairs of membranous wings are present. Antennae thread like and filliform . Tarsa is five segmented. These insects are found world wide.



Example- *Compendium sp*

Order-VI-Coleoptera

These insects are commonly known as beetles and weevils. It is the most diversified group and largest order. The most important character is the presence of elytra which is the modified fore wing. Elytra is the protective covering of the membranous hind wing. Mouth parts are mandibulate type. Majority of the insects are herbivorous but some are predacious . Some insects are scavengers also. Larval stages are known as grubs. Tarsi are 2-5 segmented. Slender campodiform larval stages also present. The number of species is more than 300000 in number which belongs to 166 families.

Example-*Apion sp , Rhizopertha sp , Tenebrio sp and Tribolium sp*

Order-VII-Diptera

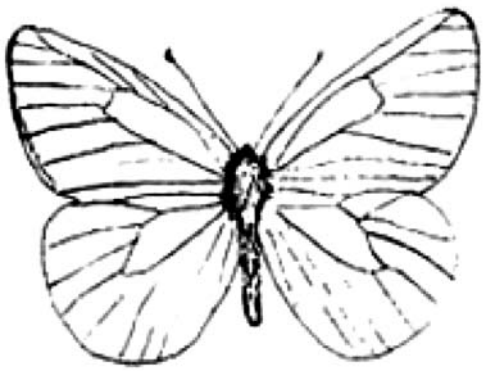
These are commonly known as true flies. These insects posses only fore pair of wing and hind pair is modified into haltere which is a balancing organ. They have large compound eyes and long or short antenna. They have either sucking or haustellate type of mouth parts. Mesothorax is larger than pro and metathorax. Larval stages are known as maggots.

Head is normally small and retractile. Some of insects are acting as a vector causing major diseases of humans. They have a proboscis formed principally by the elongated labium, which ends in a pair of lobes, the labella. This labium may serve as a support and guide to the remaining mouthparts that areenclosed within it.

Example- *Musca sp, Anophelis Sp, Culex sp., Aedis Sp., Calliphora sp.*

Order-VIII-Lepidoptera

These insects are commonly known as butterflies and moths. The name means "scale wing," and lepidopteran wings are covered with microscopic scales, which are iridescent and brightly colored. Mouth parts formed coiled tube known as proboscis. Antenna is either knobbed ,hooked or comb comb like. There are almost 113000 species found all over the world.

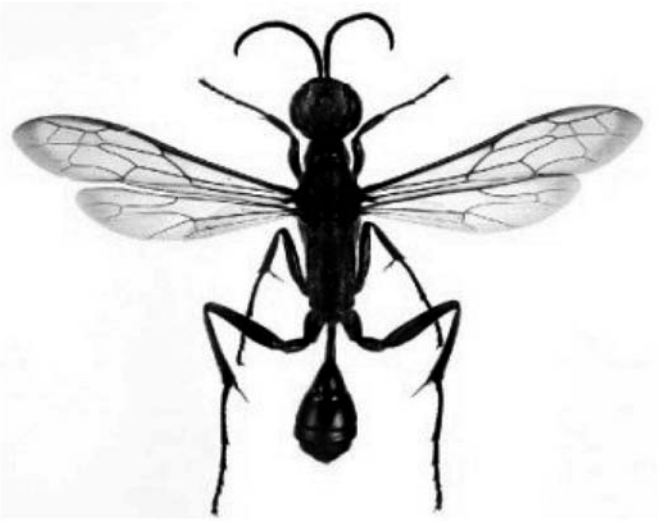


Example- *Bombyx sp., Papilio sp., Antherea sp. Pieris sp., Tryporyza sp.*

Order-IX-Hymenoptera

These insects are commonly known as bees , wasps and ants. Some the social insects belongs to this group.These insects are also known as membrane winged insects.

Almost 150000 species are so far described from this order which are distributed all over the worls. Mouth parts are chewing type. Compound eyes are well developed . Tarsi are usually 5 segmented and a spot is present in the fore wing which is known as pterostigma. Hind wing is smaller than the fore wing.



Example- *Apis sp., Formica sp.,*

I.V General morphology of Insect and their adaptations

All the insects have following characters:-

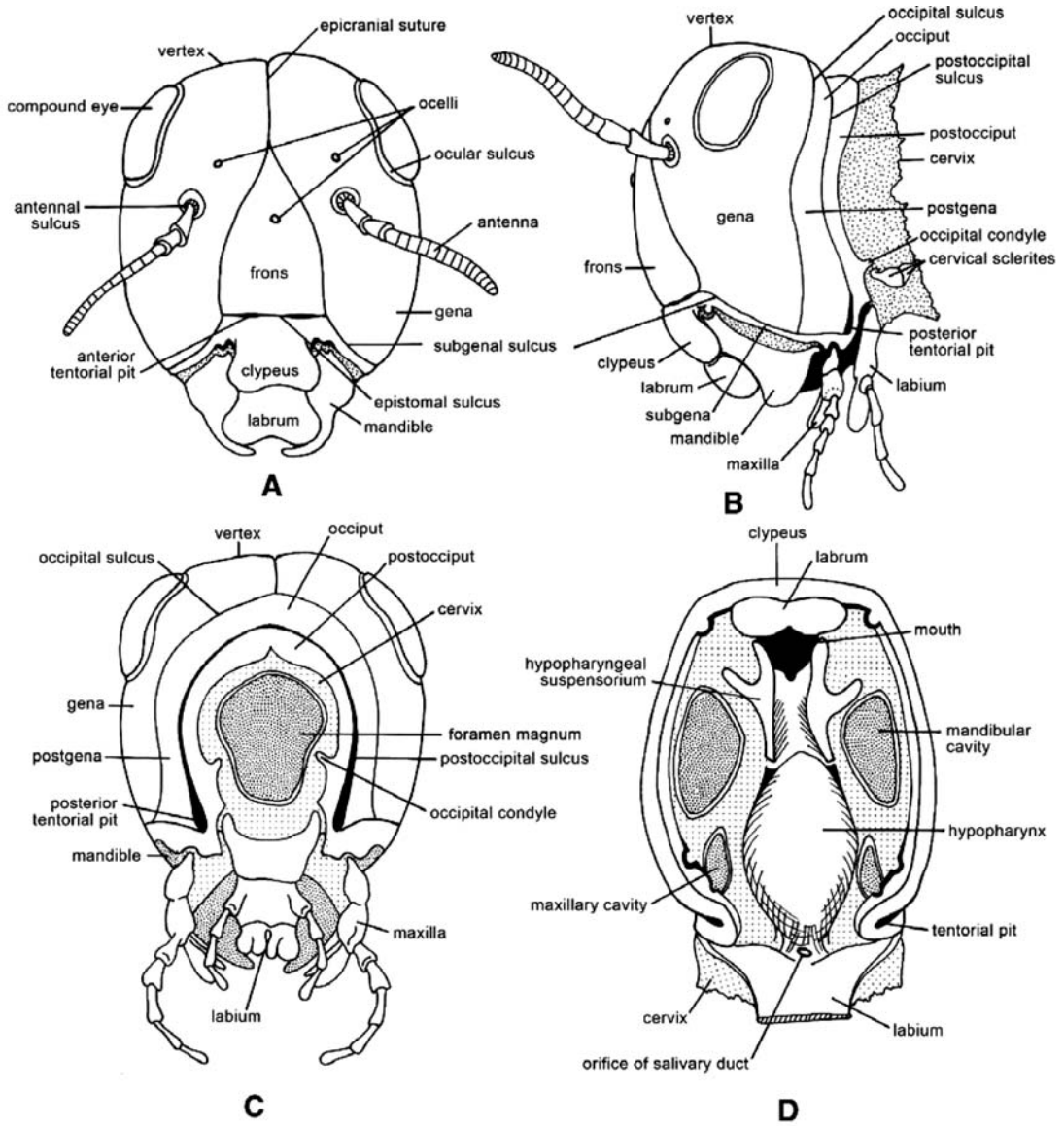
1. The body is comprised of 3 distinct body regions —head, thorax, and abdomen
2. The thorax of adults bears 3 pairs of legs and 2 pairs of wings (sometimes it is absent)
3. The "breathing" system is comprised of air tubes
4. Body is covered by integument which is multiple layered and made up of chitin.

Morphology of Insect Head

Insect head is made up of fusion of first six segments of the body , of them three are preoral and three are post oral segments. The head is divided into different regions or sclerites by a pattern of grooves known as sutures. The uppermost surface of head is known as vertex. A suture is present along the midline of vertex known as coronal suture which ultimately splits into two frontal suture. Triangular sclerite which is present in between the frontal suture is known as frons. The epistomal suture or epicranial suture (this is

also known as ecdysial line is a deep groove that separates the base of the frons from the clypeus, a rectangular sclerite on the lower front margin of the head capsule. The genae ("cheeks") are lateral sclerites that lie behind the frontal sutures on each side of the head. Below each gena there may be another sclerite (the subgena), separated from the gena by a subgenal suture. A pair of compound eyes, sockets for two antennae, and one or more ocelli (simple eyes) also may be found on the front, top, or sides of an insect's head. Near the back of the head, an occipital suture circumscribes the head capsule at the posterior margin of the vertex and genae. This suture marks the location of an internal sclerotized ridge (apodeme) that strengthens this part of the head capsule. Just behind the occipital suture lie the occiput and postgenae, tiny sclerites that are probably remnants of the fifth primitive segment that fused to form the insect's head. At the posterior-most margin of the head, a vestige of the sixth primitive segment is marked by a faint postoccipital suture and a thin, band-like sclerite (the postocciput) that adjoins the neck membrane. The grooves or sutures described above delimit particular areas of the cranium that are useful in descriptive or taxonomic work of insects. The major areas are as follows. The frontoclypeal area is the facial area of the head, between the antennae and the labrum. When the epistomal sulcus is present, the area becomes divided into the dorsal frons and the ventral clypeus. The latter is often divided into a postclypeus and an anteclypeus The vertex is the dorsal surface of the head. It is usually delimited anteriorly by the arms of the epicranial suture and posteriorly by the occipital sulcus. The vertex extends laterally to merge with the gena, whose anterior, posterior, and ventral limits are the subocular, occipital, and subgenal sulci, respectively. The horseshoe-shaped area lying between the occipital sulcus and postoccipital sulcus is generally divided into the dorsal occiput, which merges laterally with the postgenae. The postocciput is the narrow posterior rim of the cranium surrounding the occipital foramen. According to the orientation pattern of insect head along the line of the body axis it can be classified into three types :-

1. **Hypognathous:** The long axis of the head is vertical i.e. at right angle to the long axis of the body. The mouthparts point downwards e.g. grasshopper, cockroach etc.
2. **Prognathous:** The long axis of the head is horizontal and in line with the long axis of the insects body. The mouthparts are directed forwards e.g. Stick insect, soldier caste of termites etc.
3. **Opisthognathous:** The head is reflexed ventrally so that the mouth parts are directed backwards between the coxae of the front legs e.g. Red cotton bug.



Morphology of insect Head, A-Frontal view, B-Lateral view, C-Posterior view D-Cross sectional view

Morphology of Insect Eye

Compound eyes are the prominent visual organs for the majority of insects . Unlike the single-chamber eyes of vertebrates, the compound eyes of insects are generally composed of many independent optical units called ommatidia (in dragon fly one compound eye contain 28000 ommatidia) and can perform significant functions of flight control,

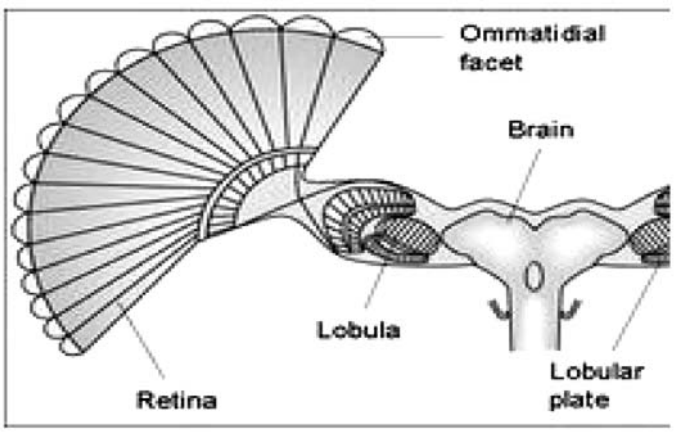
navigation, prey capture, predator avoidance, and mate recognition. The two basic optical designs of the insect compound eyes are the apposition type and the superposition type . In the apposition type, the ommatidia are optically isolated with longitudinal pigments. In the superposition type, there is a pigmentless clear zone between the cornea and rhabdomeres , so that all photoreceptors share corneal dioptrical units, increasing the light sensitivity of the eye . Superposition eyes are commonly found in nocturnally active insects , but also exist in some diurnally active insects . The insect compound eyes can adapt to different environmental conditions by diverse structural modifications . Compound eyes are often present in most adult insects and juvenile exopterygotes, but may be reduced or absent in some cave-dwelling, parasitic, and sedentary species. The compound eye is excellent at detecting motion. As an object moves across the visual field, ommatidia are progressively turned on and off. Because of the resulting "flicker effect", insects respond far better to moving objects than stationary ones. Honeybees, for example, will visit wind-blown flowers more readily than still ones. Not only that some insects have colour vision also. Insects can also visualize the object under UV light for that region insect ommatidia have special protein. Each ommatidium consists of following elements:

A lens (the front surface of which makes up a single facet)

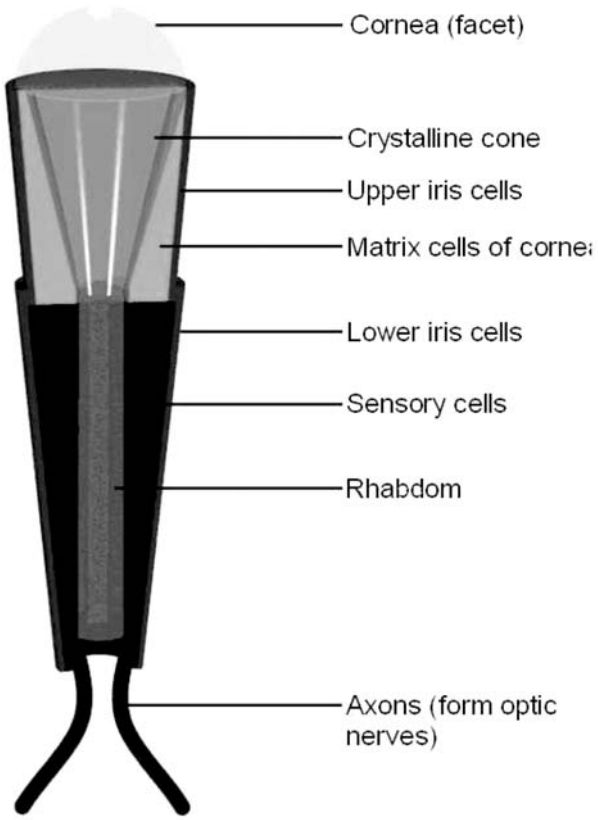
A transparent **crystalline cone**

Light-sensitive **visual cells** arranged in a radial pattern like the sections of an orange

Pigment cells which separate the ommatidium from its neighboring ommatidium



Schematic view of compound eye



Structure of an ommatidium

Morphology of insect mouth parts

Typical insects mouth parts consists of one labrum or upper lip, two mandibles or jaws, two maxillae or small jaw, one labium or lower lip, one hypopharynx or tongue like structue, and one labrum-epipharynx This typical mouth parts are modified in different insects according to to their feeding habit and need. The other modifications are described below:

1. Piercing and Sucking mouth parts:-In parts this type mouth parts formed a tube. The labium is elongated and acts as a sheath. This encloses the mandibles and maxillae which are modified modified as stylets for piercing. The maxillae have two tubes running along their length on the inside surface. 'Saliva' may be pumped down one of the tubes. This saliva makes the food into a liquid. The liquified food is sucked up the other tube. Examples are the Hemipteran bugs, some of Dipteran flies etc

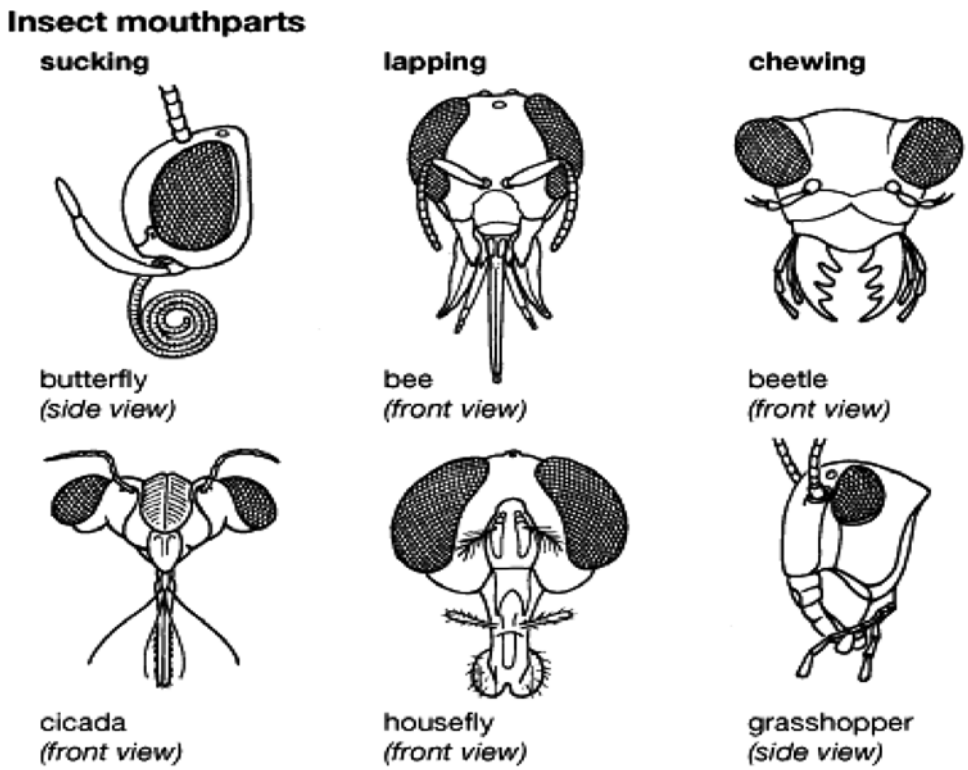
2. Chewing mouth parts :-This is the most commonest type of mouth parts found in different orders of insects. The most visible parts is the large mandibles on each side of

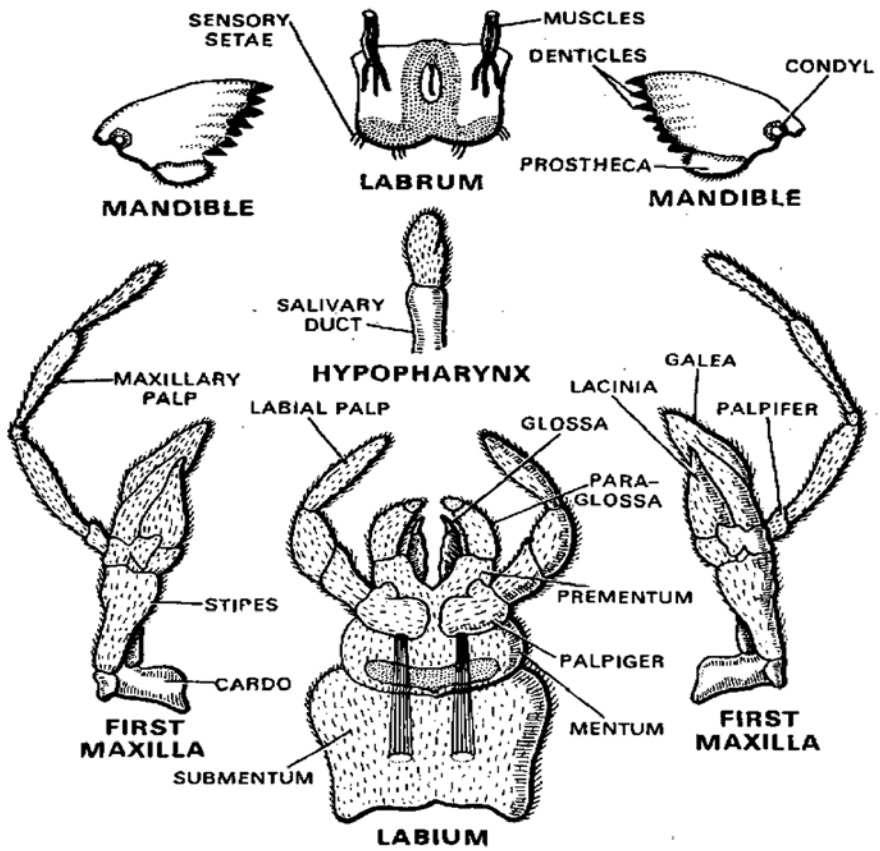
the mouth. Many of the insect orders have chewing mouthparts, including beetles (Coleoptera), caterpillars (Lepidoptera), the Orthoptera, and termites (Isoptera).

3. Siphoning mouth parts:- Many moths and butterflies have this type of mouth parts which are adapted to draw nectar from long-throated flowers. Unlike piercing-sucking mouthparts, these do not penetrate into the plant. When at rest, the tube is held as a coil under the head. A few moths have tubes that may be several inches in length when extended.

4. Sponging mouth parts :- In this case proboscis shows a capillary mechanism. The labium is elongated and forms two lobes at the tip. These lobes have a series of fine tubes (pseudotracheae). The hypopharynx runs down the proboscis and digestive juices pass down this onto the food. The food is made into a liquid by these juices. This liquid is then drawn up the pseudotracheae by capillary action. This type is found in house fly and other Dipteran flies also.

5. Mouth parts found in Honey bees:- In this insect mandibles are very small and suitable for moulding wax, the labium is curved downwards and inwards forming a tube used for sucking up nectar.





Mouth parts of cockroach

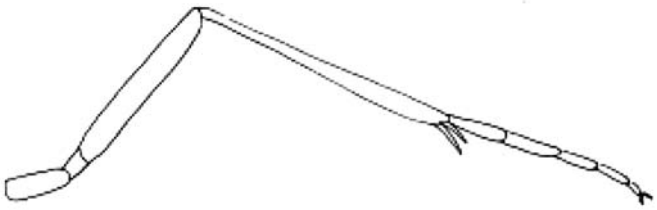
Morphology of insect legs

Insect have three pairs of legs, one pair on each of the three segments of the thorax and are generally called the fore-, mid-, and hind legs. Any of the pairs of legs may be modified according to the needs of insect concern and are important for locomotion, prey capture, mating, etc. From proximal (toward or against the body) to distal (away from the body) the parts of an insect leg are: coxa, trochanter, femur, tibia, and tarsus. The tarsus is almost always have one or two claws at the type used to grasp the substratum.

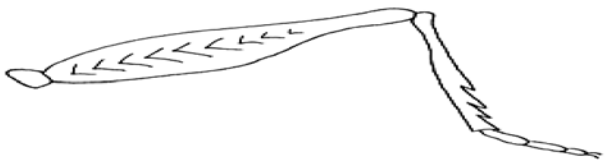
Legs in some insect species have some extra structures such as setae, spines, and dactyls. Following are the different modifications of typical insect legs.

1. Cursorial legs. These are the types of legs most people likely think of if they've ever pondered insect legs before. Cursorial is a fancy word for running, so these are the kinds of legs you see on swiftly moving insects such as roaches and tiger beetles. Cursorial

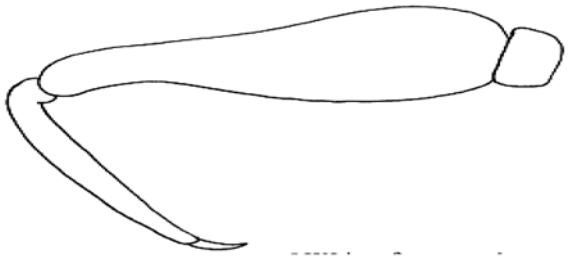
legs tend to be long and narrow and are designed so that the insect can move very quickly.



2. Saltatorial legs. Saltatorial legs are jumping legs. Grasshoppers are the example for saltatorial legs, but other jumping insects like fleas have them as well. Saltatorial legs work well for jumping because they are enlarged legs filled with bulky, strong muscles. All those muscles allow insects with this type of leg to jump, propelling themselves forward very long distances very quickly. Normally Saltatorial legs are usually hind legs.



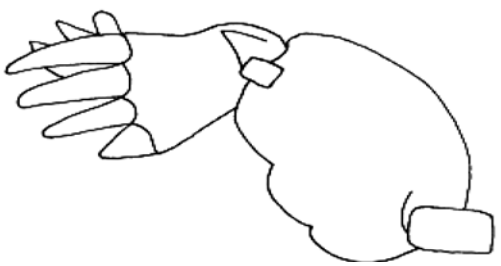
3. Raptorial legs. Raptorial legs are hunting legs, and this kinds of legs are seen on predatory insects such as mantids and giant water bugs. Like the saltatorial legs, these are enlarged legs full of strong, powerful muscles. However, these legs are usually at the front of the insect and are used to grab and hold prey while they eat. Many insects with raptorial legs hold them out in front of their bodies, positioned so that they can strike at prey at any time.



4. Natatorial legs. Natatorial is another word for swimming, therefore insects with natatorial legs are aquatic insects that require modified legs to move easily through water. Natatorial legs are often flattened, broad, and fringed with dense hairs, as in the image of the predaceous diving beetle hind leg pictured at right. Many aquatic insects exhibit natatorial

legs, especially in the hind and middle pairs of legs, but not all of them do. They are especially common in aquatic beetles and bugs.

5. Fossorial legs. Insects with fossorial legs live underground and use their highly modified legs, usually the forelegs, to dig burrows. The mole cricket,(Gryllotalpa Sp) the fore legs are the prime example. Fossorial legs tend to be very broad, very flat, and very dense. They often have big, strong claws. Fossorial legs work somewhat like shovels to rip soils apart quickly and easily and allow the insect to bury itself in the ground surprisingly quickly. This type of leg is less common than the others.



I.VI Conclusion

Apart from the above morphological structures the insect antennae are also known as feelers.They are paired, highly mobile and segmented. Antennae are located between or behind the compound eyes. All insects except protura have a pair of antennae. Antennae are well developed in adults and poorly developed in immature stages. The antenna is set in a socket of the cranium called antennal socket. The base of the antenna is connected to the edge of the socket by an articulatory membrane. This permits free movement of antennae. The basal segment is called scape . It is conspicuously larger than succeeding

segments. The second antennal segment is called pedicle whcih immediately follow the scape. A mass of sense cells called Johnston's organ is present in the pedicel, which is used as a chordatonal organ in some of the insects like mosquitoes. Both scape and pedicel are provided with intrinsic muscles.The remaining annuli or flagellomeres are known as flagellum or clavola which lack individual muscle. Surface of the flagellum is supplied with many sensory receptors that are innervated by the duetocerebrum of brain brain.Flagellum may very in size and form in different insects.

I.VII Summary

Insects may be found in nearly all environments, although only a small number of species reside in the oceans,which are dominated by another arthropod group, crustaceans. Insects are the earliest groups to make their life on the earth and to occupy vast habitats of soil and water. Insect abundance and distribution are regulated by several biotic and abiotic factors and their interactions.

I.VIII Glossary

Ocellus-simple eye in adult insects consisting of a single bead like lens

Pronotum-the upper or dorsal surface of the prothorax; on the beetles this appears to be the middle segment when viewed from above

Prothorax-the first segment of the thorax bearing the first pair of legs

Paleopterous- Insects having wings, but the wings cannot fold back over the insect's abdomen.

Pterygote- This term refers to all winged insects.

I.IX Further reading

R.F.Chapman (1995)-The insects-structure and functions,Oxford University Press.

I.X Model questions

1. Explain the importance of insects
2. Describe three basic insect characters

3. Describe the basic classification of economically important insects
4. Explain how insects affect humans.
5. Explain the following terms:
   a) Apterygota
   b) Polyembryony
   c) Pheromones
   d) Nomenclature
   e) Apneustic
6. Describe briefly five methods used in the classification of insects.
7. Which groups of insects have larvae called caterpillars?
8. Which group of bees is not social insect?
9. Which groups of arthropods has six pairs of legs?
10. Which insect groups does NOT have complete metamorphosis?
11. Which stages in the insect life cycle is called the resting stage?
12. What is the name of ventral surface of the thorax in insects?
13. When insect first originated ?

UNIT II ❑ Insect Physiology - Respiration and endocrine system, Sensory receptors, Growth and metamorphosis.

Structure / Content

II.I Objective

From this unit learners will be able to understand the mechanism of respiration in insects in different medium and how the insects will grow and metamorphosed and the role of endocrine system on it.

II.II Introduction

In general the physiological system in insects are similar with other multicellular metazoan animals. But some physiological system insects are typical in insects which enables the insects to adapt in all ecosystem in the world.

II.III Physiology of insect respiration

Respiratory system means which enables the organism to take oxygen from the environment and expels carbon dioxide produced due to metabolic activity from the body of the organism. Insects take in Oxygen and expel Carbon Dioxide using a series of internal air tubes, the tracheae. These pass fine branches, the tracheoles, to all parts of the body. Insects do not have any lungs and their blood do not have any respiratory pigments in blood which will carry the oxygen or carbon dioxide. The primary goals of the insect respiratory system are to deliver oxygen from the air to the tissues and to transport carbon dioxide from the tissues to air. In contrast to many other animals, most oxygen and carbon dioxide transport occurs in the gas phase, with gases transported through the tracheal system by both diffusion and convection. Trachea, Tracheoles and Spiracles are the primary respiratory structures found in terrestrial insects. According to the number , location of functional spiracles insect respiratory system can be classified into following types :

1. **Holopneustic Respiratory System-** Here spiracle number are10 pairs, of which 2 pairs in thorax and 8 pairs in abdomen . e.g. grasshopper
2. **Hemipneustic Respiratory System-**Out of 10 pairs of spiracles, one or two pairs are non functional . e.g. Coleopteran and Dipteran insect
3. **Peripneustic Respiratory System-** Spiracle number are 9 pairs -1 pair in thorax 8 pair in abdomen. e.g. Caterpillar
4. **Amphipneustic Respiratory Systwem-**Spiracle number are 2 pairs of which One pair anterior, one pair posterior, e.g. maggot
5. **Propneustic Respiratory System-** Spiracle number is 1 pair and it is anterior pair e.g. Puparium
6. **Metapneustic Respiratory System-**Spiracle number is 1 pair and it is posterior pair e.g.Wriggler
7. **Hypopneustic Respiratory System-** Spiracle number are 10 pairs of which 7 pair are functional (1 thorax + 6 abdominal), 3 pairs are non functional. e.g. head louse.
8. **Apneustic Respiratory System-** All spiracles are closed and tracheal system is also closed e.g. naiad of mayfly.

A. What is Spiracle ?

Spiracle are the external opening of the insect respiratory system. Spiracles have a chamber or atrium with a opening and closing mechanism called valve. This regulates air passage and minimise water loss. Each spiracle is set in a sclerotized cuticular plate called a peritreme.

B. What is Trachea ?

Tracheae are invaginations of the epidermis and thus their lining is continuous with the body cuticle. The ringed appearance of the tracheae is due to the spiral ridges called taenidia. This allows the tracheae to be flexible but resist compression. The cuticular linings of the tracheae are shed when the insect moults, but not the linings of tracheoles.

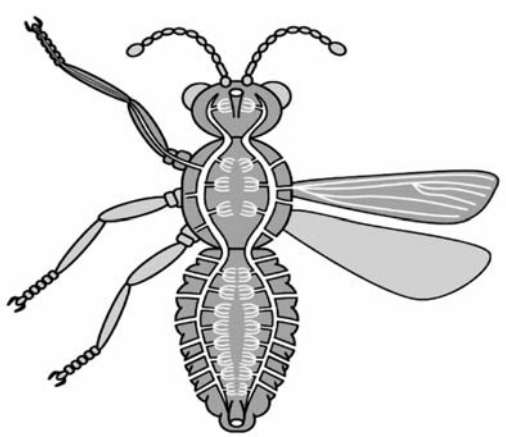
C. What is Tracheole ?

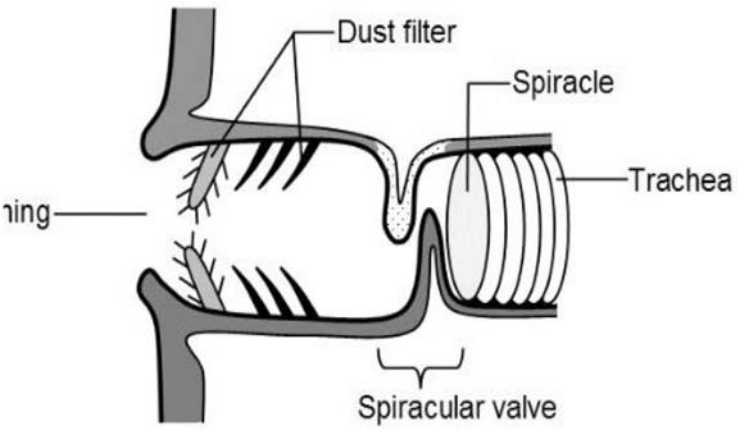
Tracheoles are less than 1 micrometer in diameter; they end blindly and closely contact the respiring tissues. Taenidia and waxlayer is absent. Cuticulin layer is permeable to gases. It is intracellular in nature, but enclosed only in the cytoplasm of tracheal and cell called tracheoblast. Gaseous exchange occurs across tracheoles.

II.III.I Structure of Respiratory System:-

1. In Terrestrial Insects :

There are four tracheal trunks viz., lateral, dorsal, ventral and visceral, helping in the passage of air. In the trachea, thin walled-collapsable collapsable sac like dilations are present, called as airsacs where taenidia is absent. Airsacs acts as oxygen reservoir. Provide buoyancy to flying and aquatic insects. Provide space for growing organs. Acts as sound resonator and heat insulators. There are 2 to 10 pairs of Spiracles.





A spiracle equipped with valve, atrium and dust filter

2. In Aquatic Insects and Endoparasitic Insects :

Aquatic and endoparasitic insects generally retain an internal, air-filled air filled tracheal system. The air-filled, buoyant tracheal system may inhibit insects from being able to dive deeply and avoid predators, limiting their ecological success in deep waters. in many aquatic dipteran larvae such as mosquitoes, the posterior spiracles are surrounded by water-repellent repellent hairs and are kept in the air while the animals feed in a head head-down position. In water scorpions (Hemiptera: Nepidae), spiracles are located on the end of a long tube which is eextended up to the water surface and these are known as Caudal breathing tube. Similarly, endoparasitic insects such as chalcid (Hymenoptera) larvae and tachinid (Diptera) larvae connect to the air using posterior spiracles inserted through the host's integument or tracheal system.Some Coleopteran and Heteropteran insects use their hairs or wings to carry air bubbles adjacent to their spiracles when they dive. These are known as Plastron.These air bubbles serve as oxygen stores and as temporary gas exchange structures. Oxygen is removed from the air bubble by the diving insect, causing oxygen partial pressures in the air bubble to fall below that in the surrounding water. Many aquatic and endoparasitic insects never access air and must obtain oxygen directly from water or the blood of the host. Some insects have tracheal gills, leaflike structures of thin cuticle containing many tracheae and tracheoles, that increase the available surface area for obtaining oxygen from water . Gills may be on the abdominal tip (Diptera, Odonata: Zygoptera), laterally along the abdomen (Ephemeroptera, Trichoptera), or within the rectum (Diptera, Odonata : Anisoptera). Insect gills which are actually the thin tracheated outgrowth of the body wall and are of following types :

1. **Lamellate gills -** present in mayfly naiad (larvae)
2. **Filamentous gills -**present in damselfly naiad (larvae)
3. **Rectal gills -** present in dragonfly naiad (larvae)

II.III.II Physiology of Respiration in Insects :-

Gas exchange in Insects occurs in a series of steps. Oxygen molecules first enter the insect via the spiracle, then proceed down the branching tracheae to the tracheoles. The terminal tips of the tracheoles are sometimes fluid-filled, so at this point gas transport may occur in a liquid medium rather than air. Oxygen then must move across the tracheolar walls, through the hemolymph, across the plasma membranes of the cells, and finally through the cytoplasm to the mitochondria. Insects show breathing movements - that is they actively pump air through the tracheal system. This is why the abdomen pulses in these insects. Sometimes only the tergum of each abdominal segment moves up and down, as in beetles, or both the sternum and tergum, as in flies, or the side-walls (pleura) may be very flexible and also move in and out, greatly changing the internal volume of the abdomen, a sin moths and butterflies. In this way a rapid stream of air flows through the tracheal system. Air sacs may facilitate this movement of air through the tracheae. Air sacs can occur in almost any part of the system, and in rigid structures like the head and thorax they may be permanently expanded, acting as reservoirs of air, whilst in the abdomen they may greatly inflate and contract (flatten and empty). Carbon dioxide generally follows a reverse path. An internal spiracular valve often occurs between the spiracle and atrium, which can open or close the spiracle. Insects respiratory adaptations is manifested by perfect neuromuscular coupling and synchronization of spiracular valves with the changes in internal body pressure, which are made by extracardiac haemocoelic pulsations or the abdominal pressure pump. The oxygen enters into the body of insects by the following processes.

1. Diffusion

Diffusion is the passive movement of molecules down their concentration gradient, driven by random molecular motions. Because oxygen is transported to the tissues as a gas and the diffusion rate of oxygen is much more rapid in air than in water, the insect tracheal system is capable of high rates of gas exchange by diffusion. Consumption of oxygen by the tissues lowers internal oxygen levels, creating a partial pressure gradient from air to tissues that drives diffusion of oxygen through the tracheae. The converse occurs for carbon dioxide. The final steps of oxygen delivery, from the tracheoles to the mitochondria, may occur by diffusion in all insects, because diffusion operates rapidly

over micron distances. Unlike vertebrates, most insects can recover from exposure to anoxia; during such recovery oxygen delivery to the mitochondria seems very likely to occur by diffusion since the ventilatory muscles are paralyzed.

2. Convection

Convection is the bulk movement of a fluid (gas or liquid) driven by pressure. Differential air pressures can drive gas movement through the tracheae and spiracles at much higher rates and over longer distances than diffusion. The advantages that insects gain by using convective gas exchange are somewhat controversial. In general, the use of convective gas exchange increases with metabolic rate, suggesting that convection is necessary to allow most insects to achieve high rates of gas exchange. However, it is also plausible that the increased convection is at least also important for other functions such as reducing gradients for oxygen within the active insect or is a byproduct of hemolymph pumping. The mechanisms by which insects achieve convective gas exchange are complex and varied. In many insects, well-coordinated actions of muscles and spiracles produce regulated convective air flow through the tracheae and spiracles. Most commonly, convection is driven by contractions of respiratory muscles attached to the body wall, which produce increases or decreases in body volume, causing compressible portions of the tracheal system to inflate or deflate. One common mechanism by which insects accomplish convective air flow through the trachea is abdominal pumping.

II.III.III Plasticity of Insect Respiratory Structure and Function :-

Insects requires differential amount of oxygen according to the functional status due to variation of metabolic activity of the insects as well as insect environment may contain varying concentration of oxygen. Therefore the respiratory structure in insects must have the plasticity of gaseous exchange . Increased gas exchange with a set tracheal system structure can be accomplished by at least five mechanisms:-

1. First, insects can simply tolerate lower internal oxygen and higher internal carbon dioxide partial pressures. The increased gas partial pressure gradients will enhance gas exchange by either diffusion or convection.
2. Secondly, insects can increase diffusive gas exchange by opening the spiracles to a greater degree or for longer time periods.
3. Third, insects can increase convective ventilation through the spiracles and tracheal system (terrestrial insects) or over the gills (aquatic insects) by mechanisms such as abdominal pumping or gill waving. Convection in the

hemolymph may also be important for insects that utilize hemolymph hemocyanin.

4. Fourth, insects can reduce fluid levels in the tracheoles, enhancing diffusive oxygen delivery within the tissues because of the faster diffusion of oxygen through air than water.
5. Fifth, the alterations in tracheal morphology (e.g., tracheal diameter and number of tracheoles) and perhaps the level of oxygen-binding pigments may affect gas exchange capacity.

II.III.IV Regulation of Insect Respiration :-

The control mechanism of insect respiration by an autopnomic (brain independent) neuro-endocrine system known as coelopulse system. The coelopulse system consists of nervous system located in the meso thoracic gangilion of the ventral nerve cord, the neuromotoric spiracular nerve , and the intersegmental or dorsoventral abdominal muscles. This system functions as a abdominal pressure pump.

II.IV Endocrine system of Insecta

Endocrine system means the total number glands present in any metazoan animals which are responsible for the synthesis and secretion different kinds of hormones or chemical messengers for the purpose of coordinated functions of different physiological process, development ,reproduction, growth etc. Insect possess a welldeveloped endocrine system. In insects this endocrine system is better known as neuro endocrine system because some parts or cells of the nervous system are also integrated with the endocrine system for their proper functioning. The cells which are found in the nervous system but performs the synthesis and secretions of different hormone or hormone like products are known as neurosecretory cells. Protocerebrum of brain, subesophagial ganglia and chains of ventral ganglia contains these neurosecretory cells. Hormones are chemicals synthesized and secreted by the endocrine glands or cells and transported by the circulatory system and produces slow but long term and permanent effects within the animals. There are three kinds of endocrine structures are found in the insect body which are :-

A. Endocrine cells located in the nervous system :-

Neurosecretory cells found in the brain and other nerve ganglia. Neurosecretory cells are specialized nerve cells that secretes hormones like neurosecretory cells in pars intercerebralis of protocerebrum, neurosecretory cells present in other p[arts of the brain

and neurosecretory cells present in the ganglia of ventral nerve cord. Not only that a whole ganglia may become a hormone synthesis and secretion organ like corpora allata and corpora cardiaca. Neurosecretory cells produced the following hormones :-

1. **Prothoracotropic hormone (PTTH)**-This is a peptide hormone and stimulate the prothoracic glands to produce moulting hormone (MH) or Ecdysteroid.
2. **Ovarian ecdysteroidogenic hormone (OEH)**-It is also a peptide hormone and stimulate the ovary to produce moulting hormone (MH) or ecdysteroid.
3. **Allatostatin**-It is also a peptide hormone and the main function is to stop the production of Juvenile hormone (JH) from corpora allata.
4. **Allatotropin**-It is a peptide hormone and the primary function is to stimulate the production of Juvenile hormone from corpora allata
5. **Brain hormone or Neurosecretions**- All hormones produced from brain and having different functions.
6. **Eclosion hormone (EH)**-This is also a peptide hormone and produced from neurosecretory cells present in nervous system other than brain. The main function is to control the ecdysis behaviour.
7. **Diapause hormone (DH)**-It is also a peptide hormone and produced by the neurosecretory cells present in suboesophageal gland . The primary function of this hormone is to initiate the diapause in embryonic stages.
8. **Adipokinetic hormone (AKH)**- It is a peptide hormone produced from the corpora cardiaca and the main function is to stimulate the fat metabolism or energy metabolism.
9. **Hypertrehalosomic hormone (HTH)**- It is also a peptide hormone and produced from corpora cardiaca. It controls the sugar metabolism and resulting high concentration of trehalose in the haemolymph of the insects.
10. **Diuretic hormone (DUH)**-It is also a peptide hormone. The primary function is to contropl the water balance of the insect body and controls the urine production of insects.
12. **Juvenile hormone (JH)**-It is a sesquinoid compound and produced from the corpora allata. There are four kinds of JH found in insects which are JH-I , JH-II , JH-III and JH-0 (mostly in Lepidoptera) having different function in insect body. JH-I & II helps to retain the juvenile characters of the insects

while JH-III functions as a gonadal maturation hormone. JH-0 is found only in eggs and embryonic stages of insects. In majority of insects JH-III is the primary hormone.

13. **Crustacean cardioactive peptide (CCAP)-**It is a peptide hormone produced from neurosecretory cells of ventral ganglia. The primary function is to control ecdysis behaviour and controls the heart rate of Insects.?

14. **Bursicon-** It is also a peptide hormone and produced from neurosecretory cells of ventral ganglia.The main function is to control the tanning of the cuticle.

15. **Pheromone biosynthesis activating neuropeptide (PBAN)-**It is also a peptide hormone and produced from neurosecretory cells of ventral ganglia. The main function is to stimulate the synthesis and secretion of pheromone (a kind of semiochemicals or exohormone).

B. Pure glandular endocrine structure :-

Prothoracic glad and epitracheal glands (particularly found in Lepidopteran insects).Prothoracic glands is destructed in adult phases excepting in Thysanura.The primary hormone produced are:-

1. **Ecdysterone or ecdysone or moulting hormone :-** This is the primary hormone produced by prothoracic gland. This is a steroid compound and its most role is to initiate moulting in larval stages and maturation in adult insect. This hormone is produced after the initiation of PTTH hormone from neurosecretory cells. There are several kinds of ecdysone secreted in different insects like Makisterone, 3-dehydroecdysone & 20-hydroxyecdysone etc.

2. **Ecdysone triggering hormone (ETH)-**This is a peptide hormone secreted from epitracheal gland and found only in Lepidoptera. This hormone controls the ecdysal behaviour in Lepidopteran insects.

C. Endocrine cells located in other systems :-

Cells located in the testis , ovary and alimentary system. These are primarily located in the mid gut region in alimentary system . The ovary also produced some hormone. The hormones are described below :-

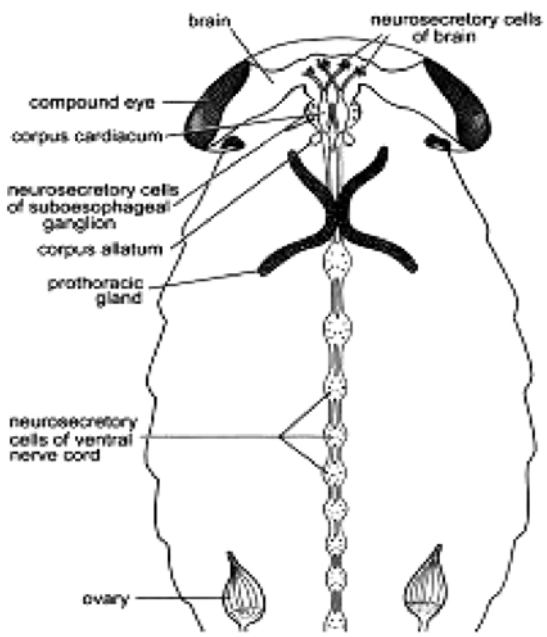
1. **Ovarian ecdysteriod -**This hormone is also known as ovarian hormone. This is a steroid hormone and produced from ovarian tissue follicle cells. The

important function of this hormone is the initiation and regulation of vitellogenin (a kind of egg protein which nourishes the developing embryo.

2. **Dromyosuppressin-** This is also a peptide hormone and produced from midgut endocrine cells. It inhibits the intestinal muscle contraction. There are two types of cells found in the midgut which are open type cell and close type cell.

C. Ring gland :-

It is not a separate gland but it actually the fusion of corpora allata , corpora cardiaca and prothoracic gland. It is found only in Dipteran insects.



II.IV.I Functions of Endocrine glands in Insects:-

Insect hormones and neurohormones have been studied with respect to their involvement in a number of general physiological functions like influencing development, diapause, mating and oviposition, metabolism, development of nervous system, control of circadian rhythms, regulation of dormancy, pheromone production and regulation of migratory behaviour. The whole developmental process by which the first instar immature stage of an insect is transformed into the adult insect is called metamorphosis. Metamorphosis can occur slowly in some insects or abruptly in others. The insects are divided into two groups based on their types of metamorphosis which are Holometabolous and Hemimetabolous insects. In both the cases brain hormone, ecdysone, juvenile hormone are needed to complete metamorphosis.

II.V Insect Sensory receptors

Insects, like other animals, are responsive to various stimuli in their surroundings, such as light, heat, touch, chemicals, and vibrations. Insects have a variety of receptors which, when stimulated, pass information in the form of nervous signals to the central nervous system of the insect. The number of signals that are sent will depend on how strongly the receptor is stimulated and for how long, and the actions of the insect will vary accordingly. All insects have only primary sensory cells in contrast to the other vertebrate animals which have secondary sensory cells. The difference between primary and secondary sensory cells is that in case of primary cells stimuli is received and information sent to brain by a same cells but in case of secondary sensory cells the receptor cell and sender cells are different. According to the quality of stimuls received the sensory system in insects are classified into following groups :-

II.V.I Touch receptor or Mechanoreceptor :-

The bodies of insects are covered with sensitive hairs. These are most numerous and most sensitive on parts such as the antennae (feelers) and on the lower sections of the legs . Each hair is a stiff modified part of the cuticle and/or the underlying skin to which it is jointed. A sense cell beneath the joint is supplied with a nerve fiber and, when the hair is touched, the mechanical disturbance of the associated sense cell or the resulting chemical changes causes signals to pass along its nerve and the insect “feels”. These are known as Trichoform Sensilla. Besides the sensitive hairs insects have also other touch sense organs. These are modified dome-shaped patches of cuticle which, like hairs are associated with a sense cell and its nerve. They occur on the tail spines (cerci), the wings, and the lower parts of the limbs. Stresses in the cuticle move the dome, which disturbs the sense cell. If the sensory hairs are long then it will respond to the weak and minute force but if the hair is short, stout and spiny it will response to the strong force. Some mechanoreceptors produce a phasic response when stimulated i.e, they fire once when activated and again when deactivated. Other receptors generate a tonic response, firing repeatedly as long as a stimulus persists. Neural processing centers in the brain or segmental ganglia interpret the combinations of tonic and phasic signals sent from nearby receptors.

II.V.II Stretch receptor or Proprioceptor :-

These are also group of sensilla present on joints of legs , trachea and other parts of the insect. There are two kinds of sensilla found in insects which are campaniform sensilla

and chordotonal sensilla. Any kinds of deformation and stress can stimulate these sensilla. Camponiform sensilla have the directional sensitivity while the chordotonal sensilla have the positional sensitivity. Multipolar neuron is attached to these sensilla. The primary function of this type of receptors is to sense the pressure, stretch of organ system or muscles , peristalsis and frequency of wing movements etc.

II.V.III Smell and taste receptor or Chemoreceptor :-

Because of this relationship between the two senses it is often difficult to say definitely which is used in a particular instance. A rough distinction is that smell detectschemicals which exist in the air as vapor, while taste recognizes liquids or solids which come into contact with the receptors. These receptors are supplied with one or more bipolar neuron . The sense of smell is used for various purposes – sexual attraction, recognizing the odor of their own species, finding suitable sites in which to lay eggs, and finding food. The males of certain moths are attracted by the scent of virgin females, for example. Some moths are able to scent their mates at a distance of three kilometers (two miles). Certainly social insects are able to detect members of their own species, even of their own colony. Often an ant of the same species but from another colony will invade the home of a neighboring colony. It will be recognized as foreign because its different smell can be detected and so will be evicted or killed. Some ants will follow trails left by others and so they are guided on their food-foraging expeditions. The taste receptors occur mainly in the mouth and on the mouthparts, the antennae, and the lower parts of the legs of many insects. Insects are able to taste with their feet. In insects there are olfactory receptor genes which belong to the G protein coupled receptor family or GPCR. In insects, it has been shown that the levels of second messenger inositol triphosphate (IP3) increase transiently upon olfactory stimulation in olfactory receptor neurons and their dendrites have also been shown to have ion channels opened by IP3. It has been shown that in Drosophila sp. there are almost 60 genes in drosophila odorant receptor family gene and of these at least 42 genes are expressed in adult olfactory receptor neurone.

II.V.IV Photoreceptors or sight receptor :-

Insects respond to light in three different ways:-

1. through the whole of the body surface which appears to be sensitive,
2. through simple eyes called ocelli, (Two types of “simple eyes” can be found in the class Insecta: dorsal ocelli and lateral ocelli (=stemmata). Although both types of ocelli are similar in structure, they are believed to have separate phylogenetic and embryological origins. and

3. through compound eyes.

Insects can perceive visible light , polarized light and also ultraviolet light . Compound eyes are the main organs of sight. The outer part of each eye consists of numerous units or facets varying in number from about ten to thirty thousand in different insects. They are usually hexagonal, forming a honeycomb-like mosaic. Each facet or lens is at the top of a cone-shaped tube (ommatidium) at the bottom of which are the light receptive cells. All the ommatidia together produce a mosaic of spots of light, each spot representing the part of the field of view in line with a particular ommatidium. Actually each image consists of a series of dots – rather like a printed picture in a newspaper. The insect vision is indistinct. Insects can certainly distinguish shapes and can recognize certain patterns, but insect eyes are best suited to pick out moving objects or those moving across their flight path. A dragonfly is an expert, for example, at catching its prey on the wing. In most insects the field of view of both compound eyes overlap so that they have stereoscopic vision or binocular vision. Many insects can distinguish colors. Apart from the eye and ocelli the insects can sense the intensity of light through their dermal light sensing mechanism.

II.V.V Hearing receptor or Audioreceptor :-

This receptor is commonly known as Tymbal or Tympanal Organ. This sensory system is not equally developed in all the insects. Some insects do not have any hearing receptors. The ranges of hearing of different insects cover a wider frequency band than that to which the human ear is sensitive. Hearing organs are of two kinds, sensitive hairs and tympanum .Few insects have the latter. The sensitive hairs are similar to those used for touch. Each tympanal organ consists of a thin membrane connected to sensitive cells that are supplied with nerve fibers. The positions of the tympana vary considerably. Crickets and long-horned grasshoppers have them on the fore-legs, but short-horned grasshoppers have them on the first segment of the abdomen. Others may have them on the thorax or the abdomen. The purpose of the insect's hearing organs seem to be the location of the other sex for mating purposes.

Hearing receptors are of two types : -

1. Simple hearing system as in case of moths (Lepidoptera) and
2. Complex hearing system as in case of crickets(Orthoptera).

Insects who have no hearing receptor can also receive sound waves through their mechanoreceptors but they cannot understand complex sound like song etc.

II.V.VI Humidity receptors or Hygroreceptors :-

It is generally located on antennae, but also around the spiracles of insects. It is also a kind of mechanorecptor. The sensitive hairs change their shape along with the change of humidity of the insect environment. It is present in Tribolium sp. (Coleoptera).

II.V.VII Thermoreceptors or temperature receptors :-

It is again a type of mechanoreceptor which is sensitive to temperature change of the environment. This receptor is well developed in Locusta sp (Orthoptera). Normally it is present in Insect legs and antennae. Its mechanism of transduction is still unknown.

II.V.VIII Pressure receptor :-

It is also a kind of mechanoreptor and provide sensory information about an aquatic insect's depth in the water. These receptors are usually associated with a cushion of air against the body or within the tracheal system. Increasing water pressure deflects hair-like processes within the receptor and stimulates tonic and phasic impulses.

II.V.IX Subgenual organ or Vibration receptor:-

It is another kind of mechanoreptor . It is located in the legs of many insects, these receptors contain relatively few scolopidia yet they appear to be very sensitive to substrate vibrations. Insects may lack specialized sound receptors, yet they can still "hear" vibrations transmitted through the substrate.

II.V.X Johnoston's organ:-

It is found within the pedicel of each antenna. In some insects, they function as a proprioceptors, supplying information on position or orientation of the antennae. In mosquitoes and midges, they respond to certain frequencies of airborne sound by detecting resonant vibrations in antennal hairs.

II.VI Insect Growth

Growth in insects as in the higher vertebrates only occurs in the immature stages, so adult body size is determined by the size of their larva has reached when it stops feeding and begins to metamorphosis. As a result, the control of adult body size is intimately connected to the mechanism that controls metamorphosis. Immature stages that are hatched from the insect egg are called larva or nymph or naiads according to the insect development pattern. After hatching from an egg insect grows and changes by distinct stages. Each

time an insect makes a change into the next growth stage, it has to molt (shed) its skin. After each molt, the insect becomes a little larger and somewhat different in form until it reaches the adult stage. After it reaches the adult stage, it does not molt or grow any more. The change in form as an insect grows is called metamorphosis. The exact style of metamorphosis is not the same for all insects, but insects in the same order have the same style of metamorphosis. Following terminology are very important for study the insect growth and development :

1. Larva is a generic term for the immature stage of insect with complete metamorphosis (Larva may be named differently like : caterpillars - butterflies/ moths, grubs - beetles, maggots - flies etc)
2. Nymphs - immature stage for insects with gradual metamorphosis
3. Naiads - immature stage for insects with incomplete metamorphosis
4. Instar - developmental stage of a larva between molts; if an insects molts only once it is said to have 2 instars (i.e. Larva 1 is right after hatching and Larva 2 after the molt); many insects have 5-7 instars
5. Stadium - time period between molts

After hatching insect grows and developed into adult stages either by any one of the following growth pattern which depends upon the orders of the insect concern :-

1. Simplest Pattern:- It occurs in a few kinds of primitive wingless insects, including silver fish and springtails. When these insects hatch, they look exactly like their parents, except for size. The young insects live in the same surroundings and eat the same food in the same way as the adults. They grow to adulthood by splitting the old shell when it becomes too tight and wiggling out of it. After the insects reach a certain size and their reproductive organs have fully developed, they can mate. From the time they hatch until they die, these insects change little, except to grow larger. Example- *Thysanura, Collembola* etc

2. Gradual metamorphosis or paurometabolus development Pattern :- Among dragonflies and damsel flies, the nymphs differ greatly from their parents. The adults are beautiful winged insects that spend much of their time in flight. The wingless nymphs live in water and breathe by means of gills. The nymphs are often called naiads. After they reach full growth, they crawl out of the water onto a plant stem or rock. They then shed their shells for the last time and become winged adults. Example- Odonata

3. Incomplete Metamorphosis or Hemimetabolus Pattern :-It occurs in such insects as grasshoppers, mayflies, roaches, cicadas, and chinch bugs. These insects pass

through three stages: (1) egg, (2) nymph, and (3) adult. Among such insects as grasshoppers and chinch bugs, the nymphs look much like their parents, except that they have no wings. The wings first appear as little pads after the insect has shed its exoskeleton a few times. With each molt, the wings enlarge. After the last molt, the adult comes out with its wings fully developed. The nymphs usually live in the same places and eat the same food as the adults.

4. Complete Metamorphosis or Holometabolus Pattern :-This type of growth and development occurs in most species of insects, including butterflies, moths, beetles, flies, bees, wasps, and ants. These insects go through four stages: (1) egg, (2) larva, (3) pupa, and (4) adult. The larvae of these insects are wormlike creatures that look completely different from their parents. Among many species, the larvae live in different places and eat different foods. They do not have their parents' compound eyes and wings. Most of them have chewing mouth parts, though their parents may have sucking mouth parts. Some larvae have no legs. Others may have many extra leg like structures on the abdomen. The larvae of many species have special names. For example, the larvae of butterflies and moths are called caterpillars; those of flies, maggots; those of beetles, grubs; and those of mosquitoes, wrigglers. Larvae simply eat and grow, molting several times as their skin becomes too tight. In one day, a caterpillar may eat several times its weight in leaves. After a larva completes its growth, it stops eating. It then becomes a pupa. During this stage, some larvae spin a cocoon or form some other protective covering around their bodies. Most pupae lie quietly and appear lifeless. But inside the protective covering there is great activity. The larval structures are being broke down largely into a liquid and re-formed into adult organs. After the change is complete, the pupal covering cracks open and the adult insect crawls out.

5. Hypermetabolus Pattern :- It is a kind of metamorphosis in which there are two or three distinct types of larval instars with different habits and structures found in certain insects. This type of metamorphosis is seen in blister beetles

II.VII Insect Metamorohosis mechanism and its regulation

It is now assumed that at the time of early development, in the developing egg the cells are segregated into two groups—one group for working at the larval life and the second group to take charge during pupal and adult life. In a growing larva, the larval cells increase only in size but never undergo division. The second group of cells, called imaginal buds and discs, remain inactive in the body of larva. When the larva is full-grown, second group of cells take over the charge. Within the apparently inactive pupa

tremendous activities go on at cellular level. Imaginal buds grow by division. During metamorphosis, most of the larval organs in the pupa except the central nervous system and developing reproductive organs are broken down by enzymes and the process of disintegration of the larval organs is called histolysis and these larval disintegrated cells die and is used up by the imaginal cells. In certain insects, within larva, pupal cells become fluid in consistency and imaginal cells continue to form the adult structures. The imaginal buds are the groups of formative cells but remain inactive in the larva but form the rudiments of future organs by mitosis. These formative cells set aside in the pupa and reach functional organs by differentiation in the imago (adult). The process of formation of tissues and organs from the imaginal buds, called histogenesis. The wings, mouth parts, internal organs, muscles and legs develop from the imaginal buds.

Similarly the process by which larval characters are destroyed in pupal stage is known as histolysis.

The total process of metamorphosis is regulated by hormones whether it is of any kinds. Metamorphosis, therefore, involves the destruction of some larval muscles, the rebuilding of others, and the formation of muscles which were never represented in the larva. The first endocrine sequence to be considered is that controlling molting. Two endocrine sources are involved: the neurosecretory cells of the brain and the prothoracic glands. It is most striking that the brain- prothoracic gland system is involved in the molting of a wide range of insects and. that the prothoracic gland hormone tells the anima1 to molt-but it does not tell it what to molt to. The prothoracic gland hormone can lead to a larval, a pupal, or an adult molt, depending on the past history of the insect.

A measure of specific control of morphogenesis does lie within the endocrine system. Specificity is contributed by another pair of endocrine organs of the head ,the corpora allata. The secretion of the corpora allata is known as the juvenile hormone for its presence favors the retention-or even in special cases, the redevelopment of larval characters. Apart from its morphogenetic action, it is interesting that the corpora allata can trigger the secretion of the prothoracic gland. But it is not known whether an interaction between the corpora allata and the prothoracic gland plays a part in normal development or not. Only when the corpora allata are inactive is the larva free to begin its transformation. One possible means of control would be that the corpora allata itself ‘counts’ the molts, and stops secreting once it has been exposed to prothoracic gland hormone a set number of times. It is important to mention that both the medial neurosecretory cells of the brain and the corpora allata appear to play a part in affairs of the insect other than molting.

The neurosecretory cells of the brain have been implicated in :-

a) Triggering the prothoracic glands,

b) Stimulating oviposition,

c) Promoting water retention,

d) Controlling activity rhythms,

e) Stimulating proteinase synthesis in the gut.

II.VIII Conclusion

In general the physiological system in insects are similar with other multicellular metazoan animals. But some physiological system insects are typical in insects which enables the insects to adapt in all ecosystem in the world. The sensory system and respiratory system in insects are most developed .

II.IX Summary

In insects this endocrine system is better known as neuro endocrine system because some parts or cells of the nervous system are also integrated with the endocrine system for their proper functioning. The insect growth and development is directly regulated by neuroendocrine system of insects.

II.X Glossary

Ecdysis- The moulting process, by which a young insect changes its outer skin or pupal case.

Eclosion- Emergence of the adult or imago from the pupa

Cocoon- A case, made partly or completely of silk, which protects the pupa in many insects, especially the moths. The cocoon is made by the larva before it pupates.

II.XI Further reading

S.Mandal (1989)- Handbook of Insect Neuroendocrinology, Emkay Publication,New Delhi

II.XII Model questions

1. How do trachea and tracheoles differ and how is this related to their different functions.
2. What happens to the opening and closing of spiracles during discontinuous gas exchange?
3. Juvenile hormone is chemically unstable how are JH levels maintained if it is so easily broken down?
4. Give three examples of insect peptide hormones, where they are produced and what they regulate.
5. Insect haemolymph has a variety of different functions; briefly explain each with an example
6. Apneustic insects have gills, what are the various types and briefly explain the differences between them
7. How do changes in juvenile hormone and ecdysone explain holometabolous and hemimetabolous metamorphosis?
8. Describe early development of an insect egg from fertilization to dorsal closure and when the yolk becomes surrounded by endoderm.
9. What is the cryptonephric system and how does it work.
10. Describe what the egg needs are and how it is provisioned with the materials in a polytrophic ovariole.

UNIT III ❑ Insect-plant interaction, role of allo-chemicals in host plant

Structure / Content

III.I Objective

This unit helps the learners to understand the mechanism of interaction occurs between plants and insects and how an insect identifies its proper host plant from the millions type of plant species. This unit also helps the learners to know about the evolutionary pattern of plant and insect species.

III.II Introduction

Insects and Plants are the highly diverse groups due to their power to exploit a wide range of ecological niches, from the desert to the arctic zone and also almost all the plant species growing on the planet are directly or indirectly interacts with insects. Plants and insects make up together approximately half of all known species of multicellular organisms. Each plant interacts with insects in a different manner like insects may act as protection, dispersers, or fertilizers for plants while plants may be act as a food/energy resource or

nest location for insects. It is now, well known that insects are originated during Devonian period and since then co-evolution has been taken place with plants reaching to a vast diversity in the context of their interaction with plant, so called insect-plant interaction.

III.III Insect-plant interaction

Each plant interacts with insects in a different manner like insects may act as protection, dispersers, or fertilizers for plants while plants may be act as a food/energy resource or nest location for insects. It is now, well known that insects are originated during Devonian period and since then co-evolution has been taken place with plants reaching to a vast diversity in the context of their interaction with plant, so called insect-plant interaction. Plants synthesizes numerous chemicals within their body and some of them are volatile organic compound and they play an important role for the interaction with the insects. These volatile organic compounds play a very crucial role by acting as chemical message to help herbivore insects to locate their perfect host plant facilitating feeding, copulation, oviposition and also helping parasitoids and predators to locate their prey species , serving as attractants for species-specific pollinators and even by inducing defense against pests by acting as feeding and/or oviposition deterrents. Following are the interaction types ;-

Types of insect - plant interactions

1. **Herbivory**-Plant as food to insect, this is of three types

   Polyphagy- One Insect species depends upon various species of plant

   Oligophagy:- Insect sometimes uses plant as food

   Monophagy:- One Insect species depends upon only one species of plants, i.e. specialist feeder

2. **Mutualism**-insect saves plants from the attack of other animals plants acting as nest to insects
3. **Pollinators**-Insect helps in pollination and plants give nectar to insects as food
4. **Insectivory**- Plants eats insects for supplement of nitrogen

Signals that received from plants by the insects and vice versa

There are three kinds of signals functioning between insect and plant for their interaction which are :

1. Plant defense compound or allelochemicals and proteinase inhibitors

2. Plant defense signaling hormone like jasmonic acid and ethylene
3. Signals that received from insects by plants like wounding etc.

Theory of Co-evolution in respect to insect - plant interaction

The term co-evolution is used to describe the cases where two (or more) species reciprocally affect each other's evolution. As for example, an evolutionary change in the morphology of a plant, might affect the morphology of an herbivore that eats the plant, which in turn might affect the evolution of the plant, which might affect the evolution of the herbivore and so on. Plants and insects represent a classic case of co-evolution. Co-evolution can occur between any interacting populations: prey and predator, pathogen, competitor or mutualists. The selective pressures that each individual can exert on the other is expected to depend on the intimate nature and strength of the association . Many plants and their pollinators are so reliant on one another and their relationships are so exclusive that biologists have good reason to think that the "match" between the two is the result of a co-evolutionary process. According to Bruce (2015) the phytophagous insects that exist today and the plants they feed on are the product of a co-evolutionary process that has been ongoing for 400 million years.

According to Yuan et al., (2013) the huge number species of flowering plants on our planet (approximately 275 000) is thought to be the result of adaptive radiation driven by the co-evolution between plants and their beneficial animal pollinators. Studies of fossil plant–insect associations suggest that insects have been feeding on plants for 400 million years. Co-evolution between insects and plants was drawn attention to in the classic review by Erhlich and Raven (1964). The physiological condition of an insect has long been known to influence insect–plant interactions. According to Schuler and Berenbaum, (2013) the biological role of plant defense chemicals can change over time. Although many plant secondary metabolites have evolved as plant defense, insects may overcome the defenses by coevolving adaptations such as cytochrome P450 monooxygenases (P450s) that metabolize plant toxins. Not only that the specialist insects may even use the plant secondary metabolites to defend themselves against their own attackers at the third trophic level. Insect oral secretions contain specific proteins and chemicals that are likely to have evolved as effectors to inhibit plant defenses but, with time, some plants have adapted to recognize some of these substances so that they may even trigger defense responses. Insects have a nervous system and the capacity to learn which has consequences for their responses to plant volatiles. The physiological condition of an insect has long been known to influence insect– plant interactions. It is necessary to mention that co-evolutionary

relationship is the most important factor for the outcome of co-evolution. Co-evolutionary relationship can be summarized in following three points :-

(1) The natural enemy must have significant selective impacts on the host through a severe reduction of host-population fitness,

(2) Host-resistance diversity must impact on the evolution of enemy virulence, and

(3) Host and enemy populations must exhibit considerable genetic variability.

But it must be remembered that the outcome of co-evolution depends upon may criteria such as such as genotypes of host and biotic enemy, whether the genome is haploid or diploid. The number of alleles involved, the dominance relationships between alleles, the number of loci involved and epistasis relationships, whether reproduction is sexual or asexual and the relative generation times of host and enemies are important determinants as well. Plant-feeding insects have engaged an evolutionary antagonistic interaction that led to the development of a variety of plant defense strategies to avoid extinction.

III.IV Role of allo-chemicals in host plant

Plants can release some chemicals into the environment that suppress the growth and establishment of other plants in their vicinity, and this process is known as ‘allelopathy’. However, chemicals with allelopathic functions or allelochemicals have other ecological roles, such as plant defense, nutrient chelation, and regulation of soil biota and insects in ways that affect decomposition , soil fertility and in total plant life . These ecosystem-scale roles of allelopathic chemicals or allelochemicals can augment, attenuate or modify theircommunity-scale functions.

The production, storage, and release of allelochemicals are key mechanisms of plant behavior which affect almost all aspects of a plant’s ecology. Biotic components of the ecosystem such as herbivores, competitors, pathogens and belowground decomposers can alter concentrations of chemicals already in plant tissues or released from plants, or stimulate the production of chemicals that are otherwise not present or occur at very low levels. The effects of allelopathy are also dependent on the evolutionary history of the interaction.

An allelochemical produced by a species can provide multiple ecological functions, making its effects highly dependent on specific environmental conditions. There is substantial evidence that plant allelochemistry can act as a selective agent on insect population and

also insect herbivore act as a selective agent on plant population. This is a kind of reciprocal interaction that is a system where there is both these systems are operating. There is also abundant evidences that there is substantial qualitative and quantitative variation in allelochemical content both within and between plant population.

Not only that there may be a variation among individuals within a species. Insect herbivory is potentially a potent selective force on allelochemical make of plant population. Herbivorous insects may prefer certain allelochemical make up of a plant and avoid other plants with a different allelochemical make up. This avoidance is probably due to the effects of allelochemicals on the growth and survivability of insects. It is also true that plant chemistry acting as a selective agent on insect population.

According to Stephan J Gould(1979) the importance of particular group of allelochemicals in determining the host plant range of many insect species. The ability of insect populations to adapt to novel chemicals in their environment is the only hazard to the agriculture industry. It must be remembered that short term co-evolutionary change may be an important factor in the interaction of plant and herbivorous insect populations.

Differential herbivory of certain allelochemical composition of plants may alter the genotype make up of plants populations and such changes in the plant population can act as a selective force to alter the genetic makeup of insect population.

Therefore the causal mechanisms of plant-mediated interaction between insect herbivores are diverse and include induced plant allelochemistry, nutrition, morphology, and altered natural-enemy attack. Insect herbivores can also induce changes in plant morphology, such as increased branching and the re-flush of leaves, or alter architecture by building leaf shelters and leaf rolls that favor other herbivore species.

Similarly it is conceivable that one herbivore might induce allelochemicals that are then sequestered by another species for use in defense against natural enemies. This would represent a case of plant-mediated facilitation involving induced defenses and reduced enemy attack. Plant-mediated allelochemical interactions between insect herbivores, may be both negative and positive. It is also interesting that herbivorous insects can be attacked by parasitoids whose larvae develop inside their host plant.

It is now well established that plants can influence parasitoid performance. Bruce (2015) provides an interesting discussion of the mechanisms of plant recognition of insect attack as well as downstream signaling and defense mechanisms, but broadens the subject by also introducing mechanisms by which insects recognize their hosts and overcome plant defenses. Bruce also introduces the concept of insect effecter proteins that modulate

host immune responses in favour of the attacker and the importance of the ecological context of the plant–insect interaction and the role that additional organisms interacting with either the host plant or the insect can have on the outcome of the primary interaction.

Very recently (Coleman et al., 2015) the molecular mechanisms of plant–insect interactions has been advocated. According to Coleman at al it is the insect effectors molecule, which enable insect colonization of plants via modulation of plant processes, including probable defense pathways. The knockdown of effect of genes by RNA interference (RNAi) is a key technology for the identification of aphid effectors and subsequent functional characterization of these proteins. Recently, it was demonstrated that aphid gene knockdown is achieved by plant-mediated RNAi in which the dsRNAs are introduced into the aphid by feeding the insects on transgenic plants that transiently or stably produce the dsRNAs. Allelochemicals can play their role only when sensory modalities is active in insects.

They may use chemical stimuli either from the host plant or from the interaction between insect and its host plant. The utility of this chemical information depends upon

(1) its reliability in indicating herbivore presence, identity, accessibility and suitability; and

(2) its detectability.

III.V Conclusion

The interaction between insects and plants may be mutualistic but there are antagonistic interaction also. This unit amply demonstrates the depth of the field including host finding and host choice of the insects.

III.VI Summary

Plants synthesizes numerous chemicals known as allelochemicals within their body and some of them are volatile organic compound and they play an important role for the interaction with the insects.

III.VII Glossary

Confluent- running together

Morphological- relating to form and structure

Moult- process of larval growth involving the shedding of outgrown skin

III.VIII Further reading

Schoohoven, L.M. , Van Loon, J.J.A and Dicke,M (2007) - Insect – plant biology , Oxford University Press, London , New York.

III.IX Model questions

1. What is allelochemicals ?
2. What is allelopathy ?
3. What is co-evolution ?
4. What is relative generation time ?
5. What is biotic enemy ?
6. How an insect recognizes a host plant ?

UNIT IV❑ Insect as mechanical and biological vectors, adaptations as vectors and host specificity

Structure / Content

IV.I Objective

By studying this unit learners can understand about vectors , its types as well as its importance in zoological studies. This unit also elaborates the breeding mechanism of vectors and how the population of vectors are increased.

IV.II Introduction

Vectors are living organisms that can able to transmit infectious diseases between humans or from animals to humans or a vector is an invertebrate organism that transmits the parasitic agents from vertebrate host to the next.

IV.III Insect as mechanical and biological vectors

A vector is an organism that carries disease causing pathogen or parasites, transmits these organisms and cause infectious diseases among living beings. Few vector species

are 'haematophagous', which feed on blood of their specific animal hosts during different stages of their lives. However, many vectors are herbivores, which transmit pathogens or parasites to various plant species during they feed on plants. Thus, vectors introduce a pathogen such as a bacterium or virus or fungi or parasites into a plant or animal to cause an infection.

The insects which become vectors to many animals including humans are:-

1. Mosquitoes
2. Flies
3. Lice
4. Fleas
5. Louses
6. Assassin bugs, etc, transmits a different type of infectious diseases among humans and domestic animals.

Similarly, many insects become vectors to plants and they include:-

1. Aphids
2. Thrips
3. Beetles
4. Grasshoppers
5. Leafhoppers
6. Earwig
7. Wasps, etc., which transmit viral, bacterial fungal and mycoplasm diseases in various wild and cultivable plants.

Vectors can be classified into two types :-

Mechanical Vectors :-

It is the organism in which no development or multiplication of parasites takes place.

The parasites are attached to the outside of vectors body, such as in legs and thus transmit the parasites from one host to another without involving any developmental stages of the parasites in their body. These types of vectors are known as mechanical vectors e.g. in housefly, cockroach etc. So they are known as mechanical vectors.

Biological Vectors :-

It is the organism in which either multiplication or development of the parasites occurs.

Biological vectors are also known as intermediate host.

Many of the biological vectors are blood sucking insects, which ingest disease-producing microorganisms during a blood meal from an infected host (human or any other animal) and later inject it into a new host during their subsequent blood meal. Insect vector-borne diseases are human illnesses caused by parasites, viruses and bacteria that are transmitted by mosquitoes, house flies , sandflies, reduvid bugs, blackflies, ticks, tsetse flies, and lice. Every year there are more than 700 000 deaths from diseases such as malaria, dengue, schistosomiasis, human African trypanosomiasis, leishmaniasis, Chagas disease, yellow fever, Japanese encephalitis and onchocerciasis, globally. The major vector-borne diseases, together, account for around 17% of all infectious diseases. Distribution of vector-borne diseases is determined by complex demographic, environmental and social factors. Global travel and trade, unplanned urbanization and environmental challenges such as climate change can impact on pathogen transmission, making transmission season longer or more intense or causing diseases to emerge in countries where they were previously unknown. Due to high adaptive radiation of the insects they are well associated with different parasites in comparison to any other animals acting as vectors.

The biological vectors transmitted the parasites by three ways :-

1. **Propagative transmission:** When the disease agent or parasite undergoes multiplication within the body of biological vector but no cyclical change is observed, then the transmission is said to be propagative.

   Example: Plague bacilli in rat fleas.

2. **Cyclo-propagative transmission:** Here the parasite undergoes multiplication in the body of the vector and at the same time cyclical change is also noticed.

   Example: Plasmodium (malarial parasite) in female Anopheles mosquito.

3. **Cyclo-developmental transmission:** When the disease agent or parasite undergoes no multiplication in the body of vector but they undergo cyclical changes. Example: Guinea- worm embryo in Cyclops and filarial parasite (Wuchereria) in Culex mosquito.

IV.IV Adaptations as vectors and host specificity

Changes in climate will influence arthropod vectors, their life cycle and life history resulting in changes in both vector and pathogen distribution and changes in the ability of arthropod to transmit pathogens. Climate can affect the way the pathogen interacts with both the arthropod vector and the human or animal host. Predicting and mitigating the effects of future changes in the environment (like climate change on the complex arthropod-pathogen-host epidemiological cycle) requires understanding of a variety of complex mechanisms from the molecular to the population of a given parasite or vector species respond similarly to temperature, regardless of their source population.

Mosquitoes that carry malaria are constantly adapting. Some develop resistance others alter their behaviour. Mosquitoes of the genus *Anopheles,* the vectors of malaria always find a way to foil human attempts to protect themselves from this disease.

Typically most vectors are located in tropical regions currentle variations in temperature and different climate patterns could be driving changes in their native range. The increase of annual mean temperatures and the introduction of disturbances in seasonal rhythms in latitude located above tropics seem to be the major causes of the spreading of these organisms. Thus in a few years the number of cases of vector borne diseases will probably increase greatly in different non tropical locations arround the world. Changes in some agricultural practices forced by the changes in temperature and precipitations could be influencing on the spreading on the vector borne diseases , mainly due to an inappropiate use of water sources , since many insects go through an aquatic larval phase.

However climate change is not the only possible cause of their expansion ; global transport and commercial exchanges world wide are an open door in the international transport of vectors. If there is also a climate matching between the native and the new range then it is way easier for vectors to settle in the new location.

The condition necessary for an insect to become a vector are multiple but require an innate vector competence as a genetic basis. Next to the vector competence plenty of entomological, ecological and pathogen related factors are decisive , given the availability of infection sources. The various modes of pathogen transmission by vectors are connected to the developmental routes of the microorganisms in their vectors.

Host specificity encompasses the range and diversity of host species that a parasite is capable of infecting and is considered a crucial measure of a parasite’s potential to shift hosts and trigger disease emergence. There is a strong interplay between a parasite’s

evolutionary history, transmission mode, and environmental filters that shape host-parasite interactions .

IV.V Conclusion

A vector is a living organism that transmits an infectious agent from an infected animal to a human or another animal. Vectors are frequently arthropods, such as mosquitoes, ticks, flies, fleas and lice.

Vectors can transmit infectious diseases either actively or passively. Diseases transmitted by vectors are called vector-borne diseases. Many vector-borne diseases are zoonotic diseases, i.e. diseases that can be transmitted directly or indirectly between animals and humans.

IV.VI Summary

Different disease vectors carry and transmit pathogens into other living organism but vector never cause disease by itself. Carriers also serve as potential source of infection.

IV.VII Glossary

Vector - A vector may be any arthropod (insect or arachnid) or animal which carries and transmits infectious pathogens directly or indirectly from an infected animal to a human or from an infected human to another human.This can occur via biting (e.g. mosquitoes, tsetse flies), penetration (e.g. guinea worm), or the gastrointestinal tract (e.g. contaminated food or drink).

IV.VIII Further reading

Konstans Wells and Nicholas J Clark (2019)- Host Specificity in Variable Environments, Trends Parasitol.,35 (6):452-465. doi: 10.1016/j.pt.2019.04.001. Epub 2019 Apr 29.

IV.IX Model question

Distinguish between biological and mechanical vectors with example.

What do you mean by host specifity ?

UNIT V ❑ Dipteran as disease vectors - mosquito, house-fly, sand-fly

Structure / Content

V.I Objective

After going through this Unit, the learner will be able to explain the characteristic features and biology of housefly, detail and draw the life cycle of housefly,mosquito and explain the behavior of housefly, and the role of houseflies as vector of diseases, and also ablke to describe the preventive and control measures of houseflies.

V.II Introduction

Blood-sucking arthropods transmit a variety of human pathogens acting as disseminators of the so-called vector-borne diseases. Leishmaniasis is a spectrum of diseases caused by different *Leishmania* species, transmitted *quasi* worldwide by sand flies.

V.III Dipteran as disease vectors

The insect Order Diptera, with more than 124,000 currently described, extant species, ranks as one of the worlds largest groups of organisms. It is a potential mechanical vector for diseases like typhoid, paratyphoid fever, cholera, gastroenteritis, amoebiasis, salmonellosis, diarrhea, dysentery, anthrax, tuberculosis, trachoma, conjunctivitis and yaws. Eggs and larvae of tapeworm (Taenia)and roundworm (Ascaris) may be transmitted by housefly.

V.III.I Mosquito as disease vectors

Mosquitoes are a large arthropod group with 3,100 species occurring in the world. Only about a hundred of them are vectors of human disease. Mosquitoes can be divided into two subfamily groups:-

1. **The anopheline subfamily** including the most important mosquito genus Anopheles which is responsible for transmitting malaria. Anopheles are also involved in transmission of filariasis in West Africa.
2. **The culicine subfamily** where the important genera Aedes, Culex, and Mansonia belong. Several diseases are transmitted by them such as yellow fever, and dengue by Aedes, encephalitis virus by Culex. All of these mosquitoes are also involved in the transmission of filariasis.

In all species, only the female mosquito takes blood-meals from animals and/or humans. The female mosquitoes are attracted by the odour, the carbon dioxide and the heat from animals and humans. The blood sucked is used to provide proteins to mature batches of eggs.

Several diseases are transmitted by them such as yellow fever, and dengue by Aedes, encephalitis virus by Culex. All of these mosquitoes are also involved in the transmission of filariasis . Both male and female mosquitoes feed on sugary secretions such as nectar from plants. In all species, only the female mosquito takes blood-meals from animals and/or humans. The female mosquitoes are attracted by the odour, the carbon dioxide and the heat from animals and humans. The blood sucked is used to provide proteins to mature batches of eggs. The life cycle of the mosquito consists of four stages : the immature stages of egg, larva, and pupa require an aquatic environment. The adult develops in aerial and terrestrial environments. The females are able to lay between 30 and 300 eggs at a time, according to species. The anopheline mosquitoes lay their eggs separately over

the surface of any kind of unpolluted water. The culicine mosquitoes, Culex and Mansonia, lay their eggs on water as an egg-raft form. The eggs of Aedes mosquitoes are laid just above the water line or in wet mud. Provided that they are kept dry they can survive for 3 to 4 years and hatch only when flooded by rising water levels or heavy rain. Following are the importance of different mosquito species acting as vector for different diseases.

Mosquito Genus	**Breeding site and time**	**Distribution**	**Vector of Diseases (name)**
Anopheles sp	Anopheles breed in non polluted water Biting period : nightnormally at the edges of rivers, swamps, impoundments, ditches, tanks, saltwater habitatsprotected from waveaction, rice fields, temporary rainpools, hoofprints.	World wide	**Malaria:** Tropical and sub-tropicalareas **Bancroftian filariasis:** Asia and Africa **Brugian filariasis:** Asia O'nyong nyong virus: Africa
Aedes sp	One species lives in closeassociation with man, in anykind of human settlement. The *A. aegypti* breeds in anysmall water collection. Aedesspp. are primarily forestmosquitoes. Biting period :day. Tin cans, plastics, cartyres, gutters, ornamentalponds, tanks, jars, any typeof container, waste disposalareas, tree holes.	World wide	**Yellow fever:** Africa and Americas Dengue: Africa, Americas, Asia **Dengue** Haemorrhagic fever: Americas, Asia **Bancroftian filariasis:** Pacific **Other arbovirus:** Africa, Americas, Asia
Culex sp.	*C. quinquefasciatus* breed in any dirty waterin urban and rural areas. Other	World wide	**Bancroftian filariasis :** Mosttropical areas

	species are alsovery common in ricefields in Asia. Biting period :night. Normally waste waterditches, latrines, septic pits, cesspools, drains, waste disposal.		**Encephalitis virus :** Africa, Americas, Asia, Europe
Mansonia sp	Mainly associated withaquatic plants, in ruralareas where irrigationcanals occur. Biting period : night Ditches, ponds, irrigation canals, swamps.	Tropical	**Brugian filariasis :** Asia **Other arbovirus :** Rare in Africaand America

Life cycle of Mosquito :-

1. Eggs- Mosquito eggs are white in colour but when first deposited eggs are darken. The eggs of all mosquitoes are similar excepting the eggs of Anopheles whose eggs are float attached to each side. The incubation period is dependent upon environmental condition and genetic factors. Some species lays their eggs directly on the water surface while some species deposit their eggs on moist soil or any other wet substrate. Mosquito eggs can undergo diapauses or quiescence for a long period of time under unfavorable environmental conditions.

2. Larvae - This stage is also known as wigglers or wrigglers. There is a siphon or air tube in the last abdominal segment which serves as a respiratory apparatus. Larvae of Anopheles however breathe through a cluster of small abdominal plates. Depending upon the species and environmental conditions larval stages will take from few days to few weeks for its complete development.

3. Pupa - This stage is also known as tumblers. Pupal stages are very active and showed movements when disturbed. They respire through two respiratory horns. This stage never feeds.

4. Adult -Adult mosquitoes are terrestrial and are capable to flight. Females have piercing and sucking type of mouth parts and feed mostly on bloods but may feeds on nectar. Male mosquito have modified mouthparts and totally dependent on flower nectar. Female mosquito needs at least one blood meal for the development of their ovum. Adult mosquitoes are normally migratory in habit and may migrate up to 50 miles or more.

Females oviposits on water , crevices and also in damp soils. Normally most of the mosquitoes have multiple generations in a year. One of the peculiarities of mosquitoes is that they are adaptable to changing environmental conditions and that's why they are associated with multiple habitat types. Aedes and Culex mosquitoes are known as artificial container and tree hole group mosquito because these mosquitoes can complete their life cycle within this micro habitats.

V.III.II House-fly as disease vectors

The common housefly, Musca domestica, lives in close association with people all over the world . The insects feed on human foodstuffs and wastes where they can pick up and transport various disease agents. In warmer climates, the filth fly, Musca sorbens is of particular interest in this regard. It is closely related to the housefly and considered important in the spread of eye infections. Blowflies (Calliphora sp , Calliphoridae) and other flies have been associated with the transmission of enteric infections. There are four distinct stages in the life of a fly: egg, larva or maggot, pupa and adult . Depending on the temperature, it takes from 6 to 42 days for the egg to develop into the adult fly. The length of life is usually 2–3 weeks but in cooler conditions it may be as long as three months. The adult fly is grey, 6–9 mm long and has four dark stripes running lengthwise on the back. Adult house flies have haustellate (sucking) type of mouth parts and that's why their food must be either in the liquid state or readily soluble in the salivary gland secretions or in the crop. Liquid food is sucked up and solid food is wetted with their saliva, to be dissolved before ingestion. Water is an essential part of a fly's diet and flies do not ordinarily live more than 48 hours without access to it. Other common sources of food are milk, sugar, syrup, blood, meat broth and many other materials found in human settlements. The flies evidently need to feed at least two or three times a day. House flies are known to responsible for spreading a range of diseases and infections in human. According to World Health Organization house flies are the mechanical vectors of diarrhoeal diseases, skin and eye infections . It has also been proven that house flies can transmit food-borne pathogens and their associated toxin and resistance. Areas in close proximity to animal production sites are at higher risk of accumulating food borne diseases from flies. House flies transmit these range of diseases due to their feeding and breeding habits. House flies will often feed on rotting or decaying matter, as well as human and animal faeces. When a house fly feast upon an item of food infected with bacteria they accumulate the pathogen within their esophagus or digestive system. One unique characters of house flies feeding habit is that the fly is able to regurgitating their stomach contents onto solid

objects to liquefy them, any bacteria living in their esophagus will be transmitted to the item they are consuming. Similarly the bacteria living within their digestive system will be transmitted to items which they defecate on through their faeces. The house flies can accumulate the bacteria on the tiny hairs on their legs and body. When the house fly lands on a food product, or any other item, any pathogen which has attached itself to said hairs can easily be transmitted. House flies are known to act as mechanical vector and carrier of the following diseases:-

Cholera- a bacterial disease

Conjunctivitis- both viral and bacterial disease

Dysentery- a bacterial disease

Gastroenteritis- a viral disease

Salmonellosis- a bacterial disease

Tuberculosis- a bacterial disease? Typhoid fever- a bacterial disease

Life cycle of House Fly

There are four distinct stages in the life of a fly: egg, larva or maggot, pupa and adult . Depending on the temperature, it takes from 6 to 42 days for the egg to develop into the adult fly. The length of life is usually 2–3 weeks but in cooler conditions it may be as long as three months.

1. Eggs :- Eggs are usually laid in masses on organic material such as manure and garbage. Hatching occurs within a few hours. The young larvae burrow into the breeding material; they must obtain oxygen from the atmosphere and can, therefore, survive only where sufficient fresh air is available. When the breeding medium is very wet they can live on its surface only, whereas in drier materials they may penetrate to a depth of several centimeters.

2. Larvae :- The larvae of most species are slender, white, legless maggots that develop rapidly, passing through three instars. The time required for development varies from a minimum of three days to several weeks, depending on the species as well as the temperature and type and quantity of food available. After the feeding stage is completed the larvae migrate to a drier place and burrow into the soil or hide under objects offering protection.

3. Pupa :- Larva form a capsule-like case, the puparium, within which the transformation from larva to adult takes place. This usually takes 2–10 days, at the end

of which the fly pushes open the top of the case and works its way out and up to the surface.

4. Adult :- The adult fly is grey in colour, 6–9 mm long and has four dark stripes running lengthwise on the back. A few days elapse before the adult is capable of reproduction. Under natural conditions an adult female rarely lays eggs more than five times, and seldom lays more than 120–130 eggs on each occasion. Both male and female flies feed on all kinds of human food, garbage and excreta, including sweat, and on animal dung. Under natural conditions flies seek a wide variety of food substances.

Breeding Habits of House Fly

Female flies deposit their eggs on decayed, fermenting or rotting organic material of either animal or vegetable origin. Unlike blowflies and fleshflies, houseflies rarely breed in meat or carrion. Normal breeding places of house fly are :

A. Dung:- Heaps of accumulated animal faeces are among the most important breeding sites for houseflies. The suitability of dung for breeding depends on its moisture (not too wet), texture (not too solid) and freshness (normally within a week after deposition).

B. Garbage and waste from food processing:- Garbage provides the main medium for breeding. It includes waste associated with the preparation, cooking and serving of food at home and in public places, and with the handling, storage and sale of food, including fruits and vegetables, in markets.

C. Organic manure:- Fields that are heavily manures with organic matter such as dung, excrement, garbage and fish-meal may provide suitable breeding places for flies.

V.III.III Sand-fly as disease vectors

These vectors, commonly called as sand flies are grouped under family Psychodidae and two subfamilies, namely Psychodinae and Phlebotominae which transmit different type of leishmaniasis. The subfamily Phlebotominae comprises six genera namely *Phlebotomus, Segentomyia, Brumptomyia, Lutzomyia, Warileya, and Parvideus.* All species of sand flies feed on sugary nutrients derived from the plant nectar and honey dew, while the females are sanguivorous (feed on blood). Host availability and blood feeding is an important factor for the vectorial capacity of sand flies. As discussed earlier, female sand flies feed on a wide variety of vertebrate hosts, including humans, livestock, dogs, urban and wild

rodents, reptiles, amphibians and birds. Each species of sand fly may have its own specific host preferences. Lutzomyia shannani feeds on white-tailed deer, horses, donkeys, mules, cattle, swine, raccoons, rodents, birds and humans while Phlebotomus feed on only mammals.

Sand Fly borne diseases

Visceral leishmaniasis is a chronic disease caused by *Leishmania donovani*. It is a visceral infection of reticulo-endothelial system. Cutaneous leishmaniasis commonly known as oriental sore is caused by *Leishmania tropica.* Sand fly fever, also known as Pappataci fever or KALA-AZAR. Phlebotomus fever or 3-day fever is an interesting disease mimicking other conditions which cause fever, myalgia and malaise along with abnormalities in liver enzymes and hematological test results. The disease is caused by Phlebovirus carried by sand fly.

Life cycle of Sand fly

The life cycle of P. argentipes consists of 4 stages namely Egg, Larva, Pupa and adult.

Adult- The adults of sand fly (Phlebotomus) are small, fuzzy, with delicately proportioned body, usually ¼ of the size of the mosquito. These are golden, brownish or grey-coloured with large black eyes. These are 1.5 to 3.5 mm long and possess a highly fragile body. The males and unfed females can pass through mosquito net easily. The body, wings, and legs are heavily clothed with long hairs. The wings and legs are larger than the size of body. The sand fly can be distinguished from other insects and spotted easily because of the posture of its wings which are held vertically erect on the abdomen, in V-shape, when at rest.

Eggs - Sand fly adult females lay single eggs in small batches of roughly 30-70 eggs. The freshly laid eggs are creamy-white in colour which later turn dark. The eggs are usually deposited in cracks and crevices with high organic content, humidity and darkness. Sometimes eggs are also found in loose soil .

Larvae - The larva is creamy-white with distinct head, thorax and abdomen provided with numerous hairs on its body. They are mainly scavengers and feed on organic matter available in the soil such as decaying vegetation, fungi, animal faeces etc. The life cycle comprises four larval stages.

Pupae- The pupa is elongated and comma-shaped. It is milky white in the beginning

and turns brown gradually. During pupal emergence, the larval skin is not completely shed and remains attached to the end of pupal body. Presence of larval skin with two pairs of peculiar caudal bristles at the abdominal end makes the most characteristic feature of sand fly pupa and aids in its recognition. The pupa is a non-feeding stage lasting for about 6-10 days. The sexes are differentiated in this stage.

The sand flies are the natives of warm climate. They can be grouped into two categories based on climatic conditions, species associated with the wet zone the species associated with the arid zone. *Phlebotomus argentipes* is one of the widely distributed sand flies and is essentially the species of wet zone. The prevalence of vector is dependent upon the environmental factors which include humidity, temperature and rainfall. The ecological factors like alluvial soil, kuccha mud-houses and large-scale vegetation also influence buildup of vector density.

V.VI Summary

The Order Diptera (true flies) includes many common insects such as mosquitoes, midges, sand flies, blowflies and the House Fly. Most of the insects we see flying around do so with four wings (two pairs), but dipterans (meaning ‘two wings’) use only one pair.

V.VII Glossary

Disease:- As used in this report, refers to a situation in which infection has elicited signs and symptoms in the infected individual; the infection has become clinically apparent.

V.VIII Further reading

C.B.Marcondes (2017) -Arthropod borne diseases, Springer, London, New York.

V.IX Model questions

1. Define vector.
2. What is difference between biological and mechanical vector ?3. What is cyclo-propagative transmission ?

4. What is the vector of Dengue fever ?
5. Which mosquito acts as a vector of filariasis ?
6. What is puparium ?
7. What is the unique feature of house fly feeding habit ?
8. Why house fly do not survive more than 48 hours without water ?

UNIT VI ❑ Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis.

Structure / Content

VI.I Objective

After studying this unit learners will be able to understand about the different serious diseases of human beings regarding their symptoms ,and the pathogens behind these diseases.

VI.II Introduction

Vectors are living organisms that can transmit infectious pathogens between humans, or from animals to humans. Many of these vectors are bloodsucking insects which ingest disease-producing microorganisms during a blood meal from an infected host (human or animal) and later transmit it into a new host, after the pathogen has replicated. Often, once a vector becomes infectious, they are capable of transmitting the pathogen for the

rest of their life during each subsequent bite/blood meal. Vector-borne diseases are human illnesses caused by parasites, viruses and bacteria that are transmitted by vectors. Distribution of vector-borne diseases is determined by a complex set of demographic, environmental and social factors. Global travel and trade, unplanned urbanization, climate change and silent spread and adaptation of the vectors have all contributed to the spread of vector-borne diseases.

VI.III Malaria

Malaria is a life-threatening disease spread to humans by some types of mosquitoes. It is mostly found in tropical countries. It is preventable and curable.The infection is caused by a parasite and does not spread from person to person. Malaria can be prevented by avoiding mosquito bites and with medicines. Treatments can stop mild cases from getting worse. Malaria mostly spreads to people through the bites of some infected female *Anopheles* mosquitoes. Blood transfusion and contaminated needles may also transmit malaria. The first symptoms may be mild, similar to many febrile illnesses, and difficulty to recognize as malaria. Left untreated, *P. Falciparum* malaria can progress to severe illness and death within 24 hours.There are 5 *Plasmodium* parasite species that cause malaria in humans and 2 of these species –*P. Falciparum* and *P. vivax*– pose the greatest threat. *P. falciparum* is the deadliest malaria parasite and the most prevalent on the African continent. *P. vivax* is the dominant malaria parasite in most countries outside of sub-Saharan Africa. The other malaria species which can infect humans are *P. malariae, P. ovale* and *P. Knowlesi*.

Symptoms of Malaria

The most common early symptoms of malaria are fever, headache and chills.Symptoms usually start within 10–15 days of getting bitten by an infected mosquito. Symptoms may be mild for some people, especially for those who have had a malaria infection before. Because some malaria symptoms are not specific, getting tested early is important. Some of the commonest symptoms are :-

1. Extreme tiredness and fatigue
2. Impaired consciousness
3. Multiple convulsions
4. Difficulty breathing
5. Dark or bloody urine

6. Jaundice (yellowing of the eyes and skin)
7. Abnormal bleeding.

Severe symptoms can include

1. Kidney failure
2. Seizures
3. Mental confusion
4. Coma

Malaria can be prevented by avoiding mosquito bites and by taking medicines. Talk to a doctor about taking medicines such as chemoprophylaxis before travelling to areas where malaria is common.Lower the risk of getting malaria by avoiding mosquito bites:

1. Use mosquito nets when sleeping in places where malaria is present.
2. Use mosquito repellents (containing DEET, IR3535 or Icaridin) after dusk.
3. Use coils and vaporizers.
4. Wear protective clothing.
5. Use window screens.

Vector control is a vital component of malaria control and elimination strategies as it is highly effective in preventing infection and reducing disease transmission.

VI.IV Dengue

Dengue or break-bone fever is a viral infection that spreads from mosquitoes to people. It is more common in tropical and subtropical climates. Dengue is transmitted by the bite of an infected mosquito. The disease has a seasonal pattern: most cases in the southern hemisphere occur in the first half of the year, and most cases in the northern hemisphere in the second half. This pattern corresponds to the warmer, rainy months. The dengue virus is transmitted to humans through the bites of infected female mosquitoes, primarily the *Aedes aegypti* mosquito. Other species within the *Aedes* genus can also act as vectors, but their contribution is normally secondary to *Aedes aegypti*. However, in 2023, a surge in local transmission of dengue by *Aedes albopictus* (tiger mosquito) has been seen in Europe. After feeding on a infected person, the virus replicates in the mosquito midgut before disseminating to secondary tissues, including the salivary glands. The time it

takes from ingesting the virus to actual transmission to a new host is termed the extrinsic incubation period (EIP). The EIP takes about 8–12 days when the ambient temperature is between 25–28°C.

Symptoms of Dengue

Most people with dengue have mild or no symptoms and will get better in 1–2 weeks. Rarely, dengue can be severe and lead to death.

If symptoms occur, they usually begin 4–10 days after infection and last for 2–7 days. Symptoms may include:

1. high fever (40°C/104°F)
2. severe headache
3. pain behind the eyes
4. muscle and joint pains
5. nausea
6. vomiting
7. swollen glands
8. rash.

Individuals who are infected for the second time are at greater risk of severe dengue. Severe dengue symptoms often come after the fever has gone away:

1. severe abdominal pain
2. persistent vomiting
3. rapid breathing
4. bleeding gums or nose
5. fatigue
6. restlessness
7. blood in vomit or stool
8. being very thirsty
9. pale and cold skin
10. feeling weak.

There is no specific treatment for dengue. The focus is on treating pain symptoms. Most cases of dengue fever can be treated at home with pain medicine. Acetaminophen (paracetamol) is often used to control pain. Non-steroidal anti-inflammatory drugs like ibuprofen and aspirin are avoided as they can increase the risk of bleeding. The mosquitoes that spread dengue are active during the day. Lower the risk of getting dengue by protecting yourself from mosquito bites by using:

- clothes that cover as much of your body as possible;
- mosquito nets if sleeping during the day, ideally nets sprayed with insect repellent;
- window screens;
- mosquito repellents (containing DEET, Picaridin or IR3535); and
- coils and vaporizers.

Mosquito breeding can be prevented by:

- preventing mosquitoes from accessing egg-laying habitats by environmental management and modification;
- disposing of solid waste properly and removing artificial man-made habitats that can hold water;
- covering, emptying and cleaning domestic water storage containers on a weekly basis;
- applying appropriate insecticides to outdoor water storage containers.

VI.V Chikungunya

Chikungunya is a viral disease transmitted to humans through by mosquitoes infected with the chikungunya virus.The mosquitoes involved in transmission are *Aedes aegypti* and *Aedes albopictus*. The disease was first described in Tanzania in 1952 and the virus was first isolated in Thailand in 1958. Chikungunya is **not** transmitted from one person to another. The virus needs a vector - a means of transportation and the vector is mosquitoes (*Aedes aegypti* and *Aedes albopictus*). When an uninfected mosquito feeds on a person who has chikungunya virus circulating in their blood, the mosquito can ingest the virus. The virus then replicates in the mosquito over several days, gets to its salivary glands, and can be transmitted into a new human host when the mosquito bites them. The virus again begins to replicate in this newly infected person and reaches high concentrations in

their blood, at which point they can further infect other mosquitoes and perpetuate the transmission cycle.

Symptoms of Chikungunya

It is characterized by an abrupt onset of fever, frequently accompanied by severe joint pain. The joint pain is often debilitating and usually lasts for a few days but may be prolonged, lasting for weeks, months or even years. Other common signs and symptoms include

1. joint swelling,
2. muscle pain,
3. headache,
4. nausea,
5. fatigue and
6. rash.

Since these symptoms overlap with other infections, including those with dengue and Zika viruses, cases can be misdiagnosed. In the absence of significant joint pain, symptoms in infected individuals are usually mild and the infection may go unrecognized.

Prevention of infection by avoiding mosquito bites is the best protection. Patients suspected of having chikungunya virus infection should avoid getting mosquito bites during the first week of illness to prevent further transmission to mosquitoes, who may in turn infect other people.The main method to reduce transmission of CHIKV is through control of the mosquito vectors. This requires mobilization of communities, who are critical in reducing mosquito breeding sites through emptying and cleaning containers that contain water on a weekly basis, disposing of waste, and supporting local mosquito control programmes. During outbreaks, insecticides may be sprayed to kill flying adult mosquitoes, applied to surfaces in and around containers where the mosquitoes land, and used to treat water in containers to kill the immature larvae.

VI.VI Viral encephalitis

Viral encephalitis is an inflammation of the brain parenchyma caused by a virus. It is the most common type of encephalitis and often coexists with viral meningitis. Viruses invade the host outside the central nervous system (CNS) and then reach the spinal cord

and brain hematogenously or in a retrograde manner from nerve endings. Viral encephalitis tends to be more common in younger people compared to elderly individuals. However, the environment also plays a critical role. Infectious encephalitis can be viral, bacterial, fungal, protozoal, or helminthic in etiology. role.

Encephalitis is inflammation of the active tissues of the brain caused by an infection or an autoimmune response. The inflammation causes the brain to swell, which can lead to headache, stiff neck, sensitivity to light, mental confusion and seizures.Many cases of viral encephalitis go undetected because of the lack of tests and mild symptoms. The most common causes of viral encephalitis are herpes simplex virus (HSV), West Nile virus, and the enteroviruses. Symptoms vary depending on the type of encephalitis. Japanese encephalitis virus (JEV) belonging to family *Flaviviridae* is an important cause of viral encephalitis in Asia. It is a mosquito-borne flavivirus and belongs to the same genus as dengue, Zika, yellow fever and West Nile viruses. Most JEV infections are mild (fever and headache) or without apparent symptoms, but approximately 1 in 250 infections results in severe clinical illness. The incubation period is 4–14 days. JEV is transmitted to humans through bites from infected mosquitoes of the *Culex* species (mainly *Culex tritaeniorhynchus*). In most temperate areas of Asia, JEV is transmitted mainly during the warm season. Early warning signs of infective encephalitis include:-

1. Confusion.
2. Drowsiness.
3. Fatigue.
4. Headache.
5. High fever.
6. Loss of consciousness.
7. Mild to moderate neck stiffness
8. Nausea and vomiting.
9. Seizure.

Viral infections and viruses carried by insects are common encephalitis causes. This disease can be prevented by :-

1. Wearing protective clothes
2. Using insect repellents

3. Keeping your property dry
4. Using screens and fans

VI.VII Filariasis.

Filariasis is a disease caused by a chronic mosquito-borne parasitic infection. Chronic infection can lead to swelling of the extremities, hydroceles, and testicular masses. Filariasis is caused by at least three species of nematode parasites (*Wuchereria bancrofti, Brugia malayi, and Brugia timori*) and is transmitted to 5 genera of mosquitoes including *Aedes, Anopheles, Culex, Mansonia,* and *Ochlerotatus.*Humans are the primary reservoir for this parasitic disease, and mosquitoes are the vector. The mosquito deposits larvae into the bloodstream. They take up residence in the lymph nodes and grow into adult worms. The larvae have a predilection to deposit in femoral lymph nodes. They undergo sexual reproduction, and females give birth to countless microfilariae, which are dumped into circulation in a diurnal pattern. Females can give off eggs for approximately 5 years, and adults can live up to 9 years. With the proliferation of adult worms, the lymphatics become occluded, which disrupts the lymphatic drainage and increases the susceptibility to repeated infections - most notably streptococcal and fungal infections. This acute-on-chronic inflammation leads to fibrosis and remodeling of the lymphatics, further perpetuating contractile dysfunction and leading to the dermal skin changes seen with elephantiasis. Mosquitoes spread lymphatic filariasis from one person to another. When a mosquito bites a person who has lymphatic filariasis, microscopic worms in the person's blood enter and infect the mosquito. When the infectious mosquito bites another person, that person may be infected and the cycle of spreading lymphatic filariasis continues.

Symptoms of Filariasis

Most people infected with the worms that cause lymphatic filariasis never show symptoms. Others may not develop symptoms until several years after infection. But for those who do, the signs and symptoms of lymphatic filariasis may include **:-**

1. Lymphedema, a swelling of the legs (severe cases are sometimes known as elephantiasis), arms, breasts, or genitalia.
2. Hydrocele, or swelling in the scrotal sac, usually of adult men.
3. Hardening or thickening of skin.

4. Persistent coughing, wheezing, or shortness of breath.
5. Bacterial infections of the skin or lymph system.

Some of these symptoms occur many months or even years after initial infection with the parasite.

The best way to prevent filariasis is to avoid mosquito bites.

1. Avoid areas with high mosquito activity, especially between dusk and dawn. Mosquitoes that carry the parasite that causes lymphatic filariasis usually bite at night.
2. Use Environmental Protection Agency (EPA)-registered insect repellents containing DEET or another EPA-registered active ingredient.
3. Wear loose-fitting, long-sleeved shirts and pants and socks.
4. Keep windows and doors closed or covered with screens to keep mosquitoes out of your house.
5. Repair broken screens on windows, doors, porches, and patios.

VI.VIII Summary

All of the above mentioned diseases are mostly transmitted through Dipteran insect vectors. The insects like mosquito,sand fly ,house fly carries a range of pathogens causing several diseases. The only way to prevent from these diseases is to control the vectors by any of the insect control methods.

VI.IX Glossary

Zoonosis - A zoonosis is an infectious disease that has jumped from a non-human animal to humans. Zoonotic pathogens may be bacterial, viral or parasitic, or may involve unconventional agents and can spread to humans through direct contact or through food, water or the environment

VI.X Further reading

Service,M.(2008)- Medical Entomology for Students,Cambridge University Press,Cambridge.

VI.XI Model questions

What diseases are transmitted by Culex mosquito ?

What is lymphatic filariasis ?

Which virus cause japanese encephalytis ?

UNIT VII ❑ Visceral and cutaneous Leishmaniasis , Phlebotomus fever; Myiasis

Structure / Contents

VII.I Objective

From this unit learners will be able to understand about three important human disease which are vector borne. This unit also tells them about the symptoms and control measures of these diseases.

VII.II Introduction

There are 3 main forms of leishmaniases which are visceral (the most serious form because it is almost always fatal without treatment), cutaneous (the most common, usually causing skin ulcers), and mucocutaneous (affecting mouth, nose and throat). Leishmaniasis is caused by protozoan parasites which are transmitted by the bite of infected female phlebotomine sandflies. The disease affects some of the world's poorest people and is associated with malnutrition. Similarly Sandfly fever, also known as 'three-day fever' or 'pappataci fever' or 'Phlebotomus fever' which is a viral infection that causes self-limited influenza-like symptoms and characterized by a rapid onset. The disease occurs commonly

in endemic areas in summer months and especially in August during which sandflies are active.

VII.III Visceral and cutaneous Leishmaniasis

Leishmaniasis is caused by a protozoa parasite from over 20 *Leishmania* species. Over 90 sandfly species are known to transmit *Leishmania* parasites. There are 3 main forms of the disease:

1. Visceral leishmaniasis (VL), also known as kala-azar, is fatal if left untreated in over 95% of cases. It is characterized by irregular bouts of fever, weight loss, enlargement of the spleen and liver, and anaemia. Most cases occur in Brazil, east Africa and India. An estimated 50 000 to 90 000 new cases of VL occur worldwide annually, with only 25–45% reported to WHO. It has outbreak and mortality potential.

Post-kala-azar dermal leishmaniasis (PKDL) is usually a phase of visceral leishmaniasis that appears as macular, papular or nodular rash usually on face, upper arms and trunk. It occurs in east Africa (mainly in Sudan) and on the Indian subcontinent, where 5–10% of patients with kala-azar are reported to develop the condition. Although uncommon, it has also been reported from Brazil and also in HIV coinfected VL cases caused by *L. infantum*. It usually appears 6 months to 1 or more years after kala-azar has apparently been cured but can occur earlier.

2. Cutaneous leishmaniasis (CL) is the most common form and causes skin lesions, mainly ulcers, on exposed parts of the body. These can leave life-long scars and cause serious disability or stigma. About 95% of CL cases occur in the Americas, the Mediterranean basin, the Middle East and central Asia. It is estimated that 600 000 to 1 million new cases occur worldwide annually but only around 200 000 are reported to WHO.

3. Muco-cutaneous leishmaniasis leads to partial or total destruction of mucous membranes of the nose, mouth and throat. Over 90% of mucocutaneous leishmaniasis cases occur in Bolivia (the Plurinational State of), Brazil, Ethiopia and Peru.

Leishmania parasites are transmitted through the bites of infected female phlebotomine sandflies, which feed on blood to produce eggs. Some 70 animal species, including humans, can be the source of *Leishmania* parasites. It should be remembered that poverty increases the risk for leishmaniasis. Poor housing and domestic sanitary conditions (lack of waste management or open sewerage) may increase sandfly breeding and resting sites, as well

as their access to humans. Sandflies are attracted to crowded housing because it is easier to bite people and feed on their blood. Human behaviour, such as sleeping outside or on the ground, may increase risk. Not only that malnutrition ,population mobility , environmental and climate change also plays an important role in the spread of Leishmaniasis.

Prevention and control

Preventing and controlling the spread of leishmaniasis is complex and requires many tools. Key strategies include:

1. Early diagnosis and effective prompt treatment
2. Vector control
3. Effective disease surveillance
4. Control of animal reservoir hosts
5. Mobilization and education of the community with effective behavioural change

VII.IV Phlebotomus fever

Sandfly fever, also known as 'three-day fever' or 'pappataci fever' or 'Phlebotomus fever' is a viral infection that causes self-limited influenza-like symptoms and characterized by a rapid onset. The disease occurs commonly in endemic areas in summer months and especially in August during which sandflies are active. Sandfly fever is a vector-borne febrile disease caused by viruses in the *Phlebovirus* genus of the *Bunyaviridae* family. Although the clinical picture is relatively benign, the infection is associated with severe morbidity and capacity for rapid spread to affect a high number of individuals. The epidemiology of sandfly fever is closely related to the presence and activity of the sandfly species, which act as vectors for transmission. Sandfly fever is one of the most common viral diseases in the world and of great importance in terms of public health.

Symptoms

1. The incubation period of the sandfly fever in humans is 4-8 days after being infected.
2. Headache
3. Severe fever
4. The viremia duration is usually less than 7 days.

5. Conjunctival hyperemia,
6. Contusion,
7. Lethargy,
8. Nausea,
9. Pain in the arms and legs and back,
10. Myalgia,
11. Abdominal pain,
12. Leukopenia.

VII.V Myiasis

Myiasis is defined as the infestation of live human and vertebrate animals with dipterous larvae, which, at least for a certain period, feed on the host's dead or living tissue, liquid body-substances, or ingested food. Myiasis has been divided into :-

1. *obligatory myiasis*, where a living host is required for fly development, and
2. *facultative myiasis*, where flies that normally use carrion or decaying organic matter for development occasionally infest macerated tissue or wounds of living hosts.
3. *Pseudomyiasis* is when maggots are found in the intestinal or urogenital tract as passersby; they have accidentally been swallowed or migrated into these areas without actually feeding on tissues.

Myiasis may also be defined based on the anatomic region infested such as :

1. Cutaneous,
2. Auricular,
3. Ophthalmic,
4. Neurologic,
5. Urogenital,
6. GI, and nasopharyngeal.
7. Cutaneous myiasis includes furuncular (subcutaneous) myiasis, traumatic (superficial cutaneous) myiasis, and creeping obligatory myiasis.

8. Migratory myiasis, or creeping myiasis, occurs when a dipteran maggot starts to migrate, aimlessly, through burrows in the skin, producing the migratory pattern of the lesions.Gasterophilus intestinalis is the most common cause of human migratory myiasis.

Ophthalmic myiasis has been divided into three types depending on the location of affected ocular tissues :

1. Ophthalmomyiasis externa (orbital or external ocular tissues),
2. Ophthalmomyiasis interna posterior (posterior portion of the globe), and
3. Ophthalmomyiasis interna anterior (anterior chamber).

A rare type of myiasis, hematophagous myiasis, is common in infants younger than 9 months, especially in those living in rural and endemic areas, and the furuncular lesions are usually on the face.

Four families of fly species have been implicated in myiasis which are :

1. Oestridae (bot flies or warble flies),
2. Calliphoridae (blow flies),
3. Sarcophagidae (flesh flies), and
4. Muscidae (house flies).

Symptoms

People infected with myiasis will develop a lump in their tissue as the larva grows. Larvae under the skin may move, but usually remain under the skin and do not travel throughout the body.

Prevention and Control

Prevention is key for protecting from myiasis. Take steps to protect yourself when visiting tropical areas and spending a lot of time outside. Take following precautions against insect bites:

1. Wear loose-fitting, long-sleeved shirts and pants to limit areas where you could get bitten.
2. Cover open wounds.
3. Use EPA-registered insect repellant.

4. Treat clothing and gear with products containing 0.5% permethrin.
5. Follow Travelers' Health guidelines.

VII.VI Summary

Mosquito is one of the most important insect vectors in humans, where it infects diseases due to transmission of viruses and parasites.Malaria is a mosquito-borne disease caused by a parasitic organism called plasmodium. This parasite invades red blood cells in the human body and destroys them.Domestic flies, including the housefly are probably the most widespread insects in the world and certainly the one most closely associated with man.

VII.VII Glossary

Definitive Host - A host in which the parasite undergoes sexual reproduction.

Host - An organism that harbors and nourishes another.

VII.VIII Further reading

Roberts, L and Janovi, Jr. J (2008) - Foundation of Parasitology, McFraw Hill, London.

VII.IX Model questions

What is migratory myiasis ?

What is vector ?

What are the types of viral encephalitics ?

What is lymphatic filariasis ?

UNIT VIII ❑ Helminth Parasites - mechanism of infection and consequences

Structure / Content

VIII.I Objective

From this unit learners will learn about those helminthes animals which are parasitic to man and other animals causing several diseases

VIII.II Introduction

There are two major groups of parasitic helminths: the roundworms (Nematoda) and flatworms (Platyhelminthes). As animals, they are multicellular and have organ systems. However, the parasitic species often have limited digestive tracts, nervous systems, and locomotor abilities. Parasitic forms may have complex reproductive cycles with several different life stages and more than one type of host. Phylum Nematoda (the roundworms) is a diverse group containing more than 15,000 species, of which several are important human parasites. Phylum Platyhelminthes (the platyhelminths) are flatworms. This group includes the flukes, tapeworms, and the turbellarians, which include planarians. The flukes and tapeworms are medically important parasites.

VIII.III Helminth Parasites

Helminths are parasitic worms that can infect humans and other animals. There are three types of helminths: flukes (trematodes), tapeworms (cestodes), and roundworms (nematodes). When these worms get into the human body, they can cause parasitic infection, which can appear as as intestinal worms or lung flukes. This infection is known as helminthiasis, although it's sometimes called helminthosis or simply a worm infection. Helminths are most common in areas that have moist, warm climates and poor sanitation. When worms are in someone's intestines, that person passes eggs through their stool. As the feces come into contact with soil, the eggs can spread. People can contract the infection if the infested soil reaches their mouths, often through dirty hands. In the case of hookworm, the parasite matures in the soil and is passed when a person walks over the soil with bare feet. Three types of helminths infect humans. A fourth type primarily infects animals but can infect humans in rare cases. The primary helminth parasites which infest humans are :-

1. Roundworms: These helminths, which have the scientific name nematodes, have a cylindrical body similar to earthworms. They can lead to infection in the intestines or elsewhere in the body. They are cylindrical in structure and usually bisexual; copulation between the male and female is important in fertilisation. Most nematodes that are parasitic in humans lay eggs that, when voided, contain either a zygote or a completely formed larva. Some nematodes, such as the filariae and *Trichinella spiralis*, produce larvae that are deposited in host tissues. The developmental process involves egg, larval and adult stages. Classification is via infection mode: direct, modified direct, or skin penetration. Direct infection occurs when eggs are transmitted from anus to mouth without reaching soil e.g. *Enterobius vermicularis* [pinworm/threadworm] and *Trichuris trichuria* [whipworm]. Modified direct infection occurs when eggs passed in faeces only become infectious following incubation time in soil e.g. *Ascaris lumbricoides* [roundworms]. Skin penetration is used by hookworms (*Ancylostoma duodenale* and*Necator americanus*).

2. Flukes or Trematodes : These helminths, or trematodes, have a flat body and leaf-shaped head with a sucker that helps them attach. They generally infect the bile ducts (thin tubes from the liver to the small intestine), liver, or blood. They are leaf-shaped, and vary in length from a few millimetres to 8cm. Excluding blood flukes, trematodes are hermaphroditic, having both male and female reproductive organs. Both self-fertilisation and cross-fertilisation occur. Blood flukes (schistosomes) are the only

bisexual flukes that infect humans (see 'Common flukes [trematodes]'). Within the definitive (human) host, male and female worms inhabit the lumen of blood vessels and are found in close physical association. Flukes go through several larval stages before reaching adulthood. Eggs are passed in the faeces, urine, or sputum of humans and, on reaching an aquatic environment, the eggs hatch, releasing ciliated larvae, which either penetrate or are eaten by snail intermediate hosts. A sporocyst develops from a miracidium within the tissues of the snail, producing cercariae that migrate to the external, usually aquatic, environment. Cercariae penetrate the definitive host and transform directly into adults.

3. Tapeworms: Tapeworms, or cestodes, are long, segmented flatworms found in or around the intestines. They are flat, hermaphroditic, parasitic worms that colonise the human gastrointestinal tract. Some are primarily human pathogens, others are animal pathogens that also infect humans. Adult tapeworms are elongated, segmented, flatworms that inhabit the intestinal lumen. Larval forms, which are cystic or solid, inhabit extra-intestinal tissues and include *Taenia saginata, Taenia solium, Diphyllobothrium latum, Hymenolepis nana* and *Echinococcus* species.

Segments (proglottids) are hermaphroditic and vary in length from 2mm–10m, with three to several thousand segments per adult tapeworm. Eggs are released when tapeworms shed gravid proglottids into the intestine, which are then shed in stools. All eggs are embryos that develop into different larval stages in both the immediate host (crustacean) and intermediate host (vertebrate). Larvae develop into adults in the definitive (human) host.

4. Thorny-headed worms: These helminths, or acanthocephalans, have a round body and barbs around their head. They mainly infect animals, and human infection is very rare.

The most serious helminth infections are acquired in poor tropical and subtropical areas, but some also occur in the developed world; other, less serious, infections are worldwide in distribution. Exposure to infection is influenced by climate, hygiene, food preferences, and contact with vectors. If an infected person or animal has defecated on soil, helminth eggs present in their feces contaminate the soil. These eggs mature and hatch to produce larvae that grow into adult worms of up to 13 mm in length. These adult worms can penetrate human skin, which can happen if a person walks on contaminated soil. The worms then enter the bloodstream and migrate towards the lungs and also the throat where they are swallowed and transported to the gut.

VIII.IV Mechanism of infection

The mode of transmission varies with the type of worm; it may involve ingestion of eggs or larvae, penetration by larvae, bite of vectors, or ingestion of stages in the meat of intermediate hosts Most of the helminth infection are soil transmitted . These infections affect the poorest and most deprived communities with poor access to clean water, sanitation and hygiene in tropical and subtropical areas, with the highest prevalence reported from sub-Saharan Africa, China, South America and Asia. They are transmitted by eggs present in human faeces, which in turn contaminate soil in areas where sanitation is poor. The main species that infect people are the roundworm (*Ascaris lumbricoides*), the whipworm (*Trichuris trichiura*) and hookworms (*Necator americanus* and *Ancylostoma duodenale*). Soil-transmitted helminths are transmitted by eggs that are passed in the faeces of infected people. Adult worms live in the intestine where they produce thousands of eggs each day. Apart from this helminth egg can be transmitted in following ways :-

1. Eggs that are attached to vegetables are ingested when the vegetables are not carefully cooked, washed or peeled;
2. Eggs are ingested from contaminated water sources; and
3. Eggs are ingested by children who play in the contaminated soil and then put their hands in their mouths without washing them.

There is no direct person-to-person transmission, or infection from fresh faeces, because eggs passed in faeces need about 3 weeks to mature in the soil before they become infective.

A. lumbricoides, T. Trichiura and hookworms do not multiply in the human host; re-infection occurs only as a result of contact with infective stages in the environment. In some cases the intermediate vector transmits infective stages when it bites the host to take a blood meal (the arthropod vectors of filarial worms); in other cases, the larvae are contained in the tissues of the intermediate host and are taken in when a human eats that host (*Clonorchis* in fish, tapeworms in meat and fish, *Trichinella* in meat). The levels of infection in humans therefore depend on standards of hygiene (as eggs and larvae are often passed in urine or feces), on the climate (which may favor survival of infective stages), on the ways in which food is prepared, and on the degree of exposure to insect vectors.

VIII.V Consequences of helminth parasites

Following are the important consequences of helminth parasite infection :-

Direct Damage from Worm Activity-The most obvious forms of direct damage are those resulting from the blockage of internal organs or from the effects of pressure exerted by growing parasites. Large *Ascaris* or tapeworms can physically block the intestine, and this may occur after some forms of chemotherapy; migrating *Ascaris* may also block the bile duct. Granulomas that form around schistosome eggs may block the flow of blood through the liver, and this may lead to pathological changes in that organ and elsewhere. Blockage of lymph flow, leading to elephantiasis, is associated with the presence of adult *Wuchereria* in lymphatics. Intestinal worms cause a variety of pathologic changes in the mucosa, some reflecting physical and chemical damage to the tissues, others resulting from immunopathologic responses. Hookworms (*Ancylostoma* and *Necator*) actively suck blood from mucosal capillaries. Many helminths undertake extensive migrations through body tissues, which both damage tissues directly and initiate hypersensitivity reactions. The skin, lungs, liver, and intestines are the organs most affected. Feeding by worms upon host tissues is an important cause of pathology, particularly when it induces hyperplastic and metaplastic changes in epithelia. For example, liver fluke infections lead to hyperplasia of the bile duct epithelium.

Indirect Damage from Host Response - All helminths are “foreign bodies” not only in the sense of being large and invasive but also in the immunologic sense: they are antigenic and therefore stimulate immunity. Immune-mediated inflammatory changes occur in the skin, lungs, liver, intestine, CNS, and eyes as worms migrate through these structures. Systemic changes such as eosinophilia, edema, and joint pain reflect local allergic responses to parasites. The fact that many worms are extremely long-lived means that many inflammatory changes become irreversible, producing functional changes in tissues. Three examples are the hyperplasia of bile ducts in long-term liver fluke infections, the extensive fibrosis associated with chronic schistosomiasis, and the skin atrophy associated with onchocerciasis.

VIII.VI Summary

Despite their immunogenicity, many helminths survive for extended periods in the bodies of their hosts. Some worms (schistosomes) disguise their outer surface by acquiring host molecules which reduce their antigenicity; intrinsic membrane changes also make these worms resistant to immune attack.

VIII.VII Glossary

Edema - inflamation and swollen tissue due to damage

Neoplasia - the uncontrolled, abnormal growth of cells or tissues in the body

VIII.VIII Further reading

Despommier, D.D., Gwadz, R.W, Hotez, P.J. (1995) : *Parasitic Diseases*. 3rd Ed. Springer-Verlag, New York,

VIII.IX Model questions

What is a helminth infection called ?

What is the most common helminthic infection ?

How is helminth infection transmitted ?

What is filariasis ?

UNIT IX ❑ Basic concept of food and nutrition; Concept of balanced diet and dietary pattern of various groups

Structure / Content

IX.I Objective

This unit under the module Food, Nutrition and Health covers the aspects of basic concept of food and nutrition. This particular unit gives an impression about food components and nutrients that serves the needs of various types of peoples of different age groups. After completion of this study material the learners would be able to understand the basic components of the foods and food nutrients and be able to solve the following -

1. What a balance diet is?
2. About the dietary pattern for different peoples and
3. The amount of food requires to maintain health.

IX.II Introduction

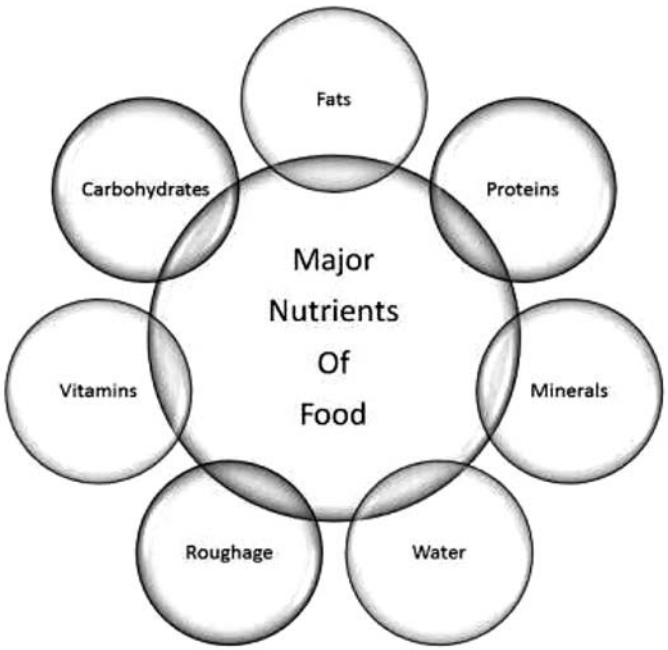
Nutrition, nourishment, or ailment refers to the nurturing of our body to keep it healthy and functioning as it is supposed to do. Nature has provided a variety of foods for man to consume and be healthy. We consume food for maintenance of health, growth and to develop greater resistance against infections. Nutrition is an art and also a science. Nutrition thus can be defined as "the science of foods, the nutrients and other substances, they are in action, interaction and balancing in relation to health and disease." On the other hand food is the material consisting essentially of protein, carbohydrate, and fat used in the body of an organism to sustain growth, repair, and vital processes and to furnish energy; also, such material together with supplementary substances (as minerals, vitamins, and condiments) Nutrition as a science was found by Lavoiser (the father of chemistry and also the father of nutrition) towards the end of 18nth century. The science of nutrition is one of the youngest of the sciences. The essential nutrients, proteins, fats and carbohydrates have been recognized in the early 19th century. Specific nutritional disorders were identified such as protein energy mal nutrition, Vitamin A deficiency, Endemic goiter, Nutritional Anemia, Nutritional blindness etc. and measures were found to prevent and control these disorders. The science of Nutrition was extended to other fields like agriculture, animal husbandry, economics and sociology. This led to "green revolution" and "white revolution" and increased food production.

IX.III Basic concept of food and nutrition

Food has many different components and each component is necessary for one function or the other. The major components of our food are:

1. Carbohydrates
2. Fats
3. Proteins
4. Mineral (salts)
5. Water
6. Roughage
7. Vitamin

The carbohydrates proteins, fats, minerals salts and vitamins are called nutrients (described below) because they are required for the survival of living beings like human



Major component of food

beings. Thus water is an important constituent of our food and makes up for two third of our body- weight, it is usually not considered a nutrient. Our diet usually contains the entire nutrient in varying amounts. For example, egg or meat give us proteins, butter and ghee give us fats, whereas fruits and vegetables give use minerals and vitamins.

Carbohydrates

Carbohydrates are the compound a made up of three elements: carbon, hydrogen and oxygen, proportion of hydrogen and oxygen being the same as in water (the term carbohydrates actually means hydrates of carbon) Glucose, sucrose, and starch are example of carbohydrates. Carbohydrates are the main source of energy in our body. Though carbohydrates are not the richest source of energy, they are the cheapest source of energy. The carbohydrates produce energy when they are the oxidized in the body. I gram of carbohydrates produce kilojoules of energy and about 60 percent to 80 percent of the total energy contained in our diet (or good) comes from carbohydrates present in it. Aabout 400-500 gram of carbohydrate is requiring daily for a normal person. A growing child, a nursing mother or a sports man, however, ended more carbohydrate than cellulose. Cellulose is also a carbohydrate, but is not a food this is because cellulose cannot be digested or absorbed in the body. When eaten, however, cellulose acts as a roughage &

help in keeping the intestinal tract in good working order that is, cellulose helps in the maintaining healthy digestive system.

Fats

Fats are esters of long chain fatty acids and an alcohol called glycerol. The fats are actually made of the same three elements, hydrogen, and oxygen, of which the carbohydrates are made. The difference lies in the fact that fats contain less proportion of oxygen as consists of three molecules of a fatty acid and one molecule of glycerol. Fats are the members of a heterogeneous group of organic compounds known as lipids. Like carbohydrates, the main function of fats in the body is to provide a steady source of energy, and for this purpose they are deposited in various fat depots within the body and under the skin. In fact, fats provide twice as much energy as that provided by the same amount of a carbohydrate. For example, I gram of a carbohydrates on oxidation in the body during respiration gives about 17 Kilojoules or calorie of energy whereas I gram of a fat (or oil) gives about 37 Kilojoules or calorie of energy which is more than double than that given by carbohydrates. The fats provide more energy than carbohydrates because fat molecules contain higher percentage of carbon and hydrogen but less percentage of oxygen than that of carbohydrates. Due to less percentage of oxygen present in it, a fat molecule requires more oxygen for it combustion and hence produces less heat energy. Form this discussion we conclude that both, carbohydrates and fats, serve mainly as sources of energy to our body actually, fats are the richest source of energy to our body, but they are more expensive than carbohydrates. Fats can also be stored in the body for subsequent use. The fats present in our food cannot be absorbed by our body as such because they are complex organic molecules which are insoluble in water.

Proteins

Proteins are highly complex organic compound made up of carbon, hydrogen, oxygen and nitrogen. Some of the protein also contains elements such as sulphur and phosphorus. Proteins are very important in our food for growth and repair of the body. Proteins are essential for the growth of the child and teenagers, and proteins are needed for maintenance and making good the wear and tear of body tissues in adults. In addition to all this, proteins also supply some energy to the body. Proteins are made up of nitrogen containing compounds called amino acids. Amino acids link through peptide bonds to form protein molecules. There are more than 20 of these amino acids and they all occur in almost all proteins. But the relative amount of each amino acid present differs in different proteins. Most of the proteins which are required to perform different function in our body are prepared with in the body form the unbounded amino acids. It should be noted that the

proteins consumed in our food are not used by our body in their original from. This is because of two reasons. Firstly because proteins are insoluble in water and secondly they are very complex molecules. When the food is digested in small intestine, the proteins present in the food are broken down into simpler substances called amino acids. The amino acids are water soluble and less complex molecules. The amino acids thus formed are absorbed from the intestine into the blood. The blood carries these free amino acids to the various body cells where they are regrouped to form specific proteins such as skin, muscle, blood & bones.

Vitamins

Vitamins are the complex organic compounds found in some foods which are necessary for the well-being of the entire body. Vitamins are necessary for normal growth, good health, good vision, proper digestion, healthy teeth, gums, and bones, and for life to be maintained. Vitamins act as catalysts in certain chemical reaction of metabolism in our body. Vitamins do not provide energy to our body, so in this respect they differ from carbohydrates and fats which provide energy. Though vitamins are needed by our body in minute quantities but their presence is essential in our diet. More than 15 vitamins are known at present and each one of these is needed for aspecific purpose is the body. Some of the important vitamins are; vitamin A, Vitamin B, complex, vitamin C, vitamin D, Vitamin E, and Vitamin K. Most of vitamins cannot be made by body, so they have to supply through various foods which contain them. Only two vitamins called vitamin D and vitamin K can be made in our body. All the vitamins are prepared in plants.

Minerals

The metals, non metals & their salts are called minerals because they are mined form the soil, ground and the earth. Our body needs minerals for its proper functioning, normal growth and good health. Minerals are needed to build bones, teeth, formation of red blood corpuscles, and coagulation of blood, functioning of muscles, never & thyroid gland etc. Several minerals are needed to enzymes to do their work. Some of the important minerals needed by our body are: iron, iodine, calcium, phosphorus, sodium, potassium, zinc, copper, magnesium, chlorine, fluorine and sulphur. The deficiency of minerals in the body causes many diseases. Minerals, however, do not supply any energy to our body. They are essential for the metabolic activities of the contraction for certain tissues. Our body can use minerals in the compound from and not as pure elements. For example, we cannot eat sodium metal or chlorine gas in their element from as such; because they are toxic (poisonous) and can even kill a person. But their compound called sodium chloride is a mineral salt which is harmless and, in fact, essential for our body. We get most of the

minerals form plant sources. This is because plants take the various minerals form the soil through their roots and supply them to man and animals through the food chain. So, even the minerals which we get from some animals are, in fact, derived form the plants which the animals eats.

Water

Water is an inorganic substance made up of hydrogen & oxygen. Water is not considered a food because it does not give energy like carbohydrates & fats or builds body tissues like proteins. Water is however, an essential part of a man's diet because it helps in preparing food for assimilation by the body. In fact, about two – third of a man's body weight is the water in the tissues of his body. Water place an important role in a large number of process like digestion, transport & helps in regulation of body temperature. An important role of water in our body is to regulate the body temperature the process of sweating and evaporation. when the outside temperature is high, the water oozes out through the skin in the form of sweat. When this water evaporates from our body, it takes the latent heat of vaporization from skin. By losing heat, the skin cools down a little and we feel comfortable. The amount of water needed by body depends on one's age type of work, and the climate. Our body gets a lot of water from many of the food items which we eat. For example, fruits, vegetables, meat and fish give a lot of water to our body.Most of the water needed by our body, however, comes from the plain "drinking water ", tea, coffee, milk etc. Some of the water in our body comes as a byproduct of the oxidation of glucose during the digestion of the food. In fact, 1 molecule of glucose on oxidation in the body produces 6 molecules of water.

Roughage

Though roughage is not a food, it is an important part of balanced diet. Roughage neither gives us energy like carbohydrates and neither fats nor builds our body like protein do, but it is important for the normal working of the digestive system. Roughage is the fibrous material present in plants and their products like fruits and vegetables. Roughage mainly consists of the indigestible plant carbohydrates called cellulose. But our body does not enzymes to digest the cellulose remains undigested and being a fibrous material acts as roughage and keeps the digested system in order.The sources of roughage in our food are : salad ; vegetables & fruit with skin high fiber contents. Cabbage is one vegetable which provide us a lot of roughage. Corn cob & half – crushed, wheat also provide roughage to our body, along with other nutrients. All these food items have cellulose content which act as roughage. These fibrous materials are good for digestion and helps in bowel movement.

IX.IV Concept of balanced diet

A balanced diet is one that fulfills all of a person's nutritional needs. Humans need a certain amount of calories and nutrients to stay healthy. A balanced diet provides all the nutrients a person requires, without going over the recommended daily calorie intake. By eating a balanced diet, people can get the nutrients and calories they need and avoid eating junk food, or food without nutritional value. In addition, a balanced diet should provide other non-nutrients such as dietary fiber, antioxidants and phytochemicals which bestow positive health benefits. A balanced diet includes foods from five groups. Eating a balanced diet helps people maintain good health and reduce their risk of disease.

The 5 food groups

A healthful, balanced diet includes foods from these five groups :

a) vegetables

b) fruits

c) grains

d) protein

e) dairy

a) Vegetables

The vegetable group includes five subgroups: leafy greens, red or orange vegetables, starchy vegetables, beans and peas (legumes), other vegetables, such as eggplant To get enough nutrients and keep dietary monotony, people should choose a variety of vegetables.

b) Fruits

A balanced diet also includes plenty of fruit. Instead of getting fruit from juice, nutrition experts recommend eating whole fruits. Juice contains fewer nutrients. Also, the manufacturing process often adds empty calories due to added sugar. People should opt for fresh or frozen fruits, or fruitscanned in water instead of syrup.

c) Grains

There are two subgroups: whole grains and refined grains. Whole grains include all three parts of the grain, which are the bran, germ, and endosperm. The body breaks down whole grains slowly, so they have less effect on a person's blood sugar. Additionally, whole grains tend to contain more fiber and proteinthan refined grains. Refined grains are

processed and do not contain the three original components. Refined grains also tend to have less protein and fiber, and they can cause blood sugar spikes. At least half of the grains that a person eats daily should be whole grains. Healthful whole grains include: oats, brown rice, barley, buck wheat.

d) Proteins

Nutritious protein choices include: lean beef and pork, chicken and turkey, fish, beans, peas, and legumes

e) Dairy

Dairy and fortified soy products are a vital source of calcium. Consumption of low-fat versions is recommended whenever possible. Low-fat dairy and soy products include: cottage cheese, low-fat milk, yogurt and soy milk.

Importance of a balance diet

A balanced diet is important because the organs and tissues need proper nutrition to work effectively. Without good nutrition, the body is more prone to disease, infection, fatigue, and poor performance. Children with a poor diet run the risk of growth and developmental problems and poor academic performance, and bad eating habits can persist for the rest of their lives. The following are the importance of a balanced diet :

1) Balanced Diet leads to a good physical and a good mental health.
2) It helps in proper growth of the body.
3) Also, it increases the capacity to work
4) Balanced diet increases the ability to fight or resist diseases.

IX.V Dietary pattern of various groups

A dietary pattern is defined as the quantity, variety, or combination of different foods and beverage in a diet and the frequency with which they are habitually consumed. The nutrient requirements during the four main stages of the human lifecycle vary considerably. What infants and children require is different from what adults and the elderly need. In addition, there might be specific nutrients which a pregnant women and lactating mothers need in higher amounts than adult men. Nutritional requirements in the different segments of the population thus can be classified into four groups. These correspond to different parts of the lifespan, namely

(a) pregnancy and lactation,

(b) infancy and childhood

(c) adolescence and adulthood,and

(d) old age.

During Pregnancy and lactation

An unborn child needs a healthy and well-nourished mother to grow properly. Therefore, a mother needs to gain weight during pregnancy to help nourish her growing baby. Women who do not gain enough weight often have babies that weigh too little (low birth weight). A baby weighing less than 2.5 kg has an increased chance of both physical and mental health problems. It may also suffer more from infection and malnutrition compared with babies of normal weight. The increased requirement of nutrients during pregnancy and lactation are energy, protein, essential fatty acids, vitamin A, vitamin C, B vitamins (B1, B2, B3, B5, B6, B12, folate), calcium, phosphorus, iron, zinc, copper and iodine. Women should gain at least 11 kg during pregnancy (Fig.1.3). If the mother gains less than this, the baby's chances of survival and health declines. If a mother is overweight, she still needs to gain for her baby's health. She should not try to lose weight while she is pregnant.

Nutrition during lactation (breastfeeding)

If all babies are to be healthy and grow well, they must be fed breast milk. When a baby sucks at the nipple, this causes the milk to come into the breast and continue to flow. Breast milk is food produced by the mother's body especially for the baby, and it contains all the nutrients (nourishment) a healthy baby needs. A lactating woman needs at least two extra meals (550 Kcal) of whatever is available at home. In addition a dose of vitamin A (200,000IU) should be given once between delivery and six weeks after delivery. This will enable the baby to get an adequate supply of vitamin A for the first six months. During the first six months the best way of feeding the baby is for the mother to breastfeed exclusively.In addition to extra meals and one high dose of vitamin A, a breastfeeding woman also needs:

a) Iodized salt in her diet

b) At least one liter of water per day

c) Vitamin A rich foods (such as papaya, mango, tomato, carrot and green leafy vegetables) and animal foods (such as fish and liver).

Nutritional requirements in infancy, childhood and adolescence

The common feature of infancy, childhood and adolescence is that all these age groups are undergoing rapid growth and development. This in turn poses a heavy demand on their nutritional requirements. Small children and infants do not have a well developed body nutrient store, and therefore are more vulnerable to infection. In addition they have a larger surface area compared to their body size. All these factors increase their basal metabolic rate (BMR), resulting in an increased requirement for nutrients.

For school Children

Maintaining a balanced diet and regular exercise is important for all individuals, especially school-aged children (6-12 years). These children are required to eat a variety of foods from each food group to ensure optimal intake of all vitamins and minerals. At the same time, they may face new challenges regarding food choices and habits. Decisions about what to eat are partly determined by what is provided in school, at home, the influences from friends at school, and the media, especially television. Attaining optimal nutrition involves eating three meals a day and two nutritious snacks, as well as limiting the intake of high sugar and high fat foods. Consuming generous amounts of fruits, vegetables, lean meats and low fat dairy products, including three servings of milk, cheese or yoghurt to meet their calcium requirement, can also prevent many medical problems. School-aged children grow significantly, but at slower rate, whilst being very physically active in general. As a result, their nutritional needs are high and critical. Additionally, genetic background, gender, body size and shape are all important determinants of nutrient requirements. The essential nutrients for optimal health are: Energy (carbohydrates and fats), protein, essential fatty acids, calcium and iron.

Adolescent growth spurt

Adolescents also undergo a very rapid growth during their puberty (called the pubertal growth spurt). During the pubertal growth spurt, they increase rapidly both in weight and height. Therefore, they need a nutrient intake that is proportional with their rate of growth. The growth rate is very high right after birth (infancy). Then the growth rate slows down until the age of 12–14 years. At about 15–16 years (the pubertal period) there is a sharp rise in growth rate/velocity. After that, the growth rate slows down again. Requirements for macronutrients (proteins, carbohydrates and fats) and micronutrients are higher on a per kilogram basis during infancy and childhood than at any other developmental stage. These needs are influenced by the rapid cell division occurring during growth, which requires protein, energy and fat. Increased needs for these nutrients are reflected in daily requirements for these age groups, some of which are briefly discussed below.

Energy

While most adults require 25–30 calories per kg, a 4 kg infant requires more than 100 kilocalories per kg (430 calories/day). Infants of four to six months who weigh 6 kg require roughly 82 kilocalories per kg (490 calories/day). Energy needs remain high through the early formative years. Children of one to three years require approximately 83 kilocalories per kg (990 calories/day). Energy requirements decline thereafter and are based on weight, height, and physical activity. Higher intakes of protein and energy for growth are recommended for adolescents. For most micronutrients, recommendations are the same as for adults. Exceptions are made for certain minerals needed for bone growth (e.g. calcium and phosphorus). Evidence is clear that bone calcium accretion increases as a result of exercise rather than from increases in calcium intake. Since weight gain often begins during adolescence and young adulthood, young people must establish healthy eating and lifestyle habits that reduce the risk for chronic disease later in life.

Water

Infants and children need plenty of water to drink, particularly when ill, or exposed to extreme temperatures.

Essential fatty acids

Requirements for fatty acids or fats on a per kilogram basis are higher in infants than adults. Some fatty acids play a key role in the central nervous system. However infants and children should not ingest large amounts of foods that contain predominantly fats, so it is important to get the balance right. Increased nutrients required for energy during infancy and childhood is protein, essential fatty acids, calcium and phosphorus and in adolescence it is protein, calcium, phosphorus and zinc.

During adulthood

The nutritional needs in adults of 19–50 years of age differ slightly according to gender. Males require more of vitamins C, K, B 1, B2 and B3, and zinc. Females require more iron, compared with males of similar age. As we get older our bodies have different needs, so certain nutrients becomeespecially important for good health.

Calcium and Vitamin D

Older adults need more calcium and vitamin D to help maintain bone health. Have three servings of calcium-rich foods and beverages each day. This includes fortified cereals and fruit juices, dark green leafy vegetables, canned fish with soft bones, milk and fortified plant beverages.

Vitamin B12

Many people older than 50 do not get enough vitamin B 12. Fortified cereal, lean meat and some fish and seafood are sources of vitamin B 12.

Fiber

Fiber also can help lower the risk for heart disease and prevent Type 2 diabetes. Whole-grain breads and cereals, and more beans and peas, along with fruits and vegetables also provide fiber.

Potassium

Increasing potassium along with reducing sodium (salt) may lower the risk of high blood pressure. Fruits, vegetables and beans are good sources of potassium.

Fats

Foods that are low in saturated fats and trans fat help reduce the risk of heart disease. Most of the fats should be polyunsaturated and monounsaturated fats, which are primary found in nuts, seeds, avocados, olive oil and fish.

For elderly people

Elderly people are especially vulnerable to nutritional problems due to age related changes in their body (impaired physiological and anatomical capacity). An elderly person requires less energy than a younger individual due to reductions in muscle mass and physical activity. Some daily requirements for elderly people differ from those of younger adults. For example, in order to reduce the risk for age related bone loss and fracture, the requirement for vitamin D is increased from 200 IU/day to 400 in individuals of 51–70 years of age and to 600 IU/day for those over 70 years of age. Suggested iron intakes reduce however from 18 mg per day in women aged 19–50 to 8 mg/day after age 50, due to better iron conservation and decreased losses in postmenopausal women compared with younger women. Some elderly people have difficulty getting adequate nutrition because of age or disease related impairments in chewing, swallowing, digesting and absorbing nutrients. Their nutrient status may also be affected by decreased production of chemicals to digest food (digestive enzymes), changes in the cells of the bowel surface and drug – nutrient interactions. Some elderly people demonstrate selenium deficiency, a mineral important for immune function. Impaired immune function affects susceptibility to infections and tumours (malignancies). Vitamin B6 helps to boost selenium levels, so a higher intake for people aged 51–70 is recommended.

Fruits and vegetables are very nutrient rich, and contain many cancer fighting antioxidants. But they also contain fiber, which helps maintain bowel regularity.

Low-fat dairy products, leafy greens, and canned fish with soft bones provide needed calcium to help keep the bones strong.

Vitamin B12 helps in the production of red blood cells, and it also keeps the brain and nervous system healthy. B 12 is available in animal products like meat, fish, and dairy.

IX.VI Summary

I. The major components of feedstuffs are moisture, lipids, protein, fiber, carbohydrate, minerals and vitamins.

II. A diet is all that we consume in a day. And a balanced diet is a diet that contains an adequate quantity of the nutrients that we require in a day. A balanced diet includes six main nutrients, i.e. Fats, Protein, Carbohydrates, Fiber, Vitamins, and Minerals.

III. In addition, a balanced diet should provide other non-nutrients such as dietary fiber, antioxidants and phytochemicals which bestow positive health benefits.

IV. Dietary patterns are the quantities, proportions, variety or combination of different foods, drinks, and nutrients in diets, and the frequency with which they are habitually consumed.

V. Different food items have different proportions of nutrients present in them. The requirements of the nutrients depend on the age, gender, and health of a person.

VI. Dietary guidelines change over time. Current recommendations suggest that a person's plate should contain primarily vegetables and fruits, some lean protein, some dairy and soluble fiber.

IX.VII Glossary

Artificial feeding – The feeding of infants with only a breast milk substitute

Blended foods – Mixtures of milled cereals and other ingredients such as pulses, dried skimmed milk and possibly sugar and oil.

IX.VIII Further reading

Lambert Rhiannon (2008)- The Science of Nutrition, Dorling Kindersley Ltd,

IX.IX Model questions

What are the major food constituents?

Define balance diet.

State importance of balance diet.

What are the sources of carbohydrates?

Give nutritional requirements of an elderly people.

What types of foods are required for a pregnant mother?

UNIT X ❑ Nutritional biochemistry - Carbohydrate, Lipid, Protein definition, classification, dietary sources and importance

Structure / Content

X.I Objective

This unit covering the aspects of nutritional biochemistry gives a clear idea about the chemistry of the macromolecules present in the food you take regularly. After completion of the topic of interest the reader would be able to

1. Describe the different types of macromolecules along with their dietary source
2. Explain the role of individual macromolecules.
3. Describe different types of vitamins along with their dietary source and the benefits of use of vitamins
4. Describe the role of different minerals in body functions.

X.II Introduction

Carbohydrates, lipids, proteins and nucleic acids are called macromolecules because

of their large size. You are very familiar with these molecules because certain foods are known to be rich in them. When you digest these foods, they get broken down into the subunit molecules as monosaccharide, glycerol and fatty acids, amino acids and nucleotide. Your body then takes these subunits and builds from them the macromolecules that make up your cells. The largest of the macromolecules are called polymers because they are constructed by linking together a large number of the same type of subunits called monomers. A protein can contain hundreds of amino acids and a nucleic acid can contain hundreds of nucleotides. The polymers get so large by using modular approach of the cells for constructing polymers. It is just a train increases in length when an wagon hitched together one by one, so a polymer gets longer as monomers bond to one another. Organic molecules are routinely built up in cells by the removal of water (H2O) during a dehydration reaction. They are degraded in cells by the addition of water during a hydrolysis reaction. For all these reactions to occur in a cell, an enzyme must be present. The enzyme is a molecule that speeds a reaction by bringing the reactants together and the enzyme may even participate in causing the reaction to occur.

X.III Nutritional biochemistry - Carbohydrate

Carbohydrates are a large group of organic compounds occurring in foods and living tissues and including sugars, starch, and cellulose. They contain hydrogen and oxygen in the same ratio as water (2:1) and typically can be broken down to release energy in the animal body.

Carbohydrates are probably the most abundant and widespread organic substances in nature, and they are essential constituents of all living things. Carbohydrates are formed by green plants from carbon dioxide and water during the process of photosynthesis. Carbohydrates serve as energy sources and as essential structural components in organisms; in addition, part of the structure of nucleic acids, which contain genetic information, consists of carbohydrate.

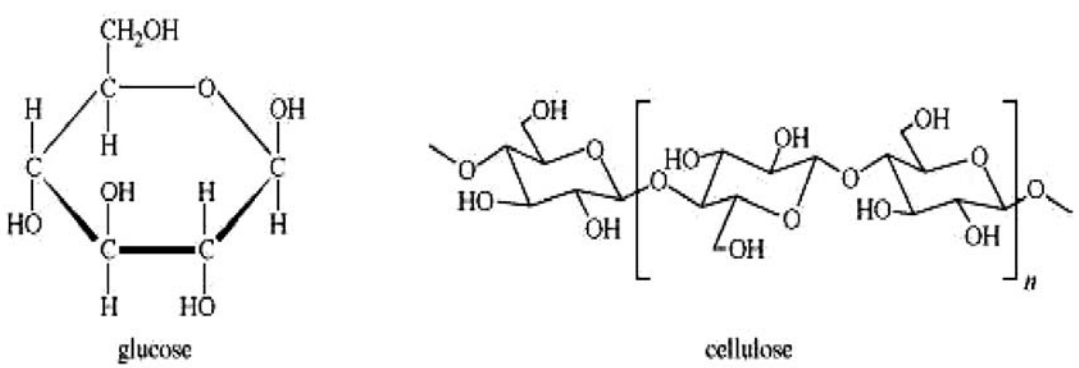
Classification of Carbohydrate

Although a number of classification schemes have been devised for carbohydrates, the division into four major groups—monosaccharide, disaccharides, oligosaccharides, and polysaccharides—used here is among the most common. Most monosaccharide, or simple sugar are found in grapes, other fruits, and honey. Although they can contain from three to nine carbon atoms, the most common representatives consist of five or six joined together to form a chainlike molecule. Three of the most important simple sugars—glucose

(also known as dextrose, grape sugar, and corn sugar), fructose (fruit sugar), and galactose—have the same molecular formula, ($C_6H_{12}O_6$), but, because their atoms have different structural arrangements, the sugars have different characteristics; i.e., they are isomers.

Two molecules of a simple sugar that are linked to each other form a disaccharide, or double sugar. The disaccharide sucrose, or table sugar, consists of one molecule of glucose and one molecule of fructose; the most familiar sources of sucrose are sugar beets and cane sugar. Milk sugar, or lactose, and maltose are also disaccharides. Before the energy in disaccharides can be utilized by living things, the molecules must be broken down into their respective monosaccharides.Oligosaccharides, which consist of three to six monosaccharide units, are rather infrequently found in natural sources, although a few plant derivatives have been identified. Polysaccharides (the term means many sugars) represent most of the structural and energy-reserve carbohydrates found in nature. Large molecules that may consist of as many as 10,000 monosaccharide units linked together.

Cellulose, the principal structural component of plants, is a complex polysaccharide comprising many glucose units linked together; it is the most common polysaccharide. The starch found in plants and the glycogen found in animals, also are complex glucose polysaccharides. Starch (from the Old English word stercan, meaning “to stiffen”) is found mostly in seeds, roots, and stems, where it is stored as an available energy source for plants. Plant starch may be processed into foods such as bread, or it may be consumed directly-as in potatoes, for instance. Glycogen, which consists of branching chains of glucose molecules, is formed in the liver and muscles of higher animals and is stored as an energy source.



Chemical composition of cellulose and glucose

Dietary source of Carbohydrates

Most dietary carbohydrates come from plants. Sugars and starches are nutritive carbohydrates, meaning they are broken down and utilized by the body, primarily to generate energy. Although dietary fiber is also a carbohydrate, it contributes no calories because it is not digested or absorbed. Aside from lactose found in milk and small amounts of specific sugars in red meat, almost all dietary carbohydrates come from plant foods. These foods will often be made up of a combination of the different types of carbohydrates in varying amounts. Following table is a brief overview of the most common dietary sources for the different types of carbohydrates.

Monosaccharides	
Fructose	Fruits, vegetables and honey Also derived from the digestion of sucrose
Glucose	Small amounts are found in some fruits, vegetables and honey,Manufactured foods Digestion and conversion of other carbohydrates
Disaccharides	
Sucrose	Derived from sugar cane and sugar beet Sweet root vegetables such as beetroot and carrots Table sugar, manufactured foods
Maltose	Malted wheat and barley, Malt extract, Beer
Lactose	Milk Milk products
Trehalose	Mushrooms and edible fungi
Oligosaccharides	
Raffinose,	Legumes ,
stachyose,	Onion, artichoke, fennel, asparagus
verbascose,	Pre-biotics
inulin,	
fructo and galacto	
oligosaccahrides	
Polysaccharides	
Starch	Cereal foods, Potato
	Small amounts in other root vegetables and unripe fruit
Non-starch polysaccharides	Vegetables, fruit Wholegrain cereals , Pulses

Role of Carbohydrates

Already it was stated that carbohydrates are molecules that contain carbon, hydrogen and oxygen atoms in specific ratios. But in the nutrition world, they're one of the most controversial issues. Some believe eating fewer carbohydrates is the way to optimal health, while others prefer higher-carb diets. Still, others insist moderation is the way to go. Within this juncture it's hard to deny that carbohydrates play an important role in the human body.

1. One of the primary functions or roles of carbohydrates is to provide the body with energy. Most of the carbohydrates in the foods taken are digested and broken down into glucose before entering the bloodstream. Glucose in the blood is taken up into body's cells and used to produce a fuel molecule called adenosine triphosphate (ATP) through a series of complex processes known as cellular respiration. Cells can then use ATP to power a variety of metabolic tasks.
2. They also provide stored energy. If the body has enough glucose to fulfill its current needs, excess glucose can be stored for later use. This stored form of glucose is called glycogen and is primarily found in the liver and muscle. The liver contains approximately 100 grams of glycogen. These stored glucose molecules can be released into the blood to provide energy throughout the body and help maintain normal blood sugar levels between meals. Unlike liver glycogen, the glycogen in your muscles can only be used by muscle cells. It is vital for use during long periods of high-intensity exercise.
3. When glucose from carbohydrates is lacking, muscle can also be broken down into amino acids and converted into glucose or other compounds to generate energy.
4. Consuming at least some carbohydrates in the diet is one way to prevent starvation-related loss of muscle mass. These carbs will reduce muscle breakdown and provide glucose as energy for the brain.
5. They promote digestive health. Unlike sugars and starches, dietary fiber is not broken down into glucose. Soluble fiber is found in oats, legumes and the inner part of fruits and some vegetables. While passing through the body, it draws in water and forms a gel-like substance. This increases the bulk of your stool and softens it to help make bowel movements easier.
6. Eating plenty of dietary fiber can benefit heart and blood sugar levels.

X.IV Nutritional biochemistry – Lipid

A lipid is chemically defined as a substance that is insoluble in water and soluble in alcohol, ether, and chloroform. These solubility criteria are not absolute. Lipids were therefore defined as compounds containing in their molecule an aliphatic chain (chain consisting of — CH2—) of at least 8 carbon atoms. Some short-chain fatty acids (like butyric acid, in C4) are the only exceptions to this rule. Although the term "lipid" is sometimes used as a synonym for fats, fats are a subgroup of lipids called triglycerides. Lipids also encompass molecules such as fatty acids and their derivatives (including tri-, di-, monoglycerides and phospholipids), as well as other sterol-containing metabolites such as cholesterol. Although humans and other mammals use various biosynthetic pathways both to break down and to synthesize lipids, some essential lipids can't be made this way and must be obtained from the diet. Cholesterol and triglycerides are lipids. Lipids are easily stored in the body. They serve as a source of fuel and are an important constituent of the structure of cells. Lipids include fatty acids, neutral fats, waxes and steroids (like cortisone).

Compound lipids (lipids complexed with another type of chemical compound) comprise the lipoproteins, glycolipids and phospholipids.

A. Classification of Lipids

Lipids may be classified based on their physical properties at room temperature (solid or liquid, respectively fats and oils), on polarity, or on their essentiality for humans, but the preferable classification is based on their structure.

Based on structure, they can be classified in three major groups.

1. Saturated Fatty Acids:

Their general formula is: CH3 — (CH2)n — COOH. The most frequent are palmitic acid (C10) and stearic acid (C18). In lower concentration are found the fatty acids with 14 or 20 carbon atoms. Longer fatty acids (up to 36 carbon atoms) are present in numerous cells (bacteria, unicellular eucaryotes, plants, vertebrates). They are generally present in some types of lipids. Milk on the contrary, is rich in short-chain fatty acids. Besides the even-carbon fatty acids, are generally found small quantities of fatty acids having 15, 17 or 19 carbon atoms.

2. Unsaturated Fatty Acids:

Fatty acids are numbered from the terminal carboxyl (carbon 1) to the CH 3 group (carbon n). The double bond is indicated by the sign “, accompanied by the number corresponding to the first carbon atom participating in the double bond. The sign: is being increasingly used; it is followed by the number of double bonds, the position of the latter being indicated within brackets. The principal unsaturated fatty acids are:

A. Monounsaturated Fatty Acids (1 Double Bond):

Oleic acid (C18), double bond between carbon atoms C 9 and C10 , abbreviated as: (C18, Δ9 or 18 :1(9) or 18 ω 9).

CH3-(CH2)7-CH = CH-(CH2)7-COOH

B. Polyunsaturated Fatty Acids (Several Double Bonds):

In the most common of such acids, the non-conjugated double bonds are separated by a methylene group. Plants can however contain fatty acids with conjugated double bonds, for example, eleostearic acid.

Linoleic acid (C18, Δ9,12 or 18:2 (9,12) or 18 ω 6)

CH3-(CH2)4-CH = CH-CH2-CH = CH-(CH2)7-COOH

Linolenic acid (C18, Δ9,12,15 or 18 : 3 (9,12,15) or 18 ω 3)

CH3—CH2—CH = CH—CH2—CH = CH—CH2—CH = CH—(CH2)7—COOH

Arachidonic acid (C20, Δ5,8,11,14).

Docosahexaenoic acid (C22 Δ4,7,10,13,16,19).

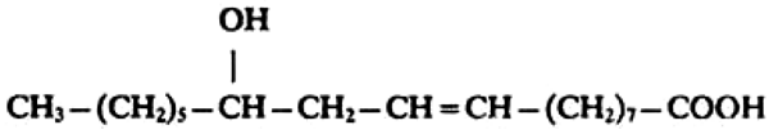
Eleostearic acid (C18, Δ9,11,3).

In mammals, polyunsaturated fatty acids can have up to 22 carbon atoms and 6 double bonds, but in plants these acids do not exceed 18 carbon atoms and 4 double bonds.

An important physical property of fatty acids is their melting point; it decreases with increasing number of double bonds. For example, the melting point of stearic acid (18: 0) is 70°C, whereas that of oleic acid (18 :1) is 13°C, that of linoleic acid (18: 2), - 5.8°C and that of arachidonic acid (20: 4), – 49.5°C.

3. Hydroxylated Fatty Acids:

Plants can synthesize a series of hydroxylated fatty acids like ricinoleic acid for example:



Some of these hydroxylated fatty acids lead to the formation of cutin. Other types of hydroxylated fatty acids are found in mammals. Some glycolipids contain large quantities of ±-hydroxylated acids (OH on carbon 2) with 22, 23, 24 and 25 carbon atoms. Moreover, cells of the epiderm have lipids containing very long-chain É hydroxylated acids which play a role in the structure of this particular tissue.

4. Branched Fatty Acids:

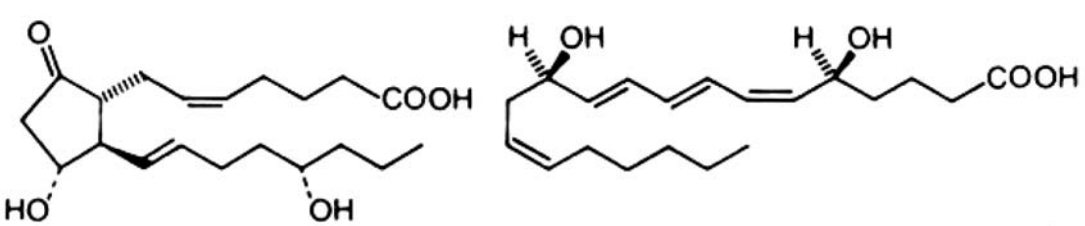
Example: 15 methylhexadecaenoic acid (CH3)2 – CH – (CH2)13 – COOH

The above type of fatty acid is particularly abundant in Gram + bacteria.

5. Prostaglandins, Leukotriens:

Prostaglandins and leukotriens (Fig. 2.3) are derived from polyunsaturated fatty acids with 20 carbon atoms É 6 and É 3 (hence their general name, eicosanoids) and especially from arachidonic acid, under the action of cyclooxygenase (prostaglandines) and lipoxygenase (leukotriens).

In mammals, these are compounds having hormonal action with various biological effects. Prostaglandines E are powerful activators of adenylate cyclase. Prostaglandines F and leukotriens B, C, D, activate the contraction of various smooth muscles.



Prostaglandine PGE2 leukotrien B4

Structure of prostaglandins and leukotriens

6. Other Close Compounds:

Besides the fatty acids, one finds aldehydes and fatty alcohols, such as for example,

palmitaldehyde, stearaldehyde, olealdehyde and the corresponding primary alcohols. These compounds are rarely in free state, but are part of the structure of glycerophospholipids or cerides. Medium- chain linear aldehydes play a role of pheromone in insects.

Glycerolipids – Glycerides :

These compounds are obtained by esterification of the alcohol groups of glycerol by fatty acids; there are mono-, di- and triglycerides. Moreover, glycerides may differ by the nature and position of esterified fatty acids. To indicate the position, the carbon atoms of glycerol are denoted 1, 2 and 3. Thus, the compound A of fig.2.4 is 1-palmitoyl 2-oleyl glycerol, compound B is 1-palmitoyl 2-oleyl-3-stearoyl glycerol.

Glycerolipids – Glycerophospholipids :

Also called phosphatides they are the most numerous representatives of the large family of phospholipids. They are found in high concentrations in the cellular and subcellular membranes of all living organisms.

Diacylphosphatides - Phosphatide Acids

They result from the esterification of glycerol by two fatty acids and phosphoric acid; the latter having only one of its acidic OH esterified, imparts an acid character to the molecule .They exist in small quantities in free state and play an important role in the biosynthesis of glycerophospholipids.

Diacylphosphatides - Phosphatidyl Cholines (Lecithins)

These compounds contain a molecule of choline (a quaternary ammonium compound having an alcohol group) esterified by phosphoric acid which is therefore involved in a phosphodiester linkage.

Diacylphosphatides - Other Phosphatides

In these compounds, which are very similar to lccithins, choline is replaced by:

(i) Ethanolamine in phosphatidyl ethanolamines

(ii) Serine in phosphatidyl serines These two types of lipids were earlier called “cephalins”.

Alkenylphosphatides (Plasmalogens)

They differ from diacyphosphatides in that the fatty acid bound in position 1 of the glycerophosphate is replaced by a fatty aldehyde, bound by an ethylcnic ether-oxide linkage.

Alkylphosphatides (Etherphosphatides)

They are distinguished from diacylphosphatides by the fact that the fatly acid in 1 is replaced by a fatty alcohol bound by an ether-oxide linkage.

Glycosyldiglycerides

They result from the binding of one or several (up to 10) molecules of monosaccharides to the free alcohol group of a 1, 2-diglyceride. The most frequent monosaccharides are galactose and glucose. The mono- and di-galac- tosyldiglycerides are important compounds of chloroplasts. The glucosyl- and galactosyldiglycerides are major constituents of the plasmic membrane of numerous bacteria. Glycosyldiglycerides were also found in some secretions (tears, saliva, gastric secretions) of mammals.

Sphingolipids

In these compounds the alcohol is not glycerol but a long-chain amino- alcohol. The most frequent is sphingosine which has 18 carbon atoms and a double bond. Dihydrosphingosine (saturated sphingosine) and phytos- phingosine (saturated sphingosine with an additional alcohol group) are also found but less frequently. Sphingosine is linked to a fatty acid by its amine group forming a ceramide. The linkage is therefore an amide bond and not an ester bond as in glycerides, sterides or phosphatides. The fatty acid of sphingolipids can be a long-chain fatty acid with or without a hydroxyl group on carbon 2. The ceramides are found in small quantities, in free state, in numerous eucaryotic and procaryotic cells.

Sphingomyelins

The ceramide is linked by its primary alcohol group (carbon 1) to a phos- phorylcholine. Sphingomyelins have been found in most organisms. They are present, like the phosphatides, in cellular membranes and particularly in the plasmatic membrane.

Sphingoglycolipids

These are lipids characterized by the presence in their molecule, of one or more saccharides linked to the carbon 1 of a ceramide.

Sphingoglycolipids – Galactolipids

In the case of galactocerebrosides, the monosaccharide fixed on the ceramide is galactose. Galactose can be esterified by a molecule of sulphuric acid. The compounds are then called sulphatides. In mammals, galactocerebrosides and sulphatides are mainly located in the renal tissue and nervous tissue (myelin sheath).

Sphingoglycolipids – Neutral Glycolipids

One or several (up to about ten) sugars are bound to the ceramide. In vertebrates, the first sugar is glucose. The compounds are then spoken of as glucocerebrosides. In addition to glucose, the most frequently found monosaccharides are galactose, mannose, fucose, glucosamine and galactosamine. Neutral glycolipids particularly the glucocerebrosides are present in a very large number of organisms ranging from the procaryotes to mammals where they can form up to 90% of lipids.

Sphingoglycolipids – Gangliosides

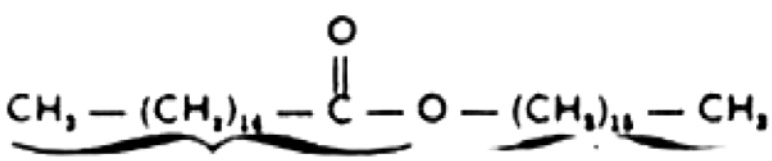
Their structure is that of a glucosylceramide to which are bound one or several molecules of galactose, N-acetyl galactosamine, N-acetylglucosamine or fucose. The most characteristic sugar of gangliosides is however neuraminic acid (or sialic acid) in the N-acetylated or N-glycosylated form. They are found only in vertebrates. The brain is particularly rich in gangliosides.

Sphingoglycolipids – Phytoglycolipids

Besides the conventional neutral glycolipids, most plants, yeasts and fungi include more complex glycolipids which generally contain phosphorus and inositol, as for example, ceramide-phosphate-inositol-glucuronic acid- glucosamine-mannose.

Cerides

These are constituents of waxes (plant waxes, insect waxes, sperm oil, etc.). They are esters formed by the union of long-chain fatty acids and long-chain alcohols (having up to 30 to 40 carbon atoms). Example: cetyl palmitate.Some lipids can be considered as derivatives of isoprene (steroids, carotenoids, quinones with isoprenic side chain).



Structure of cetyl palmitate

Steroids

These are a naturally occurring family of organic molecules of biochemical and medical interest. The steroids are members of a large, diverse collection of lipids called the isoprenoids. All of these compounds are built from one or more five-carbon units called isoprene.

B. Dietary source of lipids

Unsaturated fats, which are liquid at room temperature, are considered beneficial fats because they can improve blood cholesterol levels, ease inflammation, stabilize heart rhythms, and play a number of other beneficial roles. Unsaturated fats are predominantly found in foods from plants, such as vegetable oils, nuts, and seeds. There are two types of "good" unsaturated fats:

1. **Monounsaturated fats** are found in high concentrations in:
   - i) Olive, peanut, and canola oils
   - ii) Avocados
   - iii) Nuts such as almonds, hazelnuts, and pecans
   - iv) Seeds such as pumpkin and sesame seeds
2. **Polyunsaturated fats** are found in high concentrations in
   - i) Sunflower, corn, soybean, and flaxseed oils
   - ii) Walnuts
   - iii) Flax seeds
   - iv) Fish
   - v) Canola oil – though higher in monounsaturated fat, it's also a good source of polyunsaturated fat.

Saturated Fats

All foods containing fat have a mix of specific types of fats. Even healthy foods like chicken and nuts have small amounts of saturated fat, though much less than the amounts found in beef, cheese, and ice cream. Saturated fat is mainly found in animal foods, but a few plant foods are also high in saturated fats, such as coconut, coconut oil, palm oil, and palm kernel oil.

The biggest sources of saturated fat in the diet are

- i) Pizza and cheese
- ii) Whole and reduced fat milk, butter and dairy desserts
- iii) Meat products (sausage, bacon, beef, hamburgers)
- iv) Cookies and other grain-based desserts

v) A variety of mixed fast food dishes

Animal-based products:

Dairy foods – such as butter, cream, full fat milk and cheese

Meat – such as fatty cuts of beef, pork and lamb and chicken (especially chicken skin), processed meats like salami.

Some plant-derived products:

Palm oil

Coconut

Coconut milk and cream

Cooking margarine

Many manufactured and packaged foods:

Fatty snack foods (such as potato chips, savoury crackers)

Deep fried and high fat take away foods (such as hot chips, pizza, hamburgers)

Cakes and high fat muffins

Pastries and pies (including quiche, tarts, sausage rolls, pasties, croissants)

Sweet and savoury biscuits

Trans Fats

Trans fatty acids, more commonly called trans fats, are made by heating liquid vegetable oils in the presence of hydrogen gas and a catalyst, a process called hydrogenation. Partially hydrogenating vegetable oils makes them more stable and less likely to become rancid. This process also converts the oil into a solid, which makes them function as margarine or shortening. Partially hydrogenated oils can withstand repeated heating without breaking down, making them ideal for frying fast foods.

Partially hydrogenated oil is not the only source of trans fats in our diets.

Trans fats are also naturally found in beef fat and dairy fat in small amounts.

C. Role of lipids

Following are the important role played by the lipids :

1) Storing energy – The excess energy from the food we eat is digested and incorporated into adipose tissue, or fatty tissue. Most of the energy required by the human body is provided by carbohydrates and lipids. Glucose as carbohydrate is stored in the

body as glycogen. While glycogen provides a ready source of energy, lipids primarily function as an energy reserve. A fat gram is densely concentrated with energy—it contains more than double the amount of energy than a gram of carbohydrate. Energy is needed to power the muscles for all the physical work. A serious impact of excess fat is the accumulation of too much cholesterol in the arterial wall, which can thicken the walls of arteries and lead to cardiovascular disease.

2) Regulating and signaling - Triglycerides control the body's internal climate, maintaining constant temperature. Those who don't have enough fat in their bodies tend to feel cold sooner, are often fatigued, and have pressure sores on their skin from fatty acid deficiency. Triglycerides also help the body produce and regulate hormones. For example, adipose tissue secretes the hormone leptin, which regulates appetite. In the reproductive system, fatty acids are required for proper reproductive health. Women who lack proper amounts may stop menstruating and become infertile. Omega-3 and omega-6 essential fatty acids help regulate cholesterol and blood clotting and control inflammation in the joints, tissues, and bloodstream. Fats also play important functional roles in sustaining nerve impulse transmission, memory storage, and tissue structure.

3) Insulating and protecting - Vital organs such as the heart, kidneys, and liver are protected by visceral fat.

4) Aiding digestion and increase bioavailability - The dietary fats in the foods we eat break down in our digestive systems and begin the transport of precious micronutrients. By carrying fat-soluble nutrients through the digestive process, intestinal absorption is improved. This improved absorption is also known as increased bioavailability. Fat-soluble nutrients are especially important for good health and exhibit a variety of functions. Vitamins A, D, E, and K—the fat-soluble vitamins—are mainly found in foods containing fat. Some fat-soluble vitamins (such as vitamin A) are also found in naturally fat-free foods such as green leafy vegetables, carrots, and broccoli.

Fats also increase the bioavailability of compounds known as phytochemicals, which are plant constituents such as lycopene (found in tomatoes) and beta-carotene (found in carrots).

X.V Nutritional biochemistry – Protein

A protein is a substance that has amino acids, compounds and carbon, hydrogen, oxygen, nitrogen and sometimes sulfur and is found in many foods. An example of a protein is the type of nutrient found in meats.

Protein, highly complex substance that is present in all living organisms. Proteins are of great nutritional value and are directly involved in the chemical processes essential for life. The importance of proteins was recognized by chemists in the early 19th century, including Swedish chemist Jöns Jacob Berzelius, who in 1838 coined the term protein, a word derived from the Greek proteios, meaning "holding first place." Proteins are species-specific; that is, the proteins of one species differ from those of another species. They are also organ-specific; for instance, within a single organism, muscle proteins differ from those of the brain and liver. Proteins are required for the structure, function, and regulation of the body's cells, tissues, and organs. Each protein has unique functions. Proteins are essential components of muscles, skin, bones and the body as a whole. Proteins are one of the three types of nutrients used as energy sources by the body, the other two being carbohydrate and fat. Proteins and carbohydrates each provide 4 calories of energy per gram, while fats produce 9 calories per gram.

1. Classification of Proteins

Proteins are classified based upon:

(1) Their solubility and

(2) Their structural complexity.

A. Classification Based upon Solubility:

On the basis of their solubility in water, proteins are classified into:

1. Fibrous proteins:

These are insoluble in water. They include the structural proteins. They have supportive function (e.g., collagen) and/or protective function (e.g., hair keratin and fibrin).

2. Globular proteins:

They are soluble in water. They include the functional proteins, e.g., enzymes, hemoglobin, etc.

B. Classification Based upon Structural Complexity:

On the basis of their structural complexity they are further divided into:

(1) Simple

(2) Conjugated and

(3) Derived proteins.

1. Simple proteins:

Proteins which are made up of amino acids only are known as simple proteins.

They are further sub-divided into:

(a) Albumins:

They are water soluble, heat coagulable and are precipitated on full saturation with ammonium sulphate, e.g., serum albumin, lactalbumin and ovalbumin.

(b) Globulins:

They are insoluble in water, but soluble in dilute salt solutions. They are heat coagulable and precipitate on half-saturation with ammonium sulphate, e.g., serum globulin and ovo-globulin.

(c) Glutelins:

They are insoluble in water and neutral solvents. Soluble in dilute acids and alkalies. They are coagulated by heat, e.g., glutelin of wheat.

(d) Prolamines:

Water insoluble but soluble in 70% alcohol, e.g., gliadin of wheat, proteins of corn, barley, etc.

(e) Histones:

Water soluble, basic in nature due to the presence of arginine and lysine, found in nucleus. They help in DNA packaging in the cell. They form the protein moiety of nucleoprotein.

(f) Protamine's:

Water soluble, basic in nature, not-heat coagulable. Found in sperm cells, hence component of sperm nucleoprotein.

(g) Globin's:

They are water soluble, non-heat coagulable. e.g., globin of haemoglobin.

(h) Albuminoids or scleroproteins:

Insoluble in all neutral solvents, dilute acids or alkalies, e.g., keratin of hair and proteins of bone and cartilage.

2. Conjugated proteins:

Proteins which are made up of amino acids and a non-amino acid/protein substance called the prosthetic group are known as conjugated proteins. The various types of conjugated proteins are:

(a) Chromo proteins:

Here the non-protein part is a coloured compound in addition to the protein part. Ex. Haemoglobin has heme as the prosthetic group and cytochromes also have heme.

(b) Nucleoproteins:

These proteins are bound to nucleic acids, e.g., chromatin (histones + nucleic acids).

(c) Glycoproteins:

When a small amount of carbohydrate is attached to a protein it is known as glycoproteins, e.g., mucin of saliva. (Note: Glycoproteins have major amounts of protein and some amount of carbohydrates and proteoglycans contain major amounts of carbohydrates and little amount of proteins).

(d) Pbosphoprotein:

Phosphoric acid is present with the protein. Ex. Milk casein and egg yolk (vitellin).

(e) Lipoproteins:

Proteins in combination with lipids, e.g., LDL, HDL.

(f) Metalloproteins:

They contain metal ion in addition to the amino acids, e.g., hemoglobin (iron), ceruloplasmin (copper).

3. Derived proteins:

They are the proteins of low molecular weight produced from large molecular weight proteins by the action of heat, enzymes or chemical agents.

A. Primary derivatives

(i) Proteans:

Derived in the early stage of protein hydrolysis by dilute acids, enzymes or alkalis. Examples – Fibrin from fibrinogen.

(ii) Metaproteins:

Derived in the later stage of protein hydrolysis by slightly stronger acids and alkalis. Examples – Acid and alkali metaproteins.

(iii) Coagulated:

They are denatured proteins formed by the action of heat. X-rays, ultraviolet rays etc. Cooked proteins, coagulated albumins.

B. Secondary derivatives

(i) Proteoses:

Formed by the action of pepsin or trypsin. Precipitated by saturated solution of ammonium sulphate, incoagulable by heat. Examples – Albumose from albumin, globulose from globulin.

(ii) Peptones:

Further stage of cleavage than the proteoses. Soluble in water, incoagulable by heat and not precipitated by saturated ammonium sulphate solutions.

(iii) Peptides:

Compounds containing two or more amino acids. They may be di-, tri-, and porypeptides. e.g – Glycyl-alanine, leucyl-glutamic acid.

2. Dietary source of Proteins

Every cell of your body contains protein, which is needed to build and maintain muscles, bones, skin and other tissues. For optimum health, women need 46 grams of protein a day, while men require 56 grams, according to the Centers for Disease Control and Prevention.

Proteins from animal foods are “complete,” which means it provides all the essential amino acids. “Incomplete” proteins lack one or more essential amino acids and usually come from plant foods.

Some sources of dietary protein include:

a. lean meat, poultry and fish

b. eggs

c. dairy products like milk, yoghurt and cheese

d. seeds and nuts

e. beans and legumes (such as lentils and chickpeas

f. soy products like tofu

g. some grain and cereal-based products are also sources of protein, but are generally not as high in protein as meat and meat alternative products.

3. Role of Proteins

I. Protein is required for the growth and maintenance of tissues - the body's proteins are in a constant state of turnover. Under normal circumstances, the body breaks down the same amount of protein that it uses to build and repair tissues. Other times, it breaks down more protein than it can create, thus increasing body's needs.

II. Causes biochemical reactions- Enzymes are proteins that aid the thousands of biochemical reactions that take place within and outside of the cells.

III. Acts as a messenger-Some proteins are hormones, which are chemical messengers that aid communication between your cells, tissues and organs.

IV. Provides structure - Some proteins are fibrous and provide cells and tissues with stiffness and rigidity. These proteins include keratin, collagen and elastin, which help form the connective framework of certain structures in your body.

V. Maintains proper pH -Protein plays a vital role in regulating the concentrations of acids and bases in your blood and other bodily fluids.

VI. Balances fluids - Proteins regulate body processes to maintain fluid balance.Albumin and globulin are proteins in your blood that help maintain your body's fluid balance by attracting and retaining water.

VII. Boosters immune health - Proteins form antibodies to protect your body from foreign invaders, such as disease-causing bacteria and viruses.

VIII. Transports and stored nutrients-Transport proteins carry substances throughout blood stream into cells, out of cells or within cells.The substances transported by these proteins include nutrients like vitamins or minerals, blood sugar, cholesterol and oxygen.

IX. Provides energy -Proteins can supply your body with energy. Protein contains four calories per gram, the same amount of energy that carbsprovide. Fats supply the most energy, at nine calories per gram.

X.VI Summary

I. Carbohydrate classification is predominantly based on chemical structure

II. The most nutritionally significant carbohydrate is glucose

III. Carbohydrates vary in their complexity and are found in a wide range of predominantly plant based foods. The exception being lactose from milk

IV. Unsaturated fats are an important part of a healthy diet. These fats help reduce the risk of heart disease and lower cholesterol levels (among other health benefits) when they replace saturated fats in the diet.

V. Trans fats are the worst type of fat for the heart, blood vessels, and rest of the body because they: Raise bad LDL and lower good HDL

VI. Saturated fat is a type of dietary fat. It is one of the unhealthy fats, along with trans fat. These fats are most often solid at room temperature. Foods like butter, palm and coconut oils, cheese, and red meat have high amounts of saturated fat.

VII. Cholesterol is a type of fat found in food, but also in our blood. Cholesterol has many important functions in the body but having high levels of the wrong type of cholesterol in the blood increases heart disease risk.

X.VII Glossary

Carbohydrates -class of biochemical compounds which includes sugars, starch, chitin, and steroids.

Cellulose — carbohydrate polymer of the simple sugar glucose.

Lipids — a class of biochemical compounds which includes fats, oils, and waxes.

X.VIII Further reading

David ,L. ,Nelson Michael ,Cox ,N.A, Nelson, D.L.(2021)- Lehninger Principles of Biochemistry, MacMillan Learning

X.IX Model questions

1. What are carbohydrates? Classify them.
2. What types of lipid are essential for body?
3. Classify proteins with examples.
4. Discuss dietary source of proteins.

UNIT XI ❑ Vitamins and Minerals - types, dietary sources, biological function and importance

Structure / Content

XI.I Objective

From this unit learners will be able to learn about the different types of vitamins along with their dietary source and the benefits of use of vitamins as well as able to describe the role of different minerals in body functions.

XI.II Introduction

Vitamins are organic compounds that are needed in small quantities to sustain life. Most vitamins need to come from food. This is because the human body either does not produce enough of them, or it does not produce any at all. Each organism has different vitamin requirements. For example, humans need to consume vitamin C, or ascorbic acid, but dogs do not. Dogs can produce, or synthesize, enough vitamin C for their own needs, but humans cannot. Different vitamins have different roles, and they are needed in different quantities. Similarly minerals are inorganic substances required by the body in small amounts for a variety of functions. These include the formation of bones and teeth; as essential constituents of body fluids and tissues; as components of enzyme systems and for normal nerve function.

XI.III Vitamins

A vitamin is one of a group of organic substances that is present in minute amounts in natural foodstuffs. Vitamins are essential to normal metabolism. Thus, a vitamin is both :

1. An organic compound, which means it contains carbon
2. An essential nutrient that body cannot produce enough of and which it needs to get from food.

Classification of Vitamins

Vitamins may be classified according to their solubility as either fat-soluble or water-soluble.

Fat Soluble vitamins

Fat-soluble vitamins are stored in the fatty tissues of the body and the liver. Vitamins A, D, E, and K are fat-soluble. These are easier to store than water-soluble vitamins, and they can stay in the body as reserves for days, and sometimes months. Fat-soluble vitamins are absorbed through the intestinal tract with the help of fats, or lipids.

Water soluble vitamins

Water-soluble vitamins do not stay in the body for long. The body cannot store them, and they are soon excreted in urine. Because of this, water-soluble vitamins need to be replaced more often than fat-soluble ones. Vitamin C and all the B vitamins are water soluble.

Individual Vitamins and their dietary source

1. Vitamin A

Chemical names: Retinol, retinal, and four carotenoids, including beta carotene. It is fat soluble.

Good sources include: Liver, cod liver oil, carrots, broccoli, sweet potato, butter, kale, spinach, pumpkin, collard greens, some cheeses, egg, apricot, cantaloupe melon, and milk.

2. Vitamin B

Chemical name: thiamine. It is water soluble.

Good sources include: yeast, pork, cereal grains, sunflower seeds, brown rice, whole-grain rye, asparagus, kale, cauliflower, potatoes, oranges, liver, and eggs.

3. Vitamin B2

Chemical name: Riboflavin. It is water soluble

Good sources include: asparagus, bananas, persimmons, okra, chard, cottage cheese, milk, yogurt, meat, eggs, fish, and green beans.

4. Vitamin B3

Chemical names: Niacin, niacinamide. It is water soluble.

Good sources include: liver, heart, kidney, chicken, beef, fish (tuna, salmon), milk, eggs, avocados, dates, tomatoes, leafy vegetables, broccoli, carrots, sweet potatoes, asparagus, nuts, whole-grains, legumes, mushrooms, and brewer's yeast.

5. Vitamin B5

Chemical name: Pantothenic acid . It is water soluble.

Good sources include: meats, whole-grains (milling may remove it), broccoli, avocados, royal jelly, and fish ovaries.

6. Vitamin B6

Chemical names: Pyridoxine, pyridoxamine, pyridoxal It is water soluble.

Good sources include: meats, bananas, whole-grains, vegetables, and nuts. When milk is dried, it loses about half of its B6. Freezing and canning can also reduce content.

7. Vitamin B7

Chemical name: Biotin . it is water soluble.

Good sources include: egg yolk, liver, some vegetables.

8. Vitamin B9

Chemical names: Folic acid, folinic acid . It is water soluble.

Good sources include: leafy vegetables, legumes, liver, baker's yeast, some fortified grain products, and sunflower seeds. Several fruits have moderate amounts, as does beer.

9. Vitamin B12

Chemical names: Cyanocobalamin, hydroxocobalamin, methylcobalamin. It is water soluble.

Good sources include: fish, shellfish, meat, poultry, eggs, milk and dairy products, some fortified cereals and soy products, as well as fortified nutritional yeast.

10. Vitamin C

Chemical name: Ascorbic acid . It is water soluble.

Good sources include: fruit and vegetables. The Kakadu plum and the camu fruit have the highest vitamin C contents of all foods. Liver also has high levels. Cooking destroys vitamin C.

11. Vitamin D

Chemical names: Ergocalciferol, cholecalciferol. It is fat soluble.

Good sources: Exposure to ultraviolet B (UVB) through sunlight or other sources causes vitamin D to be produced in the skin. Also found in fatty fish, eggs, beef liver, and mushrooms.

12. Vitamin E

Chemical names: Tocopherols, tocotrienols . It is fat soluble.

Good sources include: Kiwi fruit, almonds, avocado, eggs, milk, nuts, leafy green vegetables, unheated vegetable oils, wheat germ, and whole-grains.

13. Vitamin K

Chemical names: Phylloquinone, menaquinones . It is fat soluble.

Good sources include: leafy green vegetables, avocado, kiwi fruit. Parsley contains a lot of vitamin K.

Roles of vitamins

Vitamins allow body to grow and develop. They also play important roles in bodily functions such as metabolism, immunity and digestion.

1. Vit. A needed for vision, healthy skin and mucous membranes, bone and tooth growth, immune system health.
2. Vit. B1 needed for energy metabolism; important to nerve function.
3. Vit. B2 needed for energy metabolism; important for normal vision and skin health

4. Vit. B3 needed for energy metabolism; important for nervous system, digestive system, and skin health.
5. Vit.B12 needed for making new cells; important to nerve function.
6. Vit. C needed for protein metabolism; important for immune system health; aids in iron absorption.
7. Vit.D needed for proper absorption of calcium; stored in bones.
8. Vit. E antioxidant; protects cell walls.
9. Vit. K needed for proper blood clotting.

XI.IV Minerals

Minerals are inorganic substances required by the body in small amounts for a variety of functions. These include the formation of bones and teeth; as essential constituents of body fluids and tissues; as components of enzyme systems and for normal nerve function. Some minerals are needed in larger amounts than others, e.g. calcium, phosphorus, magnesium, sodium, potassium and chloride. Others are required in smaller quantities and are sometimes called trace minerals, e.g. iron, zinc, iodine, fluoride, selenium and copper. Despite being required in smaller amounts, trace minerals are no less important than other minerals.

Individual mineral and its biological role

1. Iron - Iron in food exists as two types, heme and non-heme. Animal foods such as meat, seafood and poultry provide both types and are better absorbed by the body. Non-heme iron is found in plant foods, such as spinach and beans, grains that are enriched, like rice and bread, and some fortified breakfast cereals. Iron is a mineral, and its main purpose is to carry oxygen in the hemoglobin of red blood cells throughout the body so cells can produce energy. Iron also helps remove carbon dioxide. When the body's iron stores become so low that not enough normal red blood cells can be made to carry oxygen efficiently, a condition known as iron deficiency anemia develops. Babies need iron for brain development and growth. They store enough iron for the first four to six months of life. A supplement may be recommended by a pediatrician for a baby that is premature or a low-birth weight and breastfed. After six months, their need for iron increases, so the introduction of solid foods when the baby is developmentally ready can help to provide sources of iron.

2. Calcium - Calcium is perhaps the most essential nutrient when it comes to bone health.

Building strong bones is like building a healthy balance in your "calcium bank account."Bones are living tissue and constantly in a state of turnover, making calcium deposits and withdrawals daily. Calcium is a mineral that people need to build and maintain strong bones and teeth. It is also very important for other physical functions, such as muscle control and blood circulation. Calcium is not made in the body - it must be absorbed from the foods we eat. To effectively absorb calcium from food, our bodies need Vitamin D. Calcium, the most abundant mineral in the body, is found in some foods, added to others, available as a dietary supplement, and present in some medicines (such as antacids). Calcium is required for vascular contraction and vasodilation, muscle function, nerve transmission, intracellular signaling and hormonal secretion, though less than 1% of total body calcium is needed to support these critical metabolic. Serum calcium is very tightly regulated and does not fluctuate with changes in dietary intakes; the body uses bone tissue as a reservoir for, and source of calcium, to maintain constant concentrations of calcium in blood, muscle, and intercellular fluids. If we do not have enough calcium in our diets to keep our bodies functioning, calcium is removed from where it is stored in our bones. Over time, this causes our bones to grow weaker and may lead to osteoporosis — a disorder in which bones become very fragile.

3. Phosphorus - Phosphorus is a mineral that makes up 1% of a person's total body weight. It is

the second most abundant mineral in the body. It is present in every cell of the body. Most of the phosphorus in the body is found in the bones and teeth. The main function of phosphorus is in the formation of bones and teeth. It plays an important role in how the body uses carbohydrates and fats. It is also needed for the body to make protein for the growth, maintenance, and repair of cells and tissues. Phosphorus also helps the body make ATP, a molecule the body uses to store energy. In other words sequentially, it can be written as :

1. build strong bones and teeth
2. filter out waste in your kidneys
3. manage how your body stores and uses energy
4. grow, maintain, and repair tissue and cells
5. produce DNA and RNA — the body's genetic building blocks

6. balance and use vitamins such as vitamins B and D, as well as other minerals like iodine, magnesium, and zinc
7. assist in muscle contraction
8. maintain a regular heartbeat
9. facilitate nerve conduction
10. reduce muscle pain after exercise

4. Iodine - Iodine is a trace mineral and a nutrient found naturally in the body and is needed for the cells to convert food into energy. Humans need iodine for normal thyroid function, and for the production of thyroid hormones. An essential mineral, iodine is used by the thyroid gland to make thyroid hormones that control many functions in the body including growth and development. Because your body does not produce iodine, it needs to be supplied in the diet. When iodine intake is poor, the body cannot produce enough thyroid hormones. So, it is needed in the diet to ensure that the thyroid works properly. Thyroid hormones play an important role in a wide range of bodily functions, including metabolism, bone health, immune response, and development of the central nervous system (CNS). Iodine helps convert thyroid stimulating hormone (TSH) to triiodothyronine (T3) and thyroxine (T4). This conversion is important for the thyroid to function properly.

5. Selenium - Selenium is a mineral found in the soil. It naturally appears in water and some foods. Selenium is a trace mineral that is essential to good health but required only in small amounts. While people only need a very small amount, selenium plays a key role in the metabolism. Plant foods are the major dietary sources of selenium in most countries throughout the world. The content of selenium in food depends on the selenium content of the soil where plants are grown or animals are raised. Good natural food sources of selenium include:

1. Nuts, like Brazil nuts and walnuts
2. Many fresh and saltwater fish, like tuna, cod, red snapper, and herring
3. Beef and poultry
4. Grains

Whole foods are the best sources of selenium. The mineral may be destroyed during processing.

Selenium is incorporated into proteins to make selenoproteins, which are important antioxidant enzymes. The antioxidant properties of selenoproteins help prevent cellular

damage from free radicals. Free radicals are natural by-products of oxygen metabolism. Other selenoproteins help regulate thyroid function and play a role in the immune system. Some research suggests that selenium may help with the following:

1. Prevent certain cancers
2. Protect the body from the poisonous effects of heavy metals and other harmful substances.

6. Zinc - Zinc is a trace element that is necessary for a healthy immune system. A lack of zinc can make a person more susceptible to disease and illness. The best sources of zinc are beans, animal meats, nuts, fish and other seafood, whole grain cereals, and dairy products. Zinc is also added to some breakfast cereals and other fortified foods. Zinc is vital for a healthy immune system, correctly synthesizing DNA, promoting healthy growth during childhood, and healing wounds. The various functions include :-

1. Regulating immune function - the human body needs zinc to activate T lymphocytes (T cells). T cells help the body in two ways:
   a) controlling and regulating immune responses
   b) attacking infected or cancerous cells
2. Role in wound healing - Zinc plays a role in maintaining skin integrity and structure. Patients experiencing chronic wounds or ulcers often have deficient zinc metabolism and lower serum zinc levels. Zinc is often used in skin creams for treating diaper rash or other skin irritations.
3. Decreased risk of age-related chronic disease- improving zinc status through diet and supplementation may reduce the risk of inflammatory diseases. Deficiency has been linked to increased inflammation in chronic disease and triggering new inflammatory processes.
4. Preventing age-related macular degeneration (AMD)- Zinc prevents cellular damage in the retina, which helps in delaying the progression of AMD and vision loss.
5. Related to fertility - Several studies and trials have linked poor zinc status with low sperm quality. Poor zinc intake may be a risk factor for low quality of sperm and male infertility.

XI.V Summary

The B complex vitamins include thiamin (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxine (B6), biotin (B7), folic acid (B9), and B12. They serve many purposes in your body, including aiding in energy production, making red blood cells, and making new DNA so cells can multiply.

In the context of nutrition, a mineral is a chemical element required as an essential nutrient by organisms to perform functions necessary for life. The five major minerals in the human body are calcium, phosphorus, potassium, sodium, and magnesium.

XI.VI Glossary

Bioavailability - The accessibility of a nutrient to participate in metabolic and/or physiological processes.

DNA - Deoxyribonucleic acid

XI.VII Further reading

David, L., Nelson Michael, Cox, N.A, Nelson, D.L.(2021)- Lehninger Principles of Biochemistry, MacMillan Learning

XI.VIII Model questions

What are vitamins? Give example and benefit of fat soluble vitamins.

Minerals are important for body – discuss.

UNIT XII ❑ Major nutritional deficiency disorders - protein deficiency disorders, vitamin deficiency disorders, mineral deficiency disorders - remedial measures and government programmes

Structure / Content

XII.I Objective

This is the unit covering the aspects of Health under the module food, nutrition and health. After covering the whole unit the learners will be able to to know the diseases developed due to the deficiency of protein, vitamin and minerals.

XII.II Introduction

We all live in a different environment- ecosystem, social system and economy effect us physically, mentally and spiritually. Good health means capability to strive in adverse situation. Major nutritional deficiency diseases caused by insufficient dietary intake of macro

and micro nutrients. Persistent malnutrition may lead to elevated morbidity and mortality rates. Important functional disturbances may occur as a result of single or multiple nutrient deficiencies.

XII.III Major nutritional deficiency disorders

Under nutrition is a condition in which there is insufficient food to meet energy needs; its main characteristics include weight loss, failure to thrive, and wasting of body fat and muscle. Low birth weight in infants, inadequate growth and development in children, diminished mental function, and increased susceptibility to disease are among the many consequences of chronic persistent hunger, which affects those living in poverty in both industrialized and developing countries.

XII.III.I Protein deficiency disorders

Malnutrition is the impaired function that results from a prolonged deficiency or excess—of total energy or specific nutrients such as protein, essential fatty acids, vitamins, or minerals. This condition can result from fasting and anorexia nervosa; persistent vomiting (as in bulimia nervosa) or inability to swallow; impaired digestion and intestinal malabsorption; or chronic illnesses that result in loss of appetite (e.g., cancer, AIDS). Malnutrition can also result from limited food availability, unwise food choices, or overzealous use of dietary supplements. Chronic under nutrition manifests primarily as protein-energy malnutrition (PEM), which is the most common form of malnutrition worldwide. Also known as protein-calorie malnutrition, PEM is a continuum in which people—all too often children—consume too little protein, energy, or both. The term protein deficiency represents a state of deficit in body protein or one or more of the essential amino acids. Thus, the term protein deficiency can also be considered synonymous with negative nitrogen balance. The deficiency can result from a protein-deficient diet or other diseases and, in general, can also result from a global deficit of food. While true protein deficiency is uncommon in the Western world, some people get very low amounts from their diet. This may affect almost all aspects of body function and lead to various health problems. Symptoms of protein deficiency may start to occur even when protein deficiency is marginal. There are 8 symptoms of low protein intake or deficiency which are :

1. Edema - Edema is a condition characterized by swollen and puffy skin.
2. Fatty liver - It’s not clear why fatty liver disease occurs with protein deficiency

3. Skin, hair, and nail problems - Protein deficiency may be associated with changes in the skin, hair, and nails, which are largely made of protein.
4. Loss of muscle mass - When dietary protein is in short supply, the body tends to take protein from skeletal musclesTrusted Source to preserve more important tissues and body functions. As a result, a lack of protein could lead to muscle wasting over time.
5. Greater risk of bone fractures - Not eating enough protein may weaken bones
6. Stunted growth in children - Insufficient protein intake may delay or prevent growth in children.
7. Increased severity of infections - A protein deficit may cause immunity dysfunctions
8. Greater appetite and calorie intake - Protein plays a key role in appetite maintenance and total calorie intake.

The major protein deficiency disease are marasmus, kwashiorkor and intermediate states of marasmus-kwashiorkor.

Kwashiorkor

Kwashiorkor is the result of severe malnutrition or lack of protein and, usually, calories as well. A child may sometimes have a continued cereal- or grain-based diet that may have some calories but lacks sufficient nutrients and protein. Proteins are responsible for maintaining fluid balance in the body. Symptoms of kwashiorkor includes:-

1. Changes in skin pigment
2. Decreased muscle mass
3. Diarrhea
4. Failure to gain weight and grow
5. Fatigue
6. Hair changes (change in color or texture)
7. Increased and more severe infections due to damaged immune system
8. Irritability
9. Large belly that sticks out(protrudes)
10. Lethargy or apathy

11. Loss of muscle mass
12. Rash (dermatitis)
13. Shock (late stage)
14. Swelling (edema)

Marasmus

An infant with marasmus is extremely underweight and has lost most or all subcutaneous fat. The body has a "skin and bones" appearance, and the child is profoundly weak and highly susceptible to infections. The cause is a diet very low in calories from all sources (including protein), often from early weaning to a bottled formula prepared with unsafe water and diluted because of poverty. Poor hygiene and continued depletion lead to a vicious cycle of gastroenteritis and deterioration of the

lining of the gastrointestinal tract, which interferes with absorption of nutrients from the little food available and further reduces resistance to infection. If untreated, marasmus may result in death due to starvation or heart failure.

The symptoms of marasmus are :-

1. Severe growth retardation
2. Loss of subcutaneous fat
3. Severe muscle wasting
4. The child looks appallingly thin and limbs appear as skin and bone
5. Shriveled body
6. Wrinkled skin
7. Bony prominence
8. Associated vitamin deficiencies
9. Failure to thrive
10. Irritability, fretfulness and apathy
11. Frequent watery diarrhoea and acid stools
12. Mostly hungry but some are anoretic
13. Dehydration

14. Temperature is subnormal
15. Muscles are weak
16. Oedema and fatty infiltration are absent

The best way to prevent marasmus is to have an adequate intake of calories and protein, preferably from a healthful, well-balanced diet. Foods rich in protein, such as skimmed milk, fish, eggs, and nuts are ideal for energy and growth, though any protein and calorie-rich food can be used to prevent marasmus, depending on what is available.

XII.III.II Vitamin deficiency disorders

Vitamins help the body grow and ensure its systems function correctly. However, inadequate intake or the ability of the body to absorb vitamins may lead to a deficiency. This can result in a host of symptoms that vary in severity. Following is a list of major deficiency diseases that occur due to lack of vitamins :-

Vitamin A deficiency disorders - Vitamin A plays an important role in vision. To see the full spectrum of light, the eye needs to produce certain pigments for the retina to work properly. Vitamin A deficiency stops the production of these pigments, leading to night blindness. The eye also needs vitamin A to nourish other parts of the eye, including the cornea. Without enough vitamin A, the eyes cannot produce enough moisture to keep them properly lubricated.Major symptoms of vitamin A dificiency are :-

1. Dry skin- Vitamin A is important for the creation and repair of skin cells. It also helps fight inflammation due to certain skin issues.
2. Dry eyes- Dry eyes, or the inability to produce tears, are one of the first signs of vitamin A deficiency.
3. Nigh blindness- severe vitamin A deficiency can lead to night blindness. Women with night blindness given vitamin A in the form of food or supplements improved the condition.
4. Infertility and trouble conceiving- Vitamin A is necessary for reproduction in both men and women, as well as proper development in babies. One of the reasons having trouble getting pregnant, is a lack of vitamin A. Vitamin A deficiency can lead to infertility in both men and women.
5. Delayed growth- Children who do not get enough vitamin A may experience stunted growth. This is because vitamin A is necessary for the proper development of the human body.

6. Throat and chest infections- Frequent infections, especially in the throat or chest, may be a sign of vitamin A deficiency. Vitamin A supplements may help respiratory tract infections.
7. Poor wound healing - Wounds that do not heal well after injury or surgery may be linked to low vitamin A levels. This is because vitamin A promotes the creation of collagen, an important component of healthy skin.
8. Acne and breakouts- Since vitamin A promotes skin development and fights inflammation, it may help prevent or treat acne. Low vitamin A levels linked the to the presence of acne.

Thiamine (B1) deficiency disorder

The initial symptoms of B1 deficiency include , loss of appetite , irritability and difficulties with short-term memory. Thiamine deficiency may affect the cardiovascular, nervous, and immune systems.

Riboflavin (B2) deficiency disorder

Riboflavin deficiency produces fatigue , swollen throat , blurred vision , depression , skin cracks and itching , dermatitis around the mouth , liver degeneration , hair loss ,reproductive issues and deficiencies of other nutrients.

Niacin (B3) deficiency disorder

Niacin deficiency results in a condition called pellagra. It causes various symptoms, like dermatitis, diarrhea , and dementia. The condition may affect people's neurological, gastrointestinal, and integumentary (skin) systems.

Pantothenic acid (B5) deficiency disorder

Severe deficiency may cause numbness and burning of the hands and feet , headache , extreme tiredness, irritability and restlessness.

B6 deficiency disorder

Severe deficiency may result in seborrheic dermatitis and anemia.

Biotin (B7) deficiency disorder

Biotin deficiency leads to nausea , vomiting , appetite loss etc.

Vitamin B9 (folate) deficiency disorder

A deficiency in vitamin B9 can cause weakness , fatigue , difficulty in concentrating and heart palpitations.

B12 deficiency disorder

This vitamin deficiency prroduced pernicious anemia , pale skin and weight loss .

Vitamin C deficiency disorder

Common disorders of vitamin C deficiency are scurvey, gingivitis (inflammation of the gums) with bleeding , periodontal (gum) disease and tooth loss .

Vitamin D deficiency disorders

A prolonged and severe vitamin D deficiency may cause secondary hyperparathyroidism, including bone pain , joint pain , muscle aches and fatigue.

Vitamin E deficiency disorders

Possible disorders of a vitamin E deficiency are blindness , dementia and heart arrhythmias.

Vitamin K deficiency disorders

The absence of vitamin K produces bleeding disorders , impaired bone development and cardiovascular diseases.

Signs and symptoms of a vitamin deficiency vary by the vitamin and severity of the deficiency.

XII.III.III Mineral deficiency disorders

Of the different minerals iron and iodine deficiency produces major disorders which are given below.

Iron deficiency disorders

Iron is a mineral needed by our bodies. Iron is a part of all cells and does many things in our bodies. For example, iron (as part of the protein hemoglobin) carries oxygen from our lungs throughout our bodies. Having too little hemoglobin is called anemia. Iron also helps our muscles store and use oxygen. Iron is a part of many enzymes and is used in many cell functions. Enzymes help our bodies digest foods and also help with many other important reactions that occur within our bodies. When our bodies don’t have enough iron, many parts of our bodies are affected.

Iron deficiency is a condition resulting from too little iron in the body. Iron deficiency is the most common nutritional deficiency and the leading cause of anemia. The terms anemia, iron deficiency, and iron deficiency anemia often are used interchangeably but equivalent. Iron deficiency ranges from depleted iron stores without functional or health impairment to iron deficiency with anemia, which affects the functioning of several organ systems. Iron deficiency has many causes which are :

1. Increased iron needs
2. Decreased iron intake or absorption (not enough iron taken into the body)

Signs of iron deficiency anemia include

1. Feeling tired and weak
2. Decreased work and school performance
3. Slow cognitive and social development during childhood
4. Difficulty maintaining body temperature
5. Decreased immune function, which increases susceptibility to infection
6. Glossitis (an inflamed tongue)

Iodine deficiency disorders

Iodine is an element that is essential for normal growth and for the development of the brain. The body needs iodine to make thyroid hormones in the thyroid gland. Thyroid hormones influence metabolism. They are essential for the development and function of the brain, nerves and bones.

A healthy diet needs enough iodine, but too much can cause health problems.

Iodine deficiency occurs when any one don't have enough iodine in your body. This usually occurs because anybody don't consume enough iodine in their diet.Iodine deficiency is the most common cause of thyroid problems. Iodine deficiency is a growing problem in Australia, especially among children and people who are pregnant or breastfeeding. These groups are at risk of thyroid problems and other serious consequences. It's more common in people who are pregnant or breastfeeding (who have higher iodine needs), and unborn or newborn babies. Symptoms of hypothyroidism are severe tiredness and muscle weakness , unexpected weight gain , depression and thick puffy skin or puffiness of the face.

XII.IV Remedial measures and Government programmes

Remedial measures

1. Generally eating healthful diet that includes good sources of iron is the primary measure of prevention.
2. A healthful diet includes fruits, vegetables, whole grains, fat free or nonfat milk and milk products, lean meats, fish, dry beans, eggs, nuts, and is low in saturated fat, trans fats, cholesterol, salt, and added sugars.
3. In addition to a healthful diet that includes good sources of iron, it is netter to eat also foods that help the body to absorb iron better. For example, eating a fruit or vegetable that is a good source of vitamin C with a food or meal that contains non-heme iron. Vitamin C helps the body absorb the non-heme iron foods vailable to eat, especially when the food containing non-heme iron and the vitamin-C rich food are eaten at the same meal.

Government programmes

The Govt. of India has implemented through the Primary Health Centers and its subcenters, aims at decreasing the prevalence and incidence of anemia in women of reproductive age. It focuses on three vital strategies: promotion of regular consumption of foods rich in iron, provisions of iron and folate supplements in the form of tablets to the high risk groups, and identification and treatment of severely anemic cases. The program solicits the support of various departments in implementing the dietary modification and supplementation measures.

1. Pregnant women are recommended to have one big tablet per day for 100 days after the first trimester of pregnancy; a similar dose applies to lactating women and IUD acceptors.
2. Preschool children (ages 1-5 years) are recommended to take one small tablet per day for 100 days every year.
3. Adult tablets contain 100 mg iron and 500 mg folic acid, while pediatric tablets contain 20 mg iron and 100 mg folic acid.
4. For treatment of severe anemia, women in the reproductive age group are recommended to take three adult tablets per day for a minimum of 100 days.
5. Drinking tea is discouraged, as it may inhibit the absorption of iron in the stomach.

Proposals are there to take initiatives to improve coverage, quality, and efficiency of the National Nutritional Anemia Control Program (NNACP) in future plan period.

XII.V Summary

Both insufficient and excessive iodine intake can result in thyroid disease. The term "iodine deficiency disorders" refers to all of the consequences of iodine deficiency, which depend on its severity and the age of the affected subject. When severe iodine deficiency occurs during pregnancy, it is associated with fetal hypothyroidism, mental impairment, and increased neonatal and infant mortality. In adults, iodine-induced hypothyroidism is rare, while the most common manifestation is goiter that progresses to nodular goiter and eventually to thyroid autonomy and hyperthyroidism. At one end of the continuum is kwashiorkor, characterized by a severe protein deficiency, and at the other is marasmus, an absolute food deprivation with grossly inadequate amounts of both energy and protein.Vitamin A deficiency can result from inadequate intake, fat malabsorption, or liver disorders.

XII.VI Glossary

Anaemia – Characterized by reduction in haemoglobin levels or red blood cells

Body mass index (BMI) – Defined as an individual's body mass (in kilograms) divided by height (in metres squared)

Micronutrients – Essential vitamins and minerals required by the body in miniscule amounts throughout the life cycle

XII.VII Further reading

David ,L. ,Nelson Michael ,Cox ,N.A, Nelson, D.L.(2021)- Lehninger Principles of Biochemistry, MacMillan Learning

XII.VIII Model questions

How kwashiorkor disease can be prevented? Give their symptom.

What is vitamin A deficiency disorder? State their cause and symptom.

UNIT XIII ❑ Lifestyle health problems - hypertension, diabetes mellitus, obesity; Social health problems- smoking, alcoholism and drug dependence

Structure / Content

XIII.I Objective

This is the unit covering the aspects of Life style Health problems. From this unit learners will be able to understand about the social and lifestyle related health problems and their solutions.

XIII.II Introduction

We all live in a different environment- ecosystem, social system and economy effect us physically, mentally and spiritually. Good health means capability to strive in adverse situation. Good physical health can be seen from better immunity, elasticity of bones, smaller healing period, no lethargy, etc. Similarly, good mental health encircles around coping against peer pressure, anxiety, anger, depression etc.

XIII.III Lifestyle health problems

A disease associated with the way a person or group of people lives. Lifestyle diseases include atherosclerosis, hypertension, heart disease and stroke; obesity and type 2 diabetes; and diseases associated with smoking and alcohol and drug abuse. Regular physical activity helps prevent obesity, heart disease, hypertension, diabetes, colon cancer, and premature mortality. The main factors contributing to lifestyle diseases include bad food habits, physical inactivity, wrong body posture, and disturbed biological clock.

XIII.III.I Hypertension

Hypertension is the medical term for high blood pressure. This means that the blood applies too much force against the walls of the blood vessels. Normal blood pressure is 120 over 80 mm of mercury (mmHg), but hypertension is higher than 130 over 80 mmHg. Acute causes of high blood pressure include stress, but it can happen on its own, or it can result from an underlying condition, such as kidney disease. Unmanaged hypertension can lead to a heart attack, stroke, and other problems.

Causes - The cause of hypertension is often not known. Around 1 in every 20 cases of hypertension is the effect of an underlying condition or medication. Chronic kidney disease (CKD) is a common cause of high blood pressure because the kidneys do not filter out fluid. This fluid excess leads to hypertension.

Prevention (Dietary modifications) - A variety of dietary modifications are beneficial in the treatment of hypertension, including reduction of sodium intake, moderation of alcohol, weight loss in the overweight or obese, and a diet rich in fruits, vegetables, legumes, and low-fat dairy products and low in snacks, sweets, meat, and saturated fat. Individual dietary factors may also reduce blood pressure (BP). By starting a few new food habits, including counting calories and watching portion sizes, one may be able to lower blood pressure and reduce the medications that need to control high blood pressure.

Prevention (Lifestyle modifications) -

1. Socioeconomic condition in the world suggests that prevention through Lifestyle Modifications is the universal “vaccine” against Hypertension.
2. Weight Reduction – by maintaining normal body weight BMI: 18.5 – 24.9 BP reduction: (5-20 mmHg/10 kg loss)
3. DASH Eating Plan- Dietary Approaches to Stop Hypertension Fruits, Vegetables, Low-fat dairy Reduce saturated and total fat (8-14 mmHg BP reduction).
4. Dietary Sodium Reduction -2.4 grams Sodium or 6 grams Sodium Chloride (2-8 mmHg BP reduction)
5. Physical Activity – Regular aerobic physical activity (4-9 mmHg BP reduction)
6. Smoking Cessation - Any independent chronic effect of smoking on BP is small. Smoking cessation does not decrease BP, but total cardiovascular risk is increased by smoking. Therefore hypertensives who smoke should be counselled on smoking cessation. So, A healthy lifestyle must be adopted to combat these diseases with a proper balanced diet, physical activity and by giving due respect to biological clock. Kids spending too much time slouched in front of the TV or PCs, should be encourage to find a physical sport or activity they enjoy. Fun exercises should be encouraged into family outings. A pizza-and-video evening should be replaced for a hike and picnic. Kids who do participate in sport, especially at a high competitive level, can find the pressure to succeed very stressful. To decrease the ailments caused by occupational postures, one should avoid long sitting hours and should take frequent breaks for stretching or for other works involving physical movements.

XIII.III.II Diabetes mellitus

Diabetes mellitus refers to a group of diseases that affect how the body uses blood sugar (glucose). Glucose is vital for the health because it’s an important source of energy for the cells that make up muscles and tissues. It’s also a brain’s main source of fuel. The underlying cause of diabetes varies by type. But, no matter what type of diabetes you have, it can lead to excess sugar in your blood. Too much sugar in your blood can lead to serious health problems. Chronic diabetes conditions include type 1 diabetes and type 2 diabetes.Potentially reversible diabetes conditions include prediabetes — when the blood sugar levels are higher than normal, but not high enough to be classified as diabetes—

and gestational diabetes, which occurs during pregnancy but may resolve after the baby, is delivered. Of these two types of diabetes Type-II is actually the life style health problem.

Causes - Type 2 diabetes used to be called adult-onset diabetes, but with the epidemic of obese and overweight kids, more teenagers are now developing type 2 diabetes. Type 2 diabetes was also called non-insulin-dependent diabetes. Type 2 diabetes is often a milder form of diabetes than type 1. Nevertheless, type 2 diabetes can still cause major health complications, Type 2 diabetes causes are usually multifactorial - more than one diabetes cause is involved. Often, the most overwhelming factor is a family history of type 2 diabetes. This is the most likely type 2 diabetes cause.There are a variety of risk factors for type 2 diabetes, any or all of which increase the chances of developing the condition.

These include:

1. Obesity
2. Living a sedentary lifestyle
3. Increasing age
4. Bad diet

Prevention - The general dietary advice to reduce risk of type 2 diabetes is to decrease intakes of fat and increase intake of dietary fiber.

Healthy – eating plan helps diabetic people to control diabetes. The plan helps to control blood sugar (glucose), manage weight and control heart disease risk factors, such as high blood pressure and high blood fats.

Extra calories and fat intake creates undesirable rise in blood glucose which should be avoided.

Healthy food choices and tracking eating habits help keeping blood glucose level;

in a safe range.

A diabetes diet is based on eating three meals a day at regular times. This helps better use of the insulin that the body produces or gets through a medication.

Recommended foods are choosing healthy carbohydrates, fiber-rich foods, fish and “good” fats.

Healthy carbohydrates, such as: Fruits, Vegetables, Whole grains, Legumes, such as beans and peas, and Low-fat dairy products, such as milk and cheese.

Lifestyle changes are often advised for people at higher risk of diabetes and those who are newly diagnosed with type 2, to help manage their diabetes.

The recommended lifestyle interventions include:

1. Taking two and a half hours each week of moderate intensity physical activity or one hour and 15 minutes of high intensity exercise.
2. Losing weight gradually to achieve a healthy body mass index
3. Replacing refined carbohydrates with wholegrain foods and increase intake of vegetables and other foods high in dietary fiber.
4. Reducing the amount of saturated fat in the diet

XIII.III.III Obesity

Obesity is a complex disorder involving an excessive amount of body fat. Obesity isn't just a cosmetic concern. It increases the risk of diseases and health problems, such as heart disease, diabetes and high blood pressure. Being extremely obese means you are especially likely to have health problems related to your weight.

A Body Mass Index (BMI) between 25 and 29.9 indicates that a person is carrying excess weight. A BMI of 30 or over suggests that a person may have obesity.The good news is that even modest weight loss can improve or prevent the health problems associated with obesity. Dietary changes, increased physical activity and behavior changes can help to lose weight. Prescription medications and weight-loss surgery are additional options for treating obesity.

Causes - Although there are genetic, behavioral and hormonal influences on body weight, obesity occurs when you take in more calories than you burn through exercise and normal daily activities. Body stores these excess calories as fat. In general, the principal causes of obesity are:

1) Consuming too many calories – When a person consumes more calories than they use as energy, their body will store the extra calories as fat. This can lead to excess weight and obesity. Also, some types of foods are more likely to lead to weight gain, especially those that are high in fats and sugars. Foods that tend to increase the risk of weight gain include:

fast foods, fried foods, such as french fries, fatty and processed meats many dairy products

foods with added sugar, such as baked goods, ready-made breakfast cereals, and cookies

foods containing hidden sugars, such as ketchup and many other canned and packaged food items

sweetened juices, sodas, and alcoholic drinks processed, high-carb foods, such as bread and bagels.

2) Leading a sedentary lifestyle - Many people lead a much more sedentary lifestyle than their parents and grandparents did. Examples of sedentary habits include: working in an office rather than doing manual labor, playing games on a computer instead of doing physical activities outside, going to places by car instead of walking or cycling. The less a person moves around, the fewer calories they burn. Also, physical activity affects how a person's hormones work, and hormones have an impact on how the body processes food.

3) Not Sleeping enough - missing sleep increases the risk of gaining weight and developing obesity. Sleep deprivation may lead to obesity because it can lead to hormonal changes that increase the appetite.

4) Endocrine disruptors - Scientists believe there is a link between high consumption of fructose and obesity and metabolic syndrome. Authorities have raised concerns about the use of high-fructose corn syrup to sweeten drinks and other food products. Increased fructose intake may be an important predictor of metabolic risk in young people.

5) Obesity gene - A faulty gene called the fat-mass and obesity-associated gene (FTO) is responsible for some cases of obesity.

Prevention - Whether you're at risk of becoming obese, currently overweight or at a healthy weight, you can take steps to prevent unhealthy weight gain and related health problems. Not surprisingly, the steps to prevent weight gain are the same as the steps to lose weight: daily exercise, a healthy diet, and a long-term commitment to watch what you eat and drink.

Dietary modifications

1. Follow a healthy eating plan. Focus on low-calorie, nutrient-dense foods, such as fruits, vegetables and whole grains. Avoid saturated fat and limit sweets and alcohol. Eat three regular meals a day with limited snacking. You can still enjoy small amounts of high-fat, high-calorie foods as an infrequent treat. Just be sure to choose foods that promote a healthy weight and good health most of the time.

Lifestyle modifications

2. A balanced diet and gradually becoming more physically active as part of any obesity treatment plan is usually recommended. These lifestyle modifications can also help prevent obesity if overweight or otherwise at risk. Achieving and maintaining a healthy weight through diet and exercise can also help manage or reverse some of the serious conditions associated with obesity, such as hypertension and type 2 diabetes. Following lifestyle should be maintained to prevent obesity:-

Exercise regularly

Know and avoid the food traps that cause you to eat

Monitor your weight regularly

Be consistent

XIII.IV Social health problems

Social problems are the general factors that affect and damage society. A social problem is normally a term used to describe problems with a particular area or group of people in the world. Social problems often involve problems that affect the real world. It also affects how people react to certain situations. Examples can include:

1. Anti social behavior
2. Poverty
3. Drug abuse
4. Transgenderism
5. Prostitution
6. Alcohol abuse
7. Economic Deprivation
8. Unemployment
9. Sexual abuse like Rape , Early pregnancy and Female genital mutilation
10. Animal abuse

XIII.IV.I Smoking

While smoking may appear to be a socially acceptable trend on college campuses, it

still brings with it serious health problems. The consequences can be affecting social life in several ways. The biggest affect is secondhand smoke. The people around a person smoking are involuntarily inhaling smoke and toxins from cigarettes. Secondhand smoke is toxic and has been proven to lead to many health problems. Some of these health problems are:

Greater risk of respiratory infections such as bronchitis or pneumonia

1. More frequent and/or severe asthma attacks
2. Heart disease
3. Risk of heart attack
4. Increased risk of smoke
5. Lung cancer

Causes of smoking - Most smokers started when they were teens. Those who have friends and/or parents who smoke are more likely to start smoking than those who don't. Some teens say that they "just wanted to try it," or they thought it was "cool" to smoke.The tobacco industry's ads, price breaks, and other promotions for its products are a big influence in our society. The tobacco industry spends billions of dollars each year to create and market ads that show smoking as exciting, glamorous, and safe.Tobacco use is also shown in video games, online, and on TV. And movies showing smokers are another big influence. Studies show that young people who see smoking in movies are more likely to start smoking. A newer influence on tobacco use is the e-cigarette and other high-tech, fashionable electronic "vaping" devices. Often seen as harmless, and easier to get and use than traditional tobacco products, these devices are a great way for new users to learn how to inhale and become addicted to nicotine, which can prepare them for smoking.

Disorders caused by smoking - The diseases caused by smoking harm almost every organ in the body, cause many diseases, and reduces the health of smokers in general. It is responsible for a heap of other awful diseases, contributing to the tobacco epidemic we face today.

1. **Going blind-** . Smoking increases your risk of age-related macular degeneration, the leading cause of blindness in adults over the age of 65.
2. **Type 2 diabetes-** Smoking contributes to type 2 diabetes and increases the risk of complications from the disease— including poor blood flow to legs and feet.

3. **Erectile dysfunction-** Male sexual function is affected when you smoke. Tobacco causes narrowing of blood vessels all over your body, including those that supply blood to the penis.

4. **Ectopic pregnancy -** Ectopic pregnancy is a life-threatening reproductive complication in women that is more likely in smokers. It occurs when a fertilized egg implants somewhere other than the uterus. The egg can't survive and it puts mom's life at serious risk.

5. **Colorectal cancer-** Colorectal cancer, which forms in your intestines (colon or rectum), is the second leading cause of cancer.

6. **Rheumatoid arthritis -** Rheumatoid arthritis is a chronic inflammatory disease more common in women that affects the joints in your hands and feet. It causes painful swelling that can eventually result in bone loss and joint deformity. Smoking is one of the causes, and is also associated with developing the disease at an earlier age.

7. **Cleft lip and cleft palate -** These birth defects, commonly called orofacial clefts, occur when a baby's lip or mouth doesn't develop properly during pregnancy. Women who smoke during pregnancy are more likely to have babies with orofacial clefts.

8. **Fertility issues-** It causes reduced fertility in women and can contribute to other problems during pregnancy.

Prevention - Quitting smoking improves health in smokers of all ages and a good way to prevent smoking. Different ways to quit smoking have been studied. The following are the most common methods used to help smokers quit :

1. Counseling
2. Drug treatment
3. Smoking reduction
4. There are new and different types of tobacco and nicotine products.
5. New ways to help smokers quit are being studied in clinical trials.

People who have even a short counseling session with a health care professional are more likely to quit smoking.

XIII.IV.II Alcoholism

Alcoholism, now known as Alcohol Use Disorder (AUD), is a condition in which a person has a desire or physical need to consume alcohol, even though it has a negative impact on their life.

A person with this condition does not know when or how to stop drinking. They spend a lot of time thinking about alcohol, and they cannot control how much they consume, even if it is causing serious problems at home, work, and financially.

Alcohol abuse can be used to talk about excessive or inappropriate consumption of alcohol, but not necessarily dependence. Moderate alcohol consumption does not generally cause any psychological or physical harm. However, if who enjoy social drinking increase their consumption or regularly consume more than is recommended, AUD may eventually develop.

Causes - Alcohol dependence can take from a few years to several decades to develop.For some people who are particularly vulnerable, it can happen within months. Over time, regular alcohol consumption can disrupt the balance of :

1. gamma-aminobutyric acid (GABA) in the brain
2. glutamate

GABA controls impulsiveness and glutamate stimulates the nervous system. Dopamine levels in the brain rise after consuming alcohol. Dopamine levels may make he drinking experience more gratifying. Over the long- or medium-term, excessive drinking can significantly alter the levels of these brain chemicals. This causes the body to crave alcohol in order to feel good and avoid feeling bad.

Prevention - Alcoholism can impact anyone irrespective of gender, personal beliefs, ethnicity, age, or body type. However, the following groups have been identified as being at a higher risk hence the focus of prevention interventions. The groups are people of low esteem, professionals, and people with mental disorder and families with a drinking history.

If you are already into drinking, preventing the urge and ultimately stopping can be a challenge. However, there are strategies and routines on how to prevent alcoholism you can adapt to cut back and eventually stop drinking altogether.

Recognize triggers

Internal and external triggers such as places, people, times of day, positive emotions, and negative emotions like frustration can leave you craving a drink.

Recognizing these triggers is one way how to avoid alcohol. Move away from certain places, change the company, or switch to something else.

Don't keep alcohol at home

Access to alcohol increases the likelihood of drinking. Fully-stocked liquor cabinets and half-drunk bottles of wine can set off your drinking triggers. If there is no social purpose, keep alcoholic drinks out of your house. In fact, you can substitute with other drinks such as tea, water, and lemonade.

Engage in other activities

Instead of spending time in bars, look for other joints where there are non- drinking activities. You can take a walk, watch a movie or pick up a sport as a strategy on how to avoid drinking alcohol.

Cut down on the number of drinks

Stopping alcoholism is a gradual process that takes time. You should start by cutting down on the drinks you take per day or week. Work on a practical prevention schedule and have an accountability partner. The best way on how to avoid alcohol poisoning is by taking water in between your drinks.

Build a Social Support Network

Surrounding yourself with people of positive influence and those that build your confidence is hugely important as it can help you avoid excessive drinking. They can help you make life changes necessary for long-term sobriety.

XIII.IV.III Drug dependence

Drug dependence occurs when you need one or more drugs to function. To distinguish between dependence and abuse, it was felt that the mild or early phase of inappropriate drug use was considered abuse that led to dependence. People viewed dependence as a more severe problem than abuse. Drug dependence is a state in which individual uses the drug so frequently & consistently that it appears difficult for the person to get along without using the drug occurs when a person relies on a drug for normal physiological functioning. If the person abstains from taking the drug, he or she will experience withdrawal symptoms such as sweating, vomiting or diarrhea. Abstaining from drug use can also trigger problems in mental functioning such as lack of focus, depression or anxiety.

Drug dependence vs. drug addiction- People sometimes use the terms "addiction" and "dependence" interchangeably. Dependence is not the same as addiction. Addiction can occur without being dependent on drugs. Addiction may involve:

a) using drugs despite the consequences

b) being unable to stop using drugs

c) neglecting social and work obligations because of drug use

It's possible to be dependent on drugs without being addicted. Dependence can be a bodily response to a substance. This often occurs if you rely on medications to control a chronic medical condition. These conditions may include:

a) high blood pressure

b) diabetes

c) glaucoma

Dependence may involve:

a) some or all the symptoms of addiction.

b) development of a high tolerance for the substance as your body adapts to the drug, leading to a desire for larger or more frequent doses

c) physical symptoms of withdrawal when you attempt to stop using the drug

Causes Drug dependence - While specific incentives differ from person to person, generally speaking, people start using drugs to escape or mask pain. In some individuals, the onset of drug use can be from untreated psychiatric issues including anxiety and depression. The rush of pleasure from using drugs can provide temporary solace from suffering, which can stem from many mental health or other issues including the following:

a. Trauma or abuse

b. Mental illness

c. Low self-esteem

d. Poverty

e. Relationship problems

f. Loss of a loved one

g. Stress

h. Chronic pain or medical conditions

But whatever their reason for starting, once addiction sets in, the disease usually spirals more and more out of their control.

Prevention - Drug prevention programs are designed to provide the education and support necessary to diminish drug dependency in communities, schools and the workplace. Drug abuse prevention has become an important first step in informing specific individuals about the dangers of addiction prevention techniques and where to find recovery help if it should be deemed necessary.

Drug abuse prevention begins with education, spreading the word regarding the dangers of drugs to oneself and to the community. These programs are just the beginning. The information provided is most effective when it is followed up with continued support. Drug prevention programs seek to involve the family, community or workplace in the prevention process. To be effective, communities need to sustain the progress. This often requires continued leadership and financial support.

XIII.V Summary

Many factors play a role in the development of obesity. Genetic traits can increase the risk in some people. Smoking is responsible for a heap of other awful diseases, contributing to the tobacco epidemic. Drinking too much – on a single occasion or over time – can take a serious toll on your health. Alcohol can effect, brain, heart, liver as well as pancreas and weaken immune system. Many of these illnesses can be prevented with the use of medicine or through self care.

XIII.VI Glossary

Trauma - a deeply distressing or disturbing experience.

Stress - Stress can be defined as a state of worry or mental tension caused by a difficult situation.

Chronic - Chronic refers to something that continues over an extended period of time.

XIII.VII Further reading

David ,L. ,Nelson Michael ,Cox ,N.A, Nelson, D.L.(2021)- Lehninger Principles of Biochemistry, MacMillan Learning

XIII.VIII Model questions

1. Define health. Give an idea about health.
2. How kwashiorkor disease can be prevented? Give their symptom.
3. What is vitamin A deficiency disorder? State their cause and symptom.
4. What is meant by life style related disease? Name one disease and state their symptoms and prevention.

UNIT XIV ❑ General concept of food hygiene; Different types of water borne infections and their prevention; Brief account of food spoilage and preventive measures

Structure / Content

XIII.I Objective

This unit covers the aspects of Food hygiene under the module food, nutrition and health. Food hygiene is the conditions and measures necessary to ensure the safety of food from production to consumption. After finishing the study material of this unit the learners will be able to

1. Explain what is food hygiene?
2. Describe how food hygiene can be maintained?
3. Describe food and water borne infections, their symptoms and prevention.
4. Discuss about food spoilage

XIV.II Introduction

Food hygiene is concerned with every aspect of food production. The main aim is to promote health. This is the responsibility of everyone in the food industry, from managers to cleaners. All must take great care when it comes to handling and preparing food to prevent unnecessary waste of food, due to spoilage or contamination by moulds, bacteria, physical damage or vermin. Most people think that food hygiene is simply common sense, they try to do the right thing and they certainly do not set out to poison anyone. However, when you work in the food industry you must consider a number of important issues to do with your approach to personal hygiene and kitchen hygiene. Food hygiene and safety usually refer to contamination with 'microorganisms' or

'microbes'; whereas in communicable diseases, the term 'infectious agents' is preferred. Food can become contaminated at any point during slaughtering or harvesting, processing, storage, distribution, transportation and preparation. Lack of adequate food hygiene can lead to food borne diseases and death of the consumer.

XIV.III General concept of food hygiene

The term 'food hygiene' refers particularly to the practices that prevent microbial contamination of food at all points along the chain from farm to table. Food safety is a closely related but broader concept that means food is free from all possible contaminants and hazards. Food hygiene is vital for creating and maintaining hygienic and healthy conditions for the production and consumption of the food that we eat. The overall purpose of food hygiene is to prepare and provide safe food and consequently contribute to a healthy and productive society. Food hygiene falls under the umbrella term 'food safety'.Food hygiene itself does not include all the other key areas of food safety.

Food safety refers to an entire system of managing risks. Meanwhile, food hygiene refers to an individual set of practices for controlling only one aspect. Food safety will help to -

1. Prevent, detect and manage foodborne risks.
2. Contributing to food security, human health, economic prosperity, agriculture, market access, tourism and sustainable development.

XIV.IV Different types of water borne infections

Food borne or water borne diseases is caused by consuming contaminated foods or beverages. The illnesses result from the failure to control an identified (or unidentified) hazard. In its simplest form, a hazard is something that has the potential to cause harm. In food and water, it is an unacceptable contamination that causes the food or water to be unfit for human consumption. A hazard falls into three categories: a) physical, b) chemical and c) biological.

Food borne disease has the potential to be caused by all three of these categories of hazards.

Physical food borne illness (injury, in this case) results from foreign objects in food like wood splinters, glass and metal fragments, pebbles or bone fragments. Chemical illness arises from substances that do not belong in food, but can contaminate it through carelessness or malicious intent or simply by contact with the food. Pesticides and cleaners are some of the chemicals that can cause harm through food. For example, bleach can cause poisoning and should only be kept in a clearly marked container to avoid contaminating food. Following are the major water borne diseases

XIV.IV.I Cholera

Cholera is an infectious disease that causes severe watery diarrhea, which can lead to dehydration and even death if untreated. It is caused by eating food or drinking water contaminated with a bacterium called *Vibrio cholerae*. *Vibrio cholerae*, the bacterium that causes cholera, is usually found in food or water contaminated by feces from a person with the infection. Common sources include:

1) Municipal water supplies
2) Ice made from municipal water
3) Foods and drinks sold by street vendors
4) Vegetables grown with water containing human wastes
5) Raw or undercooked fish and seafood caught in waters polluted with sewage

Symptoms of cholera can begin as soon as a few hours or as long as five days after infection.

Signs and symptoms of dehydration include:

1) Rapid heart rate
2) Loss of skin elasticity (the ability to return to original position quickly if pinched)
3) Dry mucous membranes, including the inside of the mouth, throat, nose, and eyelids
4) Low blood pressure
5) Thirst
6) Muscle cramps

Prevention - Be sure to use the bottled, boiled, or chemically disinfected water for the following purposes:

a) Drinking
b) Preparing food or drinks
c) Making ice
d) Brushing your teeth
e) Washing your face and hands
f) Washing dishes and utensils that you use to eat or prepare food
g) Washing fruits and vegetables

XIV.IV.II Typhoid fever

Typhoid is a bacterial infection that can lead to a high fever, diarrhea, and vomiting. It can be fatal. It is caused by the bacteria *Salmonella typhi*. The infection is often passed on through contaminated food and drinking water, and it is more prevalent in places where hand washing is less frequent. It can also be passed on by carriers who do not know they carry the bacteria.Symptoms normally begin between 6 and 30 days after exposure to the bacteria. The two major symptoms of typhoid are fever and rash. Typhoid fever is particularly high, gradually increasing over several days up to 104 degrees Fahrenheit, or 39 to 40 degrees Celsius. The rash, which does not affect every patient, consists of rose-colored spots, particularly on the neck and abdomen.

Prevention

Two basic actions can protect you:

1. Get vaccinated against typhoid fever.
2. Find out how to stay safe when it comes to foods and drinks.

Carefully selecting what you eat and drink when you travel is important. This is because the typhoid fever vaccines do not work 100% of the time, and there is no paratyphoid fever vaccine. Avoiding risky foods will also help protect you from other illnesses, including travelers' diarrhea, cholera, dysentery, and hepatitis A.

1) If you drink water, buy it bottled or bring it to a rolling boil for 1 minute before you drink it. Bottled carbonated water is safer than uncarbonated water.
2) Ask for drinks without ice, unless the ice is made from bottled or boiled water. Avoid popsicles and flavored ices that may have been made with contaminated water.

XIV.IV.III Dysentery

Dysentery is an intestinal infection that causes severe diarrhea with blood. In some cases, mucus may be found in the stool. This usually lasts for 3 to 7 days. Other symptoms may include:

a) abdominal cramps or pain
b) nausea
c) vomiting
d) fever of 100.4°F (38°C) or higher
e) dehydration, which can become life-threatening if left untreated

Dysentery is usually spread as a result of poor hygiene. For example, if someone who has dysentery doesn't wash their hands after using the toilet, anything they touch is at risk.There are two main types of dysentery which are Bacillary dysentery or shigellosis and Amoebic dysentery or amoebiasis. Bacillary dysentery is caused by the Shigella bacillus while amoebiasis is caused by *Entamoeba histolytica.*

Prevention

Dysentery mostly stems from poor hygiene.To reduce the risk of infection, people should wash their hands regularly with soap and water, especially before and after using

the bathroom and preparing food.This can reduce the frequency of Shigella infections and other types of diarrhea by up to 35 percent. Other steps to take when the risk is higher, for example, when traveling, include:

a) Only drink reliably sourced water, such as bottled water

b) Watch the bottle being opened, and clean the top of the rim before drinking

c) Make sure food is thoroughly cooked

XIV.IV.IV Hepatitis

Hepatitis refers to an inflammation of the liver cells and damage to the liver. There are different types and causes, but the symptoms can be similar. The liver's functions include detoxifying the blood, storing vitamins, and producing hormones. Hepatitis can disrupt these processes and create severe health problems throughout the body. At least five viruses can cause hepatitis. The three most common are hepatitis viruses A, B and C. Infection with any of these three can be fatal. Each is caused by a different virus. All three types can be acute, lasting for 6 months or less, and types B and C can be chronic, lasting for longer. Each type has different characteristics and is transmitted in different ways, but symptoms tend to be similar Hepatitis A is always an acute, short-term disease, while hepatitis B, C, and D are most likely to become ongoing and chronic. Hepatitis E is usually acute but can be particularly dangerous in pregnant women. Other types of hepatitis can result from overconsumption of alcohol or an autoimmune condition. Hepatitis A is caused by an infection with the hepatitis A virus (HAV). Hepatitis B is transmitted through contact with infectious body fluids, such as blood, vaginal secretions, or semen, containing the hepatitis B virus (HBV). Hepatitis C comes from the hepatitis C virus (HCV). Hepatitis D is a serious liver disease caused by the hepatitis D virus (HDV). Hepatitis E is a water borne disease caused by the hepatitis E virus (HEV). Hepatitis E is mainly found in areas with poor sanitation and typically results from ingesting fecal matter that contaminates the water supply.

Prevention - Practicing good hygiene is one key way to avoid contracting hepatitis A and E. If you're traveling to a developing country, you should avoid:

a) local water

b) ice

c) raw or undercooked shellfish and oysters

d) raw fruit and vegetables

Hepatitis B, C, and D contracted through contaminated blood can be prevented by:

a) not sharing drug needles

b) not sharing razors

c) not using someone else's toothbrush

d) not touching spilled blood

Hepatitis B and C can also be contracted through sexual intercourse and intimate sexual contact. Practicing safe sex by using condoms and dental dams can help decrease the risk of infection.

XIV.IV.V Giardiasis

Giardia infection or giardiasis is an intestinal infection marked by abdominal cramps, bloating, nausea and bouts of watery diarrhea. It is an infection of small intestine. It's caused by a microscopic parasite called Giardia lamblia. Giardiasis spreads through contact with infected people. And one can get giardiasis by eating contaminated food or drinking contaminated water. Pet dogs and cats also frequently contract giardia.

Giardia infections usually clear up within a few weeks. But you may have intestinal problems long after the parasites are gone. Several drugs are generally effective against giardia parasites, but not everyone responds to them. Prevention is your best defense. Giardia parasites live in the intestines of people and animals. Before the microscopic parasites are passed in stool, they become encased within hard shells called cysts, which allows them to survive outside the intestines for months. Once inside a host, the cysts dissolve and the parasites are released. Infection occurs when you accidentally ingest the parasite cysts.The most common way to become infected with giardia is after swallowing contaminated water. Giardia parasites are found in lakes, ponds, rivers and streams worldwide, as well as in municipal water supplies, wells, cisterns, swimming pools, water parks and spas. Ground and surface water can become contaminated from agricultural runoff, wastewater discharge or animal feces.

Prevention

There isn't a vaccine, but there are steps that can be taken:

1) Practice good hygiene: Wash hands often with soap and clean running water for 20 seconds, especially before and after eating, after using the toilet, and after coming in contact with your own or someone else's germs.

2) Do not drink water that may be contaminated: Do not drink untreated water from pools, lakes, rivers, ponds, and so on. If there is even a slight chance the water may be contaminated, either drink bottled water or boil the water for 5 minutes.

3) Avoid eating food that may be contaminated: Wash all fruits and vegetables thoroughly under hot water. Do not eat raw or undercooked meats, especially in underdeveloped countries where the water and food may be contaminated. Drink bottled water when in underdeveloped countries.

4) Prevent contact with feces during sex: Practice safe sex, especially using protection during oral-anal sex, and wash hands immediately after.

5) Clean up after sick pets: Use gloves and dispose of pet feces in a plastic bag and put it in the garbage. After, wipe up the infected area with hot steaming water and a strong disinfectant. Wash anything that may have been contaminated in the washer with detergent and hot water.

XIV.V Brief account of food spoilage

If food items are kept for a long period of time and not stored properly, they get spoil such food items are bad for health. When food items kept for a long time gets spoil as germs start growing on it. Once the food is spoiled, it cannot be eaten and has to be thrown away. Spoilage is a process in which food items deteriorate to the point in which it is not edible to human. Food spoilage thus can be defined as a disagreeable change in a food's normal state.

Such changes can be detected by smell, taste, touch, or sight. These changes are due to a number of reasons — air and oxygen, moisture, light, microbial growth, and temperature.Food spoilage results when microbiological, chemical or physical changes occur, rendering the food product unacceptable to the consumer. Microbiological food spoilage is caused by the growth of microorganisms which produce enzymes that lead to objectionable by-products in the food. Chemical food spoilage occurs when different components in the food react with each other or with some added component which alter the food's sensory characteristics. Examples of this include: oxidation; enzymatic browning; and nonenzymatic browning. Physical food spoilage results when moist foods are excessively dehydrated or dried foods absorb excessive moisture. Examples of physical spoilage include water loss; increase in moisture of dry foods; freezer burn; and recrystallisation of frozen foods.

XIV.V.I Causes of food Spoilage

The food and water may be infected by germs. Flies carry germs. When they sit on our food, they pass on these germs to our food. There are various factors which are responsible for food spoilage such as bacteria, mould, yeast, moisture, light, temperature, and chemical reaction.

Microbial spoilage is caused by microorganisms like fungi (moulds, yeasts) and bacteria. They spoil food by growing in it and producing substances that change the colour, texture and odour of the food. Eventually the food will be unfit for human consumption.

Physical spoilage is due to physical damage to food during harvesting, processing or distribution. The damage increases the chance of chemical or microbial spoilage and contamination because the protective outer layer of the food is bruised or broken and microorganisms can enter the foodstuff more easily. For example you may have noticed that when an apple skin is damaged, the apple rots more quickly.

Chemical spoilage in food are responsible for changes in the colour and flavour of foods during processing and storage. Foods are of best quality when they are fresh, but after fruits and vegetables are harvested, or animals are slaughtered, chemical changes begin automatically within the foods and lead to deterioration in quality. Fats break down and become rancid (smell bad), and naturally-occurring enzymes promote major chemical changes in foods as they age.

Enzymic spoilage (autolysis) is due to enzymes which play a role in the decomposition of once-living tissue, in a process called autolysis (self-destruction) or enzymic spoilage. For example, some enzymes in a tomato help it to ripen, but other enzymes cause it to decay . Once enzymic spoilage is under way, it produces damage to the tomato skin, so moulds can begin to can attack it as well, speeding the process of decay.

XIV.V.II Preventive measure of food spoilage

Food is valuable. Preserving food can help to avoid wasting of food. Food preservation involves preventing the food from being spoilt. Food preservation is the process of treating and handling food to stop or slow down food spoilage, loss of quality, edibility, or nutritional value and thus allow for longer food storage. Preservation of food is the process by which food is stored by special methods. Cooked or uncooked food can be preserved in different ways to be used later.

Preservation usually involves preventing the growth of bacteria, fungi (such as yeasts), and other microorganisms, as well as retarding the oxidation of fats which cause rancidity. Following are the best methods to prevent food spoilage :

Food kept in a refrigerator remains fresh for some days.

Boiling of foods

Salting or curing draws moisture from the meat through a process of osmosis.

Excess sugar in food also acts as a preservative.

Dehydration of the food items in sun to stop the growth of bacteria in them. Certain foods, like raw mangoes, fishes, potato chips and papads are preserved by this method. Drying is one of the most ancient food preservation techniques, which reduces water activity sufficiently to prevent bacterial growth.

Air is removed from food and put in airtight cans so that germs do not grow on them.

Vacuum-packing stores food in a vacuum environment, usually in an air-tight bag or bottle.

Pickling is a method of preserving food in an edible anti-microbial liquid. Pickling can be broadly categorized into two categories: chemical pickling and fermentation pickling.

Certain additives like propionic acid , sulphur dioxide , nitrates and nitrites are used to control the growth of undesirable bacteria, yeasts and moulds.

XIV.V Summary

I. Food hygiene is the conditions and measures necessary to ensure the safety of food from production to consumption.

II. Drinking water, also known as potable water or improved drinking water, is water that is safe to drink or to use for food preparation, without risk of health problems.

III. People earlier would store their water in earthen pots to keep the water clean and cold. People then moved on to filters and now it’s the age of water purifiers.

IV. Waterborne diseases are caused by drinking contaminated or dirty water.Contaminated water can cause many types of diarrheal diseases, including

Cholera, and other serious illnesses such as Guinea worm disease, Typhoid, and Dysentery.

V. Food spoilage can be defined as: any changes in the visual, smell and texture of food that makes it unacceptable for consumption or is the process in which food deteriorates to the points it is not edible to humans or its quality of edibility becomes reduced.

XIV.VI Glossary

Blended foods - Mixtures of milled cereals and other ingredients such as pulses, dried skimmed milk and possibly sugar and oil.

Malnutrition – A broad term commonly used as an alternative to 'undernutrition',

XIV.VII Further reading

Carolyn D. Berdanier, Johanna T. Dwyer, Elaine B. Feldman - (2007)-Handbook of Nutrition and Food, Second Edition, CRC Press, London, New York.

XIV.VIII Model questions

1. What is meant by food hygiene?
2. Define potable water. Discuss various methods of water purification.
3. Write cause, symptoms, and mode of prevention of a bacterial infection studied by you.
4. Write cause, symptoms, and mode of prevention of any viral; infection studied by you.
5. Write cause, symptoms, and mode of prevention of a parasitic infection studied by you.
6. What is giardiasis? Name the causative agent and source of infection.
7. What is the cause of food spoilage?
8. How food spoilage can be prevented?

NOTES