Model answer
M.Sc. (Semester I)
Paper-LZT-102: Entomology and Fish Biology

SECTION-A (Multiple choice question)

Question No. 1. Answer

i. **a.** ii. **a.** iii. **d.**
iv. **a.** v. **c.** vi. **a.**
vii. **b.** viii. **d.** ix. **d.**
x. **a.**

SECTION (B) Long answer type question

Question No.2. Answer

Structure of the integument: The outer covering of body is composed of three layers, viz. *cuticle, epidermis* (hypodermis) and *basement membrane.*

Cuticle: It is the outermost non cellular layer and gives support, protection and restricts water loss. It is secreted by underlying epidermis and *oenocytes* as a soft and flexible layer which subsequently hardens by a process of *sclerotisation*. Cuticle is composed of two layers, primary cuticle or epicuticle and secondary cuticle or inner epicuticle or procuticle.

Epicuticle: It is non-chitinous layer, made up of protein and lipids. It bears numerous nodules and pores. It composed of four layers: *cement layer, wax layer, polyphenol layer* or protein epicuticle and *cuticulin* or lipoprotein epicuticle.

Procuticle: It is chitinous nature. It composed of exocuticle, endocuticle and mesocuticle. The exocuticle is hard and dark, the endocuticle is soft, light, made up of horizontal lamellar which provide flexibility to the insect and chitin is the main constituent.

Expansion of the cuticle: Soon after ecdysis, the soft new cuticle expands and stretches gradually to accommodate the larger size of the new instar. The expansion of cuticle is brought to an end by a process of **sclerotization**. In most insects, the new cuticle is tanned soon after ecdysis and becomes hard and inextensible. However, in *Bombyx mori* tanning does not take place after larval ecdysis. Tanning is a process by which cuticular structures are made stiffer, inextensible, darker and more resistant to adaptation.

Lines of weakness: The exocuticle is absent along the ecdysal line and this place consists of endocuticle only which constitutes the lines of weakness. Moulting hormone acts on endocuticle and split occurs along the lines of weakness at ecdysis. The procuticle in insects cosist of numerous vertical lines which run from epidermis to the inner layer of epicuticle are called pore canals. These pore canals involved with the transport of cuticular materials like moulting fluids, proteins, etc. during the formation of cuticle.

Chitin: It is a colourless polymer, insoluble in water, alcohol, ether and dilute alkaline. It is a high molecular weight nitrogenous polysaccharide, $C_8H_{13}O_5N$. This polysaccharide is made up of N–acetylglucosamine which are attached to one another by 1, 4 β glucoside linkages. The bulk of the non chitinous material in the cuticle (0.5 – 37% w) is the protein.

Glycoprotein complex: The proteins of cuticle are three types, water soluble tyrosine and glycine, water insoluble sclerotin and resilin and colourless rubber like protein.

Epidermis: It is a single continous layer of cells composed of cytoplasmic membranes. Secretory in nature, the epidermal cells become flattened during moult and as well as absorb the endocuticle at the time of ecdysis. The epidermis also bears several tricogenous cells.

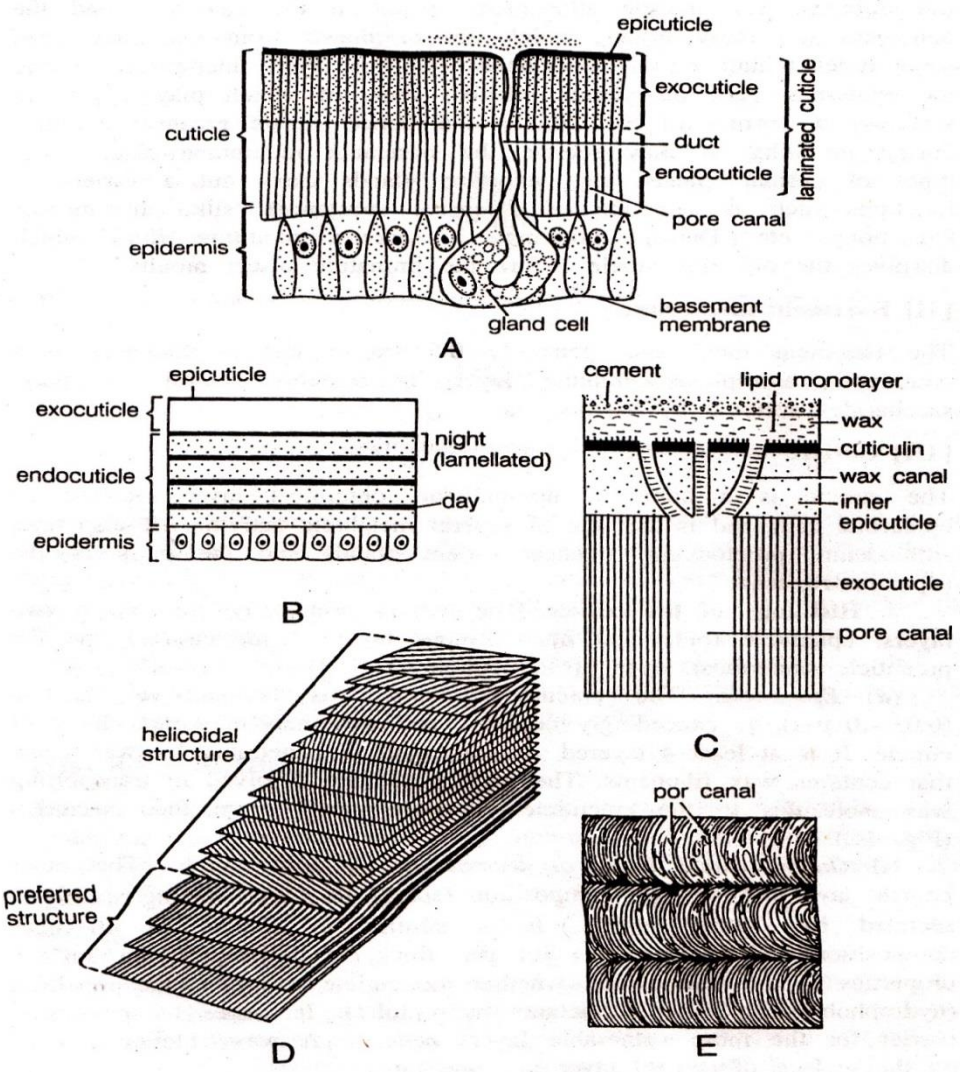


Fig. 1. Structure of the integument (diagrammatic). (A) section of generalised integument, (B) daily growth layers and lamellar pattern, (C) generalised epicuticle, (D) helicoidal and preferred structure of layers of endocuticle, (E) transverse section of endocuticle showing parabolic effect.

Basement membrane: It is a non cellular sheath on which epidermal cells rest. It formed by the secretions from haemocytes. In insects, unlike other insects, when the integument gets injured, regeneration does not occur by the multiplication of the epidermal cells but by accumulation of haemocytes which become transformed into epidermal cells and form a layer. Further insect integument playing important role in various process which is as follows:

Apolysis: Towards the end of instar, larvae stop feeding and remain immobile. However, the rhythmic peristaltic movements of the gut continue due to its emptying. The rigid cuticle becomes unable to accommodate the body which has grown in size. As a result of changes in the epidermal cells, a tension is generated at the surface of the epidermal cells which results

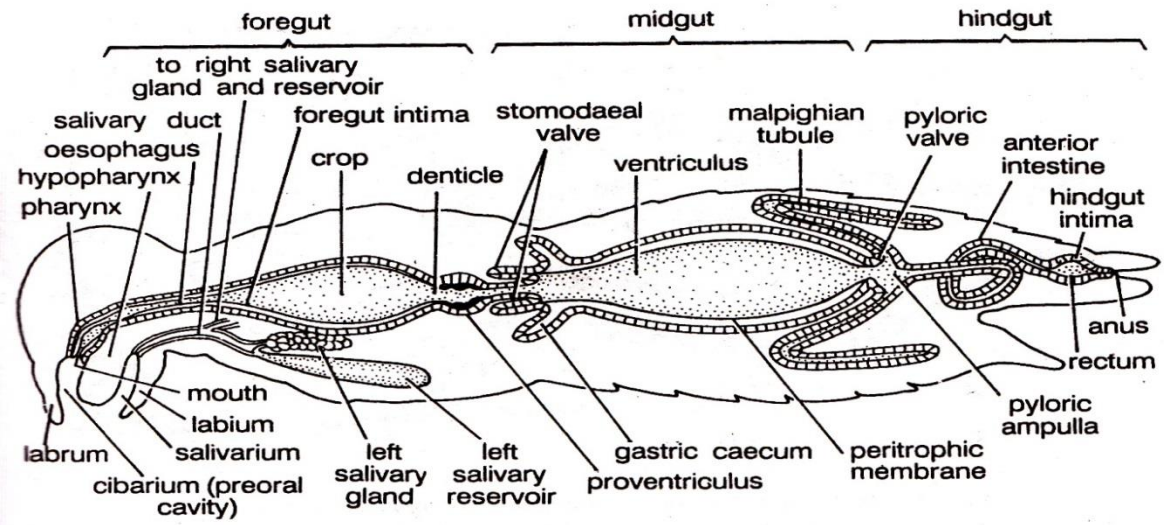
in the separation of cuticle, forming a subcuticular space. The inactive moulting fluid, secreted by the moulting glands, is discharged into the subcuticular space just before or at apolysis. The moulting fluid contains enzymes, proteinase and chitinase.

The moulting fluid gets activated and digests the chitin and proteins of the endocuticle for resorption and utilization. The hydrolysis products of the old cuticle are apparently transferred across the new cuticle into the haemolymh. Once the cuticulin is produced, the epidermal cells begin to deposit procuticle underneath it. While moulting fluid is digesting the endocuticle, it does not attack the epidermis. Since, before the activation of moulting fluid the epidermis immediately after separating from the cuticle secretes on its surface a layer of epicuticle which is resistant to moulting fluid, thereby giving protection to the epidermis. The undigested material (10-20) of the endocuticle becomes the ecdysal membrane, which persists and continues to receive stimuli from the environment till ecdysis takes place.

Ecdysis: Just before shedding off the skin and after resorption of the moulting fluid, the wax and the polyphenols are deposited on the surface of the new cuticle to make it water proof. The insect's shows muscular activity coupled with the increase in the haemolymph pressure and thereby old cuticle separates from the new one beneath it. Soon after ecdysis, a layer of cement produced by the Verson's gland is formed over the surface of the wax as an outermost layer of the epicuticle. After shedding the old cuticle, the worm rests for one or two hours before resume feeding.

Question No. 3. Answer

In insects, digestive system is a straight tube of epithelium running from mouth to anus. It has three regions, the foregut or stomodeum, the midgut or mesentrom and the hindgut or prostodeum.



Digestive system of generalised insect

Foregut: It is the anterior part of the digestive tract and is composed of three parts buccal or mouth cavity, the pharynx and oesophagus. The oral aperture opens into the mouth cavity, the anterior part of which is bounded by mandibles, the dorsal part by labrum, the ventral side by labium and two lateral sides by maxillae. The mouth cavity opens into a narrow pharynx and flask shaped oesophagus having two pair of muscles, the contractions of which enables the larvae to swallow the food. At the end of the foregut is a **cardiac valve** which helps in

retaining the chewed leaves in the crop for sometime and prevents backward motion of food midgut to foregut. The wall of foregut is made up of three layers: 1) ***tunica intima***, secreted by the ectodermal cells, 2) ***epithelial layer having glands*** with digestive function and 3) ***muscle layer*** composed of longitudinal and circular muscles.

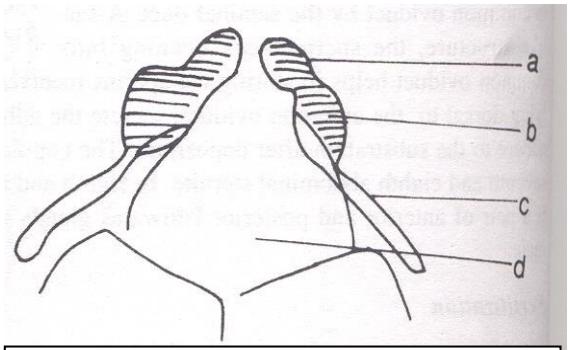
Midgut: It is largest part of digestive system and lies between the second and the ninth body segment. Digestion and assimilation of food takes place mainly in the midgut. While the midgut has endodermal lining, the fore and hindgut have lining continuous with the cuticular lining of the body wall. The wall of the midgut is composed of ***muscular layer, basal membrane, epithelium and peritrophic membrane***. The epithelium is composed of ***cylindrical, goblet and intestinal cells***. The cytoplasm of cylindrical and goblet cells has **mitochondria and Golgi bodies**. The digestive enzymes which hydrolyze the food into products capable of absorption are secreted partly by salivary glands and chiefly by **goblet cells**, whereas the cylindrical cells absorb the assimilated food. The midgut is alkaline in nature with **pH 9.5**. It is separated from hindgut by a **pyloric sphincter** which opens from time to time to allow the passage of digested food in fluid form into hindgut.

Hindgut: It is the posterior part of alimentary canal and comprises of small intestine or ileum, colon and rectum. The small intestine has a membranous valve at its junction with the midgut. This valve regulates the flow of the content from the midgut to the small intestine and at the same time prevents their backflow into the midgut. The malpighian tubules open at the junction between the small intestine and the colon. The colon continues into the rectum and terminates at the anus. On the surface of the rectum there are six longitudinal ridges. Associated anterolaterally with the rectum there are six malpighian tubules, three on each side. The residual feed after digestion in the midgut passes through the small intestine and become consolidated in the colon. Inside the rectum the undigested food become solidified into **hexagonal** pellets and extricated as faeces.

Digestive enzymes: The paired **salivary glands are small, tubular and light yellow in colour located on either side of oesophagus**. The salivary gland secretes, saliva, a weak alkaline solution, which contains an enzyme known as ***amylase***. The midgut is the place of secreting major digestive enzyme, the gastric juice, which is a string alkaline solution with pH ranging from **9.2-10.3**. The principal components of gastric juice are ***protease***, hydrolyzing proteins, ***lipase***, hydrolyzing fats, ***amylase***, hydrolyzing starch, ***invertase***, hydrolyzing cane sugars and ***maltase*** hydrolyzing maltose. Besides these the gastric juice also contains **trypsin, glucogenase and tyrosinase**.

Digestion and assimilation of food: Digestion is the process of changing insoluble substances and also impermeable substances into permeable ones. The midgut is the major site of secreting digestive enzymes as well as making food soluble to absorb. The foregut only ingests food and mixes with saliva, whereas the hindgut absorbs the water content and hardens the undigested material to expel. The **insect digests and absorbs 41-46% of *chlorophyll* and 29-34% *keratenoids* of leaves**. Ingredients of leaves such as *water, glucose, soluble salts* are absorbed by mid intestine as such but *proteins* are too large to pass through cell membrane are *converted into amino acids and peptones* by proteinase, and then absorbed. While these are being taken into various organs these get converted into glycerine and glycerol by lipase. The essential amino acids, formed after the digeston of proteins are ***arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine,***

tryptophan, valine, aspartic acid **and** ***glutamic acid***. In addition semi essential amino acid (praline) and non – essential amino acids ***cystine, tyrosine, alanine, glycine*** **and** ***serine*** **are also formed**.



Salivary glands
a: Mandible, b: Mandibular flexor,
c: Salivary gland, d: Oesophagus

Question No. 4. Answer

The word respiration has acquired several different meanings to indicate the exchange of air or ventilation, and to others it refers to the breakdown of food to obtain energy. The word is best used to indicate a series of biochemical reactions occurring in cells that liberate energy. In the presence of oxygen, the reactions may be summarized as:

$6O_2 + 6H_2O + C_6H_{12}O_6 \rightarrow 6CO_2 + 12H_2O$ + energy

In terrestrial insects, cells receive their oxygen directly by diffusion from air, which is distributed throughout the body by means of a system of tracheae. This apparently simple system has evolved to a high degree of sophistication by which they exercise considerable control over their gas exchange and support a wide range of metabolic activities in a variety of different environments.

The anatomy of the tracheal system

The tracheal system arises from paired segmental invaginations of the body surface. In some insects each branching set of tracheae remains separate from the others, but in most insects, they fuse to form a continuous, inter connected system joined by **longitudinal tracheal channels**. The tracheal system opens to the exterior by **spiracles** of which there are **two pairs on the thorax and eight pairs on the abdomen**. The spiracles are complex structures, which **prevent foreign bodies and water from entering and have a mechanism that limits loss of water**, also they may play a part in ventilation. The whole system is lined by **ectodermal epithelium**, which secretes a cuticle that is hydrophobic nature. The cuticle lining of the tracheae help to keep the tracheal tube open.

The tracheae become narrower as they penetrate deeper and the finest tracheal branches terminate as tracheal end called **stellate** cells (because of their star like shape). From each trachea a number of slender tracheoles extend as fine tubes reaching into various organs of the body. Tracheoles are extraordinarily numerous (more than **1.5 million in the larva**) and

their cuticular lining is extremely thin (**1015 nm**) it is not shed at the moult as is the rest of the cuticle and semi permeable and hydrophilic nature.

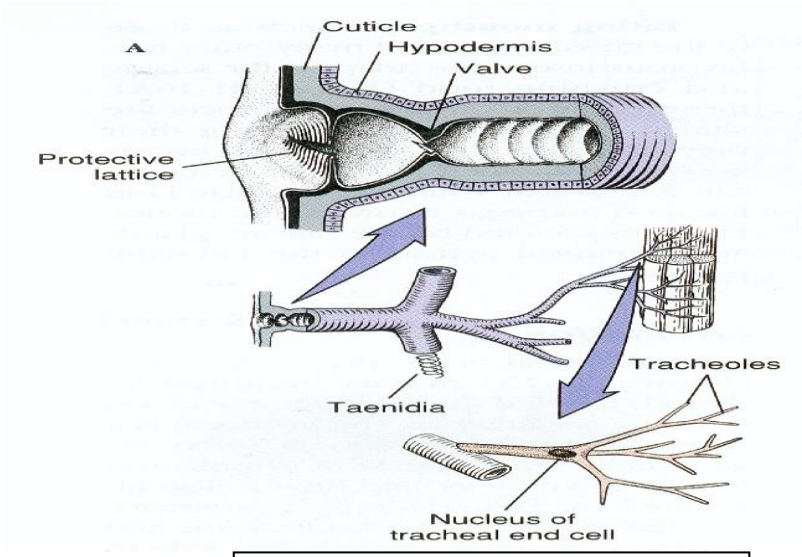


Diagram of trachea and tracheoles

The density of tracheae and tracheoles is correlated with the metabolic activity of the tissue. The flight muscles of insects are particularly well supplied with tracheae and tracheoles. During prolonged flights, insect flight muscles can increase their consumption of oxygen up to a hundred times than the resting level.

The main part of the tracheal system of many insects consists simply inter connected longitudinal channels, but in many insects there are **air sacs** associated with the major tracheae. These air sacs are compressible and are numerous and larger in active insects.

Ventilation of the tracheal system

Small insects, even if they are very active (e.g. fruit fly) can manage simply by allowing oxygen to diffuse through the spiracles and tracheal system. Similarly, large but fairly inactive insects (e.g. caterpillars) don't ventilate the system actively. On the other hand, insects such as locusts maintain a flow of air through the spiracles, air sacs, and primary tracheae by muscular contraction mainly rhythmical squeezing of the air sacs and accurately timed opening and closing the various spiracles. In locusts air enters by the anterior (thoracic) spiracles and leaves by the posterior (abdominal) ones, establishing a unidirectional flow through the air sacs and tracheal channels.

The oxygen consumption of some insects tissues, notably in their flight muscles is highest known for any living tissue, dragonfly flight muscles use 7.3 cm^3 of oxygen per gram of tissue per minute when fully active. This represents a metabolic rate far higher than anything achieved in mammals, yet the tracheal system delivers all the oxygen required.

In insects, the respiratory functions are carried out with the help of trachea which open to exterior through nine pairs of spiracles, one each side of prothoracic segment and eight on the lateral sides of first to eight abdominal segments. Each spiracle is surrounded by a hard cuticular chitinous ring, the **peritreme**. There is a **sieve plate** within the peritreme to prevent

the entry of dust. Each spiracle is connected with an air chamber (the **atrium**), (short **tracheal tube**) & **tracheal bush**. The spiracles are closed by valves present at the atrium and tracheal bush. Each tracheal bush is connected to main **longitudinal tracheal trunks** that run on the either side of the body in the anteroposterior direction. The two longitudinal tracheal trunks are inter connected by **segmental transverse trachea**. The trachea divides and form smaller trachea called **tracheoles** that reach almost all the organs and tissues of the larval body. Oxygen is carried to the various parts, tissues and cells of the body through the network of trachea and tracheoles. Tracheae are ectodermal invaginations of the cuticle and have two layers, i. e. **tunica intima and epidermal layer**.

In insects, there are only six pairs of functional spiracles located on the lateral sides of first six abdominal segments. The thorax is extensively supplied with tracheal network to supply oxygen to wings and leg muscles. Respiration is a process of interchange of gases between the environment and the blood or cellular tissues of organism. These include both chemical and physical phases: the chemical phase is concerned with the oxidation in body tissues resulting in the formation of carbon dioxide and water. The physical phase involves transportation of air to tissues and elimination of carbon dioxide. Respiration in insects is tracheal, there being no cutaneous respiration and tracheae supply oxygen directly to the tissues without the intervention of the haemolymph. Oxygen passes through spiracles to tracheae and tracheoles from where it is carried to various parts, tissues and cells of the body. Carbon dioxide is removed through the same channel.

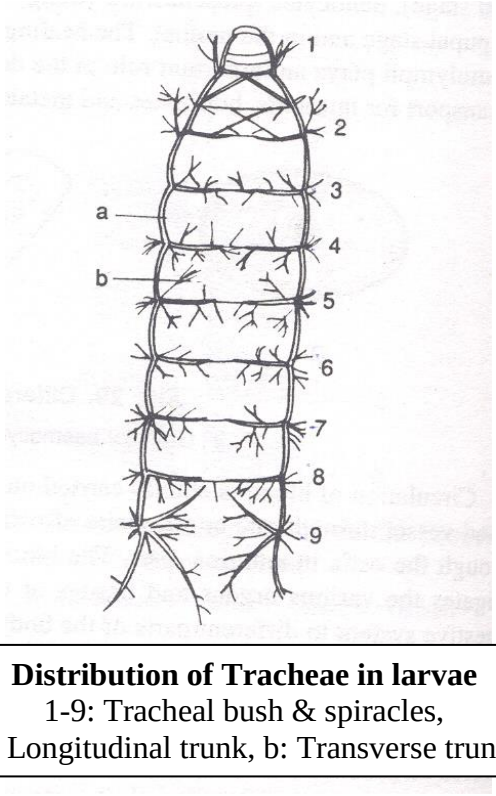
Water loss during respiration in insects

Distributing air throughout the body can lead to substantial evaporation of body water. Insects have been outstandingly successful in coping with this however the water loss is more due to their flight/higher activities. The air in the tracheae and air sacs contains water vapour, and if there is unrestricted access to the air, the loss of water must be quite considerable. For example, if the pupa of the silkworm moth *Cecropia* is kept in an environment with 30% humidity, and the spiracles are kept open by inserting cannulae into them, within two weeks 25% of the body weight is lost and the pupa dies of dehydration. Clearly, it is important for some insects to be able to conserve water by closing their spiracles.

Respiratory Pigments

In many invertebrates oxygen is carried in the blood or haemolymph by **simple physical diffusion**. This helps in bringing oxygen from the surface to various parts of the organisms. The amount of oxygen that can be carried by simple solution is small, however, and may highly organized animals (vertebrates) have blood that can bind larger quantities of oxygen, thus greatly increasing the amount of oxygen carried. In mammalian blood, the amount of physically dissolved oxygen is about **0.2 ml oxygen per 100 ml blood**, and the amount in hemoglobin is up to 100 times as higher.

The substances we know as oxygen carriers in blood are proteins that contain a metal (commonly iron or copper). Usually they are colored, and therefore they are often called respiratory pigments. Hemoglobin is the most widespread and best known respiratory pigment. It consists of a protein molecule known as porphyrin. The iron that each hemoglobin molecule contains is bound to the porphyrin. Chlorocruorin is an iron containing porphyrin group associated with a protein molecule. Hemerythrin is a respiratory pigment but it has no porphyrin structure. Hemocyanin is a copper containing pigment that occurs only in mollusks and arthropods, next to hemoglobin, it is the most widely distributed respiratory pigment.



Distribution of Tracheae in larvae
1-9: Tracheal bush & spiracles,
a: Longitudinal trunk, b: Transverse trunk

Question No. 5. Answer

Insects can be found nearly everywhere. Some insects are helpful to people. Other insects are harmful and cause damage to flora and fauna. More than half of all described species of living organisms are insects (56.3%) and 3/4ths of all animal species are insects. Insects consume12-15% of leaf area in tropical forests, compared to 2-3% by vertebrate herbivores. Farmers and gardeners need to know which insects are friends and which are enemy. Insects can carry diseases, damage crops, make fruits and vegetables look bad and can even destroy entire crops, which limits the amount of food available for people and animals. Insects are as a rule profitable breeders, although there is a great difference between them in this respect some multiply only ten-fold in the course of the season, while in others the capacity more in the same period.

Friend for flora and fauna

Insects as food for wildlife: Brood of 9 Great Tit chicks consume 120,000 caterpillars. Single swallow chick will consume 200,000 insects before it fledges. Insects recycle nutrients, enrich soils, and dispose of carcasses and dung.

The Lepidoptera include the butterflies and moths, known by the scaly covering of the wings. The scales appear as fine, dust-like particles that are easily rubbed off but under the microscope show great differences in form and color. In this order the mouth parts of the adult are modified into a coiled tongue capable of sipping liquids only but in the larval stage the caterpillars are voracious devourers of plant and other tissue. Silkworms of different races producing luster silk which is used by human kind. It is also having great demand in international market.

Insects as benefactors to the human race have been very little considered, their position on the opposite side having been so much more emphasized; and yet, if some few species were eliminated, their absence would be very seriously felt for a time, until a substitute for them could be discovered. Possibly the reference to them as benefactors it is a little inaccurate for most of those referred to here "they are useful to man rather than his benefactors. Of course, class as benefactors those that pollenize his fruits and other crops but there the benefit is indirect as to man and more direct as to the plants, hence coming under another head.

Bees, ants, wasps and the like belong to the order Hymenoptera, in which the wings are transparent, with few and often no veins never reticulated. Many of the species are of extreme interest because of their social habits and organizations and the honey bee is of direct benefit to man in more ways than one. Finally come the flies; differing from all other insects by having only one pair of wings, hence their ordinary name is Diptera.

Insect as a whole are at the top of the line of development in the Articulata: they diverged early from the worm like ancestors and their remains, already well developed, are found in the earliest fossil-bearing strata.

Farmers also use "good" or beneficial insects to protect their crops and get rid of harmful insects. Some insects can do a lot of damage to crops and orchards. An insect's worst enemies are other insects. Of the millions of insects that eat animals instead of plants, most feed on other insects. Using insects to control insects is called a "biocontrol" method. Biological control is the use of naturally occurring organisms that act as natural enemies to the pests in question. These approaches to pest management may be used to reduce pesticide use. The introduction and encouragement of natural predators is a highly effective method of controlling many bugs.

Pest is an unwanted insect: Pathogen, bacteria or fungus that causes disease in a pest; Parasite an insect that feeds in a living pest and Predator an insect that eats pests. When used effectively, biocontrol methods can be a safe and effective approach to pest management.

While, in a general way, insects frequent plants merely to feed on them, yet this feeding is not necessarily destructive and may even contain an element of advantage. Hence it is found that, far from developing structures to repel, many plants produce attractive flowers and secrete nectar as an invitation to insects to call upon or visit them.

Insects pollinate majority of the world's quarter million plant species, including many of our major crops.

Flowering plants as a rule have two kinds of sexual organs: the pistil connected with the seed or female element and the stamens, producing the pollen or male element. Fertilization takes place when the pollen or male element is brought into contact with the receptive surface of the pistil and this pollination may be produced in many different ways. Sometimes the same flower has both pistil and stamens, and the pollen from the

latter may be discharged so as to come into immediate or direct contact with the former. But this is not always the case, for the pistil may not reach the receptive condition until after all the pollen has been removed from the stamens and, on the other hand, the pistil may become receptive before the pollen on the same flower is mature. In such cases there must be pollination by some outside agency. Many flowers are of one sex only, i.e., either pistillate, bearing female organs only, or staminate, bearing male organs only: and sometimes an entire tree or plant may bear flowers of one sex only. Here again pollination by some carrier is necessary and among the carriers the most active agents are the wind and insects.

There is one other method in which insects are useful to plants and that is as food. A very few plants are carnivorous or feed upon animal food and that animal food consists mostly of insects but that is a relation which is extremely simple in character although the plant habit is exceptional.

Insects as foes

On average 15-20% of all crops grown for human consumption are consumed by insects.

Outbreak insect populations can cause much higher levels of damage. Mosquito vectored malaria kills one person every 12 seconds and infects 500 million globally.

A vast number of insects depend absolutely upon plants for their very life and give nothing at all in return. They are destroyers pure and simple using the plant tissue as food, as material to supply protection, or as a habitation. But the amount and character of the injury vary enormously and may either be a negligible incident in the life of the plant, or form the principal check to its growth or cultivation.

In the Hemiptera a well developed series of terrestrial species, the vast majority of which are feeders on plant life or on plant juices drawn from living plants. The mouth structure of the insects is such that they can feed only on the liquid which they draw from a punctured tissue, whether vegetable or animal, and therefore, primarily, the injury is due to a withdrawal of sap, severe in proportion to the amount of liquid thus withdrawn. Secondarily, injury is caused by an interruption of the circulation in the plant, due to a hardening of the exhausted tissue or the drying out of the cells from which the liquid matter has been abstracted.

Since the development and general acceptance of the microbian or "germ" theory as applied to many contagious and infectious diseases and its absolute demonstration in plagues like cholera, typhoid fever, dysentery and other enteric or intestinal troubles, as well as in consumption, pneumonia, diphtheria and other affections of the respiratory organs, the question of the agencies concerned in the distribution of these germs has come to the front.

Further, Integrated pest management (IPM) is a pest management system that focuses on managing pests with the least possible impact on people, property and the environment. Farmers use tools like crop rotation, sprays or good bugs to help their crops. Using traps, scouting and identifying insects, and controlling bugs are all important tools for farmers to use.

Question No. 6. Answer

The skin forms the external covering of the body and performs a number of important functions in fishes. Besides protecting the body against injury and infection, the skin has respiratory, excretory and osmoregulatory functions. The derivatives of skin play an important part in the metabolic activities of body. Special structures of some species like the electric organs, poison glands, and phosphorescent organs are also the integumentary derivatives.

Structure

The skin of a fish is composed of two layers, an outer epidermis and an inner dermis. The epidermis is ectodermal in origin and consists of several layers of flattened cells (stratified epithelium), of which the deepest layers are made up of columnar cells forming the stratum germinativum in which cells are alway.multiplying by mitotic divisioin to replace the outer worn cells. A superficial layer of dead horny cells, forming the stratum corneum in terrestrial vertebrates, is not present in fishes. The dermis is mesodermal in origin and is composed of connective tissue, brood vessels, nerves and cutaneou, sense organs. The thin upper layer of loose connective tissue is called the stratum spongiosum and the thicker dense lower layer, the stratum compactum. Numerous tubular or flask shaped mucous cells are scattered among the epidermal cells and may even extend into the dermis. The cells secrete mucin, a glycoprotein, which mixes with water to form thick, slimy mucus covering the whole body. Mucous cells develop from stratum germinativum and migrate to the surface. They vary in number, kind and size in different species of fishes. In general, fishes having poorly, developed scales or no scales, possess a larger number of mucous cells.

Functions

The mucus covering the body of the fish performs several important functions.

1. It lubricates the fish so as to reduce body friction in water while swimming thus enabling the fish to move with a greater speed.
2. It protects the body from parasites, fungus, bacteria and other micro-organisms.
3. In turbid or muddy water mucus has the power to precipitate the particles in suspension especially in contact with the gills and thus prevents the fish from suffocation and helps in its survival.
4. The skin and the mucus secreted by its glands help the fish in regulating to some extent, the osmotic exchanges of water and ions between the body fluids and the surrounding medium.
5. The African lung fish, *Protopterus*, makes use of the mucus secreted by the skin, in preparing the hard cocoon for its summer sleep.
6. Certain species utilise the sticky mucus for preparing nests for egg laying.
7. The skin performs an important function in repairing the surface wounds. Immediately after an injury, the wound is closed by the mucus containing a large number of lymphocytes. The marginal cells of the wound, then multiply rapidly to form a thin protective layer and gradually healing of the wound is completed.
8. The skin is also an important respiratory organ in some fishes and enables them to survive out of water for a considerable time.

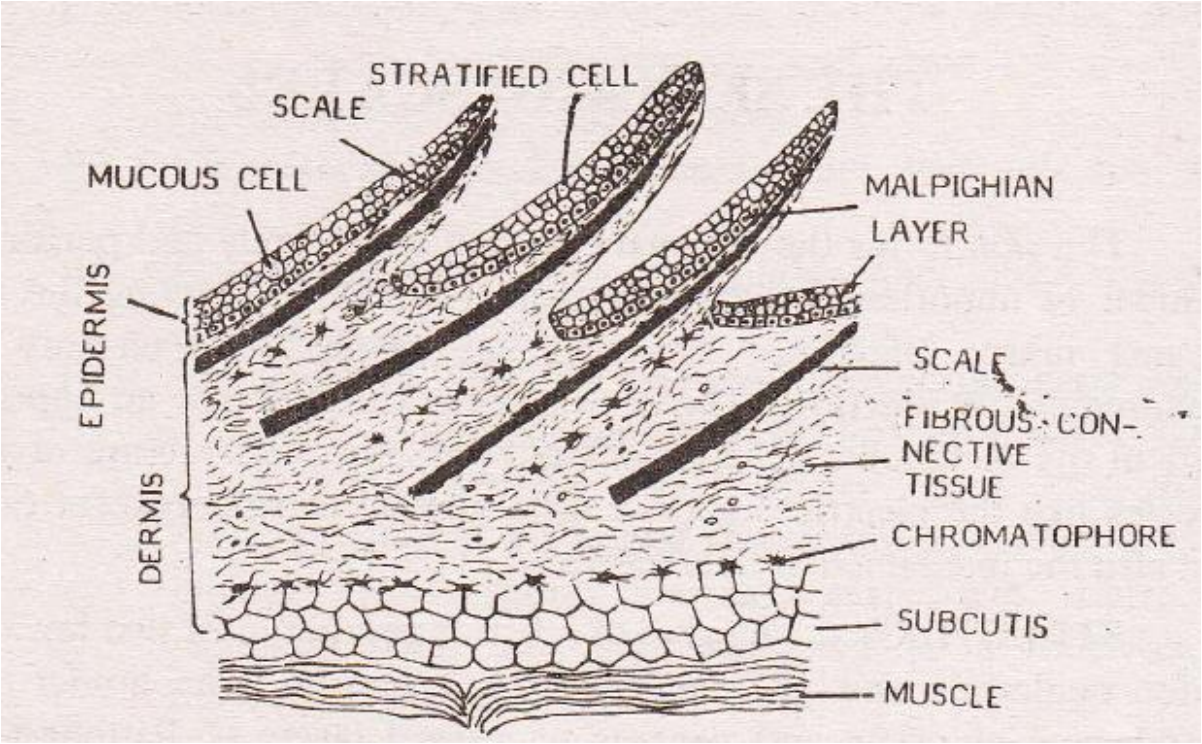


Fig. V. S. Skin of a Teleost

Glandular cells of the epidermis are modified to form poison glands in certain fishes as the scorpion fish and toad fish and are used for offence as well as defense. Light producing phosphorescent organs of a number of marine fishes are also the derivatives of the epidermis. Chromatophores of various kinds, present in the dermis, give beautiful colour patterns to the body, making it conspicuous or inconspicuous. Exoskeleton in the form of scales, plates or denticles are important derivatives of the skin which provide protection to the body. The skin has also the power to absorb dissolved nutritive substances from the surrounding water.

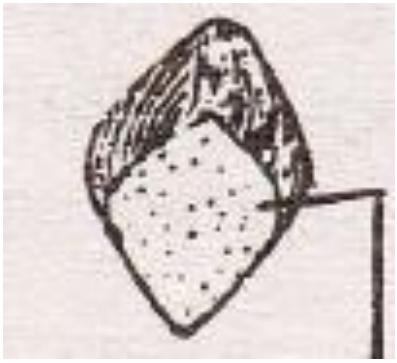
Question No. 7. Answer

In most of the fishes, the skin is covered with an exoskeleton in form of scales and^ only a few are naked having no scale on the body. According to mode of their origin, there are two types of scales: (I) those which are formed due to secretory activity of both epidermis and dermis, as the placoid scales of sharks, and (II) non-placoid scales that are derived from the dermis only as the scales of teleosts. Structurally the scales are classified as cosmoid, ganoid or rhomboid cycloid and ctenoid; the last two are also called as the bony ridge scales.

Cosmoid Scale

The cosmoid scales are found in the extinct crossopterygii and dipnoi. The external layer of the scale is thin enamel-like and is called vitrodentine. The middle layer is made up of hard, non-cellular, dentine like material called the cosmine. The inner layer is made up of vascularised bony substance, isopedine. Cosmoid scales are not found in the living fishes.

The living dipnoi possess thin cycloid scales and have lost the cosmine layer. The scales of *Latimeria* resemble ctenoid scales but have a denticulate outer surface.



Vitrodentine

Fig. Cosmoid scale

Ganoid Scale

These are characteristic of the primitive actinopterygians called the ganoid fishes, and are of various forms and structure. These scales are heavy and have an outer layer of hard inorganic, enamel-like material called ganoine. The middle layer is cosmine containing numerous branching tubules. The innermost layer is thickest and is made up of lamellar bone, isopedine. These scales grow by the addition of new layers to lower as well as upper surface. These scales are usually rhomboid in shape and articulate by peg and socket joints.

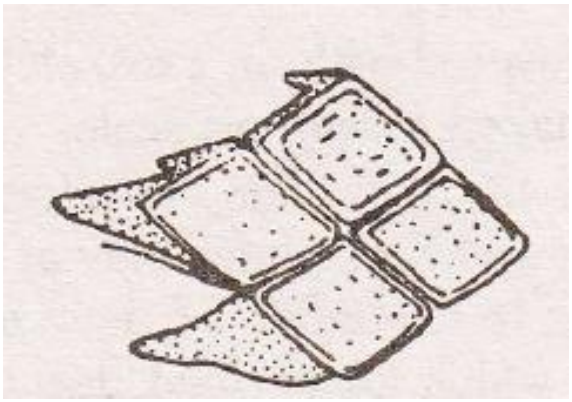


Fig. Ganoid Scale

The ganoid scales are best developed in the chondrostean and holostean fishes. In *Acipenser*, they are in the form of large, isolated, bony scutes and are present in five longitudinal rows. In *Lepidosteus*, the scales are hard, polished, rhombic plates, fitting edge to edge, thus forming complete armour. Scales of this fish have lost the middle cosmine layen thus reducing their thickness and rigidity. The scales of *Amia* are even thinner, do not possess the ganoine layer and resemble typical cycloid scales.

Placoid Scale

Placoid scales or dermal denticles are characteristic of the sharks. Each has a disc like basal plate embedded in the dermis and a spine projecting out through the epidermis. In structure, a placoid scale resembles a tooth. The spine has an external covering of enamel-like, hard, transparent material called vitrodentine. This is followed by a Iayer of dentine enclosing a pulp cavity from which several branching dentinal tubules radiate in different directions. The centre of the basal plate is perforated by an aperture to provide entrance to the blood vessels. The scales are closely set but do not overlap each other.

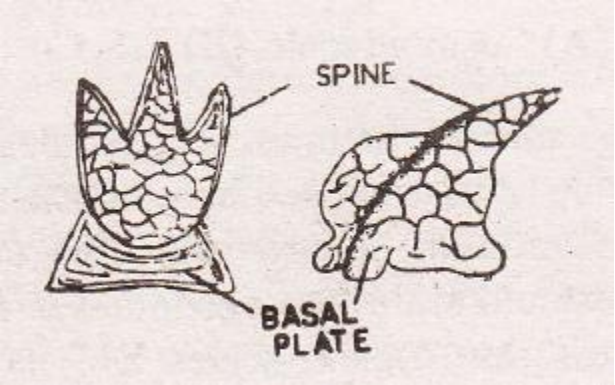


Fig. Placoid Scale

Bony Ridge Scale

The cycloid and ctenoid scales are also known as the bony ridge scales. They are present in majority of the teleostean fishes and are thin, flexible, transparent structures due to the absence of the first and the middle layers of other types. These scales exhibit characteristic ridges alternating with grooves and generally the ridges are in the form of concentric rings. The central part of the scale is called the focus and is the first part to develop. In many species, oblique grooves or radii run from the focus towards the margin of the scale.

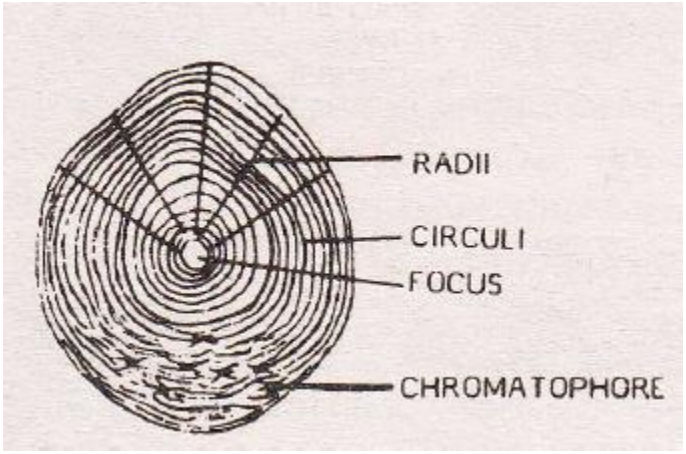


Fig. Cycloid scale

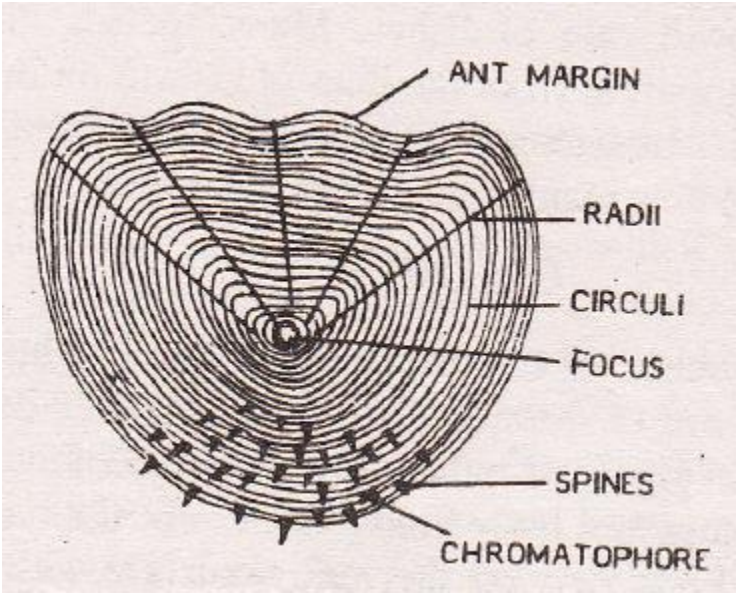


Fig. Ctenoid scale

The origin and development of both these types of scales are similar. The cycloid scales are thin and roughly, rounded in shape, being thicker in the centre and thining out towards the margin. They are found in a large number of teleostean fishes having soft rayed fins. They form a protective covering over the skin and project diagonally in an imbricating pattern. The ctenoid scales are also circular and can be distinguished from the cycloid by having a more or less serrated free edge. Moreover, several spines are present on the surface of the posterior area of the scale. These scales are found in a large number of fishes with spiny rayed fins.

Question No. 8. Answer

Growth of fishes -

- Growth pattern is remarkable, depends upon food available.
- Most fishes, in contrast to birds and mammals do not cease growth after they have reached sexual maturity.
- It has been proposed that fishes living in a fluid medium supports them mechanically and thus can continue growth throughout their lives because there are more biotic than mechanical limits imposed on their maximum size.
- Growth can be defined as addition of structural or fleshy elements; fish growth in particular is of great importance to man.
- Fishes are far superior in protein-building than birds and mammals.
- This is because birds and mammals have to expend part of their caloric intake for the maintenance of their body temperature and in supporting themselves; fish in contrast are poikilothorms and get such support from the surrounding water.

The longevity of fishes -

- Unconfirmed accounts mention that carps in pond have reached an age of 200 or even 400 years, yet authenticated records of ages of captive fishes suggest that most carp do not exceed 50 years.
- By and large few fishes in wild live longer than 12 to 20 years and even in the shelther of an aquarium 30 years are rarely exceeded.
- Generally species with large individuals may be expected to exhibit older ages than species composed of little fish.

Genetic factors -

- In nature genetic factor is usually masked by environmental factors

- Nevertheless, some selected strains in some fishes (e.g. Cyprinus) have growth that is decided by superior strains.
- Fish growth is slowed down after the onset of sexual maturity when large amounts of nutrients periodically go into egg or sperm formation.
- The onset of sexual maturity and change in growth rate in life cycle of a fish may also be genetically determined.
- Egg size also varies with genetic strains and with it varies the initial size of the fish at hatching.
- Large eggs produce large larvae that may also have the greatest growth potential.
- Size difference between male and female fish that affects growth rate and growth pattern may be due to genetic factors.

Seasonal and Temperature factors -

- Fishes with wide latitudinal distribution commonly have differences in rate of growth and in age at which they reach sexual maturity.
- Temperature also induces seasonal differences in growth since temperature affects metabolism and food consumption.
- Seasonal and temperature dependent variations determine the amount of food diverted to growth and/or maintenance requirement.
- The optimum temperatures for rapid growth are those at which the appetite is high and maintenance requirements are low whereas minimum growth occurs at intermediate

-ight, mostly through day length, may affect the rate and pattern of fish growth.

- Illumination is known to act indirectly on thyroid metabolism and peaks in thyroid activity coincide with maximum day length but these peaks also cause increased swimming activity, resulting in a reduction in growth rate.
- If food is plentiful, shorter hours of day length may be most advantageous for rapid growth because of dark-induced rest patterns, but where strong competition occurs and feeding proceeds by light, long days can be advantageous.

Biotic Factors -

- These are also termed as social factors.
- Example of biotic factor is competition, nest sites, feeding behaviour etc.
- Fishes grown in water previously inhabited by other fishes grow better than their control running mates.
- The improved growth may have been due to uptake of regurgitated food. More likely it may be due to presence of a growth-promoting substance.
- Order of dominance has been observed as a factor in growth.
- The individual at the top of the order will secure the best and the most food available to the group.
- Fish grown in crowded conditions may release a chemical that depresses growth.
- Many instances are known where fish in a fresh-water body