PROTOZOANS

GENERAL CHARACTERISTICS OF PROTOZOANS

The protozoa are unicellular animal in which the various activities of metabolism, locomotion, etc, are carried out by organelles of the cell, comparable forms occur in the plant kingdom (unicellular plants) and, in general, protozoa are differentiated from these by the absence of chlorophyll-containing chromatophores and their mode of nutrition (holozoic). The unicellular plants are frequently bounded by a fairly rigid cell wall made of cellulose and the nuclear material is often dispersed in the cell. The protozoa, on the other hand, have a well defined nucleus and do not have a rigid cell wall, allowing, at a times, a marked variation in size and shape. Never the less, this distinctions cannot be rigidly applied to all form and there is an assemblage of organisms which share the characters of both plants and animals. The term protista was introduced for such forms, but this has not been generally adopted.

Since the discovery of protozoa by Antoni van Leeuwenhock, some 45,000 species have been described. The majorities of these is free living and are found in almost every habitat on land and in water. Although the parasitic protozoa are smaller in numbers, they never the less assume an important role as producers of global disease which, apart from producing death or deformity, saps the energy and initiative and decays the world.

Of no less important is the untold loss of livestock and livestock products which is frequently a burden in those communities and areas of the world that can least support it.

STRUCTURE OF PROTOZOA

Nucleus

Protozoa are eukaryotic (nucleus enclose in a membrane) where as the bacteria are prokaryotic (nucleus disperse in cytoplasm).

Usually only one nucleus is present, although in some forms more than one nucleus may be present in some or all stages of development. The vesicular type of nucleus consist of a nuclear membrane which bounds the nucleoplasm in which, lying more or less central, is an intranuclear body, the endosome (or kayosome) or the nucleus. An endosome is devoid of deoxyribonucleic acid, where as a nucleolus possess DNA. Chromatin material frequently occurs in the inner surface of the nuclear membrane and many also be seen as strands radiating from the kayosome to the nuclear membrane. The vesicular type of nucleus is seen most commonly in the Mastigophora and the Sarcodina.

Cytoplasm: This is the extra nuclear part of the protozoan cell. It may be differentiated into an outer ectoplasm and an inner endoplasm, the former often being homogeneous and hyaline in appearance and the latter frequently containing granules, vacuoles and sometimes pigment. In some forms (e.g sarcodina) there is no definite limiting membrane, but usually a pellicle serves as such in the majority of species.

Locomotion Protozoa may move by gliding or by means of pseudopodia, flagella or cilia.

Pseudopodia are used by amoeba-like organisms, the structures being temporary locomotory organelles which are formed when required and retracted when not needed.

Flagella are whip-like filamentous structures which arise from a basal granules or blepharoplast in the cytoplasm of the organism. They are composed of a central axial filament, the axoneme, which is surrounded by a contractile cytoplasmic sheath. Ultra-structural studies indicate the axoneme to be composed of two central filaments surrounded by nine peripheral filaments. In some forms the flagellum may be attached to the body of the protozoan by an undulating membrane. Flagella are typically seen in the mastigophora.

Gliding is seen in Toxoplasma, Sarcocystis and other forms, this being achieved without the aid of cilia or flagella.

Cilia are fine, short, flagella-like structures originating from a basal granule embedded in the pellicle or ectoplasm. They are the organs of locomotion in the ciliates, but they may also aid the ingestion of food or serve as tactile structures. The ultra-structure is similar to that of the flagella and may usually occur in large numbers, arranged in rows over the body of the protozoan.

ORGANELLES OF NUTRITION

In the amoeba-like form, particulate food materials are acquired by means of pseudopodia. An advance on this is a specialized opening called the cytostome through which food particles are engulfed and passed to food vacuoles. In the ciliates the cytostome may be lined with cilia which further assist in the ingestion of food. Food vacuoles occur in the cytoplasm and contain particulate materials at various stages of digestion. Non-digestiable material may be extruded from the cell either via a temporary opening or through a permanent cytopyge.

Excretion of waste products may occur directly through the body wall or by means of contractile vacuoles which periodically discharge waste material through the body wall or, in a few instances, through an anal pore.

Phylum Sarcomastigophora (the protozoa)

- **Subphylum Mastigophora (the flagellates)**
  - **Class Zoomastigophorea**
    - **Order Retortamonadida**
      - ***Chilomastix mesnili*** **(a commensal)**
    - **Order Trichomonadida**
      - ***Dientamoeba fragilis***
      - ***Trichomonas vaginalis*** **(trichomoniasis)**
    - **Order Diplomonadida**
      - ***Giardia lamblia*** **(giardiasis)**
    - **Order Kinetoplastida**
    - **Family Trypanosomatidae**
      - ***Leishmania*** **spp. (leishmaniasis)**
      - ***Trypanosoma*** **spp. (African trypanosomiasis, "sleeping sickness")**
      - ***Trypanosoma cruzi*** **(American trypanosomiasis, Chagas' disease)**

Family CRPTOBIIDAE

Cryptobia **sp.**

- **Subphylum Sarcodina (the amoebae)**
  - **Superclass Rhizopoda**
    - **Class Lobosea**
      - **Order Amoebida**
        - ***Endolimax nana*** **(a commensal)**
        - ***Entamoeba coli*** **(a commensal)**
        - ***Entamoeba histolytica*** **(amoebiasis, amoebic dysentery)**
        - ***Iodamoeba bütschlii*** **(a commensal)**

Phylum Apicomplexa

- **Class Sporozoea**
  - **Subclass Gregarina**
    - **Order Eugregarinidia**
      - **Suborder Septatina**
          - ***Gregarina*** **sp.**
  - **Subclass Coccidia**
    - **Order Eucoccidiorida**
      - **Suborder Eucoccidea**
          - ***Hemogregarina*** **sp.**
      - **Suborder Eimeriorina**
        - **Family Eimeriina**
          - ***Eimeria*** **spp. (coccidiosis)**
          - ***Isospora*** **spp. (coccidiosis)**

                - Isospora belli
                - Tyzzeria
                - Wenyonella
            - Family Sarcocystidae
                - *Sarcocystis* spp.
                - *Toxoplasma gondii* (toxoplasmosis)
            - Family *Cryptosporidiidae*
                - *Cryptosporidium parvum* (cryptosporidosis)
                - *Cyclospora cayetanesis*
                - *Pneumocystis carinii*
        - Suborder Haemosporoina
                - *Plasmodium* spp. (malaria)
    - Subclass Piroplasmasina
            - Family Babesiidae
                - *Babesia bigemina* (babesiosis)

Phylum Myxozoa

- Class Myxosporea
    - Order Bivalvulida
        - Suborder Platysporina
            - *Myxobolus* (= *Myxosoma*) sp. ("whirling disease")

Phylum Ciliophora (the ciliates)

- Class Oligohymenophorea
    - Subclass Hymenostomatia
        - Order Hymenostomadia
            - *Ichthyophthirius multifiliis* ("ick")
    - Subclass Peritrichia
        - Order Sessilida
            - *Epistylis* sp.
        - Order Mobilida
            - *Trichodina* sp.
- Class Litostomatea
        - Order Vestibuliferida
            - *Balantidium coli*

ARTHROPODA

GENERAL CHARACTERISTICS OF ARTHROPODS

The name of this phylum, derived from Greek word *arthros,* a joint, and *podos,* a foot, refers to the fact that the members of the phylum have jointed limbs. The primitive limb of arthropods was biramous, consisting of an unbranched basal piece, the *protopodite*, which branched into an inner *endopodite* and an outer exopodite. Some of the limbs of some species of arthropod are still of this type.

Arthropoda have probably descended from ancestors which also gave origin to the soft-skinned annelid worms, an example of which is the earth worm, but the arthropod have developed an outer covering of chitin, which forms an exo skeleton in which the whole body is enclosed. This chitinous covering is secreted by chitogenous cells beneath it and it not only covers the external surface of the body, but also passes through the mouth into the anterior part of the alimentary canal called protodaeum both of which arise as invaginations from the exterior into the body. The excoskeleton is usually present in the form of chitinous plates called sclerite, called a tergum, a ventral sclerite, called a sternum and a lateral plate between the tergum and sternum, which is called a pleuron. The tergum, sternum and pleuron of each segment are united by more flexible portions of the chitinous exoskeleton.

As the arthropod grows it becomes too big for its chitinous covering and periodically this is cast off and a new exoskeleton is formed. Each casting off of the exoskeleton is called **ecdysis.**

Arthropods are metamerically segmented animals. The segment of arthropods are associated in groups, the anterior segments forming the heads, the middle ones the thorax and the posterior ones the abdomen.

The appendages found on the body of an arthropod are typically paired, one pair usually being found on each segment. The appendages on the head are typically one or two pairs of sensory antennae and behind these paired appendages modified for feeding, commonly there is one pair of mandibles and behind these two pairs of maxillae .

Behind these again there may be **maxillipedes**, which are walking legs adapted for feeding. The next group of appendages belongs to the thorax and they are walking legs. Behind them, in aquatic species such as the crustacean, there are a variable number of abdominal appendages, some or all of which are use for swimming, terrestrial species usually loss these or some of them may become modified to perform other functions.

A dominant feature of the internal anatomy of the Arthropoda is the fact that the general body cavity is not a coelom. It is a space full of blood, which is called the haemocele. The blood in it bathes all the organs of the body. The heart pulsates; it sucks in blood from pericardium through openings in its walls called ostia. It then pumps the blood into the haemocele through short arteries which are usually the only blood vessels in the body.

The respiratory organs of arthropods are also characteristic of the phylum. They are:

1. Gills (branchiae) of various kinds found in larvae, nymphs and adults of species that are aquatic.
2. Tracheae, which are fine, elastic tubes, with a thin, chitinous lining which are held open by rings or spiral thickenings of the chitinous lining tracheae branch and ramify among the internal organs, to which they take air that enters them through their external openings or stigmata; trachae are especially characteristic of insects.

Other respiratory structures are lung-books and gill-books of spiders and crabs respectively. In some forms, e.g the parasitic mites, respiration is through the cuticle.

The alimentary canal varies in the different classes of arthropods. In all, however, it consist of (a) the stomodaeum mentioned above, which is lined by chitin and may be divided into a sucking phayrnx, a provetriculus (crop) and a gizzard, (b) the proctodaeum mentioned above, which is also line by chitin, (c) a mid-gut, or mesenteron, which connects the protodacum with stomodacum.

The excretory organs of arthropods vary in the different classes of the phylum. Those of the class Crustacea are a pair of nephridia which open on the bases of the second antennae. The excretory organs of the insecta are tubules, called malpighan tubules, which are arranged in a ring round the alimentary canal. Usually they open into the anterior end of the proctodaeum. Arachnida also have malpighian tubule that open into the anterior end of the proctodaeum, but they have, in addition, coxal glands, which open on the coxae of the legs. These latter are true nepridia homologous with the nephridia of the crustacean.

The nervous system of arthropods consists of cerebral ganglia in the head, united circumoesophageal commissures to a ventral double nerve cord that runs along the ventral side of the body and has nerve ganglia on it. Typically, there is one ganglion in each segment, but fusions of segment carry with them fusions of the ganglia associated with them. Associated with this central nervous system are eyes, sensory setae and other special sense organs.
The sexes of arthropods are usually separated.

ARTHROPODA

- **Subphylum Crustacea**
  - **Class Maxillopoda**
    - **Subclass Ostracoda**
    - **Subclass Copepoda**

- Order Cyclopoida
  - *Lernea* sp. ("anchor worms")
- Order Poecilostomatoida
  - *Ergasilus* sp.
- Subclass Branchiura
  - Order Argulidea
    - *Argulus* sp.
- Class Insecta
  - Order Dictyoptera
    - *Periplaneta americana* (American cockroach)
  - Order Anoplura
    - *Pediculus humanus* (body louse)
    - *Phthirus pubis* (pubic or crab louse)
  - Order Hemiptera
    - *Cimex* spp. (bedbugs)
    - *Panstrongylus megistus*
    - *Rhodnius prolixus*
    - *Triatoma* sp. (assassin bug)
  - Order Coleoptera
    - *Tenebrio molitor* (grain beetle)
    - *Tribolium confusum* (flour beetle)
  - Order Siphonaptera
    - *Ctenocephalides* sp. (fleas)
    - *Tunga penetrans* (sand flea)
  - Order Diptera
    - *Anopheles* spp. (mosquito)
    - *Cuterebra* spp. (bot fly)
    - *Glossina* spp. (tsetse fly)
    - *Tabanus* spp. (horse and deer flies)

- Subphylum Chelicerata
  - Class Arachnida
    - Order Acari
      - Suborder Metastigmata
        - Family Ixodidae (hard ticks)
          - *Amblyomma americanum* (lone star tick)
          - *Boophilus microplus*(southern cattle tick)
          - *Dermacentor* spp. (dog tick)
          - *Ixodes scapularis* (deer tick)
        - Family Argasidae (soft ticks)
          - *Ornithodorus turicata* (relapsing fever tick)
      - Suborder Astigmata
        - *Notoedres cati* (face mange)
        - *Sarcoptes scabiei*

Suborder Prostigmata

- ***Demodex* spp. (follicle mites, demodetic mange)**

. **Astigmata**
. **Sarcoptidae**
- *Sarcoptes scabiei* **(itch mite)**
- *Notoedres cati* **(mange mite)**
- *Knemidocoptes* spp **(scaly mite,depluming mite)**

. **Psoroptidae**
- *Psoroptes* spp **(scab mite)**
- *Otodectes cynotis* **(ear mite)**
- *Chorioptes bovis* **(chorioptic mange mite)**

. **Listrophoridae**
- *Lynxacarus radovskyi* **(cat fur mite)**

. **Analgidae (feather mites)**
- *Megninia ginglymura*

Economic importance of Parasites of domestic animals and poultry

Overt manifestations of the effects of parasitism may take a number of forms and almost invariably result in loss associated with product or with productivity. The most drastic form that this can take is, of course, where parasitism results in death of the affected animals. Most severe forms of parasitic disease can produce this effect. For example, Theileriosis or East Coast fever in newly infected susceptible cattle frequently results in heavy mortality in the affected animals. These effects are often most pronounced in younger animals because of lack of resistance. This lack of resistance may be immunological since in many instances the age at which the young are affected is too early in their development for the immune system to mount an adequate response. In other cases the physical attributes of the younger animals, because of requirements for growth and development, do not allow for the additional stresses impose by heavy parasitism and this results in death. Parasitic organisms other than protozoans can also cause death. Many of the nematode parasites, like *Haemochus contortus*, particularly if there is overcrowding leading to extensive build-up of the infective stages, will produce fulminating outbreaks of disease with heavy mortality.

In some instances, there may be interaction between mortality due to parasitism and other facets of productivity. Thus, the effects of parasitism actually represent a complex interplay of a variety of factors. Such as age of animal movement of animals, treatment as well as weather, all influence the size of worm burdens that directly affect the productivity of animals.

Of the ectoparasites of livestock, ticks cause the greatest economic losses. These effects include the production of toxins and loss of blood, their role as vectors of protozoan, nutritional, bacterial and viral diseases and a variety of nuisance, irritative and anorectic effects as well as their predisposing of affected animals to other diseases like screw-worm infestation (myasis). On a global basis, their economic toll is staggering. They transmit such major diseases as babesiosis, anaplasmosis, East Coast fever (therleriosis) and heart water (Cowdriosis).

It has been estimated that every tick completing it life cycle on an animal consumes 1 – 3ml of blood.

Animal fibre production can be adversely affected by parasitism by some of the trichostrongyle worms like *Trichostrongylus colubriformis* and trematodes. Sheep infected with ectoparasites like Psoroptes ovis show broken and light weight fleeces because of the effects of intense pruritis. This is reflected adversely in the quality of the product from animals but additionally can result in increased stress on the animal under conditions of environmental adversity such as cold.

Because of the debilitating nature of many forms of parasitic diseases in animals, there may be a number of indirect deleterious effect on reproduction. Lowered rates of fecundity as a result of poor condition leads to reduction in the number of offspring being produced by these animals. Lesions caused by the chorioptes mites that extended over one third of the scrotum of rams lowered the quality of semen similar to that noticed when testicular temperature was raised and could thus interfere with fertility. Some parasites like *Trichomonas fetus* by causing abortion and chronic sterility, can severely compromise breeding programs.

They not only cause loss of product by abortion but result in lengthening of the breeding intervals, through fertility, with the attendant economic loss.

Because of the effects on breeding programs, parasitism may make it impossible for the livestock producer to maintain either the desired age structure or rate genetic gain through selection. Parasitism may distort the value of some parameters used for genetic selection and thereby influence selection process.

Additionally, parasitic infestation can cause economic losses by adversely affecting the quality of whole carcasses, or parts thereof, may be condemned as unfit for human consumption. Thus there is condemnation of livers of sheep and cattle, because of the presence of flukes, and potions of meat, because of the occurrence of the cysts of *Taenia saginata* or *Taenia solium*. Parasitism may also influence the product characteristics, including composition, so that the consumer obtains less value from its use. Hides may be severely damaged by the activities of larval flies like Hypoderma bovis, or by mites like Demodex folliculorum necessitating down grading of the product for leather manufacture.

Immeasurable losses may result by consumer knowledge concerning the potential presence of a parasite in product, thus discouraging its consumption and lowering the market price. Such an example would be the suspected presence of Trichinella in pork.

This is also the matter of public health considerations. Diseases like trichinosis, cysticercosis and toxoplasmosis are readily transmissible to man by consumption of inadequately cooked meat. Because of the actual or potential presence of some of these agents in various animal products, important international economic sanctions may be imposed on the transfer of these products from one country to another. The cost of monitoring by various regional and national agencies concerned with quality of meat, milk and other animal products can impose a substantial economic burden. Coupled with these are, of course, all those additional costs imposed on the individual producer as well as the whole livestock industry of a country in the farm of medication cost, veterinary fees, lost labour, lost feed and other management practices aimed at reducing level of infection, minimizing the effect of parasitism and controlling the causative organisms, their vectors and intermediate host.