Chapter

1

General Veterinary Parasitology

All the organisms in the universe, as a whole, can broadly be divided into dependent and independent organisms. The independent organisms do not require other organisms for their physiological activities like nutrition, metabolism and reproduction, etc. whereas dependent organisms require other organisms. Dependent relationship either may be **heterospecific or homospecific**. Heterospecific relationship occurs between two individuals of different species. On the other hand, homospecific relationship occurs between two individuals of the same species.

The branch of science which deals with the multidisciplinary aspects of biochemistry, physiology, biology, immunology, etc. of parasite is called **Parasitology.** The applied part of this discipline explores a detailed profile of parasite morphology, pathogenesis and control regimen as well.

Importance of Veterinary Parasitology

1. This branch of science provides knowledge of morphology, biology and pathogenesis caused by parasite.
2. Parasitic diseases are of great economic constraints in India which causes huge losses in terms of loss of production and mortality.
3. There should have been taxonomic knowledge to identify any parasite. It is the subject where from we can get a great deal of taxonomic knowledge.
4. This subject also provides concrete knowledge of parasitic immunity which is required for immunoprotection and immunodiagnosis.
5. From this subject we can get the knowledge of diagnosis of parasites.
6. Finally, knowledge regarding control of parasitic diseases can be achieved.
7. Animal experimentation is prerequisite for research on any parasitic disease. Veterinary parasitology has a great role in this context.
8. There are so many zoonotic parasites which are intercommunicable between man and animal. Both medical and veterinary parasitology have importance in the field of zoonotic diseases.

Animal Association

The term '**parasitism**' is very difficult to define as the relationship between two organisms always remain complex. Since decades there has been controversial discussions in this regard which ultimately brought a novel, well-accepted and distinguished definition of parasitism. During the search for a suitable definition of

parasitism, a number of other definitions have been derived which are symbiosis, commensalism, phoresis, mutualism indicating different types of association. These definitions are frequently used in this subject. These useful definitions are as follows:

Symbiosis: Symbiosis is not a single type of association. Different types of associations are under it. It can be defined as a close ecological relationship between two organisms of two or more different species wherein both species benefit; one species benefits at the expense of other in some cases neither species benefit each other. Note: Parasitism, commensalism, mutualism, etc. are the examples of symbiosis.

Symbiont: The partner–organism of symbiosis is called symbiont.

Mutualism: It is the association between two organisms where each partner gets benefit from the other. One organism inevitably (physiological dependence) depends on the other organism. One partner cannot live without the other.

Example: Beneficial bacteria present in the gut of insect is physiologically necessary for the insect.

Mutualist: The partner—organism of mutualism is called mutualist.

Parasitism: Parasitism can be defined as obligatory and intimate association between two different (heterospecific) organisms, whereby one organism is smaller than (parasite) the other (host) and the parasite takes the benefit from the host leading to the cause of disease or any harmful effect. However, the extent of harm may vary in accordance to the load of infection and virulence of the parasite. Therefore, the disease entity produced by the parasite, either may be clinical or subclinical.

Example:

- *Taenia solium* (Parasite)
- Human being (Host).

Continuous parasitism: The parasite lives on the host generation after generation.

Example: Lice remains on hosts generation after generation.

Commensalism: The literal meaning of the term commensalism is 'eating at the same table'. Food and shelter is shared by each partner. More specifically, it could be defined in a way that one partner of this association gets benefits from other partner but the other partner is neither harmed nor gets benefits.

Example: A typical example of commensalism is the relationship between sea anemone and the clownfish. The fish takes shelter in the tentacular zone of sea anemone and protect themselves from the attack of host's nematocysts and take host's food. But the sea anemone is neither harmed and not gets benefit from clownfish.

Endocommensalism: Commensalism which occurs within the host body is called endocommensalism.

Ectocommensalism: Commensalism which occurs over the host body (not inside) is called ectocommensalism.

Commensal: The partner—organism of commensalism is called commensal.

Phoresis: In this relationship, two partners have no metabolic or nutritional relationship. One organism is simply carried by the other organism. The smaller partner is carried by the larger partner. The smaller partner is called phoront.

Example: Bacteria is transported by the legs of flies.

Phoront: The partner—organism (smaller one) of phoresis is called phoront.

Hyperparasitism: It is the condition when one parasite parasitise another parasite. The parasite which shelters another parasite is called hyperparasite. This kind of association is called hyperparsitism.

Example: Nosema dollfusi is one hyperparasite of larval stage of a flatworm (trematode), *Bucephalus cuculus*.

Parasitosis: It is called parasitosis when parasitic infection produces any disease entity comprising clinical signs.

Example: Theileria annulata causes disease entity in cross breed animals.

Note: At present, any parasitic infection which may or may not produce clinical sign is called parasitosis.

Parasitiasis: It is called parasitiasis when parasitic infection does not produce any disease entity comprising clinical signs though the organisms are pathogenic.

Example: Theileria annulata does not cause disease entity in the indigenous animals which remains as carrier.

Parasitoidism: The parasites lay their eggs in other organisms. The larvae feed and destroy the organisms.

Example: Hymenopteran arthropods live on other arthropods.

Parasitoid: The partner-organism of parasitoidism which destroys other organism is called parasitoid.

Predation: In this relationship one partner lives by eating other partner.

Predator: The partner-organism of predation which eats other organism is called predator.

Delusional parasitosis: The term is applicable in medical parasitology. This is obsessive compulsive neurosis characterised by delusion of infection or infestation of parasite. There is no parasitic infection but the patients feel so.

Polyparasitism: Mulitple parasitic infection is called polyparasitism.

Example: The host may be infected with multiple haemoprotozoan parasites or metazoan parasites.

DIFFERENT TYPES OF PARASITES

Obligatory Parasite

A parasite would be called obligatory parasite if it is completely dependent on the host during its whole life cycle or a part of its life cycle. This is called obligatory parasite because the parasite cannot live without the host during their parasitic phase.

Examlpes:

- *Taenia solium* — Found in the intestine of man.
- *Ascaris suum* — Found in the intestine of the pig.
- *Toxocara canis* — Found in the intestine of dog.
- *Fasciola hepatica* — Found in the liver and bile duct of sheep, goat and cattle.

Facultative Parasite

Facultative parasite is not a regular parasite but adapt to be a parasite if unusual situation arises. Normally, these organisms are free living but develop to become a parasite when these are accidentally eaten or enter a wound or any body opening.

Example:

1. *Naegleria* spp.
2. *Micronema* spp.

These two parasites are free living but cause extremely serious condition when these infect human beings.

Accidental parasite: These parasites affect unnatural hosts.

Example: Rodent flea bites dog and man which are unnatural hosts.

Permanent parasite: The parasites which spend their whole life on or within their hosts are called permanent parasite.

Example: Melophagus ovinus

Temporary parasite: These parasites feed on the host and they live. The parasites are not restricted to a single host and do not stay permanently. But they take their meal from the host and survive.

Example: Blood sucking flies

Intermittent parasite: Same as temporary parasite

Periodic parasite: Same as temporary parasite

Sporadic parasite: Same as temporary parasite

Note: The temporary or intermittent parasites are also called micropredator.

Aberrant parasite: These are parasites which migrate aberrantly in an unusual location.

Example: Larvae of *Setaria* spp. may migrate to the CNS of the unnatural hosts.

Ectoparasite: The parasite lives on the body of the host particularly on the skin.

Example: Tick, mite, lice, etc.

Endoparasite: The parasites live within the body of the host.

Example: Tapeworm, roundworm and flukes.

Monoxenous parasite: The parasite is monoxenous when it does not require any intermediate hosts or vectors for completion of their life cycle.

Example: Eimeria spp.

Heteroxenous parasite: The parasite is heteroexenous when it requires any intermediate hosts for completion of their life cycle.

Example: Trypanosoma rhodesiense

Stenoxenous parasite: Stenoxenous parasites are those parasites which have narrow host range.

Example: Gigantocotyle explanatum

Autoheteroxenous parasite: Same vertebrate animal acts as both definitive and intermediate host of this parasite.

Example: Trichinella spiralis

Protelean parasites: These are organisms whose immature stages are parasitic but the adults are free living.

Example: Larvae of many myiasis causing flies are parasitic but the adults are free living.

Pathogenic parasite: The parasites which cause pathogenicity in the host are called pathogenic parasites.

Example: Fasciola spp.

Non-pathogenic parasite: The parasites which do not cause any pathogenicity are non-pathogenic parasites.

Example: Endolimax nama (protozoa) is non-pathogenic in man and monkey.

Zoonotic parasites: The parasites are transmissible from man to animal or *vice versa*.

Example: Taenia solium

Hyperparasite: The parasite which parasitise other parasite is called hyperparasite.

Example: A protozoan parasite *Nosema dollfusi* parasitise another parasite, *Bucephalus cuculus* (trematode).

Pseudo-parasite: They are not the parasites at all but the appearances of some structures look like parasites which create confusion during routine laboratory examination.

Opportunist parasite: Same as facultative parasite.

Unicellular parasite: Single celled parasite is called unicellular parasite.

Example: Trypanosoma spp.

Multicellular parasite: The body of the parasite is composed of more than one cell.

Example: Fasciola spp.

Histozoic parasite: The parasites which live in tissues are called histozoic parasite.

Example: Sarcocystis spp.

Coelozoic parasite: The parasites which live in the lumen of the GI tract or other hollow part of the organ are called coelozoic parasite.

Example: Taenia solium (adult)

Unisexual parasite: The parasite which has either male or female reproductive system is called unisexual parasite. The male and female parasites are different.

Example: Ascarid worms, Hookworms

Bisexual parasite: The parasites which have both male and female reproductive systems are called bisexual parasites.

Example: Cestodes

Monocious parasite: The parasites which have both male and female reproductive system in the same individual. Indeed they are bisexual parasites.

Example: Cestodes

Diocious parasite: The parasites which have either male or female reproductive system are diocious parasite. The parasites are sexually dimorphic.

Example: Roundworms

Hermaphrodite parasite: Same as bisexual parasite

Parthenogenetic parasite: The parasites produce offspring from unfertilised egg.
Example: Strongyloides spp.

Migratory parasite: The parasites which can migrate through the tissues are called migratory parasites.

Example: Larval stages of some nematodes.

Occasional parasite: Same as accidental parasite

Wandering parasite: Same as aberrant parasite

Haemoparasites: The parasites which live in blood are called haemoparasite.
Example: Trypanosoma spp.

Haematophagus parasite: Haematophagus parasites are those parasites which take/suck blood as food.
Example: Haemonchus spp.

Mucophagus parasites: The parasites which ingest mucus material for their nutrition.
Example: Gastrointestinal nematodes

Biliphagus parasite: These parasites utilise bile for nutrition.
Example: Fasciola gigantica

Protozoan parasite: The members coming under the subkingdom Protozoa are called protozoan parasites. These parasites are unicellular but have distinct enclosed nucleus.
Example: Trypanosoma spp., *Theileria* spp. and *Babesia* spp., etc.

Metazoan parasite: The tapeworms, roundworms, thorney headed worms are the metazoan parasites.

Helminthic parasite: The parasites coming under the phyla Platyhelminthes, Nemathelminthes and Acanthocephala are called helminthic parasites.

Worm parasite: Same as helminthic parasites.

HOSTS

Hosts are those organisms which harbour other organisms providing shelter, nutrition and other biological or biochemical factors. The extent of requirement of host material for an organism is variable. Some organisms are solely dependent on host and others need the host partially. Whatever the amount of host material or duration of parasitism is, parasite cannot perform its full span of life without the host. A parasite or an dependent organism requires a host for shelter, nutrition and other biological factors for metabolic reason.

Definitive Host

A definitive host is the host where the parasites attain their sexual maturity.

Example:
1. Cysticercus of *Taenia solium* gets sexual maturity in human beings. Therefore, human beings are the definitive hosts.
2. Cysticercoid of *Moniezia* spp. gets sexual maturity in sheep and goat. Therefore, sheep and goat are the definitive hosts.

Intermediate Host

Those hosts are called intermediate hosts in which a part of biological development of the parasite occurs but sexual maturity does not occur. In most of the parasites the intermediate hosts are required for completion of their life cycle.

The intermediate hosts are as significant as definitive host. Multiplication of flukes occur in the snail. A single miracidium starts multiplication which leads to produce a number of cercariae eventually. And these events occur in snail host in case of *Fasciola* and other trematode infection.

So, from these examples it is easy to understand that intermeditate host has equal importance for multiplication, nutrition, reproduction, etc. However, all parasites do not require intermediate host for their development. On the other hand, some parasites require even two intermediate hosts for the completion of their life cycle.

Example:

- Pig – *Taenia solium*
- Cattle – *T. saginata*
- Mite – *Moniezia expansa*
- Fish – *Gnathostoma spinigerum*
- Beetle – *Gongylonema pulchrum.*

Parataenic Host or Transport Host

When a parasitic stage is simply sheltered by a host and no biological development occurs in it, that type of host is called parataenic host or transport host.

Example:

In the life cycle of *Toxocara canis*, rats and rodents act as parataenic or transport host because no biological development occurs in that host. The second stage of larvae remains in dormant status in the muscles of rats and rodents without any further biological development.

Reservoir Host

Reservoir host is the host which harbour the organisms without manifesting any disease. Occasionally, the organisms manifest disease in adverse condition of the host. In fact the reservoir host is the continuous source of the organisms.

Example: Rodents act as reservoir hosts of *Leishmania tropica*.

Natural host: The host is called natural host in which the parasites commonly occur and easily survive and reach to their final stage. In the natural host, complete biological development occurs.

Example: Fasciola gigantica occurs commonly in the sheep, goat and cattle. These hosts are called natural hosts.

Unnatural host: The hosts are called unnatural hosts in which the parasites do not occur commonly but in some unusual situations the parasite may infect and develop.

Example: The rabbits may be experimentally infected with *Fasciola gigantica*. Here the rabbits are considered as unnatural hosts.

Frequent host: The host in which the parasites usually occur is called frequent hosts.

Example: Sheep harbouring *Haemonchus.*

Experimental host: The hosts which are experimentally infected with natural or unnatural parasites are called experimental hosts.

Final host: Definitive hosts are also called final host.

Transitory host: Intermediate hosts are also called transitory host.

Incidental host: The host which accidentally harbour the parasite. Actually those parasites do not usually occur in those hosts.

Vector: The arthropods which harbour the parasitic pathogen without any recognisable disease entity and act as a constant source of infection to other animals are called vectors. Sexual maturity of parasite may have occurred in the vector.

Example:

- Mosquitoes
- Blood-sucking fly.

Mechanical Vector

Biological development does not occur in this vector.

Example: Tabanus fly transmits *Trypanosoma equinum*. *Tabanus* fly is mechanical vector of *T. equinum* because no biological development of this parasite occurs in *Tabanus*.

Biological Vector

Biological development of organisms occurs in this vector.

Example: Biological developement of *Trypanosoma brucei* occurs in *Glossina* fly.

Hosts and Sites of Important Trematodes

Name of parasite	*Definitive hosts*	*Intermediate host*	*Site*
Fasciola giganitica	Cattle, sheep, goat and other ruminants	***Lymnaea rufescens, L. auricularia, etc.***	Bile duct and liver
Fasciola hepatica	Cattle, sheep, goat and other ruminants	***Lymnaea tomentosa, L. bulimoides, L. truncatula***	Bile duct and liver
Fascioloides magna	Cattle, sheep	***Fossaria sp.***	Liver
Fasciolopsis buski	Man and pig	***Segmentina sp***	Small intestine
Dicrocoelium dendriticum	Sheep, goat, cattle, etc.	***1st—Zebrina detrita, Cionella lubrica 2nd—Ants (Formica fusca, F. cunicularia)***	Bile duct, liver, gallbladder, pancreas
Opisthorchis tenuicollis	Dog, cat and fox, etc.	***1st—Bithynia 2nd—Fish (Tinca, Cyprinus, Idus, etc.)***	Bile duct and liver
Paramphistomum cevi	Cattle, sheep, goat, etc.	***Indoplanorbis sp, Planorbis sp***	Rumen and reticulum
Cotylophoron cotylophorum	Cattle, sheep, goat, etc.	***Indoplanorbis sp***	Rumen and reticulum
Gigantocotyle explantum	Buffalo	***Gyraulus convexiusculus***	Bile duct and gall-bladder

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Name of parasite	*Definitive hosts*	*Intermediate host*	*Site*
Gastrothylax crumenifer	Sheep, cattle, buffalo	***Gyraulus convexiusculus***	Rumen and reticulum
Gastrodiscus aegyptiacus	Equines	***Cleopetra sp***	Small and large intestine
Gastrodiscoides hominis	Man and pig	***Helicorbis sp***	Caecum of man and colon of pig
Fischoederius	Cattle	***Lymnaea luteola***	Rumen
Schistosoma spp.	Sheep, goat, cattle, pig, etc.	***Indoplanorbis sp, Bulinus sp, Planorbis sp***	Nasal vein, mesenteric vein, portal vein
Prosthogonimus Pellucidus	Fowl	***1st—Bithynia tentaculata 2nd—Dragon fly***	Oviduct and bursa of fabricius
Paragonimus westermani	Dog, cat, fox and pig, etc.	***1st—Ampularia, Melania sp, Assiminia sp. 2nd—Crabs and cray fish***	Lung

Hosts and Sites of Important Cestodes

Name of parasite	*Definitive hosts*	*Intermediate host*	*Site*
Raillietina cesticillus	Birds	**Beetle**	Small intestine
Raillietina echinobothrida	Birds	***Ants and house fly (Musca domestica)***	Small intestine
Raillietina tetragona	Birds	***Ants and house fly (Musca domestica)***	Small intestine
Davainea proglottina	Birds	**Snails**	Small intestine
Dipylidium caninum	Dogs, cat and fox	**Flea—*Ctenocephalides felis and C. canis***	Small intestine
Amoebotaenia sphenoides	Birds	**Earthworm**	Small intestine
Anoplocephala spp.	Horse	**Oribatid mite**	Small intestine
Paranoplocephala sp	Horse	**Oribatid mite**	Small intestine
Moniezia spp.	Sheep, goat and cattle	**Oribatid mite**	Small intestine
Thysanosoma actinioides	Sheep, goat and cattle	**Psocids**	Bile duct
Thysaniezia giardi	Sheep, goat and cattle	—	Small intestine
Avitellina spp.	Sheep, goat and cattle	**Psocids**	Small intestine
Stilesia spp.	Sheep, goat and cattle	**Mites**	Bile duct
Hymenolepis nana	Man and rodents	**Flour beetles and fleas (indirect life cycle in rodents)**	Small intestine
Hymenolepis carioca	Fowl	**Flour beetle and dung beetle**	Small intestine
Hymenolepis diminuta	Rodents	**Flour beetle and fleas**	Small intestine
Tenia solium	Man	**Pig**	Small intestine
Taenia saginata	Man	**Cattle**	Small intestine

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Name of parasite	*Definitive hosts*	*Intermediate host*	*Site*
Taenia hydatigena	Dog and different wild carnivores	**Sheep and other ruminants**	Small intestine
Taenia pisiformis	Dog and different wild carnivores	**Rabbits**	Small intestine
Taenia taeniaeformis	Cat	**Rodents**	Small intestine
Taenia multiceps	Dog	**Sheep and goat**	Small intestine
Echinococcus spp.	Dog	**Sheep, goat, cattle and other related animals**	Small intestine
Mesocestoides spp.	Dog, cat, fox and other related animals	**1st—Mite 2nd—Birds**	Small intestine
Diphyllobothrium latum	Dog, cat, fox man, etc.	**1st—Cyclops 2nd—Fish**	Small intestine

Hosts and Sites of Important Nematodes

Name of parasite	*Definitive hosts*	*Intermediate host*	*Site*
Strongylus spp.	Horse	—	Caecum and Colon
Oesophagostomum spp.	Sheep, goat, cattle, pig, etc.	—	Large intestine
Syngamus trachea	Birds	—	Trachea
Stephanurus dentatus	Pig	—	Kidney (perirenal fat, pelvis and ureter)
Ancylostoma caninum	Dog and fox	—	Small intestine
Ancylostoma braziliense	Dog and cat	—	Small intestine
Ancylostoma duodenale	Man	—	Small intestine
Ancylostoma tubaeforme	Cat	—	Small intestine
Bunostoum phlebotomum	Cattle	—	Small intestine
Bunostomum trigonocephalum	Sheep and goat	—	Small intestine
Necator americanus	Man	—	Small intestine
Uncinaria stenocephalus	Dog, cat and fox	—	Small intestine
Globocephalus longemucronatus	Pig	—	Small intestine
Gaigeria pachyscelis	Sheep and goat	—	Small intestine
Dictyocaulus viviparus	Cattle and buffalo	—	Bronchi and lung
Dictyocaulus filaria	Sheep and goat	—	Bronchi and lung
Dictyocaulus arnfieldi	Horse and donkey	—	Bronchi and lung
Ostertagia spp.	Sheep, goat and cattle	—	Abomasum
Cooperia spp.	Ruminants	—	Small intestine and abomasum
Haemonchus spp.	Sheep, goat and cattle	—	Abomasum

Contd...

Name of parasite	*Definitive hosts*	*Intermediate host*	*Site*
Trichostrongylus axei	Sheep, goat and cattle	—	Abomasum
Chabertia ovina	Sheep, goat and cattle	—	Colon
Metastrongylus apri	Pig	**Earthworm**	Bronchi and bronchiole
Filaroides osleri	Dog	—	Bronchi and trachea
Protostrongylus rufescens	Goat, sheep, etc.	**Snail**	Bronchiole
Mullerius capillaris	Sheep and goat	**Snail**	Lungs
Ascaris suum	Pig	—	Small intestine
Toxocara canis	Dog	—	Small intestine
Toxocara cati	Cat	—	Small intestine
Toxocara vilullorum	Cattle	—	Small intestine
Parascaris equorum	Horse	—	Small intestine
Oxyuris equi	Horse	—	Large intestine
Heterakis gallinarum	Turkey fowl and pea fowl	—	Caeca
Strongyloides papillosus	Sheep, goat and cattle	—	Small intestine
Strongyloides cati	Cat	—	Small intestine
Strongyloides westeri	Pigs and horses	—	Small intestine
Strongyloides ransomi	Pigs	—	Small intestine
Strongyloides stercoralis	Human beings	—	Small intestine
Thelazia rhodesii	Cattle, sheep and goat	***Musca fly***	Eye
Thelazia lacrymalis	Horse	— *do* —	Eye
Thelazia gulosa	Cattle	— *do* —	Eye
Thelazia alfortensis	Cattle	— *do* —	Eye
Thelazia callipaeda	Dog	— *do* —	Eye
Thelazia skrajabini	Cattle	— *do* —	Eye
Spirocerca lupi	Dog, fox and other related animals	**Beetle**	Stomach, oesophagus and aorta
Ascarops strongylina	Pig	**Beetle**	Stomach
Gongylonema verrucosum	Sheep, goat and cattle	**Beetle**	Rumen
Gongylonema pulchrum	Sheep, goat and cattle	**Beetle**	Oesophagus
Gongylonema ingluvicola	Fowl	**Beetle**	Crop
Habronema muscae	Horse	**House fly**	Stomach
Habronema majus	Horse	**Stable fly**	Stomach
Draschia megastoma	Horse	**House fly**	Stomach
Acuaria hamulosa	Fowl	**Grasshopper**	Gizzard
Dispharynx spiralis	Fowl	**Isopod**	Proventriculus and oesophagus

Contd...

Name of parasite	*Definitive hosts*	*Intermediate host*	*Site*
Gnathostoma spinigerum	Dog and cat	**1st—Cyclops 2nd—Fish**	Stomach
Physaloptera praeputialis	Cat	**Cockroach and Beetle**	Stomach
Dirofilaria immitis	Dog	**Mosquitoes**	Heart
Parafilaria multipapillosa	*Horse*	***Haematobia***	Subcutaneous tissue
Parafilaria bovicola	Cattle	***Musca***	Subcutaneous tissue
Setaria digitata	Cattle	***Mosquito***	Peritoneal cavity
Setaria labiatopapillosa	Cattle	***Mosquito***	Peritoneal cavity
Setaria cervi	Deer	***Mosquito***	Peritoneal cavity
Setaria equina	Equines	***Mosquito***	Peritoneal cavity
Stephanofilaria assamensis	Cattle	***Musca sp.***	Skin of hump
Stephanofilaria kaeli	Cattle	***Musca sp.***	Skin of leg
Stephanofilaria stilesi	Cattle	***Lyperosia sp.***	Skin of abdomen
Stephanofilaria dedoesi	Cattle	***Musca sp.***	Skin
Stephanofilaria zaheeri	Cattle	***Musca sp.***	Skin of ear
Onchocerca cervicalis	Horse	***Culicoides sp.***	Ligamentum nuchae
Onchocerca gutturosa	Cattle and buffalo	***Simulium sp.***	Ligamentum nuchae
Dracunculus medinensis	Man and dog	**Cyclops**	Subcutaneous tissue
Trichuris ovis	Sheep	—	Large intestine
Trichuris suis	Pig	—	Large intestine
Trichinella spiralis	Pig and man	**Pig**	Small intestine

Hosts and Major Sites of Important Protozoa

Name of parasite	*Definitive hosts*	*Vector Int. host*	*Site*
Eimeria tenella	Poultry	—	**Caecum**
E. necatrix			Intestine
E. acervulina			Intestine
E. maxima			Intestine
E. hagani			Intestine
E. mitis			Intestine
E. brunetti			Rectum
E. praexoc			Intestine
E. mivati			Intestine
E. bovis	Cattle	—	Intestine
E. zuernii			
E. ellipsoidalis			
E. cylindrica			
E. braziliensis			
E. canadeensis			

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Name of parasite	*Definitive hosts*	*Vector Int. host*	*Site*
E. ninakohlyakimoviae *E. gilruthi* *E. ovina* *E. ashata* *E. arkhari* *E. arloigi* *E. parva* *E. punctata* *E. ovinoidalis* *E. crandalis*	Sheep and goat	—	Intestine
E. debliecki *E. porci* *E. polita* *E. scabra* *E. spinosa* *E. suis* *E. perminuta*	Pig	—	Intestine
E. leukarti *E. uniungulati* *E. solipedum*	Horse	—	Intestine
E. stedai *E. intestinalis*	Rabbit	—	Liver and small intestine
Toxoplasma gondii	Cat	**All worm blooded animals except cat**	Brain, skeletal muscle, heart, mesenteric, lymph node, etc.
Sarcocystis cruzi	Dog	Cattle	Brain, kidney, intestine, etc.
Sarcocystis bovifelis	Cat	Cattle	— do —
S. ovicanis	Dog	**Lamb**	— do —
S. porcihominis	Man	**Pig**	— do —
S. hominis	Man	**Ox**	— do —
Plasmodium vivax	Man	*Anopheles* mosquitoes	RBC and other cells
Plasmodium gallinaceum	Birds	*Culex* mosquitoes	RBC and other cells
Haemoproteus columbae	Domestic and wild birds	***Hippoboscid flies (Pseudolynchia canariensis)***	RBC, endothelial cells, etc.
Leucocytozoon spp.	Ducks, turkeys, etc.	***Simulium flies***	Liver cells, RBC, etc.
Babesia spp.	Cattle, sheep, goat, etc.	***Boophilus spp, Rhipicephalus spp, Haemaphysalis spp, etc.***	RBC
Theileria spp.	Cattle, sheep, goat, etc.	***Hyalomma spp***	RBC and lymphocytes
Trypanosoma evansi	Cattle, sheep, goat, etc.	***Tabanus, Stomoxys and Lyperosia***	Blood

Contd...

Name of parasite	*Definitive hosts*	*Vector Int. host*	*Site*
Trypanosoma equinum	Cattle, sheep, goat, etc.	***Tabanus, Stomoxys and Lyperosia***	Blood
Trypanosoma congolense	Cattle, sheep, goat, etc.	***Glossina sp***	Blood
Trypanosoma rhodesiense and T. gambiense	Human beings	***Glossina sp***	Nervous system
Tritrichomonas foetus	Cattle	—	Genital organs
Histomonas meleagriidis	Turkey	—	Liver and intestine
Giardia lamblia	Human	—	Intestine
Entamoeba histolytica	Man and dog	—	Intestine
Balantidium coli	Pig	—	Intestine

MODE OF INFECTION OF PARASITES

Parasites are transmitted from one host to another host in many ways which is influenced by port of entry.

A. Ingestion

i. **Parasitic eggs:** The hosts get the infection by ingestion of the eggs of the parasite.
Example: The typical example of this feature is the eggs of Ascarid worms. Eggs containing the second stage larvae are the infective stage and set up infection after ingestion.

ii. **Parasitic cysts:** The infective stages of some parasites are cysts. The hosts get the infection after ingestion of these cysts.
Example: The typical example of these parasitic cysts are *Entamoeba histolytica* and *Giardia canis*.

iii. **Oocysts:** The sporulated oocysts are infective stage of some protozoan parasites.
Example: Birds get the infection of *Eimeria tenella* by ingestion of sporulated oocysts.

iv. **Parasitic larvae (roundworm):** In some parasites it is found that the eggs hatch out in the environment. After hatching the larvae develop to become the infective larvae and these larvae act as the infective stage of the parasite.
Example: As for instance the third stage larvae of strongyle worms act as infective stages of those parasites. In case of tapeworms the bladder worms/cysts/metacestodes act as the infective stage. There are different types of bladder worms like cysticercoid, cysticercus, coenurus, strobilocercus, hydatid cyst, etc.

v. **Metacercaria:** In case of some parasites, infection of the hosts occurs after ingestion of the metacercaria. These metacercariae are formed in the life cycle of almost all flukes.
Example: Metacercaria of *Paragonimus westermanii* develops in the crabs and cray fishes. Infection occurs in the definitive host after ingestion of the infected crabs and cray fishes.

vi. **Fishes:** Infection of hosts occurs by ingestion of fish harbouring some infective stages of parasite
   a. Larvae of *Diphyllobothrium latum* and metacercarial form of *Chlonorchis sinensis* develop in the fish.

b. Metecercariae of *Heterophyes, heterophyes* occur in second intermediate host, a fish, (*Mugil cephalus, M. capito*). The cercaria encyst under the scales or in the tissue of the gills, fins or tail. And finally the host gets the infection by eating the raw fish.

vii. **Flesh/Meat:** Infection of hosts occurs by ingestion of flesh containing the infective stages of parasites.
Example: Human beings get the infection of *Taenia saginata* by ingestion of the beef containing *Cysticercus bovis*.

viii. **Ingestion of aquatic or non-aquatic arthropods:** Ingestion of aquatic or non-aquatic arthropods is also a source of infection.
Example: Human beings get infected with medina worm, when cyclops infected with the larval forms of *Drancunculus medinensis* are ingested along with water.

ix. **Earthworm:** Hosts get infection by ingestion of earthworm harbouring infective stage of parasite.
Example: The birds get the infection of *Amoebotaenia sphenoides* by ingestion of earthworm harbouring the cysticercoid.

x. **Aquatic vegetation:** Cercariae become encysted on the aquatic vegetation and develops to metacercarial stage. Final host gets the infection by ingestion of infected vegetation.
Example: F. hepatica and *F. gigantica.*

B. Skin Penetration

Hosts get the infection by contamination of skin or mucus membrane.

Example

1. Hookworm, larvae of *Ancylostoma duodenale, A. braziliense, A. caninum, Necator americanus* and *Strongyloides stercoralis* are found in moist soil and penetrate through the skin of the definitive host. The gardeners, plumbering workers and field workers are generally affected by this infection which lead to a condition called cutaneous larva migrans.
2. Cercariae of various *Schistosoma* spp. penetrate through the skin of their hosts.
3. Deposition of egg and larva on the skin by myiasis causing fly (Calliphoridae). The adult bot fly (Oestridae family) deposits their larvae in the nasal orifice of sheep and goat.

C. By Insect

Blood sucking arthropods act as vector of many protozoan parasites. These flies are mainly *Tabanus* spp., *Stomoxys* spp., *Lyperosia* spp., *Glossina* spp., etc. These flies transmit *Trypanosoma* spp.. In addition to these flies *Anopheles* spp. transmits human malaria, *Plasmodium vivax* and *Culex* spp. transmits bird malarial pathogen, *Plasmodium gallinacium*.

D. Direct Contact

Some kinds of organisms infect the animals by direct contact.

Example: Mites like *Demodex* spp., *Sarcoptes* spp. and *Psoroptes* spp. are transmitted by direct contact.

E. Inhalation

Example: Eggs of *Enterobius vermicularis* may be inhaled.

F. Transuterine/Congenital

The individual gets infection in foetus stage from his mother.
Example: Tachyzoites of *Toxoplasma gonolii* pass through the placenta from mother to foetus.

G. Transmammary/Transcolostral/Lactogenic

The individual gets infection through clostrum and milk.
Example: The pups get infection (*Toxocara canis*) when they suck mother's milk.

H. Venereal/Sexual

Parasitic pathogens may be transmitted through coitus.
Example: Trichomonas vaginalis, Tritrichomonas foetus are transmitted through coitus.

I. Through existing wound

Example: Larvae of *Drascia* and *Habronema* are deposited in the existing wound and cause granular dermatitis, summer sore, etc.

J. Rural therapy

For dressing of wounds, frog or snake flesh is used by the rural people and plerocercoids or spargana, if present in flesh migrate in human being and cause sparganosis.

K. Blood transfusion

Parasitic organisms may be trasmitted through blood transfusion.
Example: Trypanosoma, Babesea and *Plasmodium* may be transmitted through blood transfusion.

L. Auto infection

Auto infection of *Taenia solium* occurs in human beings.

SPREAD OF PARASITE

It is understood how the bacterial diseases spread from one animal to another animal and also from one place to another place. One thing which is to be kept in mind that for development and/or multiplication of bacterial and viral organism, no intermediate host is required but as far as the life cycle of parasitic organisms is concerned there appears two type of life cycles. One is direct and another is indirect type of life cycle. In indirect type of life cycle, intermediate host is required. In this type some parts of the biological development occur in the environment and some parts occur in the host. While describing the spread of any parasitic disease the thing which is to be considered is that the organism is either transmitted from the host or from the environment. These are the following routes through which spread of infecton of parasite occurs:

Water

Water is one of the major sources of dissemination or perpetuation of the disease. Cyclops are the aquatic arthropods which are abundantly found in the water and

these cyclops act as the intermediate host of some parasites. For instance, it acts as the intermediate hosts of *Diphyllobothrium latum* (an important tapeworm of dog) and *Gnathostoma spinigerum*.

Soil

Soil contain many parasitic pathogens which may spread due to soil erosion or strong wind spread the soil dust.

Aquatic Plants

Aquatic plants or vegetations are also the good source of parasitic infection. Metacercariae are formed on the grass blades which are the infective stages of *Fasciola* spp. Water nuts are the source of the *Fasciolopsis buski*.

By Vectors

Many blood sucking flies and other vectors spread parasitic diseases.

By Direct Contact

Mange, lice infestation, etc. spread by direct contact.

By Fungi

Some parasitic larvae are distributed by fungal spores. Larvae of Trychostrongylids are distributed by spores of the fungus pilobolus.

By Transport of Animals

Spread of parasites also occurs by transportation of infected animals from one place to another place.

By Export/Import of Meat/Animals/Biomedicines/Biological Products

Export/import of infected meat/meat product, etc. are important sources of spread of parasitic disease from one place to another.

By Natural Calamity

Natural calamity like flood, earthquake, etc. play great a role in the spread of parasitic diseases. These calamities destroy the nests/dwelling places of the transmitter organisms and alter their habitat which result in spread of disease.

Example: Rat's habitat is altered due to natural calamity and the rat flea randomly bite human beings and thus perpetuate the plague.

Ecological Factors

Industrialisation, urbanisation, deforestation and change of settlement may cause alternation of parasite's habitat and they may spread.

Fertilisers

Manure and other biofertiliser may cause spread of disease.

Human Migration

Migration of human beings causes spread of parasitic diseases including zoonotic diseases.

Example: Dracunculus, Necator americana reached to Western hemisphere from Africa due to human migration.

SPECIFICITY OF PARASITES

Before understanding host parasite specificity one should have a clear concept about evolutionary development of parasite. That means how does an organism becomes a parasite. It could be hypothetically considered that due to environmental stress and ecological selection pressure, an organism enters from a free living stage to parasitic stage. During the course of evolution parasite selects different specific host in terms of species, breed, sex and organ. In this way the parasites become species specific, breed specific, sex specific and organ specific. These different specificities have been developed in accordance with the specific requirements of the parasite. The following factors are responsible for developing specificity.

1. Preadaptation.
2. Availability of fauna.
3. Compatibility of the host to accept the parasite.
4. Internal host environment.
5. Reproductive potential of the parasite.
6. Host recognition mechanism.
7. Immune evasion by the parasite.

1. Preadaptation

Before complete adaptation into the host the parasite enters a phase of preadaptation. It is understandable that a parasite cannot survive if it enters into the host without the preadaptation. The parasite changes itself to some extent as per the host's internal environment. This change may be physiological, biochemical, antigenic, etc. The host is selected by the parasite for which it has performed preadaptation.

2. Availability of Fauna

For host specificity, availability of fauna is an important thing. The parasites enter into the stage of preadaptation for the fauna which are available surrounding it. If the fauna is not available to the parasite cannot develop preadaptation. A parasite should experience the host several times and gradually develop preadaptation as per the status of the host's biological environment. Hence availability of host is important for adaptation and specificity of host develops as per the specific host available to the parasite.

3. Compatibility of the Host

Compatibility means accessibility of the parasite to the host. More specifically, how much the parasite is comfortable to the host. Specificity of the parasite to a particular host develops to which the parasite is compatible.

4. Internal Host Environment

The pH, O_2 tension of the organs are important for survivality of the parasite in the host. The parasites adapt to those hosts where internal host-environment is suitable for the parasite.

5. Reproductive Potential of the Parasite

The parasite can make the fauna available if it has high reproductive potential. High reproductive potential means high capability of production of subsequent generations.

High number of parasite spreads over a large area which can cover a long distance to catch the host. Thus reproductive potential is an important factor for host selection.

6. Recognition Mechanism

Recognition mechanism is an important factor for host parasite compatibility. Duffy blood group of red blood cell act as erythrocyte receptor for the *Plasmodium vivax* infection. Here it is clear that components of immune system is used by the parasite to survive. That host becomes specific for the parasite in which the parasite/part of the parasite/any component of the parasite is recognised.

7. Immune Evasion

Immune evasion is another example. Against every parasite, some kind of immunological reactions occur. So to survive in a host, the parasite has to evade host's immunological reaction. Those hosts become specific for a particular parasite in which the parasites have evaded the immunological reaction. Immune evasion occurs by the following mechanisms:

i. By mimicry or absorption of host antigen.
ii. Antigenic variation.
iii. Shading of glycocalyx.
iv. Blocking of antibodies and tolerance.

Specificity of Parasites in Tabulated Form

Specificity	*Name of disease/parasite, etc.*
Type of host	*Gigantocotyle explanatum* only occurs in buffalo.
Breed specificity	Trypanotolerant animals (N-Dama, Lagune) are resistant against *Trypanosoma* spp. The indigenous breeds are resistant against many parasites, however, cross-breed animals are susceptible to many parasitic diseases. Red masai sheep is resistant against *Haemonchus* spp. However, many other sheep are susceptible to *Haemonchus* spp.
Sex specificity	The female cattle suffer more from *Tritrichomonas foetus*. The males suffer less and act as the carriers. *Trichomonas vaginalis* invariably occurs in the female.
System specificity	*Trypanosoma gambiense* and *T. rhodesiense* affect the nervous system.
Organ specificity	Some parasites affect only the organ/organs of the system. The whole system is not affected. *Fasciola* spp. affect liver and bile duct.
Cell specificity	*Theileria* schizonts occur in the lymphocytes.
Location specificity	*Eiemria bombayansis* occurs in Mumbai.
Specificity to pH	Parasites are specific to pH in which they are to survive. The parasites occurring in the stomach can survive in that pH. That's why they are specific to that pH
Specificity to host food	The parasites are specific to the host's food and the required components should be present in the host's diet. Many works were carried out in this aspect and it was found that establishment of parasite in the host depends on host's food.

Contd...

Specificity	*Name of disease/parasite, etc.*
Specificity to biochemical components	Specific biochemical components necessary for the parasites as food or otherwise should be present in the location where the parasites reside. Parasites occurring in the bile require specific bile component.
Specificity to host's body temperature	The parasites are specific to specific body temperature. The avian parasites can establish in the specific body temperature of birds.
Color specificity	Some temporary parasites are specifically attracted to particular skin—color of animals. Host color specificity is found in *Tabanus* flies.
Smell specificity	Some temporary parasites are sensitive to specific smell of the hosts and get attracted to those hosts. The mosquitoes identify the human hosts by their smell. The smelling agents are CO_2, body odour, etc.
Season specificity	Parasites have season specificity. Magnitude of parasitic infection varies in different seasons. *Example:* Summer sore occurs in summer season.
Ecological specificity	One work was carried out to test the ability of *Vampirolepis nana* to infect a variety of mammals including some hosts which are not known to harbour this parasite and interestingly it was found that some of the latter hosts were susceptible to this parasite. It means that some parasites do not occur in some hosts because of lack of opportunity. But if they get opportunity they can establish.

Host Parasite Relationship

This term broadly means compatibility between host and parasite. A parasite can be held as a successful organism as it fairly sets up the infection and survives in the host. Many factors determine the host–parasite relationship. The following points are the considering factors:

1. Genetic correlation between host and parasite.
2. Chances for contact between host and parasite.
3. Foreignness of the parasite.
4. Size of the parasite.
5. pH of the host environment.
6. O_2 tension of host environment.
7. Immune effector system of the host.
8. Site or location of parasite.

Biological Development of Parasite

Different types of biological development occur. In case of Ascarid worms the larvae develop within the egg shell. The larvae hatch after being ingested by the hosts and then develop further in the host to become adult. In strongyles, the eggs hatch in the environment and the larvae moult in different stages. L3 stage is the infective stage for the host. Further development occurs in the host after ingestion. In spiruroidea, the eggs expell out of the host and ingested by intermediate host wherein they hatch and the larvae develop to become infective stage. Final host gets infection by ingestive of intermediate host. In Metastrongyloidea, the eggs expel out of the host. Then the eggs hatch and the larvae come out. The larvae are then ingested by the intermediate host where they reach to infective stage. Final host gets the infection by ingestion of infected intermediate host. In Filarid worms, the life cycle is different. The viviparous female lays the larvae which mix in the blood. The larvae reach to intermediate host

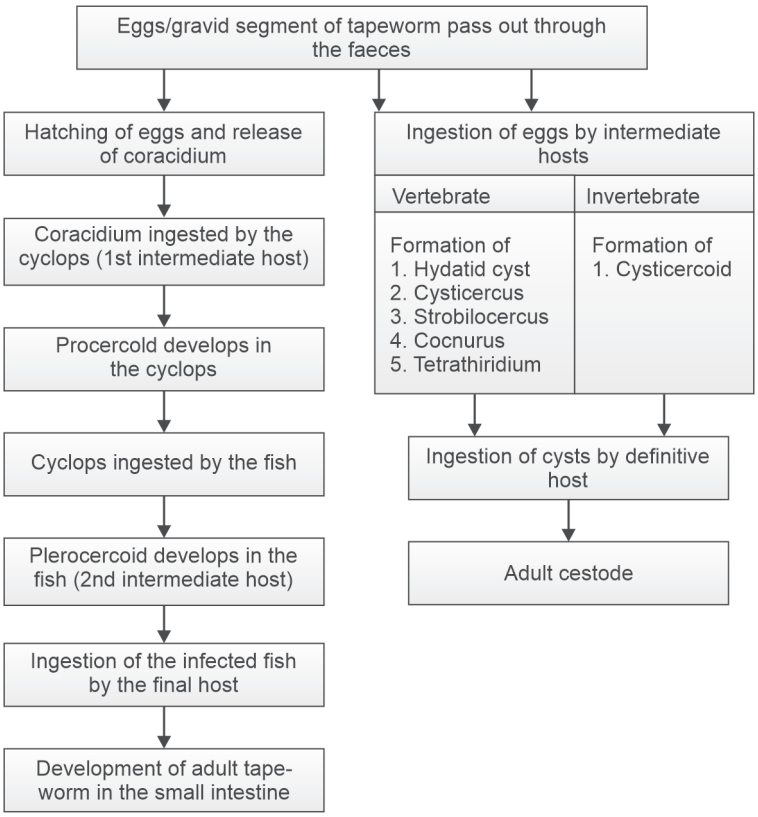
(blood sucking fly, mosquitoes, etc.) when they suck blood. The larvae reach to infective stage in the intermediate hosts. Healthy hosts get infection during blood meal by these flies.

In cestode, developmental stages are quite different. In almost all cestodes, life cycle is of indirect type where there occurs requirement of an intermediate host (Flowchart 1.1). In Hymenolepids, there are both direct and indirect types of life cycle. Immature stages or the larval stages occur in the intermediate host. These are also called bladder worms, cysts or metacestodes. The larval stages are different types of cysts or the bladder worms. The bladder worms are cysticercoid, cysticercus, hydatid cyst, coenurus, strobilocercus, procercoid, plerocercoid, tetrathyridium, etc. The final host gets the infection by ingestion of the intermediate hosts or the meat/flesh of the intermediate host harbouring the larval stage.

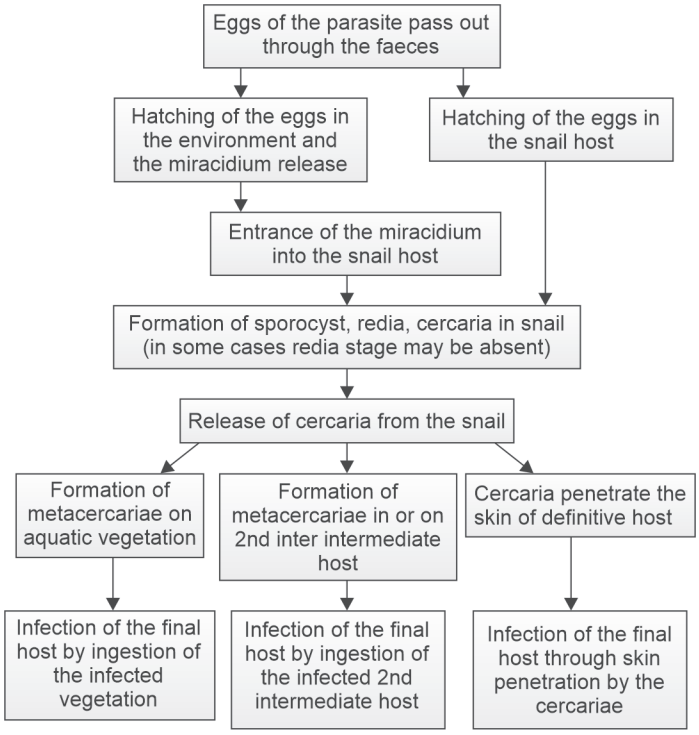
In almost all the trematodes of veterinary importance, indirect type of life cycle is found (Flowchart 1.2). That means an intermediate host is required for completion of the life cycle. In the intermediate host, the intermediate or the larval stages are formed. The developmental stages are egg, miracidium, sporocyst, daughter spocysts, redia, daughter redia, cercaria, metacercaria, etc. The metacercariae stages are the infective stages which occur in the intermediate hosts or on the plants.

In the arthropods, always direct type of life cycle is found where intermediate host is not required for completion of their life cycle (Flowchart 1.4). In the arthropods complete

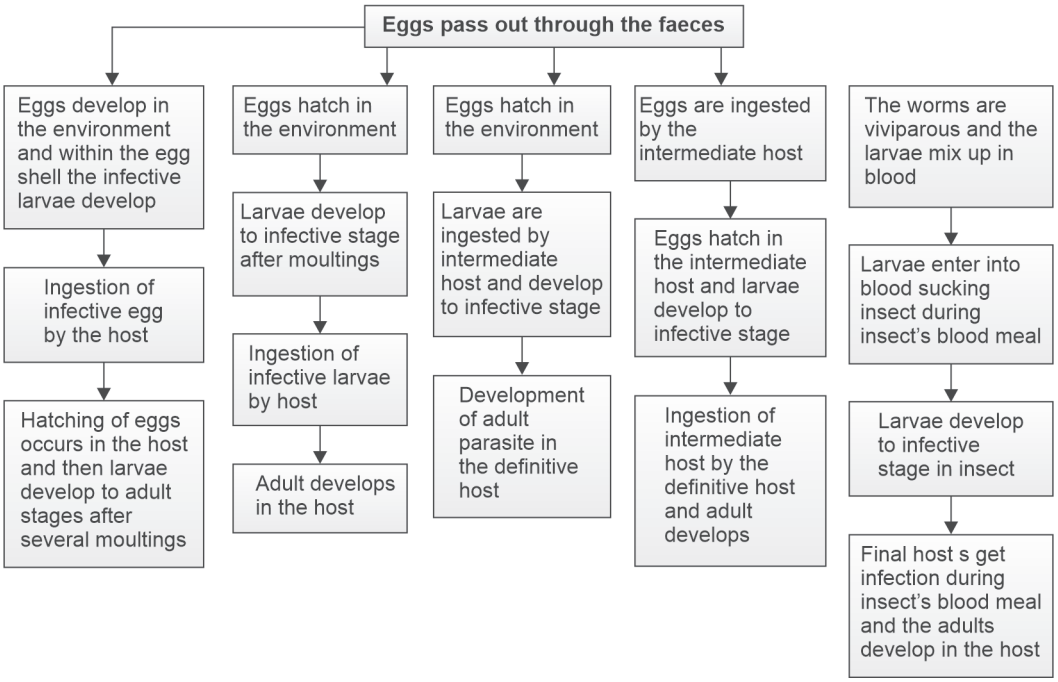
Flowchart 1.1: Life cycle of cestode



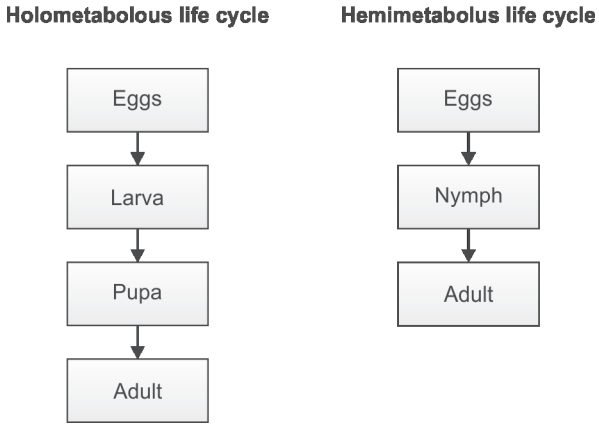
Flowchart 1.2: Life cycle of trematode



Flowchart 1.3: General life cycle of nematode



Flowchart 1.4: Life cycle of arthropod



and incomplete types of metamorphosis occur. In complete type of metamorphosis egg, larva, pupa and adult stages occur, whereas in incomplete type of metamorphosis, egg, nymph and adult stages occur.

In the protozoa, direct and indirect, both types of life cycle occur. The multiplication of the organisms occurs by the following phenomenas:

a. Binary fission
b. Schizogony
c. Endodyogeny
d. Endopolygeny
e. Syngamy
f. Sporogony
g. Conjugation, etc.

Different Important Systems of Parasites

Digestive System

Digestive systems are varied in different parasites. In some parasites fully formed digestive system is absent. In tapeworms digestive system is completely absent. Though the digestive system is absent but these tapeworms take up the preformed food material through their whole body surface as the whole body surface is metabolically active. It is to be kept in mind that the body surface of tapeworms cannot absorb the complex food material, rather it absorbs the simplified food like amino acid and glucose, etc. Although tapeworms have suckers but these suckers are not used as mouth for accumulation of food but the same is used as organs of attachment to their particular location or seat of predilection. In the trematode, digestive system is present but not complete as that of higher animals. The digestive system is incomplete or blunt in fluke. It includes oral sucker, pharynx, oesophagus and two blind caecae. In nematode, digestive system is present which comprises mouth, buccal capsule, oesophagus, intestine and anus, etc. In the arthropod the digestive system is developed to some extent. It includes mouth, oesophagus, proventriculus, stomach and anus. In the protozoa, there is no complete digestive system. In the amoeba the food material is taken into the food vacule and the excreta is excreted through one opening which is called cytopyge.

Respiratory System

Respiratory system is absent in cestodes, trematodes, nematodes and protozoa. In the arthropods, different body appertures perform the function of respiration. These respiratory appertures are lung book, gill book, trachea and spiracles, etc.

Excretory System

Excretion is performed by flame cells in cestodes, trematodes and by pored osmoregulatory system in nematodes. The excreta is collected from the flame cells by the collecting tubes and excreted through the excretory duct. Excretory bladder is an important component of excretory system in trematode and it has got taxonomic importance.

Nervous System

Very simple type of nervous system is present in cestodes, trematodes and nematodes. In cestodes there is presence of rostellar nerve ring which is a major component of nervous system of cestodes. A number of nerve ganglia are present. From the nerve ganglia there arise the nerve cords which run anteriorly or posteriorly. This system is similar to the trematodes. In the roundworms there is presence of circums oesophageal nerve commissure, nerve ganglia and nerve cords, etc. Study of nervous system is very difficult in helminth as delimiting membrane is absent. In roundworms there are some sensory organs like phasmids and amphids.

Reproductive System

Unique type of reproductive system is present in different types of parasites. If the cestodes are taken into account, it is found that these are hermaphrodite in nature. That means both male and female reproductive systems are present. Another peculiarity is that complete reproductive system is present in a single mature segment. Furthermore, reproductive systems are present either in single or in double set. In *Dipylidium* and *Moniezia* two sets of reproductive systems are present, whereas in *Taenia* or *Davainea* single set of reproductive system is present. The reproductive system of trematode includes testes, vasa efferrentia, vas deferens, laurer's canal, ovary, oviduct, vagina, uterus and melhis gland, etc. The trematodes are also hermaphrodite in nature. Only one exception is *Schistosoma* spp. which are unisexual. Female parasite is carried by the male parasite during the time of copulation. Testes of the parasites are important in their location. As per the position of the testis these are called tandem (one testis is behind another), oblique (one testis is situated oblique to another testis), dorsal (one testis is situated dorsal to another testis). The reproductive system of the roundworm is different. These worms are bisexual. The male reproductive system contains testis, vas deferens, gubernaculum, bursa, telamon, etc. The female reproductive system contains valva, vagina, uterus, ovary, vitelline glands, etc.

DIFFERENT TYPES OF LIFE CYCLE

What is Life Cycle?

This is a chain of gradual development of one individual to reach to its matured stage/ sexually matured stage.

Types of Life Cycle

1. *Direct type of life cycle:* This is a type of life cycle whereby intermediate host or any vector is not required for completion of the life cycle of the parasite.
   Example: Eimeria spp.
2. *Indirect type of life cycle:* This is a type of life cycle whereby one or two intermediate hosts are required for completion of the life cycle.

   Involvement of one intermediate host: This is a type of life cycle whereby one intermediate host is required for completion of the life cycle.
   Example: Taenia solium requires one intermediate host (pig) for completion of its life cycle.

   Involvement of two intermediate hosts: This is a type of life cycle whereby two intermediate hosts are required for completion of the life cycle of the parasite.
   Example: Diphyllobothrium spp. requires two intermediate hosts (1st is cyclops and second is fish).
3. *Homogonic life cycle:* It is called homogonic life cycle when all generations of the organism are either parasitic or free living.
   Example: Strongyloides spp.
4. *Heterogonic life cycle:* It is alternation of free living and parasitic life cycle.
   Example: Strongyloides spp.
5. *Zoonotic life cycle:* In this life cycle, parasites transmit from animals to man or from man to animals.
   Example: Taenia solium
6. *Simple life cycle:* The parasites increase their number by simple propagation or multiplication.
   Example: Trypanosoma spp.
7. *Complex life cycle:* In this life cycle, both sexual and asexual cycles occur.
   Example: Eimeria spp.
8. *Holometablous life cycle:* This type of life cycle is described for arthropod. Complete metamorphosis (egg, larva, pupa and adult) occurs.
   Example: Mosquitoes.
9. *Hemimetabolous life cycle:* Incomplete metamorphosis occurs in this type of developement. The developmental stages are egg, nymph and adult.
   Example: Cockroach.

Description of Different Intermediate Stages of Parasites

Trematode

Egg: Eggs of trematode are mostly oval. The colour may be yellowish (*Fasciola* spp.), transparent or colourless (amphistomes), grayish or brownish (*Dicrocoelium* spp.). The eggs of some trematodes are operculated. Those are eggs of *Fasciola* and amphistomes. The eggs may be elongated (Schistosome).

Miracidium: The embryo remaining within egg develop to become another stage which is called miracidium. One important thing is that miracidium either may hatch out in the environment or hatching occurs after the egg has been ingested by intermediate host

(aquatic snail). The miracidium is actively motile. It has one prominent anterior spine and the body is ciliated. According to the reports of different workers the miracidium has eye spots, though these eye spots are not used as organs of vision.

Sporocysts: Sporocysts are formed from the miracidium. This is the third stage of biological development of trematode. A number of sporocysts develop in a single miracidium.

Redia: The redia develops in the sporocyst in many numbers. The redia has several birth pores through which many cercariae are released.

Cercaria: Most of these are tailed. The shape of cercaria and length of tail are variable. Tail may be short, long or bifurcated (*Schistosoma* spp.). In some cercariae, pigment is present which are called *Cercaria pigmentata*. There may be presence of eye spots in cercaria. The colour of cercaria also varies from individual to individual. Cercaria of *Fasciola* spp. is white, whereas it is black in amphistomes. Cercaria is motile and it can move from one place to another place. The cercaria can swim also in the water by using their tail appendage.

Metacercaria: Metacercaria is the encysted form of cercaria. Cercaria looses its tail and encyst either on grass blades, aquatic vegetation or in the intermediate host. As for instance *Dicrocoelium dendriticum* metacercariae are formed in ants (*Formica fusca*).

Cestodes

Eggs: Eggs of cestodes are very characteristic. Eggs remain in different egg envelopes. These are egg capsule (*Dipylidium caninum*) paruterine organ (*Avitellina* spp., *Stilesia* spp., etc.) or the uterus itself acts as a protective envelope (*Taenia* spp.). Eggs have got several coverings like outer envelope, inner envelope and oncospheral membrane. In some species (*Taenia* spp.) there is another one protective covering which is called embryophore. Embryophore is striated in *Taenia* spp.. In the oncosphere there are presence of six hooklets remaining in three pairs. That is why embryo of cestode is called hexacanth embryo. There are variable shapes of cestode eggs. Most of the eggs are round. Others are like the eggs of trematode (*Diphyllobothrium latum*). It is oval in outline and operculated. Eggs of *Moniezia expansa* and *M. benedeni* are triangular and square respectively. After hatching the oncosphere comes out. Hatching may occur in the environment (*Diphyllobothrium latum*) or it may occur in the gut of the intermediate host (*Moniezia sp*). The oncosphere, when formed in vertebrate intermediate host, can penetrate tissues and migrate into different organs like lung, liver, heart and diaphragms where these lead to form different cysts. These cysts are also called bladder worms or metacestodes. Different types of cysts are described below.

The oncosphere develops to become a bladder worm. The bladder worms, which are formed in invertebrate intermediate hosts, are called cysticercoid. Those which occur in vertebrate intermediate hosts are hydatid cyst, strobillocercus, cysticercus, coenurus, etc. Different bladder worms/cysts/metacestode are described below:

Cysticercoid

1. It is a solid bodied cyst.
2. Anteriorly is broader and narrower in the posterior.
3. There is a single scolex which is invaginated.

Cysticercus

1. Outer covering is formed by connective tissue.
2. Body is rounded and filled up with fluid.
3. There is a single scolex which is invaginated.

Hydatid cyst

1. Outer covering is formed by a connective tissue under which there is germinal layer.
2. The cyst is filled up with fluid.
3. The daughter cysts are formed from the germinal layer called brood capsules. These cysts may get detached and called the hadatid sands.
4. Germinal layers are present both in large cysts and daughter cysts, where from the scolices arise.

Coenurus

1. Outer wall is partially transparent through which the fluid can be visible.
2. A number (300–400) of invaginated scolices are found.

Strobillocercus

1. Presence of single evaginated scolex which is associated with a small chain of a few segments.
2. Posteriorly, there is presence of a bladder which is filled with fluid.

Procercoid

1. Solid bodied metacestode.
2. Posteriorly attached to a bladder bearing embryonic hooks.

Plerocercoid

1. Solid bodied metacestode.
2. Anteriorly scolex is found.
3. Embryonic hooks are absent.

Nematode

The eggs of nematodes are of different sizes and colour.

There are different stages of larva. Each stage of these larvae has its individual morphobiological character. In general the larva has oral opening, buccal capsule, oesophagus and intestine. Oesophagus may have clubbed posterior end, rhabditiform (two parts of oesophagus, one of which is pear-shaped and attached to the posterior rounded part), ventriculous and filariform type.

Protozoa

There are many developmental stages found during the biological development of protozoa. Some important stages are described here.

Oocysts/Cysts: In some protozoa sporulated oocysts (coccidian parasites) and cysts (amoeba) are the infective stages. The oocysts contain two or four sporocysts. Each sporocyst contains two or four sporozoites. In some species the sporozoites are not retained in sporocysts but they are free in the oocysts. In an ideal oocyst, polar cap, micropyle, oocystic residual material and sporocystic residual material are present. When the sporulated oocysts are ingested by the host, these are affected by enzyme (trypsin), bile, CO_2 and some other biochemical factors and the sporozoites come out.

Cysts are formed in case of amoeba, *Giardia,* etc. Cysts are generally double-walled and the embryo remains within it. The cyst contains one or more nuclei in accordance with the species.

Sporozoites: Sporozoites are released from the oocysts after being affected by different biochemical factors. These are elongated organisms which are motile and can penetrate through the cell membrane and enter within it. It is thought that the sporozoites release some proteolytic enzymes and enters into the cells. Sporozoites of *Eimeria* spp. easily enter into the cells like the epithelial cells.

Trophozoites: The sporozoites after entry into the cell become rounded up which are called trophozoites.

Schizonts: The nucleus of the trophozoite split up into several particles. Each particle takes a part of cytoplasm and ultimately becomes individual organism. Thus a number of organisms are produced in the cell from a single trophozoites. This is called schizont.

Merozoites: The organisms present in the schizont are called merozoites. Schizont bursts and merozoites come out. These are elongated and fusiform. The organisms are motile and can attack another cell and round up again.

Gamets: After formation of second generation schizonts the merozoites are transformed into macrogametes which are large rounded bodies. Some are transformed into microgametes.

Tachyzoites/Bradyzoites: These are developmental stages which are found in *Toxoplasma* and *Sarcocystis* spp.. In acute stage of the disease the tachyzoites are formed. These are elongated banana-shaped organisms, whereas the bradyzoites are formed in chronic stage of the disease.

There are no locomotory organs of cestodes, trematodes, nematodes. In these cases the whole body is involved in locomotion, whereas special locomotory organ is present in protozoa. In *Entamoeba* spp., temporary locomotory organ is produced at trophozoites. These are called pseudopodia which are finger-like structure of cytoplasmic elevation. From any part of cytoplasm the pseudopodia may arise. In *Trypanosoma* spp. locomotion is performed mainly by the flagella. In some species of *Trypanosoma*, the flagella remains up to the body end, whereas in others there are presence of free flagella. The membrane connecting the flagella with the body is an undulating membrane. This undulating membrane also participates for locomotion. *Trypanosoma vivax* organisms show very jerky movements. The movement is easily decernible only by taking a drop of fresh blood on the slide. Though the organisms will not be visible yet their movement can be perceived easily. In the *Tritrichomonas* spp., there is a trailing flagella and three anterior flagellae. The flagella trails behind the body and the anterior flagella guides the organism towards the anterior part. In *Balantidium coli*, locomotion is performed by cilia. The organism's outer surface is provided with numerous cilia.

Important Parasites and their Common Names

Name of parasite	*Common name*
Toxocara canis	Arrow-headed worm
Toxascaris leonina	Arrow-headed worm

Contd...

Name of parasite	*Common name*
Enterobius vermicularis	Pin worm or seat worm
Stephanurus dentatus	Kidney worm
Syngamus trachea	Gape worm or Y-shaped worm
Strongylus sp	Palisade worm, Red worm
Ancylostoma caninum	Hookworm of dog
Ancylostoma tubaeforme	Hookworm of cat
Ancylostoma braziliense	Hookworm of dog
Ancylostoma duodenale	Hookworm of man
Agriostomum vryburgi	Hookworm of zebu (*Bos indicus*)
Necator americanus	Hookworm of man
Bunostomum trigonocephalum	Hookworm of sheep and goat
Bunostomum phlebotomum	Hookworm of cattle
Gaigeria pachyscelis	Hookworm of sheep and goat
Globocephalus longemucronatus	Hookworm of pig
Bathmostomum sangeri	Hookworm of elephant
Haemonchus contortus	Stomach worm, wire worm, barber's pole worm
Ostertagia sp	Brown stomach worm
Dictyocaulus filaria	Lungworm of sheep and goat
D. viviparus	Lungworm of cattle
D. arnfieldi	Lungworm of horse and donkey
Metastrongylus elongatus	Lungworm of pig
Filaroides osleri	Lungworm of dog
Aelurostrongylus abstrusus	Lungworm of cat
Thelazia rhodesii, T. gulosa	Eye worm of cattle
T. lacrymalis	Eye worm of horse
T. callipaeda	Eye worm of dog
Oxyspirura mansoni	Eye worm of fowl
Trichuris sp	Whipworm
Trichostrongylus sp	Black scour worm
Spirocerca lupi	Park worm
Dirofilaria immitis	Heart worm
Dioctophyma renale	Giant kidney worm
Dracunculus medinensis	Guinea worm, Dragon worm, Medina worm, Serpent worm
Acanthocephala sp	Thorney-headed worm
Taenia saginata	Beef tapeworm
Echinococcus granulosus	Hadatid worm hyper or worm
Thysanosoma actinioides	Fringed tapeworm

Contd...

Name of parasite	*Common name*
Hymenolepis nana	Dwarf tapeworm
Proteocephalus ambloplictus	Bass tape worm
Gigantocotyle explanatum	Biliary amphistome
Paragonimus westermani	Lung fluke
Dicrocoelium dendriticum	Lancet fluke
Prosthogonimus pellucidus	Oviduct fluke
Clonorchis sinensis	Chinese liver fluke
Fasciola gigantica and F. hepatica	Common liver fluke
Fasciola jacksoni	Liver fluke of elephant
Schistosoma spp.	Blood fluke
Menopon gallinae	Shaft louse of poultry
Menacanthus stramineus	Body louse of poultry
Cuclogaster heterographus	Head louse of poultry
Lipeurus caponis	Wing louse of poultry
Goniocotes gallinae	Fluff louse of poultry
Haematopinus eurysternus	Short-nosed cattle louse
Linognathus vituli	Long-nosed cattle louse
Cimex sp	Bed bugs
Triatoma sp	Cone-nosed bugs, Kissing bugs or Assassin bugs
Echidnophaga gallinacea	Sticktight flea of poultry
Tunga penetrans	Jigger or chigoe
Xenopsylla cheopis	Oriental rat flea
Simuliidae	Black fly, Buffalo gnat
Ceratopogonidae	Biting midges, punkies, no-see-ums
Psychodidae	Sand flies or owl midges
Tabaneidae	Horse fly or Breeze fly
Musca domestica	House fly
Musca autumnalis	Face fly
Stomoxys calcitrans	Stable fly
Haematobia irritans	Horn fly
Haematobia exigua	Buffalo fly
Glossinidae	Tse tse fly
Calliphoridae	*Blow fly*
Calliphora sp	Blue bottle fly
Lucilia sp	Green bottle fly
Callitroga hominivorax	Screw worm fly
Cordylobia anthropophaga	Tumbu fly

Contd...

Name of parasite	*Common name*
Cordylobia rodhainai	Lund's fly
Sarcophaga spp.	Flesh fly
Oestrus ovis	Sheep nasal fly
Gasterophilus	Horse bot
Hypoderma lineatum	Ox warble fly
Hypoderma spp.	Cattle grub, Gad fly, Heel fly
Hippobosca spp.	Forest fly, ked
Melophagus ovinus	Sheep ked or tick fly
Dermanyssus gallinae	Red mite of poultry
Otobius megnini	Spinose ear tick
Argas persicus	Fowl tick
Ixodes ricinus	Castor bean tick
Ixodes scapularis	Shoulder tick or black-legged tick
Boophilus decoloratus	Blue tick
Rhipicephalus appendiculatus	Brown ear tick
R. evertsi	Red legged tick
Haemaphysalis leachi leachi	Yellow dog tick
Dermacentor nitens	Tropical horse tick
Amblyomma hebraeum	Bont tick
A. americanum	Lone star tick
A. variegatum	Variegated tick or tropical bont tick
Trombiculidae	Hearvest mite or Chigger mite
Pediculoides ventricosus	Grain itch mite
Cytodites nudus	Air-sac mite
Linguatula serrata	Tongue worm

PATHOLOGY CAUSED BY PARASITE

Different tissue reactions are caused by different parasites. Basic pathology caused by the parasite is similar to other organism. The pathology is initiated by inflammation. There occurs aggregation of different types of inflammatory cells. These cells also have immunological role. The reaction caused by different immune cells is also called immunopathology. As a consequence, different cellular changes occur. The changes are as follows:

Hypertrophy: It is simply an increase in size of cells which occur due to presence of the parasite within the cell.

Example: RBC infected with *Babesia* spp. is commonly enlarged. Another example is RBC infected with *Plasmodium vivax*.

Hyperplasia: Hyperplasia is an increased level of cell division. This condition occurs in several parasitic infections. When any organ is remarkably damaged by parasite, there occurs excessive level of tissue repair. For repairment rapid cell division occurs.
Example: There are many examples of hyperplasia. Hyperplasia of the wall of the bile duct occurs in infection of *Fasciola* spp. and *Dicrocoelium sp*.

Metaplasia: It is transformation of tissue without alternation of the embryonic tissue.
Example: The typical example is appearance of epithelial and elongate fibroblast cells in lungs infected with the *Paragonimus westermanii*. Usually, these cells do not occur in the lung but in *Paragonimus infection* formation of these cells occurs. In many other parasitic infections, like *Ostertagia* spp., one type of cells are differentiated into another type of cells.

Neoplasia: Neoplasia is the formation of new structure. Tumours are the neoplastic tissues. There are two type of tumours, benign and malignant.

- **Benign tumour:** The cells cannot metastasize.
- **Malignant tumour:** Cells can metastasize.

Many parasites are harmful to the hosts as these cause detrimental effect to the host leading to ill health. There are many ways by which a parasite can cause damage to the hosts. Hereby, the following aspects are described.

HARM CAUSED BY PARASITE

1. Utilisation of Nutrition

Utilisation of host's nutrient is a common feature. The parasites get nutrition from two sources.

a. *Utilisation of preformed food:* The parasite can take up the preformed food of the host (glucose, amino acids).
b. *Utilisation of crude food:* The parasite can take up the unprocessed food consumed by the host (carbohydrate, protein, etc.).
   Example: A citable example of utilisation of host's nutrient by the parasite is competition for Vit B_{12} by *Diphyllobothrium latum* which results in pernicious anaemia in man.

2. Removal of Blood

Some nematodes are blood-suckers (*Haemonchus* spp., *Ancylostoma* spp.). The worms suck blood from the host continuously and the hosts become anaemic and even death of animals may occur due to excessive loss of blood.

3. Mechanical Interference

Damage is caused to the host due to mechanical interference by parasites. It becomes very dangerous when these parasites occur in the vital organs, viz. lung, liver and eye, etc.

a. Elephantiasis is a good example of mechanical interference. The adult worms of *Wuchereria bancrofti* are lodged in lymphatic duct leading to blockage of the duct due to extra accumulation of lymph.
b. The larvae of the cestodes/bladder worms/cysts/metacestodes cause mechanical obstruction at the vicinity of the parasites. Hydatid cysts cause mechanical

obstruction of the oesophagus and diaphragm of the host. Coenurus cyst (larval stages of *Taenia multiceps*) causes extreme pressure in the brain of the host.

c. The large tapeworms and roundworms in large numbers mechanically obstruct the lumen of the intestine causing functional disturbances. The worms cause formation of bundle or ball which obstruct the passage of the GI tract. Long tapeworm (*Diphyllobothrium latum*) causes formation of bundle or ball which obstructs the food passage of the intestine resulting in functional disturbance.

4. Harm Caused by Toxins/Saliva, etc.

Toxins/saliva of the parasites cause marked pathological changes in the host. Most of the toxins are proteinous in nature which cause allergic reaction. Allergic reaction due to tick, flea, lice and other ectoparasitic infection is common feature. A well-known parasite toxin (allergin) has been found in the body fluid of some worms. This allergin causes irritation of the cornea and mucous membrane of the nasopharyngeal cavity, a commonly encountered clinical feature occurring in the parasitologists who work regularly with ascarid worm for a long period.

5. Metabolic By-product

The tapeworms release the metabolic by-product which causes damage to the nervous system of the hosts resulting in several nervous disorders.

6. Tissue Feeding

The immature amphistomes are called plug feeders because these parasites ingest plug of intestinal mucosal materials which alter the selective permeability of intestinal wall and result in huge loss of plasma protein leading to hypoproteinemia. The hypoproteinemia is associated with the clinical signs of submandibular oedema called bottle jaw. *Fasciola* and other parasites utilise the tissue of the host.

7. Indirect Harm

a. The host fails to get optimum nutrient due to less absorption of food through affected gut wall.
b. The affected animals refuse to take food and drinking water. The heatlth of animals go down.
c. Alternation of selective permeability of gut wall results in different digestive anomalies.
d. Depression of haemopoietic system.

8. Immunopathology

Different cytokines and immune cells are responsible for causing immunopathology.

9. Hyperparasitism

Heteraxis gallinarum transmit a pathogenic protozoa, *Histomonas meleagridis*, causative agent of black head of turkey.

10. Concurrent Infection

Fasciolosis is aggravated by *Clostridium oedermatiens novyi*. Secondary bacterial infection occurs at the parasitised area.

11. Other Types of Harm

Sometimes the parasites or the larvae of the parasites die in the vicinity. The body of the parasite becomes decomposed and is absorbed through the host's tissue. This condition leads to anaphylactic condition.

RESISTANCE OF ANIMALS TO PARASITE

Suceptibility of different animals varies. Some animals are resistant to some parasites, whereas some are susceptible to some parasites. *Trypanosoma cruzi* occurs in man but they never occur in cattle. *Eimeria tenella* occurs in birds but they do not occur in man. *Paragonimus westermani* occurs in dog and man which do not occur in cattle. N Dama is resistant to *Trypanosoma* spp.. This species influence is undoubtedly due to genetic determination. Sex and age are also factors of host resistance. *Trichomonas vaginalis* occurs in female but do not occur in male. Some parasites occur in young animals and they do not occur in older animals. *Eimeria tenella* causes disease in young birds (3–4 weeks). They do not cause disease in the older birds. Young animals are resistant to *Babesia bigemina* and the older animals are susceptible to this aparasite. The differences of occurrence in relation to sex and age are largely influenced by hormone and immunity. In many cases the animals generate immunity after natural infection of different parasites. The birds which survive after coccidiosis develop a solid immunity. Self-cure phenomena is another example of acquired resistance. The animals which are already sensitised with *Haemonchus* infection, eliminate the subsequently infected parasites.

Name of pathological conditions/symptoms	***Brief description***
Clay pipe stem liver	It is a condition of bile duct occurring in the chronic fasciolosis. The highly calcified bile duct protrude out from the surface of the liver and are difficult to cut by the knife. The bile duct looks as if like a hard pipe. This condition is called clay pipe–stem liver.
Hazel nut-sized cyst condition	This condition occurs due to aberrant migration of the immature fluke of *Fasciola hepatica* in the lungs. Here they form the hazel nut-sized cysts filled up with a brownish purulent gelatinous material within which living or dead parasites remains.
Black disease	In normal healthy sheep, *Clostridium oedematiens novyi* occurs. But these organisms produce the disease when the liver is damaged by the acute fasciolosis and the organisms take the advantage of the animals under stress condition. The condition of fasciolosis is further aggravated.
Salmon poisoning or Elokomin fluke fever	It is caused by the rickettsial agent named *Neorickettsia helminthosa* transmitted by *Nanophytes salmincola*.
Snoring disease	Granulomatous growth in the nasal cavity and proliferation of nasal epithelium lead to cauliflower-like appearance which occurs due to deposition of granulamatous tissues and the deposition of the tissue is initiated by the eggs which release some kind of soluble antigen which are the enzymes present in the miracidium.

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Name of pathological conditions/symptoms	*Brief description*
Clam digger's itch/Hunter's itch/gale des nageurus/ badedermatitis/rice paddy itch/lake side disease	This is a condition which is occurred due to allergic reaction caused by the penetration by the cercariae of non-human schistosomes into the human skin. There is severe dermatitis associated with pruritus. This situation does not occur when the individual gets first exposure of cercariae but in the subsequent events different anomalies comprising dermatitis occur.
Bottle jaw	Bottle jaw condition is the occurrence of oedema in the intermandibular region as a result of hypoproteinemia due to some parasitic infection, i.e. *Fasciola*, *Haemonchus*, *amphistomes*.
Gid or staggers	A condition which occurs due to development of coenurus cyst in the brain of sheep and goat. There is pressure atrophy of skull and the skull becomes thinner with the advancement of the condition which may even lead to perforation of the skull. There is hyperaesthetic condition of the animals. The animals move in a circle and show jerky or staggering gait.
Pernicious anaemia	It is caused due to deficiency of Vit B_{12} in human beings resulting from competition between the parasite and hosts. In other words, it could be told that the parasites assimilate the host's Vit B_{12} and cause the hosts deficient from this vitamin.
Cerebral cysticercosis or neurocysticercosis	Human being is the definitive host of *Taenia solium*. But sometimes, man may act as an intermediate host and formation of cysticercus occurs in the brain. The infection occurs by ingestion of eggs of *Taenia solium* along with the food or by autoinfection.
Hump sore	It is a chronic verminous dermatitis in hump region of cattle caused by *Stephanofilaria assamensis* in the Indian Subcontinent.
Milk–spot	Due to infection of *Ascaris suum*, white spots appear in the liver and these spots are formed by varying degrees of fibrosis which is stimulated by the migrating larvae.
Husk or hoose disease	This is mainly caused by *Dictyocaulus viviparus* infection in cattle. Extensive damage occurs in lung and the animals exhibit the clinical signs of coughing, dyspnoea. Harsh respiratory sound is heard due to emphysematous crackling in lungs.
Pimply gut	Nodules are formed on the wall of the large intestine of the affected animal due to infection by *Oesophagostomum* spp.
Cutaneous larva migrans (CLM)	Larva of some nematodes causes this condition in human beings particularly children and some other hosts. The infection of larve causes formation of papule, oedema and pruritic lesion due to migration performed by the larvae. The larvae of nematodes, *Ancylostoma braziliense, Ancylostoma caninum, A. duodenale, Bunostomum phlebotomum, Gnathostoma sp* cause CLM.
Visceral larva migrans (VLM)	Larvae of some nematode migrate into different internal organs and affect them. Larvae of *Toxocara canis* are the main cause of VLM which is usually found in children. However, other species, i.e. *Toxocara cati, Toxascaris leonina, Lagochilascaris minor* can also cause VLM.
Morocco leather	This is a condition of the wall of the stomach due to *Ostertagia* infection. The wall of the stomach appears as morocco leather

Contd...

Name of pathological conditions/symptoms	*Brief description*
Cutaneous habronemiasis/ Granular dermatitis/Summer sore/Bursati	This condition is caused by deposition of larvae of *Habronema sp* and *Draschia sp* in existing wound by the infected flies. Eye region is mainly affected. Wort-like lesions are found mainly in the nictating membrane or surrounding tissue.
Sore head	It is a filarial dermatitis occurring in sheep by *Elaeophora schneideri*.
Hump sore	It is a chronic verminous dermatitis in cattle caused by *Stephanofilaria assamensis* in the Indian Subcontinent. This parasitic condition is highly prevalent in West Bengal, Asom and other north-eastern states of India.
Enzootic cerebrospinal nematodosis	It is caused due to migration of larvae of *Setaria digitata* and other *Setaria* spp. in the brain resulting in acute focal encephalomyelomalacia and other associated pathognomoic conditions like meningitis, encephalitis and meningoencephalitis.
Ocular onchocercosis or river blindness	It is the pathological condition of eye of man characterised by keratitis, conjunctivitis and periodic ophthalmia, etc. caused by *Onchocerca volvulus*.
Miliary dermatitis	This condition occurs in cats due to hypersensitive reaction caused by flea. The clinical conditions are associated with formation of small papules. The condition is further aggravated by scratching to alleviate pruritus.
Sweet itch, Sweat itch or Summer dermatitis, Queensland itch	In warm summer climate horses and ponies suffer from a condition of seasonal dermatitis. It is caused by the bite of *Culicoides* flies leading to an allergic reaction.
Miliary dermatitis	This condition occurs in cats which is characterized by formation of small papules associated with pruritus as a result of hypersensitive reaction due to flea-bite.
Queensland itch	A characteristic allergic dermatitis is caused by the bite of *Cubicoides robertsi* in horses occurring in Queensland area. The other names of the condition are sweet itch, sweat itch.
Broken head	*Hydrotaea irritans* are sheep head fly. Large number of flies swarm around the animal and cause irritation and annoyance which make the animals to knock their heads on hard objects.
Foot mange or itchy leg	*Cnemidocoptes bovis* cause lesions in the legs of horses characterized by itching and scab formation on fetlocks.
Scaly leg	*Cnemiolocoptes mutans* cause this condition in fowl which is characterised by exudations and inflammation from the toes upward.
Depluming itch	*Cnemidocoptes gallinae* cause this condition in fowls. The inflammatory condition occurs by burrowing into the skin alongside the shaft of feathers.
Strike	Strike is a myiasis condition which occurs on the skin of sheep due to deposition of larvae. In the sheep, in some areas of the body surface, skin-folds are found. In this fold, water is trapped which acts as a good medium for growth of bacteria. Due to this bacterial growth a typical smell is produced which attracts the blow flies. The blow flies deposit larvae and aggravate the condition further which is called strike.

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Name of pathological conditions/symptoms	*Brief description*
Tail strike	Strike which occurs on the tail.
Breech strike	The strike which occurs on the breech region.
Pizzle strike	This is a strike condition which occurs in the rams and wethers of sheep. The sheath of the ram is affected and the area is soiled by urine.
Poll strike	This situation occurs in the region of horn close to the head.
Body strike	The strike which occurs in the body of the animal is called body strike.
Cutaneous myiasis	This myiasis occurs in the skin of the back region of the animal due to ox warble fly, *Hypoderma lineatum* and *H. bovis*.
Ophthalmomyiasis	This myiasis occurs in the eye region caused by *Rhinoestrus purpurensis*.
Nasal myiasis	A myiasis occurring in nasal orifice caused by *Oestrus ovis* larvae.
False gid	This condition is caused by larval stage of *Oestrus ovis* in nasal cavity. The clinical signs are associated with restlessness, in coordination, high stepping gait and circling movement or interrupted straight movement.
Delhi boil	This is cutaneous leishmaniosis caused by *Leishmania tropica*. Human beings are usually affected with skin lesions. Dog may also suffer from this.
Espundia	A cutaneous form of disease caused by *Leishmania braziliense* is called espundia
Nagana	This is caused by *Trypanosoma congolense* in cattle. Massive destruction of RBC and depression of haemopoietic system result in severe anaemia which may cause death of animal. The meaning of Nagana is 'to be in low or depressed spirit'.
Mal-de Caderas	This disease is caused by *Trypanosoma equinum* transmitted by *Tabanus* fly. The disease is characterised by eye lesions, pyrexia, plaques on neck and flank region, etc.
Sleeping sickness	This disease occurs in man and caused by *Trypanosoma rhodesiense* and *T. gambiense* which are transmitted by *Glossina* spp. The organisms affect the nervous system. The affected individual looks sleepy.
Dourine	This a venereal disease caused by *T. equiperdum* occurring in equines. The disease is characterised by oedema in vagina, prepuce and formation of sharply circumscribed urticarial plaques. These plaques appear as dollar spots under skin. The meaning of 'dourine' is unclean.
Surra	This disease is caused by *Trypanosoma evansi* which is transmitted by *Tabanus, Stomoxys* and *Lyperosia.* The disease occurs in different animals. The major pathological features in horse are anaemia, emaciation, urticarial plaques and ulcerative lesions in mucocutaneous junctions.
Punched out ulcer	This is a type of ulcer (punched out appearance) found in the abomasum and intestine due to *Theileria annulata* infection.
Flask-shaped ulcer	This is a typical ulcer found in the intestine of affected individual due to the infection by *Entamoeba sp*.

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Name of pathological conditions/symptoms	*Brief description*
Post Kala-azar Dermal Leishmanoid	Some patients after cure of visceral leishmaniosis show a kind of dermal leishmanoid containing numerous parasites. In this case, no generalised infection is found. This is called post kala-azar dermal leishmanoid (PKADL)
Black head	This is a protozoan disease caused by *Histomonas meleagridis* occurring in turkeys. The head and wattle become discoloured and cyanotic. Mainly, the liver and intestine are affected. That is why this is also called enterohepatitis. Yellow sulphur coloured dropping is the characteristic clinical sign.
Chagoma	Reduvid bugs (Kissing bugs) feed near the lips and near eyes and transmit *Trypanosoma cruzi* in man. The organisms at first multiply in histiocyte. There occurs inflammation and swelling on different areas of face. These are called chagoma lesions. The disease is called Chagas disease.

IMMUNITY

General Information

Immunoparasitology has taken a major part in the field of veterinary parasitology mostly in respect of the diagnosis and immunoprotection. In the yesteryears most of the research works were concerned to the study of basic morphology, biology, treatment and general control measures. In the present decades, there have been an explosion on the parasitic immunology and it has entered to the field of molecular parasitic immunology. In this respect it is a remarkable development in the field of parasitology. The most remarkable constraint in developing suitable diagnostic technique and vaccination lies to the nature of the parasitic antigen which is very complex one. Antigenic variation is another constraint of the same. Still workers are engazed to the search more and more new antigens which may be worth of diagnosis as well as control. In 1940s parasitic immunity was first recognised by viewing self-cure phenomena. Since then work on parasitic immunity has been a continuous process.

Some Important Definitions

Adjuvant: A substance which is used along with the antigen to potentiate the vaccine.

Agglutination: The reaction between the particulate antigen and the antibody.

Allergy: This is immediate type of hypersensitivity (type 1).

Antibody dependent cell mediated cytotoxicity: This is lysis of target cell by the action of the antibody and the cells possessing Fc receptor.

Attenuation: The reduction of the virulence of an infectious agent by chemical, radiation, heat, etc.

Carrier: This is immunogenic substance and is bound to the hapten for eliciting immune response.

Cluster of differentiation: These are specific receptor molecules which recognise specific protein molecules.

Complements: These are complex-linked proteins which are activated as a result of antibody–antigen reaction.

Cytokines: These are regulatory proteins released by a specific type of cells.

Dendritic cells: These are macrophage like cells performing the function of antigen presentation.

Desensitisation: Multiple injections of the antigens result in prevention of type 1 hypersensitivity reaction.

Effector cells: These are the cells responsible for the immune response.

Fc receptor (FcR): This is a receptor presents in the cell surface which bind with the Fc region of the immunoglobulin.

Granulocytes: These are the leucocytes containing the cytoplasmic granules.

Epitopes: These are the sites of a large antigenic molecules against which the immune response is triggered. It is not that whole surface can mount an immune response. The sites which can stimulate immune response called epitopes or antigenic determinant.

Hapten: These are substances of low molecular weight (less than 1000 Da) which fails to trigger an immune response because these are not appropriately processed and presented to the immune system. If these small molecules are chemically linked with large protein molecules they can stimulate an immune response. These small molecules are called hapten and the large molecules with which they are linked are called carriers. Penicillin is small molecule which get degraded to penicilloyl which binds with serum protein (albumin) and form penicilloyl—albumin conjugates and this conjugate can elicit an immune response.

General Character of Antigen

Structural stability: The antigen which is not stable and having highly flexible shape is not a good antigen. That is why gelatin is a poor antigen because it lacks structural stability.

Molecular size: The size of the antigenic molecules is very important. Large molecules are better antigen than the small molecules. However, the small molecules may elicit immune response, if they bind with other large molecules and the resulting complex acts as a good antigen.

Foreignness: The antigen should be non-self. Immunogenicity of an antigen depends on the degree of foreignness. Some antigens are partially similar to the host antigen and this type of antigen cannot confer complete immune response. Actually in the foetus stage some specialised cells recognise their own antigen. However, these specialised cells sometimes fail to recognise their own antigen and develop autoimmunity.

Degradability: The substance which is not degraded easily cannot elicit an immune response. Stainless steel is not degraded. That is why these are used for implantation. On the other hand, if the substance is unstable or destroyed very rapidly cannot be a good antigen.

Important Immune Cells and their Roles

Neutrophil

These are major cells of myloid system. In the nutrophils, there are two types of enzyme rich granules. The primary granules contain the major enzyme myeloperoxydase and lysozymes. Other enzymes in these granules are elastase, acid hydrolases, etc. The secondary granules contain collagenase and lysozyme. The surface of the nutrophil is negatively charged and the particles are also negatively charged and repel each other (zeta potential). But the negativity of the particles is neutralised when antibody or complement (C3) binds with it. Then the nutrophils become able to bind with the particle. This process is called opsonisation. The organisms are killed by the process called respiratory bursts and subsequently digested by different enzymes.

Eosinophil

These are second major polymorphonuclear granulocytes. These cells come from the bone marrow and get matured in the spleen. They perform many roles in destruction of the large organisms, i.e. parasites. The eosinophils destroy the small particles by engulfing but extarcellular destruction occurs in case of large parasite. Unlike the nutrophil, it contains acid phosphatase and peroxidase. The enzymes of the eosinphils are far more strong than the nutrophils. The eosinphils also perform respiratory burst. However, they use the bromides instead of chloride producing OBr. Other properties are more or less same as that of the nutrophils. The eosinophils also contain some proteins like eosinophilic basic protein. The eosinophils reach to the affected place as a result of a chemotactic action and start their function. They get attached to the particles by opsonisation.

Basophil

Basophils are the granulocytes. The cytoplasmic granules take the basic dyes (haematoxylin). The basophils come to the tissues by the influence of the lymphocytes. The granules contain vasoactive amines, i.e. histamines and bradykinin, etc.

Macrophage

These are mononuclear phagocytic cells. They have great role in immunity. The primary role is phagocytosis. The phagocytosis pattern is similar to that of the nutrophil. The macrophages have different names. They are called kupffer cells when they are present in the liver sinusoids. They are called the alveolar macrophages when they are present in the lung and are called the histiocytes when they are found in the connective tissues. They are called the glial cells when they are present in the brain. The precursor of the macrophages are the monocytes. The stem cells diffentiate to form promonocytes. These promonocytes further differentiate to form the monocytes under the influence of the colony stimulating factors. If we want to understand the phagocytosis by the macrophages, it is better to discuss about the phagocytosis nature of the neutrophils. At first the nutrophil comes to the tissues when any foreign enters in the body. The nutrophil performs its role. The dying nutrophils release elastase and collagenase which act as the monocytic chemotactic factors. The macrophages contain catalases but they do not have myeloperoxidase. They perform respiratory burst but this is not so

prominent as that of the neutrophils. They can produce nitric oxide which are utilised for killing the organisms. It is the fact that activation of the macrophages is very important. When the monocytes enter the area of the inflammation, the lysosomal enzymes are increased, the expression of the receptor for the antibody, complement, etc. occurs. These are called the inflammatory macrophages. The inflammatory macrophages get activated by the action of the product of the foreign body (bacteria, etc.). Then the macrophages are called the activated macrophages. In a long-standing inflammatory conditions, a large number of macrophages gather around the foreign body giving the appearance of the epithelium, thus called the epitheloid cells. The epitheloid cells fuse to form the giant cells.

Immunity to Different Parasites

Protozoal Immunity

1. There are many records of non-immunological defence mechanisms. As for example, N-dama cattle are resistant to *Trypanosoma* organisms. This has occurred due to continuous genetic selection of the hosts against the organisms. Another one good example is sickle cell anaemia. The patients do not suffer from malaria infection.
2. Protozoa can initiate both humoral and cell mediated immunity.
3. There are many records that protozoa elicit good antibody response. Prozoa are also killed by antibody dependent cell mediated cytotoxicity. There is another one important example of protozoa elimination. Due to *Tritrichomonas* infection, there occurs formation of local mucosal antibody (IgE). This initiate a type 1 hypersensitivity. Due to this hypersensitivity reaction, the released histamin and other biochemicals increase the permeability of blood vessel. Then IgG can easily pass through the blood vessel which kill the organisms.
4. In *Babesia* infection, the infected erythrocyte incorporates the antigen into their membrane and the antibody molecules get adhere to the surface of the RBC (opsonisation). These opsonised cells are cleared up by mononuclear phagocytic system.
5. Both cell mediated and humoral immune response have been found in *Toxoplasma* infection. The sensitised T lymphocytes release a kind of cytokine which activates the macrophages for fusion of lysosome—phagosome and after fusion, lytic enzymes are released which kill the organisms. T cytotoxic cells release toxic substance which kill the organisms.
6. In *Theileria* infection cytotoxic T cells kill the infected lymphoblasts.

Helminthic Immunity

1. There are many records of non-immunological defence mechanism in case of helminthic infection. Breed, sex, species, etc. are the factors which create the differences of infection. All types of immunoglobuilins are produced in helminthic infection, i.e. IgG, IgD, IgA, IgM, IgE, etc. However, IgE has a great role in helminthic immunity. This antibody creates a characteristic hypersensitivity 1 reaction which kills the organisms. A good example of role of IgE antibody is self-cure phenomena. The reaction of antigen and mast cell-bound IgE causes release of vasoactive amines (i.e. histamine). This causes high contraction of intestinal musculature and at the same time it increases the permeability of blood vessels which result into efflux of body fluid. This conjoint effect causes expulsion of the worms. Macrophages bind

with IgE through Fc receptor which then get activated and release interleukin 1, leukotrienes, etc. which conjointly cause destruction of parasite.

2. There are many evidences of cell-mediated immune response in helminthic infection. The eosinophil has also a great role in destruction of the parasites. Eosinophils release eosinophilic basic protein which kills the organisms. Cytotoxic T cells release toxic substances which kill the parasites.

Arthropod Immunity

There are some good examples of arthropod immunity. In case of flea bite, a kind of immunological reaction occurs. The flea release saliva which contain proteins of low molecular weight. This protein acts as hapten and bind with skin collagen. This in turn causes a local type IV hypersensitivity reaction. This reaction invites infiltration of mononuclear cells. In some arthropod infection, Type 1 hypersensitivity occurs as a result of reaction between antigen and mast cell-bound IgE. This activate the mast cells which subsequently degranulate and release vasoactive amines. In tick infection, both cell mediated as well as humoral immunity occur. Many works have been carried out on vaccination against tick by using tick gut antigen.

Immune Evasion by Parasites

What is Immune Evasion?

It is simply the phenomena of parasite to escape the host's immune attact. Host immunity tries to kill the parasite. But the parasite tries to resist this attack by different means as follows:

1. *By molecular mimicry or adsorption of host antigen:* The parasites disguise themselves by musking their surface with host antigen molecules. In this situation the host's immune system cannot recognise the parasite. Many helminthic parasites do this.
2. *Antigenic variation:* Once the host has been able to develop immunity against any particular parasite, then the parasite immediately changes their surface antigen. Previously developed host's immunity fails to destroy the parasite with new antigen. *Trypanosoma* parasites frequently change their antigen.
3. *Blocking antibodies:* Some parasites are able to destroy the antibody molecules. The antibody molecules get separated into Fab and Fc regions by the enzymes and other bio components from the parasite.

   Frequent and long-term exposure of parasite causes development of tolerance against the antigen and they become desensitised. No immunological reaction occurs further.

Immunity: It is the defence of the body against any infection.

Parasitic immunity: It is the defence of the body against any parasitic infection.

Antigen: Antigen is a substance which can elicit an immune response.

Antibody: It is the immunoglobulin produced against an antigen.

Parasitic antigen: It is a substance of the parasite which can elicit an immune response in the host.

Immunogenicity: The ability of a molecule of an immunogen to produce an immune response.

Antigenicity: The ability of a molecule of an antigen to be recognised by immune response.

Characters of Parasite Antigen

1. The parasitic antigen is a complex mosaic protein. In a crude mass of a parasitic protein, a number of individual proteins are present.
2. Foreignness of parasitic antigen is less. In most of the cases, host proteins and parasitic proteins have common antigenic determinant. Due to less foreignness, it is difficult to produce potent vaccine.
3. Crude parasitic antigens elicit poly-specific sera.
4. The parasites can frequently change their antigens as per requirement.

Different Types of Parasitic Antigen

A. Crude Antigen

a. *Somatic antigen:* Somatic antigen is prepared by homogenisation of the whole parasite.
b. *Excretory and secretory antigen:* The excretory-secretory or the metabolic by-product of the parasite is called excretory-secretory antigen.

B. Purified Antigen (Defined Antigen)

a. *Purified native antigen:* A particular protein from a crude mass of the parasitic protein is called purified antigen. The protein is isolated from the crude protein derived from the whole parasite by different protein-purification protocol like gel exclusion chromatography, ion exchange chromatography, affinity chromatography, etc.
b. *Recombinant antigen:* A particular parasitic protein is expressed in expression-v cells by recombinant DNA technology.

N.B. Some isoenzymes like Glutathione S-transferases, cathepsin-L and FABP, etc. have already been expressed by recombinant DNA technology.

Different Parts/Stages of Parasites used as Antigen

1. *Cuticle or tegument:* Outer covering of parasite is used as antigen.
2. *Subcellular fraction:* Flagellar antigen of *Trypanosoma* spp. is a good example.
3. *Excretory–secretory antigen:* Metabolic by-product and other excretory–secretory material is used as antigen.
4. *Eggs:* Eggs of parasites are used as antigen.
5. *Larva:* The antigen can be prepared from the larva of the parasite.
6. The moulting fluid can be used as antigen.

Definitions of Different Immunities

Invertebrate immunity: The immunity or defence which occurs in the invertebrate host is called invertebrate immunity.

Vertebrate immunity: The immunity which occurs in vertebrate host is called vertebrate immunity.

Innate immunity: The immunity or defence which is naturally present in the body is called innate immunity.
Example: Saliva contains some kind of enzymes which kill the organisms.

Acquired immunity: The immunity which is acquired by natural or artificial means.
Example: Immunity against coccidian parasites occurs after infection of coccidian parasites.

Active immunity: Immunity which occurs as a response of administration of an antigen.
Example: Immunity after occurrence of any parasitic infection is an example of active immunity.

Passive immunity: It is passive transfer of immunity from immuned individual to unimmuned individual.
Example: Antibody is transferred from the immuned individual to unimmuned individual

Humoral immunity: It is antibody-mediated immunity. B lymphocytes play predominant role in this immunity.
Example: Humoral immunity occurs in many haemoprotozoan infections.

Cell-mediated immunity: It is the immunity which is mediated by lymphocytes, macrophages, NK cells and other immune cells and not by antibody.
Example: Tc cells (T-cytotoxic cells kill many organisms).

Autoimmunity: It is a type of immunity which occurs against self-antigen.
Example: In many autoimmune diseases (rheumatoid arthritis) immunity occurs against self-antigen.

Parasitic immunity: Immunity which occurs against the parasites is called parasitic immunity.

Bacterial immunity: Immunity which occurs against the bacteria is called bacterial immunity.

Viral immunity: Immunity which occurs against the virus is called the viral immunity.

Sterilising immunity: The immunity which remains still in absence of organisms after any infection has taken place is called sterile immunity.
Example: After the infection of coccidiosis, the immunity remains in absence of the organisms.

Preimmunity: This is a type of immunity which occurs when the parasites are present in the host. In other way, it is called preimmunity, which is elicited only in presence of parasite. Immunity wanes in absence of the parasites.
Example: Preimmunity is found in *Babesia* and *Theileria* infection.

Latent immunity: Same as preimmunity.

Partial immunity: It is a type of immunity when complete immunity does not occur.

Concomitant immunity: The immunity which occurs against invading larva but not against existing infection.

Mixed immunity: The immunity which occurs due to infection of mixed parasitic or any other organism-infection.

Cross immunity: The immunity elicited by one organism can also protect other organism is called cross immunity.
Example: Immunity against *Fasciola* parasite can also protect amphistomes.

Basic Events Which Occur in the Humoral and Cell-Mediated Immunity

A. Cellular immunity

1. Antigen enters into the body and is processed endogenously.
2. Antigen is recognised by the antigen presenting cells (APC) having MHC-I molecules.
3. Antigen bound to MHC-I molecules triggers cytotoxic T cells.
4. Cytotoxic T cells kill the antigen.

B. Humoral Immunity

1. Antigen enters into the body.
2. Antigen is recognised by the antigen presenting cells (APC) having MHC-II molecules.
3. Antigen is processed and presented to helper T cells.
4. B cells get activated after priming with antigen getting physical contact with helper T cells.
5. Activated B cells transform into the plasmoblast cells.
6. Plasmoblast cells transform into plasma cells which secrete antibody.

General Note: The activated T cells produce four types of effector T-cells as follows:

a. T-helper cells (Th 1 and Th 2)
b. T-cytotoxic cells (Tc)
c. T-DTH cells
d. T-suppressor cells (Ts)

Tc cells play major role in cell-mediated immunity. Tc cells release some kind of chemical which kills the organisms. T-helper cells have role in humoral immunity.

GENERAL CONTROL OF PARASITIC DISEASE

A. Control Target Towards the Hosts

a. Affected animals should be treated properly.
b. Unaffected animals should be provided with the prophylactic treatment.
c. The affected animals should be kept isolated.
d. New stock should be detected properly for presence of any parasitic infection.
e. General managemental practices:
   i. The animals should be maintained in a hygienic way.
   ii. The animals should not be allowed to graze on the low land area. The animals should be allowed to graze on the high land area.
   iii. As far as possible, animals should be allowed to drink underground water.
   iv. Pond, lake or any water reservoir should be fenced off.
   v. The animals should be allowed to graze rotationally in different areas as follows:
      1. Rotational grazing with the same animals.
      2. Rotational grazing with different animals.
   vi. The faeces of the animals should be disposed off properly. In a particular pit, the faeces should be disposed off. This has an added advantage that the fermentation of the faeces produces some amount of heat which can kill the eggs or larvae.

vii. Pasture management should be done as follows:
    1. Pasture resting
    2. Pasture burning

f. Vaccination of animals should be done as follows:
    i. Vaccination by crude antigen
        1. Live parasite
        2. Attenuated parasite
        3. Somatic antigen
        4. Excretory and secretory product of parasite
    ii. Vaccination by the purified antigen
        1. By native purified protein of parasite
        2. By recombinant protein.
    iii. Vaccination by naked DNA (gene immunisation): The animals are immunised by respective naked DNA of a parasite protein.

g. Breeding policy: Tolerant animals which are genetically resistant to some parasites are used for breeding.

B. Control Targets Towards Intermediate Hosts/Vectors

1. Chemical control: Different chemicals are used to kill the intermediate hosts/vectors. $CuSO_4$ is used to kill the mollusca. Insecticides are used to kill the blood sucking flies which are the vectors of different haemoprotozoan parasites.
2. Biological control: One organism is used to control other organism. Gambusia fishes are used to kill the mosquito larvae. Birds are reared to control the snails. Nematophagus/nematode-trapping fungi are used to control the nematodes.
3. Genetic control: Breeding of insects is done in such a manner that sterile insects are produced.
4. Other indirect control: The game animals are killed. The blood sucking flies die being deprived of the blood meal which is taken from game animals because of less population of the game animals.

CHEMOTHERAPY

Use of Antiparasitic Drug

The antiparasitic drugs are used either therapeutically by treating the existing infection or prophylactically by using the drug in an attempt so that the disease does not occur, which is based on the epidemiological knowledge. Some drugs are administered in a particular interval throughout the year or in some particular season in a routine manner which prevents the occurrence of disease. The uses are as follows:

Therapeutic usage: There are several points which should be taken into account. Drug should be chosen as per the stage of parasitic infection. The drug should remove the parasite satisfactorily so that the exhibited clinical signs would stop. The drug should not cause any side effect.

Prophylactic usage: Prophylactic treatment is far more important than therapeutic treatment. A person should concern to many important aspects while performing prophylactic treatment. There should not be any misuse of drug. Proper selection of

season or time is essential for prophylactic use of drug. Use of drug should be cost effective. Continuous use of drug should not develop any drug resistance. It should not affect normal immunity.

Some important drugs and their mechanism of action

Benzimidazole/probenzimidazole: Prevent glucose uptake of the parasite.

Imidazoles/tetrahydropyrimidines: The drugs act as depolarising neuromuscular blocking agents.

Piperazines: The drugs have anticholinergic action and cause paralysis to the parasites.

Avermectins: The drugs potentiate the release and binding of Gama-aminobutyric acid (GABA). This results in paralysis of the parasites due to disturbances of signal transmission which is performed by GABA.

Salicynilides/substituted phenols: The drugs cause uncoupling of oxidative phosphorilation resulting in interference of ATP production.

Organophosphates: These drugs are cholinesterase inhibitor, thus causing muscular paralysis of the parasites.

Carbamates: These drugs are cholinesterase inhibitor and cause muscular paralysis of the parasites.

Pyrethroids: This acts as neurotoxin and affect motor as well as central nervous system.

Administration of antiparasitic drugs

Oral administration

a. By drenching (liquid or suspension)
b. Through drinking water
c. Through the feed
d. Through the tablets in small ruminant
e. Paste for licking
f. Self-medication by licking urea block.

By injection

a. Intraruminal injection
b. Intravenous injection
c. Intramuscular injection
d. Subcutaneous injection

Topical application

a. Pour-on
b. Spraying
c. Dipping
d. Dusting powder
e. Ear tag
f. Tail bands, leg bands
g. Collars

Some considerations of drug use

1. The proper dose of the drug should be maintained.
2. The drug should be properly chosen.
3. Proper timing for the drug administration is necessary.
4. Proper interval of drug administration should be maintained.
5. The drug should have proper combination.

The following points should be considered while administering any drug:

1. The drug should be non-toxic.
2. The drug should be easily administrable.
3. The drug should be easily metabolised.
4. The drug should be effective against all stages of the parasites.

Different Drugs Administered against Different Parasites

Drugs Administered against Nematodes

1. *Benzimidazole/Probenzimidazole:* Albendazole, Fenbendazole, Oxfenbendazole, Oxifenbendazole, Flubendazole, Netobimin, Thiophanate, Fenbantel, Mebendazole, Cambendazole, Parbendazole.
2. *Salicylanilides/substituted phenols:* Closantel, Nitroscanate
3. *Imidazothiazole/Tetrahydropyrimidine:* Levamisol, Tetramisol, Morantel, Pyrantel.
4. *Organophosphorus compounds:* Haloxon, Dichlorovos, Trichlorphon (Metriphonate)
5. *Piperazine salts:*
   - Piperazine citrate
   - Piperazine adipate
   - Piperazine dihydrochloride
   - Diethyl carbamazine
6. *Avermectin:* Ivermectin

Drugs Administered against Cestodes

1. *Salicylanilides/substituted phenol:* Niclosamide
2. *Benzimidazole:* Mebendazole
3. *Others:* Praziquantel, Arecoline (Arecoline hydrochloride and Arecoline acetarsol), Bunamide

Drugs Administered against Trematodes

1. *Salicylanilides/substituted phenols:* Nitroxynil, Oxyclosanide, Rafoxanide, Brotiamide, Closantel, Diamphenetide
2. *Benzimidazole:* Albendazole, Triclabendazole, Oxfenbendazole.

Drugs used against Ectoparasites

1. *Organophosphates:* Coumaphos, Crotoxyphos, Dichlorovos, Crufomate, Chlorfenvinphos, Diazinon, Fenthion, Malathion, Trichlorphon, Ronnel, Tetrachlorovinphos, Phosmet, Propetamphos
2. *Chlorinated hydrocarbons (organochlorines):* Benzene hexachloride (BHC), Hexachlorocyclohexane (HCH), Aldrin, Dieldrin, Lindane, Chlordane Toxaphene.

3. *Synthetic pyrithroid (SP compound):* Cypermethrin, Permethrin, Cyhalothrin, Fenvalerate
4. *Avermectin:* Ivermectin

Drugs used against the Protozoans

1. Pyrimethamine (daraprim), Sulphadiazine (used in toxoplasmosis)
2. Ionophorus compounds (antibiotics): Lasalocid, Monensin, Salinomycin
3. Hydroxyquinolines (Decoquinate, Buquinolate)
4. Sulphur drugs (Sulphaquinoxaline, Sulphadimidine)
5. Thiamine analogues–Amprolium
6. Nitrobenzamides (Zoaline)
7. Nicarbazin
8. Nitrofurans (Nitrofurazone, Furazolidone)
   (Above drugs are from point 2 to point 8 used in coccidiosis)
9. Diloxanide, Di-iodohydroxyquin, Metronidazole (used in amoebiosis)
10. Chloroquine, diodoquine (used in malaria)
11. Trypan blue, Imidocarb, Diminazene (Berenil), Pyrivan, Phenamidin (used in babesiosis)
12. Menoctone, Halofuginone, Buparvaquone (Butalex) (used in theileriosis)
13. Quinapyramine, Isometamedium chloride, Sulphonated naphthylamine (Suramin), Phenanthridine (homidium chloride, homidium bromide) (used in trypanosomosis).

Characteristics of Different Phylum

Platyhelminthes

1. The members coming under this phylum are dorsoventrally flattened usually.
2. Excretory organs are flame cells.
3. Circulatory system is absent.
4. Respiratory system is also absent.
5. In most of the parasites, an intermediate host is required for completion of the life cycle.

Nemathelminthes

1. Generally, the members are cylindrical and the members coming under this phylum are called roundworms. However, there is an exception. The female *Tetrameres* spp. is globular.
2. Metamerical segmentation is absent.
3. Both ends are somewhat pointed.
4. There are many cuticular structures which have taxonomic importance.
5. Below the cuticle, there is hypodermis followed by a layer of muscle cells.
6. Alimentary canal is present which has several parts
   a. Mouth
   b. Muscular oesophagus
   c. Intestine
   d. Anus

7. Excretory organs are one lateral canal and glands.
8. Flame cells and cilia are absent.
9. The members coming under this phylum are unisexual.

Protozoa

1. These are eukaryotic (nucleus is enclosed in a membrane). Usually only one nucleus is present.
2. These organisms are polymorphic.
3. The organisms have an outer ectoplasm and inner endoplasm.
4. Pseudopodia, flagella and cilia are the locomotory organs of protozoa.
5. Holophytic, holozoic, saprozoic types of nutrition are found in protozoa.
6. Reproduction is performed by binary fission, schizogony, endodyogeny endopoligeny, syngamy, sporogony.

Arthropods

1. The name arthropods has been derived from the Greek word arthros (a joint) and podos, (leg) and as a whole the meaning is jointed legs.
2. The arthropods have a chitin, an outer covering.
3. The alimentary canal is divided into three parts, anterior part (stomodium), the middle part (mesenteron) and the proctodaeum (hindgut).
4. Arthropods are metamerically segmented.
5. A circulatory system is present.
6. Gills, trachea, lung book and gill book are the respiratory organs.

Binomial Nomenclature

Nomenclature

Nomenclature is the specific naming of any individual. In the universe, there are innumerable organisms which are not completely different from each other. In many of the organisms, there are fair similarity. But still, there have some distinguishing features. Basing on these distinguishing features, names are given to the organisms to provide separate identity to differentiate them from each other. Day-to-day, newer and newer species are being discovered and a need is being increased to give them proper scientific names. For this, a branch of science has been developed which is called Binominal Nomenclature. Linaeus was a pioneer man and is really a historical person in the field of binominal nomenclature who wrote the famous book "Systema naturae".

What is *binomial* nomenclature?

Each organism is designated by two names or connotations; the first name is for genus and the second name is for species.

Basic aspects of nomenclature

A. **Basing on the name of scientist/discoverer:** The name of a particular species of parasite may be given as per the name of the scientist, or, discoverer.
Example: Leishmania donovani donovani

B. **Basing on the name of the particular place:** The name of the species of the organism may be given as per the name of the place where the parasite is more prevalent, first isolated or otherwise else.
Example: Eimeria bombayansis, E. brasiliensis

C. **Basing on the shape of the organism:** The name of a particular parasite may be given considering the specific shape of the parasite.
Example: Eimeria ellipsoidalis

D. **Basing on the seat of predilection of the parasite:** The name of a parasite may be given in accordance with seat of predilection of the parasite.
Example: Schistosoama nasalis

E. **Basing on the type of host:** The name of the parasite may be given in accordance with the host of the parasite.
Example: Toxocara canis

Rule for binomial nomenclature

1. Several terms are used to indicate two-part species name which are binomen (plural binomina), binomial name, binominal name, binominal and species name.
2. Above the specific name all taxa have 'uninominal name'.
Example: Ancylostoma, Ancylostomatoidea
3. Trinomial nomenclature is used to mention subspecies.
4. If common name of a species is also used in a sentence, the scientific name usually follows in parentheses.
Example: House fly (*Musca domestica*) spread many diseases.
5. The scientific name should always be written in full. However, if several species of the same genus are to be mentioned, the first species should be written in full and the genus could be abbreviated to an initial from the next.
Example: Trypanosoma evansi, T. cruzi, T. vivax.
6. "SSPP" or "subspp" indicates number of subspecies.

Derivation of names

1. Genus name of specific descriptor may come from any source. Usually, they are Ancient Greek or New Latin.
2. Systematic names are given from a list of Latin and Greek words.
3. Family names are derived from the generic name.
4. As per Latin Grammar, generic name should be a noun and it should be unique.

Simplification of some rules

1. Scientific names of animal species are written in Latin. The generic name, specific name and subspecific name should either be underlined or italicised. Generic name always start with a capital letter and the remaining parts (species or subspecies) begin with small letter.

Name of parasite	*Generic name*	*Specific name*	*Subspecific name*
Leishmania donovani donovani	*Leishmania*	*donovani*	*donovani*

2. The connotation of specific name could be avoided.
Example: Leishmania spp.

Several suffixes are used as follows. It is to be kept in mind that the suffixes are not used invariably except a few lower positions of classification like 'idae', 'inae', etc.

Item as per classification	*Suffixes*	*Example*
Class	-ea	Sporozoea
Subclass	-ia	Coccidia
Order	-ida	Eucoccidiida
Suborder	-ina	Eimeriina
Superfamily	-oidea	Ancylostomatoidea
Family	-idae	Eimeriidae
Subfamily	-inae	Ancylostominae

3. **Law of priority:** If two or more names are suggested by different workers for the same species, then that worker gets priority over others whose publication first appears with recognisable description.
4. The author's name is written with date (year) after the scientific name.
   Example: Trypanosoma, Gruby, 1843.

Nomenclature of parasitic diseases

SNOPAD is an abbreviation of standardised nomenclature of animal parasitic disease which is a formulated guidelines for uniform terminologies of animal parasitic disease.

Specific nomenclature of parasitic diseases

Several suffixes are used after deletion of one letter or two letters from the generic name or otherwise.

Item	*Suffixes*	*Deletion*	*Word after deletion*	*Addition*	*Word after addition*
Inflammation of any organ or part Example: Meninges	*itis*	-es	Mening	+ itis	Meningitis *Though the disease is not parasitic but to have general concept it has been given here.
Schistosoma	*osis* (singular)	-a	Schistosom	+ osis	Schistosomosis
Schistosoma	*oses* (Plural)	-a	Schistosom	+ oses	Schistosomoses
Eperythrozoon Hepatozoon Cytauxzoon	*osis*	nil	Eperythrozoon Hepatozoon Cytauxzoon	nil	Eperythrozoonosis Hepatozoonisis Cytauxzoonosis *Some genera are there where no addition or deletion is done and 'osis' is added to the entire generic name
Schistosoma	*iasis*	-a	Schistosom	iasis	Schistosomiasis *At present the use of 'iasis' is obsolete. In all cases of parasitic infection 'osis' is used.

Nonspecific nomenclature of parasitic diseases

Basis	*Name of scientist/country/others*	*Name of disease*
Name of scientist	Carlos Chagas	Chagas disease
Name of country	Africa	African sleeping sickness
Clinical sign	Cyanotic discolouration of head region of Turkey	Black head disease of Turkey
Parasitic stage	Cysticercus	Cysticercosis
Season	Summer Winter	Summer dermatitis Winter coccidiosis
Body part	Hump	Hump sore
Profession	Dhobi	Dhobi itch (cercarial dermatitis)
Comparison	Similarity with elephant's leg	Elephantiasis
Activity of the organism	Migratory activity of the organism	Cutaneous larva migrans

International code of zoological nomenclature

The international code of zoological nomenclature was framed after long and exhaustive struggle by many devoted persons. It takes very long period to bring out an amicable solution. The historical events are as follows.

1889 **First Zoological Congress** was held in Paris. R Blanchard presented different codes but did not get universal response or sanction.

1901 **Fifth Zoological Congress** was held and codes and plans were developed.

1904 A **permanent commission** was established who would take care and serve as quasi-judicial body on Zoological names.

1958 Complete **International Code for Zoological Nomenclature** was adopted.

1961 **Publication** of International Code for Zoological Nomenclature in English and French was done in London.

Law of priority in detail

1. For any organism, the first published name takes priority but the latter name of that organism is junior synonym.
2. The first published names take priority. But the later uses the same name for the different organism (Junior homonyms) is discouraged. A suitable replacement name is chosen.
3. The first published species epithet is fixed. If the species enter into another genus, the specific name would not be changed until a homonym is created.
4. If a junior name has been used for a long period, the rule of priority can be reversed.

PHYLOGENETIC TREE IN BRIEF

Kingdom

Subkingdom

Phylum

Subphylum
Class
Subclass
Order
Suborder
Superfamily
Family
Subfamily
Genus
Subgenus
Species
Subspecies

PHYLOGENETIC TREE IN DETAIL

Domain or Superkingdom
Kingdom
Subkingdom
Branch
Superphylum or Superdivision
Phylum or Division
Subphylum
Infraphylum
Microphylum
Superclass
Class
Subclass
Infraclass
Parvclass
Magnorder
Superorder
Order
Suborder
Infraorder
Parvorder
Superfamily
Family
Subfamily

Tribe
Subtribe
Allianae
Genus
Subgenus
Superspecies
Species
Subspecies
Infraspecies

HISTORY OF PARASITOLOGY

Who is the father of Parasitology?

Francesco Redi of Italy is considered as the father of Parasitology. He discovered *Taenia taeniaformis* in the year 1684.

CHRONOLOGICAL PRESENTATION OF HISTORICAL EVENTS OF PARASITOLOGY

1600 BC	*Ancylostoma duodenale*, an important hookworm of human being, was probably referred to in Ebers papyrus of ancient Egypt.
1200 BC	Calcified eggs of *Schistosoma* spp. were detected in the mummies in Egypt.
384–375 BC	Hippocrates and Aristotle were familiar with hydatid cysts and other tapeworms (armed tapeworm, *Taenia*). Aristotle and Aristophane described *Cysticercus cellulosae* in the tongue of pig.
1379	Liver fluke, *Fasciola hepatica* was first recorded by Jehan De Brie in France.
1592	*Diphyllobothrium latum* was first described by Dunas.
1632	Avicenna gave the name of guinea worm as medina worm.
1665	F. Balder first discovered the parasitic crustaceans.
1674	Leeuwenhoek first recognised the coccidian (*Eimeria*) oocyst from the rabbit. This was named *Eimeria stiedae* in the year 1922 by Dobell.
1675	Wepfer first stated that gid condition of sheep was caused by presence of a bladder, larval stage of *multiceps* in the brain.
1681	The cysts of *Giardia lamblia* was first detected by the renowned person, Leeuwen Hoek from his own stool.
1683	Anatomic structure of *Ascaris lumbricoides* was given by E. Tyson.
1684	Francesco Redi first discovered *Taenia taeniaeformis* (the larva is *Cysticercus fasciolaris*) from a hare.
1688	Redi first described *Fasciola hepatica* with illustration.

1694	PJ Hartmann first discovered *Echinoccus granulosus* from a dog.
1699–1700	N Hartsoeker of Netherlands, N Andry of France and G Baglivi of Italy first described that the helminthic infections are occurred due to ingestion of the eggs of them.
1700	*Taenia* of man and its scolex were first described by Andry.
1717	GM Lancisio of Italy was a renowned person who first postulated that malaria is caused by the animalic elements transmitted by the mosquitoes and the periodicity is due to the copulation and multiplication of these agents.
1737	Swammedam was a renowned person who first isolated *Ascaris nigrovenosa* in a frog.
1758	Detailed description of *Fasciola hepatica* was provided by Linnaeus.
1770	M Mongrin first described Loa loa infection thus started the era of filarial disease.
1771	Linnaeus was the first man who detected *Trichuris trichiura*.
1773	OF Muller first detected *Trichomonas tenax*.
1782	JAE Goeze was a renowned person who first initiated the study of taxonomy of different helminthes.
1790	PC Abildgaard was the first man who infected the ducks with *Diphyllobothrium* by feeding them with the larvae from the fish.
1799–1801	*S. haematobium* was detected in the Napoleon's army in Egypt.
1817	CL Nitzsch was the first man who drew correlation between the cecaria with the adult digenean trematode.
1818	LH Bojanus was a German zoologist who rediscovered rediae in the snail and found similarity between rediae and cercariae.
1828	Peacock first described *Trichinella spiralis* in the muscle of patient in London.
1835	J Paget of England was the first man who described *Trichinella spiralis* in muscles in human being.
1835	Von Siebold was the first man who observed that *Taenia eggs* contained embryo containing small hooks.
1837	FHC Creplin of Germany was the first man who described the coracidium released from the eggs of *Diphyllobothrium latum*.
1838	Angelo Dubini first detected *Ancylostoma duodenale*.
1841	GG Valentinn of Switzerland was the first man who discovered trypanosome from the blood of Salmo fario.
1843	A Dubini was a physician in Italy. He described the hookworm *Ancylostoma duodenale*.

1845	F Dujardin first made the correlation between Cysticerci and the adult *Taenia species*.
1847	Black pigment granules of Malaria organisms were first detected in the blood by Muckel.
1848	Josiah Nott of New Orleans postulated that the mosquitoes transmitted the malaria disease as well as the virus of yellow fever.
1849	G Gros was the first man who discovered *Entamoeba gingivalis* in human beings.
1849	Black pigment granules of Malaria organisms were detected in the blood by Virchow.
1851	M Bilharz discovered three parasites, *Heterophyes heterophys, Hymenolepis nana, Schistosoma haematobium.*
1851	Kuchenmeister was the first man who established the cyclophylidiean life cycle pattern.
1853	CTE Von Siebold recovered adult *Echinococcus granulosus* from the dog fed with the metacestode (hydatid cysts).
1857	PH Malmstem first described parasitic ciliate, *Balantidium coli* in human.
1857–59	FR Leuckart and R Virchow described the life cycle of *Trichinella spiralis.*
1869	NM Melnikov discovered that the dog louse *Tricodectes canis* was the intermediate host of *Dipylidium caninum*.
1860	*Sarcocystis hominis* or *Sarcocystis suihominis* were described by Virchow.
1875	In Calcutta *Chlonorchis sinensis* was first recorded in the bile duct of a Chinese carpenter by McConnell.
1875	FA Losch first evidently described *Entamoeba histolytica*.
1876	Bavay discovered *S Trongyloides* spp..
1878	Kerbert first detected *Paragonimus westermani.*
1880	*Plasmodium malariae* of human being was first discovered by CLA Laveran.
1881–83	Life cycle of *Fasciola hepatica* was separately established by two renowned scientists, Leukart and Thomas.
1883	G Bunge, a Swiss chemist, was a first man in pioneering parasitic physiology. He described the acid production by the parasite.
1885	Cunningham discovered *Leishmania tropica.*
1889	*Babesia* protozoa was first described by Theobold Smith.
1890	Bruce discovered *T brucei*, a causative agent of Nagana.

1893	Theobold Smith and Kilbourne described the transmission of *Babesia* by the tick, *Boophilus annulatus*.
1895	D Bruce first stated that the tsetse fly served as the vector of *Trypanosoma brucei*.
1897	Ronald Ross first described the life cycle of malaria parasite in the mosquitoes.
1898	*Theileria parva* was first described by Koch.
1898	*Leishmania tropica* was first demonstrated by Borovsky.
1899	Braun detected *Paragonimus westermanii* after Kerbert.
1902	Forde and Dutton first detected *Trypanosoma gambiense* in Gambia.
1903	Leishmann and Donovan first isolated *Leishmania donovani* in London and Madras respectively.
1907	*Cryptosporidium* (a asporocystic tetrazoite coccidian parasite) was first described by Tyzzer.
1908	Nicolle and Manceaux discovered *Toxoplasma gondii*, an important zoonotic protozoan parasite from a rodent (*Ctenodactylus gundi*).
1909	Stephens and Fantham detected *T rhodesiense* in Rhodesia.
1909	Carlos Chagas discovered *Trypanosoma cruzi* in the intestine of *Panstrongylus megistus* (a triatomid bug).
1920	Significant work on *Histomonas meleagridis* was done by Tyzzer.
1956	B Von Bondorff described that pernicious anaemia may be due to infection by *Diphyllobothrium latum* resulted due to competition between the host and the parasite.
1959–63	Jarret and co-workers first commercialised vaccine against sheep, goat and cattle using the irradiated infective larvae.
1965	The adult *Echinococcus granulosus* was discovered by Hartman.
1965–72	Significant works on *Toxoplamsa gondii* with special reference to establishment of life cycle were done by Dubey, Frenkel and other workers.
1978	GAM Cross and K Vickerman described the antigenic variation of surface antigen of *Trypanosoma*.
1988	The species *Neospora caninum* was discovered by Dubey and coworkers.
1989–90	Many workers (Mitchel, Brophy, O'Leary, Sexton, Spithill, Wijffels and others) started their works on vaccination against *Fasciola* and other parasites utilising the isoenzyme (glutathione S-transferase). The work is in further progress using cysteine proteinases (Cathepsin–L), FABP (Fatty Acid Binding Protein), haemoglobin in addition to Glutathione S-transferase.

1989–94	Rand, Rodriquez and other workers commercialised recombinant tick vaccine. TickGard and Gavac against *Boophilus microplus* using the defined antigen, Bm–86.
2001	Recent developments in the biology of *Sarcocystis neurona* and equine protozoal myeloencephalitis were reported by Dubey.
Around 1990 till date	The field of veterinary parasitology is progressing more and more towards the minute aspects of molecular morphology, molecular pathology, molecular diagnosis, molecular therapy (gene therapy), molecular vaccination (gene immunisation), etc.

QUESTIONNAIRE: GENERAL VETERINARY PARASITOLOGY

WRITE 'TRUE' OR 'FALSE'

1. The partner—organism of symbiosis is called symbiont.
2. Parasitism is an intimate association between two different (heterospecific) organisms whereby no metabolic dependence does not occur.
3. The relationship between sea anemone and the clown fish is an example of commensalism.
4. In phoresis the larger partner which carries the other partner is called phoront.
5. *Nosema dollfusi* is one hyperparasite of larval stage of a flatworm (trematode), *Bucephalus cuculus.*
6. *Theileria annulata* does not cause disease entity in the indigenous animals which remain as carrier.
7. *Nigleria sp* is an accidental parasite.
8. The parasites always spend their whole life on or within their hosts.
9. Intermittent parasites are also called temporary parasite.
10. The temporary or intermittent parasites are also called micropredator.
11. Tapeworm, roundworm, and flukes are always endoparasites.
12. A parasite is heteroexenous when it does not require any intermediate hosts for completion of its life cycle.
13. Sexual maturity never occurs in the intermediate host.
14. Mite is the intermediate host of *Moniezia expansa*.
15. When a parasitic stage is simply carried by a host and no biological development occurs in it, that type of host is called parataenic host or transport host.
16. Rodents act as reservoir hosts of *Leishmania tropica*.
17. The hosts are called unnatural hosts in which the parasites do not occur commonly but in some unusual situations, the parasite may infect and develop.
18. Hosts get the infection only by ingestion of the eggs of the parasite.
19. Third stage larvae of Strongyle worms act as infective stages of those parasites.
20. Coenurus is an infective stage of tapeworm.
21. Metacercaria of *Paragonimus westermanni* develops in the crabs and cray fishes.
22. Some hosts occur by ingestion of fish harbouring, some infective stages of parasite.
23. Human beings get the infection of *Taenia saginata* by ingestion the beef containing *Cysticercus bovis*.
24. Birds get infection of *Amoebotaenia sphenoides* by ingestion of earthworm harbouring the cysticercoid.
25. The gardeners, plumbering workers, field workers frequently face cutaneous larva migrans.
26. The adult bot fly (Oestridae family) deposits their larvae in the nasal orifice of sheep and goat.
27. *Anopheles sp* transmits bird malarial pathogen, *Plasmodium gallinacium*.
28. Some parasitic larvae are distributed by fungal spores.
29. Export/import of infected meat/meat product, etc. is source of spread of parasitic disease from one place to another place.

30. Blocking of antibodies and tolerance are examples of immune evasion.
31. In metastrongylids, some stages of development of larva occur in the intermediate host.
32. Immature stages or the larval stages of flukes are sometimes called bladder worms, cysts or metacestodes.
33. In some arthropods complete metamorphosis occurs called holometabolous type of life cycle.
34. Some protozoa multiply by schizogony.
35. Hypertrophy is simply an increase of number of cells which occur due to presence of the parasite within the cell.
36. Hyperplasia is increase of cell size which may occur due to some parasitic infection.
37. Appearance of epithelial and elongate fibroblast cells in lungs infected with the *Paragonimus westermanii* is example of metaplasia.
38. Some worms suck blood from the host continuously.
39. The larvae of the cestodes/bladder worms/cysts/metacestodes cause mechanical obstruction in the vicinity of the parasites.
40. *Davainea proglottina* form a bundle which obstruct the food passage of the intestine resulting in functional disturbance.
41. Allergic reaction never occurs due to tick, flea, lice and other ectoparasitic infection, however, some helminthes cause this type of reaction due to allergin.
42. The tapeworms release the metabolic by-product which causes damage to the nervous system of the hosts resulting in several nervous disorders.
43. The ability of a molecule of an immunogen to produce an immune response is called immunogenicity.
44. In a crude mass of a parasitic protein, a number of individual proteins are present.
45. Due to less foreignness of protein, it is difficult to produce potent vaccine.
46. Outer covering of parasite can be used as antigen.
47. The immunity which remains still in absence of organisms after any infection has taken place, is called sterile immunity.
48. Concomitant immunity is the immunity which occurs due to infection of more than one type of parasite.
49. Activated B cells transform into the plasmoblast cells which further transform to plasma cells.
50. Pasture resting is a pasture management done for control of parasitic infection.
51. $CuSO_4$ is used to kill the mollusca.
52. Gambusia fishes are used to kill the mosquito larvae.
53. Birds are natural enemies of some parasites.
54. Proper interval of administration of antiparasitic drugs is not a matter only matter is the proper dose of those drugs.
55. Closantel, Nitroscanate are under the group of salicylanilides/substituted phenols.
56. Morantel is under the group of imidazothiazole/tetrahydropyrimidine.
57. Haloxon is an organochlorine compound.
58. Diethyl carbamazine is a piperazine salt.
59. Praziquantel is strictly used only for treatment of cestode infection.

60. Nitroxinil is under salicylanilides/substituted phenols group.
61. Triclabendazole is used for treatment of fasciolosis.
62. Crufomate is a chlorinated hydrocarbon compound.
63. Benzine is an organophosphorus.
64. Cypermethrin is a synthetic pyrithroid.
65. Ionophorus compounds (antibiotics) are lasalocid, monensin, salinomycin and pyrimethamine.
66. Nitrofurans (nitrofurazone, furazolidone) are anticoccidial drug.
67. Quinapyramine is an antitrypanosomal drug.
68. Metamerical segmentation is absent in nematodes.
69. The nematodes are unisexual but some nematodes may be bisexual.
70. Holophytic, holozoic, saprozoic type of nutrition are found in protozoa.
71. The alimentary canal of arthropod is divided into three parts stomodium, mesenchyme and proctodaeum.
72. Gills, trachea, lung book, nephridia are the respiratory organs of arthropod.
73. Linaeus wrote the famous book "Systema naturae".

FILL IN THE BLANKS

1. _____ is the association between two organisms where each partner gets benefit from each other.
2. The literal meaning of the term _____ is 'eating at the same table'; food and shelter is shared by each partner.
3. The partner-organism of commensalisms is called _____.
4. Holothurians (starfish) shelters the fish (fierasfier); it is an example of _____.
5. *Micronema* spp. is an _____ parasite
6. *Melophagus ovinus* is a _____ parasite.
7. Periodic parasite is also called _____ parasite.
8. _____ parasites are parasites which migrate aberrantly in an unusual location.
9. The parasite is _____ when it does not require any intermediate hosts.
10. *Trypanosoma rhodesiense* is an example of _____ parasite.
11. *Taenia solium* require _____ intermediate hosts for completion of life cycle.
12. _____ is the inetermediate host of *Gnathostoma spinigerum.*
13. In the life cycle of *Toxocara canis*, rats and rodents act as _____ host.
14. The host is called _____ host in which the parasites commonly occur, and easily survive and reach to its final stage.
15. Arthropods which harbour the parasitic pathogen without any recognizable disease entity and act as a constant source of infection to other animals are called _____.
16. Cysticercoid is an infective stage of _____ tapeworm.
17. Strobilocercus is an infective stage of _____ worm.
18. Larvae of *Diphyllobothrium latum* develop in _____ and _____.
19. Human beings get infected with medina worm, when _____ infected with the larval forms of *Drancunculus medinensis* are ingested along with water.

20. Cercariae of some trematode become encysted on the aquatic vegetations and develop to _____ stage.
21. _____ of *Schistosoma* spp. penetrate through the skin of their hosts.
22. _____ infect the animals by direct contact.
23. Larvae of Trychostrongylids can spread by spores of the fungus _____.
24. Natural calamity like _____ and _____ may play great role in spread of parasitic diseases.
25. The third stage larva with the retained sheath of 2nd stage larvae are infective stage of _____ worms.
26. In almost all cestode, life cycle is _____ type where there occurs requirement of an intermediate host.
27. The bladder worms occurring in the invertebrate hosts are _____and _____.
28. In some arthropods incomplete metamorphosis occur called _____ type of life cycle.
29. Some _____ multiply by endodyogony.
30. RBC infected with _____ are commonly enlarged which is an example of hypertrophy.
31. Hyperplasia of the wall of the bile duct occurs in infection of _____ and _____ sp.
32. _____ is the formation of new structure.
33. Elephantiasis is a good example of _____ interference.
34. In most of the cases host-protein and parasitic proteins have _____ antigens.
35. The moulting fluid can be used as _____.
36. Preimmunity is also called _____ immunity.
37. Antigen is processed by _____ and presented to lymphocytes (T-cells)
38. In _____ control one organism is used to control other organism.
39. Benzimidazole/Probenzimidazole are used against _____ infection.
40. Tetramisol is under _____ group of drug.
41. Dichlorovos is an _____ compound.
42. Piperazine citrate is a _____ salt.
43. Mebendazole is used as _____ drug.
44. Bunamide is an _____ drug.
45. Rafoxanide is an _____ drug.
46. Dichlorovos is an _____ compound.
47. Trichlorophon is an _____ compound.
48. Lindane is a _____ hydrocarbon.
49. Fenvelarate is a synthetic _____.
50. Nicarbazin is an _____ drug.
51. _____ and _____ are antitheilerial drugs.
52. Quinapyramine is an _____ drug.
53. Flame cells are _____ organs in Platyhelminthes.
54. Circulatory system is absent in _____.

55. Metamerical segmentation is absent in _____.
56. Flame cells and cilia are absent in _____.
57. _____ are unisexual parasites.
58. Protozoa are _____ organisms.
59. _____, flagella and _____ are the locomotory organs of protozoa.
60. _____, _____, saprozoic type of nutrition are found in protozoa.
61. Reproduction of protozoa is performed by _____.
62. Schizogony, _____, endopoligeny, _____, etc.
63. The outer covering of arthropod is formed by _____.
64. The alimentary canal of arthropod is divided into three parts, anterior part (_____), the middle part, (_____), the proctodaeum (hind gut).
65. Arthropods are _____ segmented.
66. Gills, trachea, _____, _____ are the respiratory organs of arthropod.
67. Linaeus wrote the famous book _____.
68. _____ is the father of parasitology.

TICK MARK THE RIGHT ANSWER

1. The partner-organism of mutualism is called:
   a. phoront
   b. mutualist
   c. both
   d. none
2. In commensalism:
   a. one partner of this association benefits from other partner but the other partner neither harms nor benefits.
   b. one partner of this association benefits from other partner but the other partner get benefit and is also harmed.
   c. both the partners equally get benefit
   d. both the partners do not get benefit
3. In Phoresis two partners have:
   a. no metabolic relationship
   b. no nutritional relationship
   c. both metabolic and nutritional relationship
   d. all
4. When one parasite parasitise another parasite is called:
   a. hyperparasite
   b. autoexenous parasite
   c. autoheteroexenous parasite
   d. pseudop parasite
5. It is called parasitiasis when parasitic infections:
   a. do not produce any clinical signs though the organisms are pathogenic
   b. produce clinical signs
   c. produce clinical sign but sometimes do not
   d. none

6. Some parasites are normally free living but develop to become a parasite when these are accidentally eaten or enter a wound or any body opening, these are:
   a. accidental parasite
   b. facultative parasite
   c. both
   d. all
7. Blood sucking flies are the:
   a. temporary parasites
   b. sporadic parasite
   c. both
   d. none
8. *Eimeria* spp. are:
   a. autoheteroexanus parasites
   b. autoexenous parasite
   c. monoexenous parasite
   d. none
9. A definitive host is the host where:
   a. the parasites attain their sexual maturity
   b. never attain sexual maturity
   c. both
   d. none
10. Two intermediate hosts for completion of life cycle in case of:
   a. *Diphyllobothrium latum*
   b. *Dipylidium cainum*
   c. *Eimeria tenella*
   d. *Taenia solium*
11. Sheep, goat and cattle are natural hosts of:
   a. *Fasciola gigantica*
   b. *Diphyllobothrium latum*
   c. *Dipylidium caninum*
   d. *Toxocara canis*
   e. *Toxoplasma gondii*
12. Birds get the infection of Eimeria tenella by:
   a. ingestion of sporulated oocysts
   b. inoculation of sporulated oocyst
   c. *direction transmission*
   d. none
13. Cysticercus is an inefctive stage of:
   a. tapeworm
   b. roundworm
   c. flukes
   d. protozoa
14. Hydatid cyst is an infective stage of:
   a. *Diphyllobothrium latum*
   b. *Dipylidium caninum*
   c. *Echinococcus granulosus*
   d. all
15. The hosts get the infection of *Schistosoma* spp.*:*
   a. through skin penetration
   b. inoculation by blood sucking fly
   c. ingestion
   d. direct contact
16. Hookworm infection occurs in the host by:
   a. through skin penetration
   b. inoculation by blood sucking fly
   c. ingestion
   d. direct contact

17. *Anopheles* spp. transmit:
    a. human malaria
    b. avian malaria
    c. amphibian malaria
    d. all
18. Mites like *Demodex* spp. *Sarcoptes* spp. and *Psoroptes* spp. are transmitted by:
    a. through skin penetration
    b. inoculation by blood sucking fly
    c. ingestion
    d. direct contact
19. Spread of parasites may occurs by:
    a. transportation of infected animals
    b. blood sucking fly
    c. water
    d. all
20. Immune evasion by the parasite occurs by:
    a. molecular mimicry
    b. antigenic variation
    c. shading of glycocalyx
    d. all of these
21. The egg containing 2nd stage of larva is infective stage of:
    a. Ascarid worms
    b. strongyle worms
    c. Spirurid worms
    d. all of these
22. Both direct and indirect type of life cycle occurs in:
    a. Hymenolepids
    b. Strongylids
    c. both
    d. none
23. In trematodes developmental stages are:
    a. miracidium
    b. sporocyst
    c. redia
    d. cercaria
24. Protozoa multiply by:
    a. binary fission
    b. schizogony
    c. endopolygony
    d. all
25. RBC infected with *Plasmodium vivax* is increased in size which is an example of:
    a. hypertrophy
    b. hyperplasia
    c. both
    d. all
26. The parasitic antigen is a:
    a. complex mosaic protein
    b. cross reactive protein
    c. both
    d. none
27. Vaccine can be prepared from:
    a. moulting fluid of parasite
    b. whole somatic antigen
    c. larva
    d. excretory–secretory protein
28. Antiparasitic drugs are administered by:
    a. intraruminal injection
    b. intravenous injection
    c. oral administration
    d. all
29. Benzimidazole compounds are used against:
    a. nematodes
    b. cestodes
    c. both
    d. none

30. Dichlorovos is an:
    a. organophosphorus compound
    b. organochlorine compounds
    c. synthetic pyrethroid
    d. all
31. Piperazine citrate is a:
    a. salt
    b. hydroxide
    c. ester
    d. none
32. Mebendazole is also used as:
    a. anticestodal drug
    b. antinematodal drug
    c. both
    d. none
33. Bunamide is an:
    a. anticestodal drug
    b. antinematodal drug
    c. both
    d. none
34. Rafoxanide is an antitrematodal drug:
    a. anticestodal drug
    b. antinematodal drug
    c. antitrematodal drug
    d. all
35. Dichlorovos is an:
    a. organophosphorus compound
    b. organochlorine compounds
    c. synthetic pyrethroid
    d. all
36. Trichlorophon is an:
    a. organophosphorus compound
    b. organochlorine compounds
    c. synthetic pyrethroid
    d. all
37. Nicarbazin is:
    a. anticoccidial drug
    b. anticestodal drug
    b. antinematodal drug
    c. antitrematodal drug
38. Menoctone, Halofuginone, Buparvaquone (Butalex) are:
    a. antitheilerial drug
    b. antibabesial drug
    c. antinematodal drug
    c. all
39. Circulatory system is absent in:
    a. Platyhelminthes
    b. nemathelminthes
    c. both
    d. all
40. Flame cells and cilia are absent in:
    a. Nemathelminthes
    b. Platyhelminthes
    c. both
    d. none
41. Pseudopodia, flagella, cilia are the:
    a. locomotory organs
    b. circulatory organs
    c. respiratory organs
    d. none