Course Code: ZOO 463
Course Title: PARASITOLOGY II
Number of Units: 3 UNITS
Course Duration: 5 hours per week

COURSE DETAILS:

Course Coordinator: Sammy O. Sam-Wobo (B.Sc., M.Sc., PhD)
Email: samwoboso@unaab.edu.ng; sammywobo@gmail.com
Office Location: B201, COLNAS Building
Other Lecturers: Dr. Uwem Ekpo and Dr. Olufunmilayo Idowu

COURSE CONTENT:

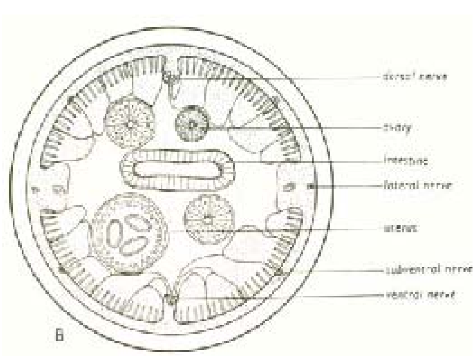
Taxonomical, epidemiological and life cycle studies of protozoa and helminths of medical and veterinary importance. Emphasis will be given to parasites of the West Africa region. Energy metabolism, protein and lipid synthesis: hatching and molting processes, arrested development and self-cure phenomena. Cultural/artificial membrane-feeding preservation and staining techniques. Habitat partition and physiological nature of different body habitats. Host-parasite relationships. A mention of vectors in order to allow for the identification of principal groups involved in the transmission of parasitic diseases.

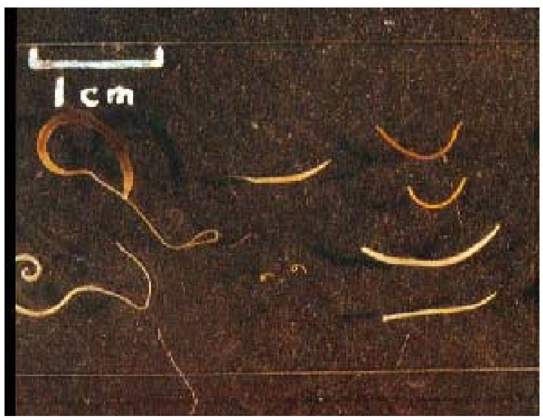
COURSE REQUIREMENTS:

The course is compulsory for all final year Zoology students. Students are expected to participate in all course activities and have a minimum of 75% attendance to be able to write the final examination

LECTURE NOTES

Lecture notes- High points

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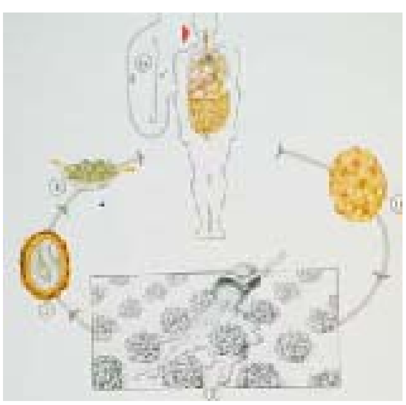

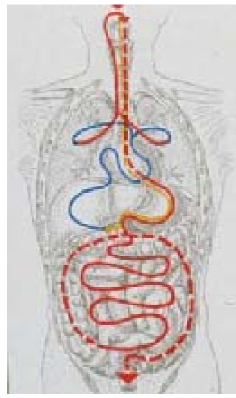

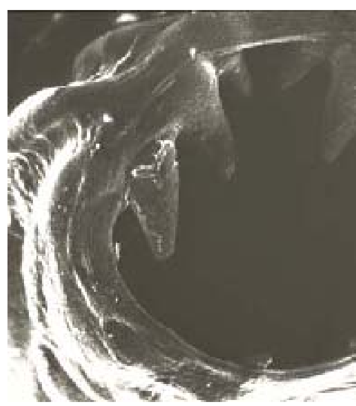

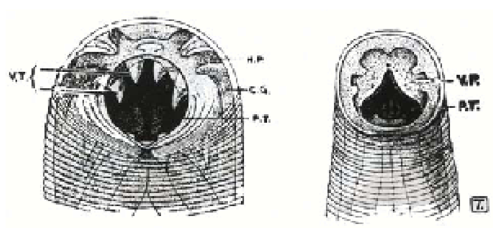

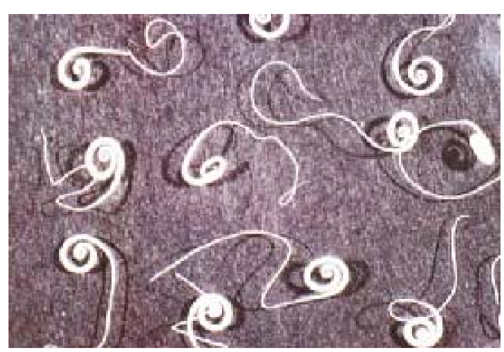

THE ROLE OF THE PARASITE

Parasitic adaptations are responses to features in the parasite's environment and this environment is the body of another organism, the host. This seems to be a difficult environment to invade but those organisms that have done so have often been very successful both in terms of numbers of individuals and numbers of species. Blood and tissues seem to be harder to invade than the gut, as is shown by the smaller number of blood and tissue parasites. This is probably in part related to the difficulties of getting eggs to the outside from sites within the host. Almost all phyla have some parasitic members (at least 50% of all species are parasites).

1. Morphological Adaptations

- Size: many parasites are large compared with their free-living relatives. This could be related to increased egg production.
- Shape: most parasites are dorso-ventrally flattened and this is related to the need to cling on to the host. Fleas are laterally flattened and rely on escape through the hairs. Nematodes are the obvious exception to the trend of flattening in parasites and parasitic nematodes, as a whole, show little morphological specialisation.
- In parasites and particularly in endoparasites there is loss of locomotory organs.
- Characteristic features of many parasites are organs of attachment. Despite the wide variety of parasites there are only two trends running through the evolution of attachment organs, the development of either hooks or suckers. Suckers occur in such widely divergent groups as protozoa, monogeneans, digeneans, cestodes,

parasitic crustaceans and parasitic annelids. Spines and hooks are present in many parasitic groups and the elaboration of spines or suckers or both into an eversible proboscis has occurred in the cestodes, acanthocephalans, and the acarines (ticks). Other types of attachment organ include claws in parasitic insects and the ctenidia (comb organ) of fleas. Penetrative filaments occur in a number of groups of parasite (Oxyurid nematodes, Microspora protozoans).

- In many parasites, particularly endoparasites, there is often a reduction in the CNS and sense organs.
- In endoparasites, again there is a trend to reduce the gut and absorb nutrients through the whole body surface.
- In those intestinal parasites, which do not absorb nutrients through the body surface, there is usually a thick cuticle. So helminths tend either to loose their gut or absorb nutrients through their teguments, or else retain their gut and have a thick resistant cuticle.
- In many parasites there is a tremendous elaboration of the reproductive organs, associated with increased gamete production. Cestodes, for example, basically consist of a small head and neck region and the rest is serially repeated gonads. Parasites can be described as being solely adapted for reproduction.

Life Cycle Adaptations

- There is usually an increase in reproductive potential compared with free-living relatives. Parasites usually produce more eggs and sperm than their free-living relatives do and there may be a great elaboration of the reproductive organs. Other adaptations, which increase egg production, are hermaphroditism and parthenogenesis, where every individual produces eggs and loss of seasonal reproductive cycles, so eggs and sperm are produced all the year round. Rapid maturation and extended life span also increase total reproductive capacity. The reproductive potential of the parasite can again be increased by asexual reproduction at different stages of the life cycle. One of the best examples are the digeneans where a single sporocyst can give rise to daughter sporocysts each of which can give rise to several generations of redia, before the cercariae are produced. It has been estimated that the reproductive potential of a single liver fluke (*Fasciola hepatica*) is four hundred million offspring in its lifetime.
- Infection of secondary and tertiary hosts. This has three advantages:
    - Increased reproductive potential, since asexual reproduction can take place in the alternative host.
    - It increases the range of the parasite in space and time. That is infection of more than one host can increase the geographical range of a parasite, particularly if one host is say terrestrial and the other aquatic. By infecting more than one host species the parasite can survive periods when one host is temporarily scarce.

- An intermediate host can channel the parasite towards its definitive host since the intermediate host is frequently part of the final host's food chain or else closely related ecologically.
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- Many parasites have no provision for infecting new hosts beyond the provision of large numbers of eggs or larvae. However, the infective stages of many parasites show adaptations that help to increase their chances of infecting a host. These include:

  - Behavioural responses to locate favourable environments.
  - Responding to chemical stimuli from their host.
  - Changing the behaviour of the infected intermediate host to increase the chances of them being eaten by the final host.
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- Integration of life cycles. There are many ways in which the life cycle of a parasite becomes integrated with that of its host, but they fall into two broad mechanisms:

Regulation of infection by the host.
Many parasites require a specific pattern of stimuli from their host before they are able to infect them. This is particularly clear in those parasites that infect their hosts passively via the gut in the form of cysts or eggs. Such stages may require pre-digestion with host enzymes and the presence of specific bile salts as well as the correct pH, temperature, redox potential, pO_2 and pCO_2 before they can hatch.

  - Regulation of the adult parasite by the host. That is reproduction of the parasite is controlled by hormonal or physiological changes in the host (e.g. the periodicity of microfilariae, reproduction in *Opalina* and *Polystoma* in the frog).

3. Immunological Adaptations

Vertebrates react to the presence of foreign material in their tissues by the production of a humoral and cell mediated response and this depends on the ability of the host to recognise the difference between self and non-self. In mammals it takes approximately 9 days for the immune response to become fully effective, so any parasite that persists for significantly longer than 9 days must have some mechanism for avoiding or mitigating the hosts' immune response. These include:

- Absorption of host antigen
- Antigenic variation
- Occupation of immunologically privileged sites
- Disruption of the host's immune response
- Molecular mimicry
- Loss or masking of surface antigens

4. Biochemical Adaptations

The major ones are:

- Energy metabolism. The energy metabolism of adult helminth parasites is essentially anaerobic and helminths characteristically breakdown carbohydrate into a range of organic acids such as acetate, lactate, succinate, propionate and branched chain fatty acids such as 2-methylbutyrate and 2-methylvalerate. The TCA cycle is usually reduced or modified and many parasites fix carbon dioxide and have a partial reversed cycle with phosphoenolpyruvate playing a central role. The cytochrome chain in helminths is often modified.

  The reduction in the TCA cycle and cytochrome chain results in a low ATP production/mole glucose catabolised. In *Ascaris*, for example, you get 6ATP/mole of glucose, compared with 36 ATP/mole in aerobic tissues. This low ATP/mole of glucose is often compensated for in parasites by high rates of glucose utilisation.

  In keeping with the anaerobic nature of adult helminth metabolism there is no beta-oxidation of fatty acids in adult helminths and only limited amino acid catabolism.

  So helminths would seem to be well adapted to live in anaerobic or microaerobic sites within the body such as the gut or lumen of the excretory system. What is not clear is why this essentially anaerobic metabolism is also found in helminths such as schistosomes that live in aerobic sites in the body (in this case the blood stream).

- Synthetic reactions. In general the synthetic capacities of parasites are reduced when compared with their free-living relatives. This could be related to the low ATP/mole glucose produced in parasites or to the abundant source of nutrients in the parasite's environment.

- Nutrient uptake. A number of parasites such as cestodes and acanthocephalans have no gut and produce no digestive enzymes of their own. Instead they rely on their host's digestive enzymes to breakdown food to low molecular weight compounds (amino acids, monosaccharides, fatty acids) which the parasites then absorb through their teguments. The absorption mechanisms of cestodes and acanthocephalans compete with the uptake mechanisms of their hosts intestine for the available nutrients. The amino acid, monosaccharide and fatty acid uptake mechanisms of cestodes and acanthocephalans (and digeneans) are kinetically very similar to those of the vertebrate intestine. So although there is a reduction of synthetic and catabolic pathways in parasites, there is an elaboration of transport mechanisms.

Parasitic adaptations are all responses to particular features of the parasite's environment, and with the exception of the host's immune response, the same features are also found in free-living environments. So few if any 'parasitic adaptations' are not also found in free-living organisms.

- Animals that live in fast flowing streams and are in danger of being swept away are frequently flattened dorso-ventrally or laterally and have developed hooks or suckers as organs of attachment.

- Reduction of sense organs is common in organisms that live in caves.

- Absorption of nutrients through the general body surface is common in soft-bodied marine invertebrates and a number of them have lost their guts.
- Much of the biochemical modification found in adult helminths is related to the anaerobic or near anaerobic conditions found in the vertebrate gut. Anaerobic conditions occur frequently in free-living environments, in mud, in waterlogged soil, in bivalves when they close up as the tide goes out. The intermediary metabolism of invertebrates living in these places is often extremely similar to the intermediary metabolism of gut parasites, involving carbon dioxide fixation, partial reverse TCA cycles and the production of organic acids such as succinate and propionate.
- Organisms that live in transient environments, such as rainwater pools, have, like parasites, developed resistant and dispersal stages and are often capable of asexual reproduction.
- A characteristic feature of parasites is their high reproductive potential. But other organisms that have hazardous phases in their life cycles, such as planktonic larvae, produce vast numbers of offspring. But even in parasites there is a relationship between fecundity and parental care. The monogeneans for example produce few well-provisioned eggs.

There is no single feature that can be said to delineate the parasite environment from the free-living environment; rather it is the combination of factors that makes the parasitic way of life unique.