NATIONAL OPEN UNIVERSITY OF NIGERIA

NSC 106

Medical Mircobiology and Parasitology

Module 4

NSC 106 (Medical Microbiology and Parasitology) Module 4

Course Developer/Writer
Prof. A. Aboderin, Obafemi Awolowo University, Ile-Ife
Dr. O.O. Irinoye, Obafemi Awolowo University, Ile-Ife
Mrs. E.J.-Shehu, National Open University of Nigeria

Content Editor
Mrs. E.M. Joseph-Shehu, National Open University of Nigeria

Course Coordinator
Adeolu Ejidokun, National Open University of Nigeria

Programme Leader
Dr. Jane-Francis Agbu, National Open University of Nigeria

Credits of cover-photo: Mr. Gbenga Aiyejumo, National Open University of Nigeria.

National Open University of Nigeria - 91, Cadastral Zone, Nnamdi Azikiwe Express Way, Jabi, Abuja, Nigeria

www.nou.edu.ng centralinfo@nou.edu.ng
oer.nou.edu.ng oerunit@noun.edu.ng OER repository
Published in 2021 by the National Open University of Nigeria

How to re-use and attribute this content

Under this license, any user of this textbook or the textbook contents herein must provide proper attribution as follows: “First produced by the National Open University of Nigeria” and include the NOUN Logo and the cover of the publication. The repository has a version of the course available in ODT-format for re-use.

If you use this course material as a bibliographic reference, then you should cite it as follows: “NSC 106: Medical Microbiology and Parasitology, Module 6, National Open University of Nigeria, 2021 at oer.nou.edu.ng

If you redistribute this textbook in a print format, in whole or part, then you must include the information in this section and give on every physical page the following attribution: Downloaded for free as an Open Educational Resource at oer.nou.edu.ng If you electronically redistribute part of this textbook, in whole or part, then you must retain in every digital file (including but not limited to EPUB, PDF, ODT and HTML) the following attribution:

Downloaded for free from the National Open University of Nigeria (NOUN) Open Educational Resources repository at oer.nou.edu.ng

Module 4 Introduction

Organisms are associated to each other for different reasons like nutrition, protection etc. this module will describe the association of organism, parasitic helminth and different types of host. The module has two units.

At the end of this module you should be able to

- describe the various association that exist between organisms
- describe human helminthes.

Unit 1 Association in Organisms and Classification of Host Organisms

1.0 Introduction

Organisms frequently associate together, often closely. There are a number of "motives" for these associations, including protection, nutrition, and as an aid to the dispersion (both geographically and temporally) of the organism. There are four main ways animals of different species may be associated to one another; Symbiosis, Mutualism, Commensalism and Parasitism. These classifications however, on closer inspection, may become blurred, one type taking on the aspects of another, for example over time as the relationship evolves. However, as a general guide these terms are still very useful.

2.0 Objectives

At the end of the study, you should be able to

- explain the various types of association existing between organisms
- give examples of various types of association
- describe the concept of parasitism and types of parasites
- explain the different types of parasites' host.

3.0 Main Content

3.1 Types of Association

Symbiosis
Here both organisms are dependent on each other. Examples being the association of flagellate protozoa in the gut of termites, where termites are dependent on the protozoa for breaking down their food stuffs, and the protozoa are dependent on the termites as host organisms. Another good example here which is often cited is the association between clown fish and anemones in tropical reefs; where the fish is dependent on anemone for protection and food while the anemone does not appear to gain anything from the association, except possibly cleaning. However, it has been observed that in some cases, in

the absence of the fish partner the anemones tend to disappear from their reef home, indicating a true symbiotic rather than a mutualistic or commensal relationship.

Another well-known example is found with the lichens, symbiotic association composed of fungi and algae. These associations may become very close, and it is thought that the eukaryotes as a group evolved as a result of such an association.

Intracellular organelles such as the mitochondria and chloroplasts appear to have their origin as intracellular symbiotes of early eukaryotes, (some extremely primitive eukaryotes, such as the intestinal parasite Giardia lamblia, lack these organelles). Other forms of symbiosis may be much less close, for example an organism that uses another organism purely as a means of dispersal for example bacterial or fungal spores on the legs of flies or coelentrates and barnacles on the carapaces of marine crustaceans. This particular form of symbiosis is sometimes called Phoresis.

Mutualism
Here the associates may or may not be dependent on each other for their existence, but both benefit when they are associated. A good example of this occurs with the association of sea anemones on the backs of crabs. Both gain from the association (the anemone providing some food for the crab, which in turn gives extra motility to the anemone), but both can survive on their own.

Another less well known example is found between certain species of ants and the caterpillars of some of the Lycaenidae butterflies (particularly the 'Blues'), where the caterpillar is protected by the ants within their nests, in return for which the caterpillar secretes a honeydew which the ants collect. In this case from the point of view of the ant, it benefits from the association, but does not appear to need it, (i.e. the association is facultative, or opportunistic). However, from the point of view of the caterpillar, this association is required for its survival (i.e. the association is obligatory). This illustrates that these definitions may become blurred, and, over time, one form of association may evolve into another.

Commensalism
Neither organism is dependent on the other for its existence, but in this case only one of the partners' benefits from the association, the other being unaffected. An example of this, found in humans, are the non-pathogenic obligate commensal protozoa such as the amoebae Entamoeba gingivalis, commonly found in the mouth, feeding of bacteria, dead epithelial cells and food particles. Purely commensal relationships tend to be rather rare, as on a closer inspection element of mutualism or parasitism may become apparent.

Parasitism
Here one of the associates live either partly or wholly at the expense of the other associate, the other partner (the host organism) not gaining anything from the association. This association may give rise to extreme pathology in the host, or the parasitism may be generally not very pathogenic. Parasitism is carried out by many organisms, the main groups including viruses, bacteria, protozoa (these usually being endoparasitic), and various metazoan groups (multicellular eukaryotic animals), these being mostly groups of helminths (often endoparasitic), and arthropods (usually ectoparasitic), as well as some higher organisms, such as ectoparasitic lampreys and hagfish. Generally however, for partly historical reasons, the term parasitology generally only refers to the study of infection with

eukaryotic protozoan, and invertebrate metazoan parasites, not bacteria, viruses or the higher chordate parasites, even though these are parasites in the true sense.

3.2 Classification of the Parasitic Organism

Organisms in these associations may either be on the outer surface of the host organism, (in which case the prefix Ecto- is used), or inside the host organism, (in which case the prefix Endo- is used). These prefixes may be used with any of the animal associations listed above. For example the flagellate protozoa in the termite guts are Endosymbionts, while the anemone can act as an Ectocommensal with the crab.

Parasites may act as both ecto- and endoparasites. Parasites may also be classified according to the closeness of the relationship. For example Facultative Parasites (such as many bacteria) are those where the parasitic lifestyle is only taken up opportunistically, whereas Obligate Parasites (such as all viruses and most of the helminth parasites described below) are those in which the organism must parasitise another organism. These parasites may often cause diseases, in which case they are referred to as

Pathogenic Parasites
In a somewhat wider interpretation of the term parasitism, some organisms exhibit parasitic behaviour only early in their life cycle, these being referred to as Brood Parasites. Examples of these include caterpillars of the Large Blue butterfly, which chemically mimic other caterpillars with mutualistic associations with ants (see above), but both fail to produce honeydew as compensation and consume ant grubs, and may in fact destroy the nest, (thereby acting as a pathogenic parasite for the ants).

In this case, the parasitic lifestyle probably evolved from the mutualistic lifestyle of the other, related butterflies, again illustrating how one form of association may change into another. Another well-known example of a brood parasite is a bird, the cuckoo.

Some parasites establish themselves in hosts in which they do not ordinarily live. These are called the Incidental Parasites. A temporary parasite is free-living during part of its existence and seeks its host intermittently to obtain its nourishment whereas Permanent Parasite remains on or in its host's body from early life until maturity, sometimes for its entire life. Parasite that has passed through the alimentary tract without infecting the host are called Coprozoic or Spurious Parasite.

Parasites often lack the necessary organs for assimilation of raw materials and depend upon the host for predigested food. An adequate supply of moisture is assured inside the host, but during the free-living existence of the parasite, inadequate moisture may either prove fatal or prevent the larval development.

Temperature is likewise important. Each species has an optimal temperature range for its existence and development. Both high and low temperatures are detrimental and even lethal.

3.3 Types of Host

Parasitic helminths may have either simple or complicated lifecycles. The terms used to describe the hosts harbouring different stages in these lifecycles are however the same. The degree of damage done to the hosts is however varied. For example in definitive host, the greatest harm is seen being the one the adult stage of the parasite is found.

Sometimes, a host might assume dual functions, and therefore could be difficult to classify strictly into one type. Human host during infection by malarial parasite is one of such. Human could be classified as the definitive host being the one in which greatest harm is seen. Also, intermediate host like human beings harbours the asexual stages of the parasite merozoites and trophozoites. A clear understanding of the relationship between host and parasite and function of host in survival and transmission of parasite is therefore necessary for a better classification.

Definitive Host

The adult parasites are found in the definitive host. This is where the parasite's sexual cycle usually takes place, with either cross or self fertilisation with hermaphroditic parasites, or sexual reproduction if the parasites have separate sexes, followed by production of eggs, or more rarely with viviparous helminths, larvae. The greatest harm is usually seen in this host.

Intermediate Host

In many cases the parasites larvae are found in different hosts, these are called the Intermediate Hosts. Parasitic helminth larvae may have one, two or more intermediate hosts in their lifecycles, or they may have no intermediate hosts. Often asexual stages of reproduction occur in these intermediate hosts, (for example with Platyhelminth parasites).

Note that when describing hosts of parasitic protozoa, these terms are slightly different owing to the asexual characteristics of many of these organisms. With parasitic protozoa the vertebrate host is generally referred to as the definitive host, whilst the invertebrate is the intermediate host. Some parasitic nematodes (e.g. Strongyloides stercoralis) are Facultative parasites, having completely free living lifecycles in addition to parasitic ones. The two terms definitive and intermediate host are the most important in Parasitology when referring to the type of host.

A vector however, should not be mistaken for intermediate host. A vector actively transmits infection to a host without necessarily harbouring the asexual stage of the parasite e.g. the vector of African trypanosomiasis Glossina spp. These groups of vectors pick up parasite (the infective stage) from the reservoir hosts during blood meal and transmit it to a susceptible definitive host. However, some vectors can still serve as intermediate hosts harbouring the asexual or the larval forms of the parasite e.g. certain Anopheles mosquitoes that harbour the microfilariae of filarial worms.

Accidental Host

Accidental hosts are those in which the parasites do not normally develop (for example to lack of exposure to infective forms of the parasite), but when occasionally chance infections occur, the parasite is able to complete its lifecycle.

Hosts where the parasite can complete its lifecycle are called Permissive hosts, and include true definitive and intermediate hosts as well as many accidental hosts. Examples here include such parasites as Fasciola hepatica, where the normal definitive hosts are ruminants, but humans and other animals may also be infected and viable adult parasites develop. Another example is human infection with the nematode Angiostrongylus cantonensis in the far East.

In comparison another form of the accidental host is the Non-Permissive host where the parasite, although it may develop to some extent, reaches effectively a dead end, the parasite not being able to complete its lifecycle and eventually dying within the host. These forms of infection often occur where the parasite has intermediate hosts which may be accidentally ingested by animals other than the true definitive host. For example, with various marine ascarids of the family Anisakidae such as Anisakis sp., which give rise to the condition of 'Anisakiasis' on ingestion of raw infected fish.

Paratenic Host

Paratenic hosts may also be included in parasitic helminth lifecycles. In these forms of infection the parasites undergo an arrested development on infection, larval forms accumulating in these hosts until they have a chance of infecting the definitive host (e.g. in the Pseudophyllidean tapeworms). These hosts are therefore not essential to completion of the parasites lifecycle. This is in contrast to the case with true intermediate hosts whose ingestion is essential to the lifecycle, for example Echinococcus sp.

Reservoir Host

These are accidental hosts and hosts of parasites which have zoonotic patterns of infection (i.e. normally infect a wide range of hosts), may act as Reservoir Hosts for the parasite. These are also a form of permissive hosts as fully viable infections develop, and a more accurate term would be alternative definitive hosts (though this is not in fact used). The term reservoir host is usually only used when describing the epidemiology of human infections.

An example of parasites with zoonotic infections is Schistosoma japonicum. This parasite, as well as infected man, can also infect other mammals as definitive hosts, including rodents, cats, dogs, domesticated ruminants such as water buffalo and a wide range of other mammals. In Human African Trypanosomiasis (HAT), the reservoir host are cattle which serve as sources of active infection to man. The presence of these Zoonoses has implications for the control of the parasite in the field.

4.0 Conclusion

In this unit, we learnt that organisms interact with each other at different degrees. While some are solely dependent on each other, however, some are opportunistic and can adopt different means for their survival. Various types of association, classification of the parasitic organisms and different types of hosts were also discussed.

5.0 Summary

In this unit, you have learnt about the following:

1. Types of Association
2. Classification of the parasitic organisms
3. Types of host.

6.0 Self-Assessment Exercise

Activity: What is the type of association that exist between salmonella typhi and its host?

Answer the following questions:

1. Write short note on the following: Symbiosis, Mutualism, and Commensalism (LO1)
2. What is/are the differences between symbiosis and mutualisms (LO1)
3. Give one example in each case of (a) Commensalism, (b) symbiosis (c) mutualism (LO2)
4. Describe the different types of Parasites with example (LO3)
5. Explain the various types of host (LO4)

7.0 References/ Further Reading

Atlas, R.M. (1995). *Microorganisms in Our World*. Mosby Year Book.Inc.

Medigan, M.T. *et al*. (2009). *Brock Biology of Microorganisms*. (12th ed.). Pearson Education Inc.

Pelczar, M.J., Chan, E.C.S. & Krieg, R.N. (2001). (5th ed.). *Microbiology*. McGraw-Hill.

Willey, J.M., Sherwood, L.M & Woolverton, C.J. (2008). *Microbiology*. (7th ed.). Boston Bur Bridge, IL: McGraw-Hill Higher Education.

Unit 2 Human Helminth Infections

1.0 Introduction

This unit aims to introduce the student to the diversity of helminth infections in man, and even more importantly, to the numbers of individuals that harbour these infections in all regions of the world. There are three major groups of helminthes containing members that have man as their main hosts, these being the digenean flukes, the tapeworms (cestodes), and the roundworms (nematodes).

2.0 Objectives

At the end of this unit, you should be able to:

- describe various helminthes parasites
- explain exemples of various helminthes parasites.

3.0 Main Content

3.1 Nematode Infections

Enterobius vermicularis - Pinworm, Threadworm
E. vermicularis infection, an extremely common nematode infection, particularly in temperate areas such as Western Europe and North America,being relatively rare in the tropics and particularly in children. It has been estimated that the annual incidence of infection is over 200 million, this probably being a conservative figure.Samples of Caucasian children in the U.S.A. and Canada have shown incidence of infection of from 30% to 80%, with similar levels in Europe.

Ascaris Lumbricoides
The Large Human Roundworm.Again the incidence rates for this parasite are very high with > 1500 million cases of infection annualy, of which about 210 million cases are symptomatic.

Trichuris Trichiuria
The Large Human Roundworm. The incidence rates for this parasite are also very high, with estimates of about 1300 million cases of infection annually, of which >133 million cases are symptomatic.

The Hookworms
These are represented by two parasites, Necator americanus in the tropics and sub tropics worldwide and the S. E. states of the U.S.A., and Ancylostoma duodenale, again with a worldwide distribution in the tropics and sub tropics as well as the Mediterranean region. There are > 1200 million cases of hookworm infection annually, of which about 100 million cases are symptomatic.

Lymphatic Filariasis - Elephantiasis
This disease is caused principally by two parasites, Wuchereria bancrofti with an annual rate of infection of about 106 million cases, and Brugia malayi with an annual rate of infection of about 12.5 million. The total number of people infected with other types of lymphatic filarial worms is much smaller, at about 1.5 million cases. These lymphatic filarial worms, along with the related filarial parasite Onchocerca volvulus, are unusual among the nematodes in that they develop with, and are transmitted by insect vector intermediate hosts.

Onchocerca Volvulus - River Blindness
The incidence rates for this parasite are not as high as some of the previously described parasites, with an annual rate of infection of about 18 million, however, due to the extreme pathology associated with this parasite, often with all adult members of affected villages losing their sight, along with severe skin conditions, the infection is significant.

Dracunculus Medinensis - Guinea Worm
The incidence rates for this parasite are much lower, with an estimated annual rate of infection of about 100 000. This is much lower than in the recent past, when up to 50 million people were infected. This reduction in incidence illustrates how successful helminth control programmes can be effective in reducing the disease caused by these organisms.

Other important nematode infections include; Trichinella spiralis, Strongyloides stercoralis, and a number of more rare infections. Nematodes that normally infect other animals may still cause disease in man. These include Toxocara canis and a number of nematodes causing anisakiasis.

3.2 Digenean Trematode Infections

Schistosomiasis - Bilharzia
Schistosomiasis is caused by Schistosoma mansoni, S. haematobium, S.intercalatum, S. japonicum and S. mekongi. This disease is the most important human helminthiasis in terms of morbidity and mortality. The numbers of people infected are lower than those of many of the nematode infections, with an estimated annual incidence of infection of > 200 million cases. In terms of active disease however, the parasite is much more important, with an estimated annual mortality rate of about 1 million deaths directly due to infection with these parasites.

Opisthorchis Sinensis - The Chinese Liver Fluke
This is also a very important trematode infection, with an estimated annual incidence of infection of about 20 - 30 million cases, mostly in the Far East, in Japan, China, Taiwan and South East Asia.

Paragonimus Spp. - The Lung Fluke
This fluke causes a pulmonary disease, the adult parasites living in the lungs of their definitive hosts (e.g. man). There are a number of different species of this parasite; the most well documented being P. westermani in the Far East. It may however, be locally very common, with up to 40 to 50% of the population infected.

There are a number of other digenean trematode infections. These include various Echinostome infections as well as a number of other flukes. In addition, there are a number of these parasites that usually infect domesticated animals, but also cause well known human infections as well. These include fasciola hepatica and dicrocoelium dendriticum.

3.3 Cestode (Tapeworm) Infections

i. Taenia Saginata - The Beef Tapeworm
This only causes very limited pathology in man, but the annual incidence of infection is high, at an estimated 50 million cases.

ii. Taenia Solium - The Pork Tapeworm
This has a similar estimated annual incidence of infection of about 50 million cases. However, in this case the consequences may be more severe, due to the added risk of contracting infection with the larval metacestode, (cysticercosis).

This may have extreme consequences in terms of the pathology associated with infection, with an estimated annual mortality rate of about 50,000 deaths. For the cestodes, these annual incidence rates are based on detection of infection with the adult parasite. This is achieved by examination of faeces, urine or sputum for parasite eggs. Diagnosis of infection with larval metacestode parasites, such as echinococcus sp. is very difficult, due to the lack of non-invasive diagnostic techniques. It is in consequence very difficult to estimate annual rates of infection, even though these metacestodes may be very important pathogens.

4.0 Conclusion

In this unit, we have discussed that Parasitic helminths can be grouped into nematodes, cestodes and trematodes. The nematodes are the most diversified groups. Parasitic helminths infect a wide range of hosts, ranging between man, domestic animals and wild animals. Morbidity is often high leading to death of several thousands of people.

5.0 Summary

In this unit, you have learnt about the following:

- Nematode infections
- Digenean trematode infections
- Cestode (tapeworm) infections.

6.0 Self-Assessment Exercise

Activity

Answer the following questions:

1. Write short note on Nematode Infections, Digenean Trematode Infections and Cestode (Tapeworm) Infections (LO1)
2. Describe the following Lymphatic filariasis, Enterobius vermicularis, Dracunculus medinensis, Schistosomiasis – Bilharzia, and Taenia solium (LO2)
3. Mention the 3 types of fluke with 2 examples of each species (LO2)

7.0 References/Further Reading

Brown, H.W. & Neva, F.A. (1983). *Basic Clinical Parasitology.* (5th ed.). Pp1-17.

Ukoli, F.M.A. (1990). *Introduction of Parasitology in Tropical Africa.* John Wiley and Sons Ltd., Chichester.

Hunter, G.W., Swartzwelder, J.C., Clyde, D.F (1976). A Manual of Tropical Medicine. (5th ed.). WB Saunders, Philadelphia.