

PARASITIC ADAPTATIONS IN HELMINTHS

INTRODUCTION: Helminthes is derived from Greek word “Helmins” meaning “worms”. The term is not correct because it is applied to all elongated invertebrates without appendages and with bilateral symmetry. The term helminths is restricted to a few phyla of invertebrate animals, all of which are superficially worm like but they differ markedly in their morphology, life history and bionomics. The helminthes are restricted to three phyla of animal kingdom. These are:

1. **Platyhelminthes** (a. Turbellaria; b. Trematoda & c. Cestoda)
2. **Nematohelminths** (Nematoda e.g., *Ascaris*, *Trichinella* (viviparous), *Enterobius*, *Dracunculus* (viviparous))
3. **Acanthocephala** (Spiny headed worms)

PARASITIC ADAPTATIONS: Adaptation may be defined as *the fitness of an organism to live in its specific habitat or environment*. The term is also applied to *the process of adjustment involved and to a characteristic that so adjusts an animal*.

According to Herbert Spencer, “adaptability is the continuous adjustment of internal relation to external relation. According to another definition, “adaptation is the power of self regulation, self preservation and race continuation so as to enable an animal to remain alive and to adjust it according to changed environmental conditions and to give rise to offsprings.

Thus adaptation to a specific environment is a dynamic feature of all living organisms.

Parasitism has begun as an accidental chance of contact between two animals and there can be no doubt that parasites may have evolved during the course of time from free living forms. Step by step changes are difficult to explain, but sooner or later the guest began to lead a more dependent life upon its host for food and shelter. This change from free-living life to one in which good shelter and nourishment are available with no efforts, has brought about profound modifications in the make up of helminth parasites. The main changes that occur in the structure and life cycle of a parasite with the help of which it is capable of leading a parasitic life successfully in its specific environment is called the Parasitic Adaptations.

The helminths are modified morphologically as well as physiologically to live in their particular environments under the stress of the parasitic mode of life. These modifications depend on the degree of parasitism.

I. **MORPHOLOGICAL ADAPTATIONS:** Though helminths come at the bottom of organ-grade of animals, yet every part of the body of a helminth parasite exhibits twist due to parasitic mode of life. The structural modifications or adaptations of helminths have taken place along two lines:

- (A) Degeneration or loss of organ/s or organ system/s.
- (B) Attainment of new organs.

(A) **DEGENERATIONS:** Structures, which are partially or wholly lost. The endoparasites undergo loss or simplification of unused organs or parts. In helminths, loss or degeneration involves particularly the locomotory, digestive and the sensory organs.

1. **LOCOMOTORY ORGANS OR ORGANS OF LOCOMOTION:** Locomotion is actually an effort for procuring food, getting mate and escaping from enemies. But parasites habitually inhabit such places in the host's body where sufficient food is available without effort. They need not to protect themselves from enemies. Thus the organs of locomotion such as cilia of free living turbellarians [(Microstomum) freshwater], are absent in the parasitic forms [(Temnocephala) ecto on prawns]. Also free living larvae of parasites possess locomotory organs – Miracidium possesses cilia & cercariae possess tail, for locomotion.
2. **ALIMENTARY CANAL OR ORGANS OF NUTRITION:** Since parasites consume digested or semi-digested food of the host, therefore alimentary canal and digestive glands are partially or wholly lost. In the adult trematodes there is an incomplete gut and in most of them suckorial pharynx is present, by means of which liquid food is sucked into the intestine. Intestine is always branched. In the larvae of Trematodes, the gut is either very simple (e.g., redia larva) or completely eliminated (e.g., sporocyst). In cestodes alimentary canal is altogether absent because digested food is readily available in the gut of the host. Stages such as rediae in lymph spaces of molluscs, microfilariae in blood vessels and *Trichinella* and *Cysticercus* larvae in vertebrate muscles, occur in such locations that they are constantly surrounded by rich nutritious food, which is absorbed through the outer layer of their body.
3. **SENSORY ORGANS:** The sense organs, necessary for quick and efficient response to the stimuli are associated with the free active life. In the host the environment is more or less uniform and so the sense organs are not essential. Hence they are reduced. In Trematodes, sense organs are absent but are generally provided with tango-receptors (bulb like nerve endings sensitive to touch and pressure). Nematodes have reduced sense organs on the lips (Amphids) and on the tail (Phasmids). There are no sense organs in cestodes. Absence of complicated sensory structures can also be correlated to sedentary life in a sheltered habitat, especially endoparasites.
4. **NERVOUS SYSTEM:** Living safely in more or less stable environments, parasites do not need a complex nervous system. In trematodes nervous system is developed (CNS + PNS). Nematodes possess ganglia and nerves. Cestodes possess two ganglia and a few nerves in the scolex.
5. **CIRCULATORY SYSTEM:** Circulatory system is absent because circulatory system is primarily meant for transport of nutrients that is not required in parasites.

(B) **SPECIALIZATIONS OR NEOFORMATIONS** (attainments of new organs): Parasitic existence leads to modification of old structures and attainment of new structures helpful in food absorption, protection, attachment and vast reproduction.

1. **BODY FORM:** The body form of parasites is such that they offer least resistance to the fluids of the host otherwise they might be expelled out, e.g., *Fasciola* is dorsoventrally flattened and leaf like. *Schistosoma* is thin and cylindrically elongated. *Taenia* is elongated like a ribbon and dorsoventrally flattened.
2. **PROTECTIVE COVERING OR TEGUMENT/CUTICLE:** The outermost layer of the body was called cuticle. It is now called tegument, because of its dynamic (living) nature as it has been found out that it contains Mitochondria and E. R. It is

non-cellular and rests directly on mesenchyme. It is semipermeable and allows the fluids to enter the body. The tegument becomes thin, serving partly or wholly for food absorption, in parasites living in rich nutritious environments, such as the adult liver flukes (in bile), blood flukes (in blood), tapeworms (in the intestine), *Trichinella* and cysticercus (in vertebrate muscles) and several larval forms developing in lymph spaces and in blood stream. In the gut parasites, such as the tapeworms, gnathosomes and nematodes, which remain attached to the gut wall, the cuticle becomes thick, impregnated with impermeable chitin-like substances and enzyme-resistant, so that it is not digestible by the host's digestive juices, but is permeable to water. The larval flukes, which have to pass through stomach, are provided with a cysts, which protects them against gastric juices. In most Trematodes, outer integument contains spines, spinules or scales of various kinds. These cuticular modifications protect the outer surface of the worm against the abrasive action of food and roughage flowing around them. In the Chinese liver fluke, *Clonorchis sinensis*, the larval stage has a spinous cuticle, suggesting that it was probably a gut parasite before converting into a parasite of the bile passage. Tegument protects the parasite from the harmful effects of the different types of digestive juices produced in the host. Tegument is absorptive in nature. In case of *Taenia*, tegument is thrown into minute projections known as microtriches which enhance the absorption by increasing the surface area. Cuticle is provided with spinules for attachment in case of *Fasciola*. Tegument has high turn over rate.

3. **MUSCULATURE:** Musculature is well developed in helminth parasites. Muscles are meant for producing undulating movements. The well developed musculature in tapeworms (e.g., *Taenia*) enables them to distribute their elongated snake-like bodies throughout the lengths of the intestine of their host. Similarly, power of locomotion enables the roundworms (e.g., *Ascaris*) to counteract gut peristalsis and to maintain their position in the intestine. The advantage is that the worm can obtain with greater ease the pre-digested nutrients of the host.
4. **ORGANS FOR ATTACHMENT:** For a firm grip on or in the host's body, some special organs of adhesion are necessary. All parasites develop suitable mechanisms for attachment with their hosts, to the exterior or to the interior of cavities. Helminths are variously modified for adhesion to the body of their hosts. Acetabula or suckers are formed in all adult parasitic flatworms. For this purpose Monogeneans possess Opisthaptor containing suckers (8 in *Diplozoon*) and hooks (8 pairs in *Gyrodactylus*). Digeneans (*Fasciola*, *Schistosoma*) possess suckers as adhesive organs (Ventral and oral suckers). The liver fluke (*Fasciola*) has two suckers, one anterior and one posterior, on the ventral side of the body. Sometimes more than one suckers are present (e.g., *Paramphistomum*). In the tapeworms, the scolex bears either four sucking cups (e.g., *Taenia solium*) or accessory suckers (e.g., *Myzophyllobothrium*), or lateral sucking grooves or bothria (e.g., *Diphyllobothrium*).

In some cestodes and nematodes, hooks or hook-like structures also develop in or near the cephalic end, which further help in attainment. In *Taenia solium* the rostellum contains a basal circlet of hooks. In *Dipylidium caninum*, several rows of hooks are present around the retractile rostellum. In *Macracanthorhynchus*, a buccal armature is present bearing tooth like structures.

5. **VAST REPRODUCTION:** Reproduction is well developed as the parasite lives in the hostile environment. It is subdivided as:
- Efficient reproductive system:** Complexity in the reproductive system gradually increases from free living forms to the parasitic ones. Large number of testes, ovaries, vitelline follicles are present in the parasites. In cestodes about 90% of the available space of the body is occupied by reproductive organs.
 - Hermaphroditism:** All trematodes and cestodes are hermaphrodite except few like *Schistosoma*. The hermaphroditism is an adaptation advantageous to parasitic mode of life, to overcome the search of the mate. In parasites both self and cross fertilization can occur.
 - Multiplication of reproductive organs:** In cestodes reproductive organs are much more elaborate and are repeated in each proglottid. Each mature proglottid possesses one (*T. solium*) or two sets (*Diphylidium*) of male and female reproductive organs. This is called multiplicity of reproductive organs. In each gravid proglottid, all other organs of the system degenerate to make room for the uterus which is greatly enlarged and branched to accommodate a large number of eggs.
 - Large egg production:** The egg production in helminthes is astronomical. The female *Ascaris lumbricoides* lays about 2 lac eggs/day. Trematodes usually produce a few thousand (10,000) eggs but cestodes produce very large number of eggs e.g., *Taenia solium* produces a few thousand eggs/segment.

The high production of eggs is simply to reach the proper destination because a parasite has to face a number of hazards.
 - Larval multiplication:** In addition to large egg production, method of asexual reproduction at larval stage is peculiar in Helminths. Each sporocyst produces 5-8 redia. From each redia 14-20 cercaria are produced. In case of cestodes larval multiplication takes place in some forms e.g., A hydatid cyst developing from a single egg may contain thousands of scolices.
 - Complex life cycle:** The complexity of life cycles in which more hosts are involved helps deriving maximum benefits from different hosts and in the proper distribution and dispersal of the parasite.
6. **PENETRATION GLANDS/HISTOLYTIC GLANDS:** In order to penetrate into the host the parasites have developed certain structures or glands e.g., Miracidia larva has a conical process at the anterior end called apical papillae. There are a pair of penetration glands inside the body near the anterior end. These glands, called the histolytic glands secrete histolytic enzymes that help in dissolving the hosts' tissue to penetrate into it.

Adult worms lack these penetration glands except hookworms (*Ancylostoma*) which possesses these glands in the buccal region whose secretion has anticoagulating and histolytic action.
7. **CYSTOGENOUS GLANDS:** In most cercaria a large number of dark or brown cystogenous glands are found beneath the cuticle. These glands help in secreting a protective cyst around the cercaria transforming it into metacercaria. These cysts help metacercaria to overcome unfavourable conditions and protect them till they are finally eaten up by their proper host.

II. PHYSIOLOGICAL ADAPTATIONS

1. **PROTECTIVE MECHANISM:** Most of the parasites live within the body of hosts and hence have to protect themselves from various substances produced by the host e.g., the parasites living in the alimentary canal of the host has to protect itself from the action of the digestive juice of the host.

The tapeworms accomplish this by:

- a) Stimulate the wall of gut to produce mucous, which then forms a protective clothing around the parasite.
 - b) By secreting antienzymes to neutralize digestive enzymes of the host i.e., in order to protect themselves from being digested by the hosts' digestive enzymes parasites produce some substances which inactivate the hosts digestive enzymes. Green in 1957 reported the presence of Trypsin and Chymotrypsin inhibitors in the body wall of *Ascaris*.
 - c) Parasites continuously renew their protective body covering (i.e., tegument). Lime cells in the body wall of tapeworms neutralize the acids produced by the host.
 - d) Parasites possess a high range of pH tolerance 4 – 11.
 - e) Blood parasites are known to withstand the effects of antibodies and phagocytes by some mechanism.
2. **NUTRITION:** The nutritional requirements of the parasites are fulfilled by the host. Trematodes and Nematodes which possess an alimentary canal, though reduced, feed on both digested and semidigested food. In cestodes alimentary canal is absent, they feed on digested food only. Microtriches, tegument etc help in absorption of food.
 3. **RESPIRATION OR ANAEROBIOSIS:** The pH tolerance of the parasites is high from 4-11. The intestinal parasites live in an environment completely devoid of free oxygen, the respiration is of anaerobic type consisting of extracting oxygen from the food stuffs. In the absence of oxygen, energy is obtained by the fermentation of glycogen in which glucose is broken down into lactic acid.
 4. **OSMOREGULATION:** The osmotic pressure of body fluids of endoparasites, especially in case of Trematodes, is almost the same as that of the host so there is no necessity of osmoregulation. But in the intestinal tapeworms (cestodes) the osmotic pressure is slightly higher than that of the surrounding medium. This permits absorption of nutrients through their body wall as they lack alimentary canal.
 5. **PERIODIC APPEARANCE:** There are some parasites which appear at definite period. The microfilariae of *W. bancrofti* circulate into the peripheral blood circulation in the night between 10.00 p.m. to 4 a.m. – the period when *Culex* bites a man (nocturnal habit) since they require *Culex* mosquitoes for further development. Thus their migration is correlated with the nocturnal habit of *Culex*.
 6. **NEOTENY:** It is a special phenomenon in which the larvae are capable of reproduction and they produce young ones. *Ligula* (Cestode) exhibits neoteny and this can be considered as an adaptation for parasitic mode of life.

7. **HIGH FERTILITY:** Parasites develop enormous fertility producing millions of fertile eggs. This is correlated with the passive transference of the infective stages of the parasites from one host into another, while passing through the complex life cycle, these potential offsprings face several hazards as a result of which, a very small percentage of the total eggs produced reaches adulthood e.g., *Fasciola*, if the eggs fall in water, if the first larva (miracidium) finds a suitable snail within a limited period, if the cercaria encyst on vegetation within the reach of final host and if the metacercaria happen to be ingested by the proper final host, only then the life cycle is completed.

The larval stages also multiply e.g., a sporocyst produces a number of redia. A single redia produces a number of cercaria larvae. Similarly, a single Hexacanth may multiply by generating buds which produce daughter and grand daughter scolices (Hydatid of Echinococcus).

8. **TRANSFERENCE OF EGGS OR INFECTIVE STAGES:** This is another major problem for which the parasites have to develop adaptations. Transference from one host to another is either:
- (a) Active transfer: This is a less common method. The infective stages are actively transferred to final host. The larval stages of most parasites bore directly through the skin of their hosts such as the larvae of Hookworms and *Schistosomes*.
 - (b) Passive transfer: This is the most common method and usually results from the careless habits of the host and is achieved in several ways such as contamination, inoculation. Oral infection occurs when the host takes uncooked food or contaminated water. The intermediate host, such as mosquitoes, inoculate parasites when they suck the blood of hosts.
9. **USE OF HOST'S HORMONES:** Some parasites use hormones of the host e.g., life cycles of frog and a frog trematode parasite (*Polystoma integerrimum*) infecting it synchronise. It has been seen that when the frog produces eggs, the parasite also produces eggs. This means that frogs secrete some hormones for producing eggs; the same hormones are used by the parasite to produce eggs.

CONCLUSION: The parasites are intelligent enough as are the other organisms which have accepted the challenge of the changing environment of host and have constantly modified / changed in order to survive in an efficient way in the host's hostile environment. The parasites always change in such a way so as to establish an equilibrium with the host and as long as this equilibrium is maintained there are no consequences of the disease in the host but when the equilibrium is shifted the disease occurs.