Bio Factsheet

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Saprobiontic & Parasitic Modes of Life

This Factsheet describes:

- saprobiontic and parasitic modes of nutrition, illustrated by the nutrition of *Rhizopus* and *Taenia*;
- the roles of saprobionts in the nitrogen and carbon cycles;
- the adaptations of *Rhizopus* and *Taenia* to their way of life;
- the life cycle of the malarial parasite and *schistosoma*.

The nutrition of *Rhizopus* and *Taenia*

There are many species of *Rhizopus* (bread mould) and *Taenia* (tapeworm). This account will refer to *Rhizopus nigricans* which obtains its nutrients from bread and *Taenia solium* which infects pigs.

The structure of *Rhizopus* is shown in Fig. 1. The stolons of *Rhizopus* enable the mycelium to spread over the surface of the bread enabling the rhizoids to penetrate the greatest possible volume of bread. The rhizoids synthesize digestive enzymes and secrete them, via golgi vesicles, from their tips into the bread. These enzymes hydrolyse the complex substances in the bread into simple products which are absorbed back into the rhizoids. The enzymes include:

- **Amylases** which hydrolyse starch into maltose sugar.
- **Maltase** which hydrolyses maltose into glucose.
- **Proteases** which hydrolyse proteins into polypeptides.
- **Exopeptidases** and **endopeptidases** which hydrolyse polypeptides into amino acids.
- **Lipases** which hydrolyse fats or oils into fatty acids and glycerol.

The products of digestion are absorbed into the rhizoids, primarily by diffusion, although facilitated diffusion and active uptake may be involved when diffusion gradients are small. Normally there will be a much higher concentration of digestive products in the bread than in the rhizoids. Salts will also be absorbed and water will be taken up by osmosis. The absorbed substances will then be assimilated in the fungal hyphae. *Rhizopus* stores surplus glucose as glycogen.

Features of saprobiontic fungi which enable their continued survival

Saprobiontic fungi must be able to:

- maintain survival and spread through the substrate they are feeding on,
- disperse to new distant suitable substrates and become established on these, and
- be able to survive during adverse conditions (lack of food, lack of water, adverse temperature or pH)

Saprobiontic fungi thus have the following features:

- fungal hyphae grow from their tips and branch frequently. They thus spread through the substrate into untapped food areas and grow away from areas where they have shed excretory waste (negative chemotropism).
- under good growth conditions fungi have very prolific powers of asexual reproduction, producing millions of light spores. These are usually dispersed widely by air currents. If a spore lands on a suitable substrate it can germinate to produce a new hypha. This hypha will use the food reserves in the substrate to grow and divide throughout the new substrate.
- When conditions become adverse, fungi reproduce sexually, producing resistant zygospores. These remain dormant and have a thick protective wall (usually made of calcium oxalate crystals) which protects them until suitable growth conditions are encountered. They can be dispersed widely by air currents. When a zygospore lands on a suitable substrate, providing water, a suitable temperature and a suitable pH is present, the zygospore will germinate to form a new hypha. This often immediately develops an asexual sporangium and asexual spores are released. The new hypha grows and branches throughout the new substrate.

Fig. 1. Structure of *Rhizopus*

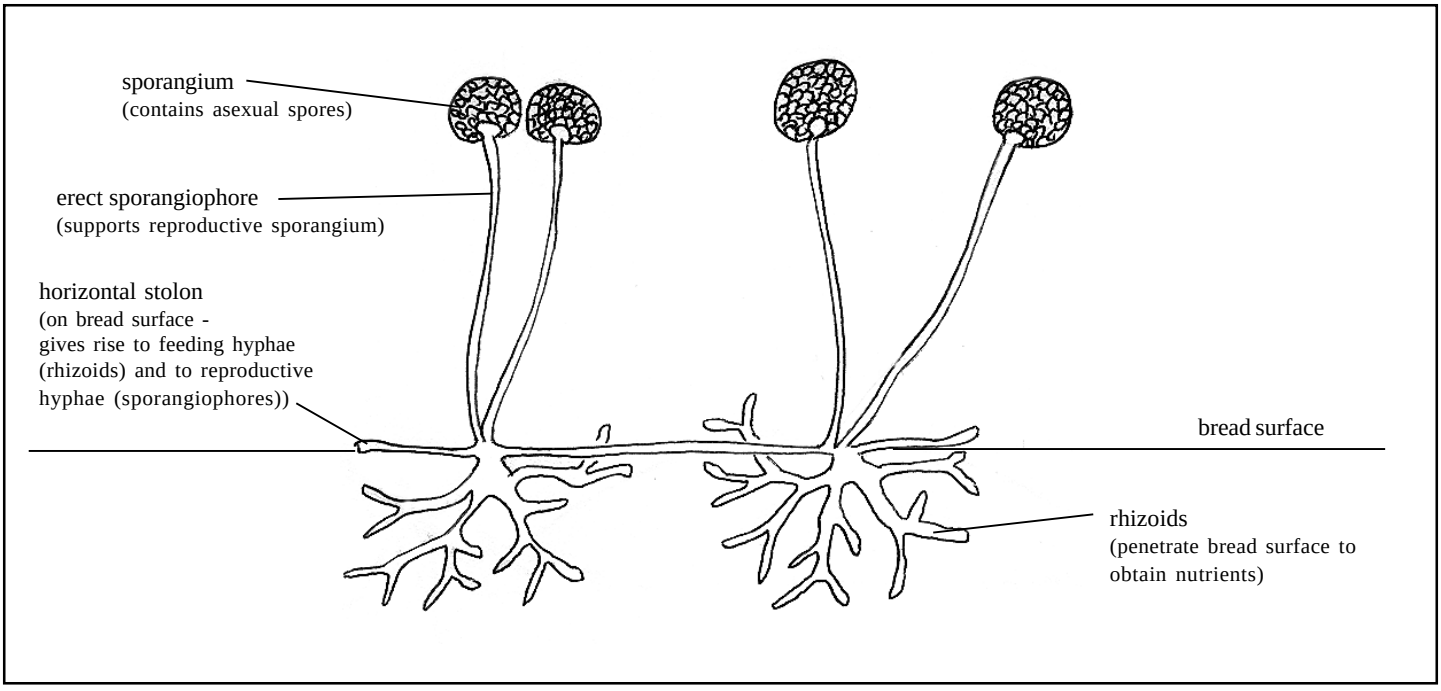
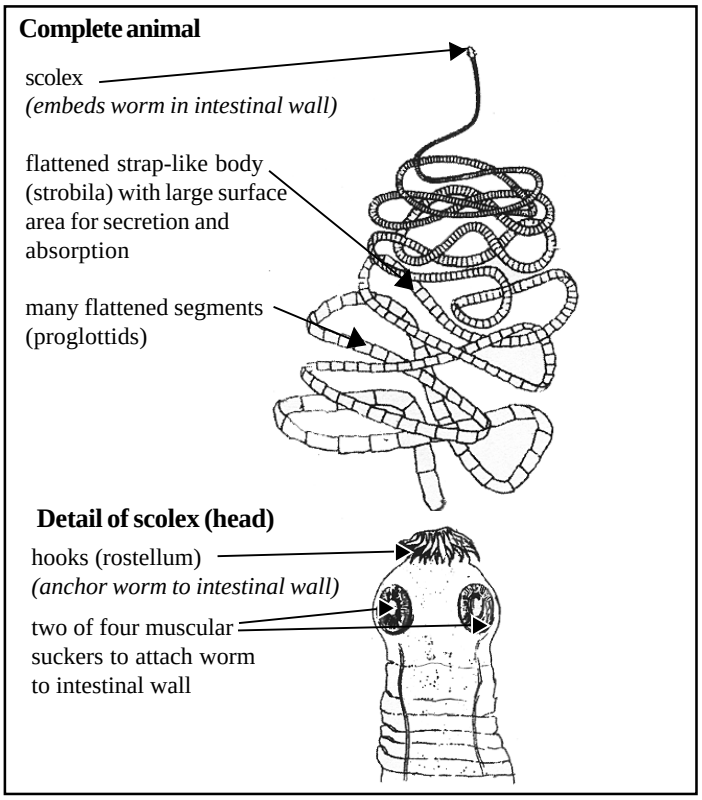


Fig. 2. Structure of *Taenia*



The structure of *Taenia* is shown in Fig. 2. Although *Taenia* can secrete minute quantities of digestive enzymes close to the body wall to increase the availability of digested food, it has lost the ability to secrete large quantities of digestive enzymes because it absorbs all necessary digested foods (and salts and water) from the digested food of the host pig. Because the tapeworm is present in the small intestine of the pig it is bathed in digested food which can be efficiently absorbed over its large body surface. Because the strap-like body (strobila) is flattened, the segments (proglottids) have a large surface area to volume ratio. This aids absorption, but also reduces resistance to the flow of substances through the intestine. The worm cannot be easily dislodged from its position because the head (scolex) is tightly anchored by hooks and suckers to the intestinal wall.

The proglottids are metabolically very active and their cells contain large numbers of mitochondria to generate energy for use in active uptake and transport. Unlike other flatworms, tapeworms do not have a digestive system (gut) because one is not needed.

***Exam Hint:**- Candidates are not expected to know the details of the tapeworm life cycle.*

The roles of saprobionts in the carbon and nitrogen cycles

Saprobionts play an important role as decomposers in nutrient cycles by contributing to the break down of the bodies of dead organisms. Many soil bacteria and fungi, including the soil sub-surface parts of mushrooms and toadstools, secrete digestive enzymes into the rotting organic matter of the soil. The enzymes include:

- **Proteases** and **peptidases** to hydrolyse proteins in dead bodies to amino acids.
  Ammonification can then occur when the amino acids are deaminated to ammonia by other bacteria and fungi. Nitrifying bacteria such as *Nitrosomonas* then convert the ammonium ions into nitrite ions. Bacteria such as *Nitrobacter* then convert the nitrite ions into nitrate ions which can be absorbed by plant roots.
- **Cellulases** break down the complex polysaccharide, cellulose, of plant cell walls into simple sugars such as beta-glucose. This liberates plant cell contents to enable further recycling.
- **Amylases and maltase** break down starches and glycogen to alpha-glucose.
- **Lipases** break down fats and oils into fatty acids and glycerol.

Adaptations of parasites to their way of life

To be successful the parasite must be adapted to:

- **survive in the hostile environment in the host.**

  Parasitic flatworms living in the digestive tract of a host, for example, *Taenia*, must withstand attack by the host's digestive juices. They are covered by a thick cuticle which, although permeable to digested food products (so enabling absorption), is resistant to attack by the enzymes and alkaline fluids found in the intestines. Tapeworms also secrete enzyme inhibitors which reduce the risk of damage due to the host's enzymes.
  Adult blood flukes, *Schistosoma* sps., which anchor themselves in veins draining the intestines or bladder, are covered by a thick cuticle which probably protects them against attack by host antibodies.
  The malarial parasite, *Plasmodium* sps., is liable to attack by antibodies produced if the parasite stimulates the immune system of the host. The parasites are particularly vulnerable when they are in the blood plasma. Thus the malarial parasites spend the majority of their time inside red blood cells, or inside liver cells, where they are protected against antibody attack and are less likely to stimulate antibody production.
  The host antibodies are produced against antigens on the surface of the parasites. Malarial parasites reduce the efficiency of the host's immune response by:
  1. having much genetic diversity which enables frequently altering of the structure of their antigens, and
  2. having several different stages in the life cycle each with different antigens on their surfaces.

- **not waste energy and resources on unnecessary tasks.**

  During evolution, tapeworms and flukes have lost organ systems which they no longer need, a process called 'parasitic degeneration'. For example, tapeworms have no digestive system because they rely totally on the digested foods supplied by their hosts. Flukes have lost external sensory organs, such as eye spots, which would be useless in the darkness of the liver or blood environments. Flukes and tapeworms have lost the function of locomotion and so have very reduced muscular systems. They can only make slight wriggling movements.

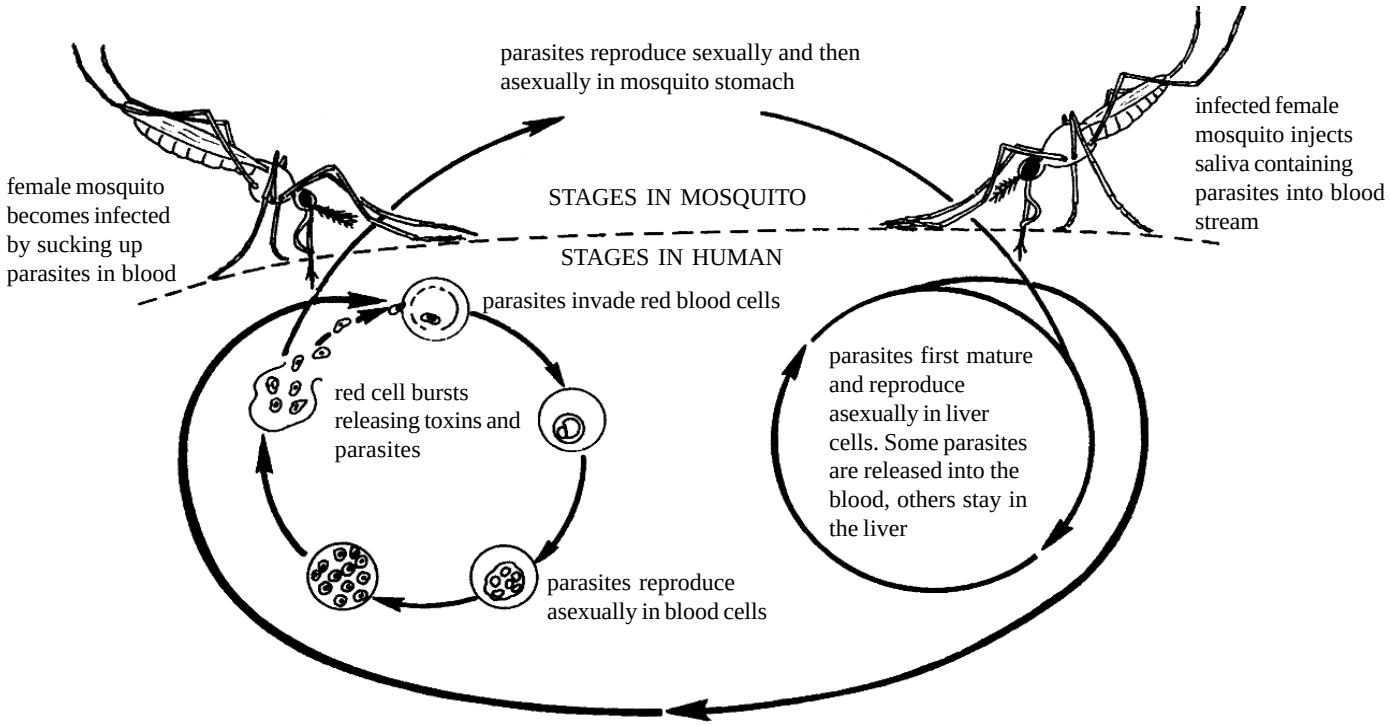
- **have a reproductive ability and a life cycle enabling efficient dispersal and infection of new hosts.**

  In general terms parasites have:
  1. the ability to produce huge numbers of offspring. This compensates for the huge wastage that must occur when parasites are transferring into new hosts. The offspring are produced by sexual reproduction which introduces much genetic diversity. In addition, many parasites also reproduce asexually, thus greatly multiplying the numbers of offspring produced.
  2. Many parasites have complicated life cycles involving secondary hosts. The secondary host is often very mobile and can disperse the parasite over wide areas and may act as a vector, transferring the parasite from infected primary host to new primary host.
  3. Parasites usually possess particular structures or physiological abilities which enable them to infect their hosts and become established in the host's body.

***Exam Hint**:- In relation to these general points, depending on the specification being studied, candidates may be required to refer to the life cycle of Plasmodium or Schistosoma, or to both of these.*

Life cycle of the malarial parasite, *Plasmodium vivax*.
The Protoctistan (single-celled) malarial parasite has part of its life cycle in the liver and blood of humans and part of its life cycle in the female *Anopheles* mosquito. Only the female mosquito sucks blood during feeding, and so only the female mosquito can carry malaria. The life cycle is summarised in Fig 3.

Fig. 3. Life cycle of the malarial parasite



Plasmodium vivax causes benign tertian malaria in which the duration of the cycle in the red cells is 48 hours. Thus the infected red cells burst every 48 hours releasing toxins, which cause the fever attacks, and parasites which quickly infect more red cells. Other species of malarial parasite have different time scales for their cycles within red cells.

- Malarial parasites have prolific powers of reproduction, thus ensuring survival within the host and transmission from host to host. A phase of sexual reproduction, which introduces genetic diversity, occurs in the stomach of the mosquito. There are three phases of asexual reproduction, each producing millions of unicellular parasites. These phases occur:

  1. in the stomach and stomach wall of the mosquito, immediately following the sexual phase,
  2. in the liver of the human (where parasites may survive for years, reproducing periodically) and
  3. in the red blood cells of humans. When the red cells are full of parasites they burst and the released parasites quickly infect new red cells, thus continuing the infection.

- The female Anopheline mosquito is well suited as a vector because it is very abundant, sucks blood of several humans during its life, and flies considerable distances, thus dispersing the parasite throughout the human population in a particular area.
- Malarial parasites have various recognition sites on their plasma membranes at different stages in their life cycle. This enables them to recognise, stick to and invade specific cells or tissues. Thus, at different stages the parasites can recognise human liver cells, human red blood cells, mosquito stomach tissue and mosquito salivary gland cells.

Exam Hint: *- Candidates are not expected to know the technical names of the malarial parasite in its various life cycle stages.*

Specification coverage

	Saprobionts	Parasites	Taenia	Rhizopus	Schistosoma	Malaria
AQA A	✓	✓	✗	✗	✓	✓
AQA B	✓	✗	✗	✗	✗	✗
Edexcel	✓	✓	✓	✓	✗	✗
OCR	✓*	✗	✗	✗	✗	✓
WJEC	✓	✓	✗	✗	✗	✓

* although the word "saprobionts" is not used in the specification

Exam Hint*:- Although the specifications differ in what they require candidates to know on this topic, candidates who introduce information on, for example Schistosomiasis, in their response to a question on parasites will gain credit. Although the examiners on Edexcel, for example, cannot set a question that demands factual knowledge of malaria, they would give credit to a candidate who provided correct facts about malaria if it was relevant. Furthermore, just because malaria is not on the spec, does not mean that the examiner can't set a question on it! Provided the question does not demand factual recall and can be answered by applying general principles, the examiner can set questions on anything! In this topic, make sure you understand the general principles of the problems that parasites etc face and the adaptations that have evolved to overcome them.*

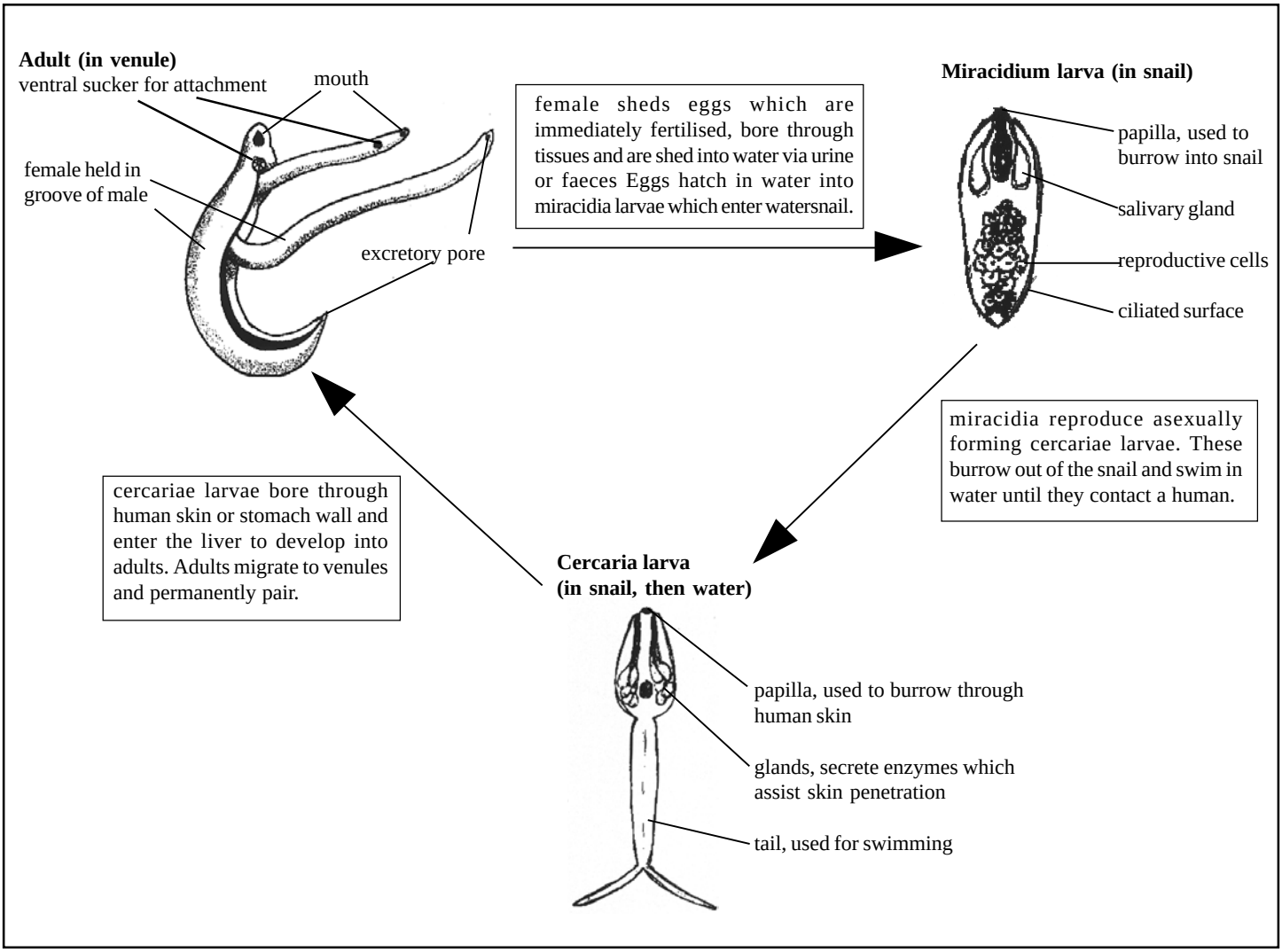
Life cycle of *Schistosoma*

Schistosoma sps. are parasitic flatworm flukes which cause the condition schistosomiasis (old name, bilharzia). The male and female adult flukes pair and live together in human blood vessels, particularly in the smaller venules of the hepatic portal system draining the intestines and in smaller venules near the bladder. The females release eggs, which are fertilised and passed out in the urine or in the faeces. Some eggs become lodged in the tissues and cause an immune response resulting in fever and other symptoms.

When in contact with water, the eggs hatch into ciliated larvae (called miracidia) which penetrate the bodies of fresh water snails. The miracidia feed on the snail tissues and reproduce asexually, forming numerous second larvae (called cercariae). These burrow out of the snail, and swim in the water until they can invade a human, either by burrowing through the skin (when the human bathes) or by being swallowed in drinking water. The cercariae initially burrow into the lymph vessels and so are emptied into the blood stream, pass through the heart and eventually reach the liver. Here they grow into adult worms, are released back into the blood and then attach to their target venules.(Fig 4)

- *Schistosoma* thus has prolific powers of reproduction, thus ensuring transmission and cross-infection from host to host. Sexual reproduction, releasing thousands of genetically diverse eggs, occurs throughout the adult life of the worms. The female is permanently held secure to the male so that fertilisation of all eggs is ensured. Also prolific asexual reproduction, producing many cercariae, occurs within the snail.
- Water snails are very abundant and are prolific reproducers and so provide a readily available secondary host. The life cycle is completed when human urine or faeces enters fresh water (ponds, streams, poorly drained areas). This is most likely to happen in poorly developed areas of the world, particularly where human faeces are used as a fertiliser. The eggs and miracidia can then run off the fields into local water courses.
- The miracidia have a papilla which enables them to bore through the skin of the snail and set up infection of the snail. They produce saliva to enable digestion of the host tissues, thus enabling them to feed and have energy for reproduction. The papilla on the cercaria enables it to burrow through human skin and other tissues and this ability is made easier by the secretion of enzymes to break down the human tissues.

Fig. 4. Life cycle of *Schistosoma*



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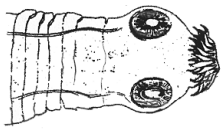
This Factsheet was researched and written by Martin Griffin.

Practice Questions

1. (a) The drawing below illustrates the head (scolex) of a parasitic tapeworm. Describe the ways in which this scolex is adapted to aid the tapeworm in its parasitic life. **3**



(b) How do saprobiontic fungi spread? **4**

2. (a) State four ways in which *Schistosoma* is adapted for its parasitic life. **6**
(b) Based on your knowledge of the life cycle of *Schistosoma*, suggest three ways by which the risk of infection by *Schistosoma* can be reduced. Explain your answers. **3**

3 The information below was included on a Health Service leaflet given to individuals who were going on holiday to a malarial region of the world. Read through the information and then using your knowledge of the malarial parasite's life cycle, answer the following questions.

There are two main lines of defence in the prevention of malaria: prevention of mosquito bites; and taking anti-malaria tablets. Both methods should to be used together to provide best protection.

1. Mosquito bites may be avoided by: **(line 4)**
- Use of insect repellents (those containing 'DEET' are most effective).
- Avoiding exposure of the skin after sunset - wear long sleeves and trousers (not shorts).
- Use of insecticide impregnated mosquito nets, and 'knock down' insecticides.

2. Taking anti-malaria tablets
- Most anti-malarial tablets act by killing the parasite once it has entered the bloodstream.
  Most need to be started 2-3 weeks before you travel **(line 13)**
  and need to be continued 4 weeks after return. **(line 14)**
- No anti-malarial drug is 100% effective in preventing malaria, but they do greatly reduce your risk, and even if you do still contract malaria, the severity of the disease will be decreased.
- There are several different types (species) of malarial parasite **(line 18)** worldwide. In some regions of the world, the parasite has developed resistance to the more commonly used anti-malarial drugs. **(line 20)**
  So the choice of anti-malarial drug is important - (don't just have some your friend has left over from that holiday in Africa last year!)

The doctor or practice nurse will advise you about which drug is suitable for you, in terms of your destination and health status.

(a) (i) Comment on the importance of avoiding mosquito bites. (line 4) **2**
(ii) Which specific type of mosquito should be avoided? **2**

(b) Suggest why (line 13 and 14):
(i) A course of anti-malaria tablets should be started 2 to 3 weeks before going on holiday. **2**
(ii) Anti-malaria tablets should be taken for 4 weeks after return from holiday. **2**

(c) Why is it important to consider which species of *Plasmodium* are likely to be common in the holiday area? (line 18) **2**

(d) Drug resistance (line 20) is shown particularly by the parasites in the liver cells. Suggest a serious implication of this. **2**

4. Saprobionts secrete enzymes which are important in recycling processes in the carbon and nitrogen cycles. Describe the actions of these enzymes and explain their importance in recycling carbon and nitrogen. **8**

Answers

1. (a) (two) suckers to aid sticking to the intestinal wall;
hooks/spines to embed into/anchor to the intestinal wall;
ref to both large and small hooks/spines; **3**

(b) by growth and branching of the hyphae/stolons through the substrate;
by producing huge numbers of asexual spores;
by producing resistant sexual spores;
spores dispersed by wind currents;
when spores land on suitable substrate they germinate to produce new hyphae; **max 4**

2. (a) the adults have a thick cuticle which may protect them against the host's antibodies;
the adults each have a sucker to attach them to the venule wall;
the miracidium larvae have a papilla to enable them to bore through the skin/body tissues of snail;
the cercaria larvae have a papilla to enable them to bore out of the snail and into the human;
the cercariae have a large tail to enable them to swim through the water to locate a human;
when adult the female is tightly bound to the male so that fertilisation of eggs is very efficient;
sexual reproduction in the venules is very prolific, producing thousands of eggs for release in faeces or urine;
asexual reproduction in the snail produces thousands of cercaria larvae thus increasing the chances of contacting a human host; **max 6**

(b) ref development of proper sanitation/WCs so that urine and faeces do not enter fresh water supplies/the link to the water snail is severed;
use molluscicides to kill the snails in areas where they are likely to encounter human faeces/urine;
heat treat/compost human faeces which are to be used as fertiliser since this should kill the eggs;
avoid using human faeces as fertiliser in areas where fresh water may become contaminated with eggs;
avoid drinking contaminated water/boil drinking water so that cercariae are killed;
wear protective Wellington boots when wading in water/rubber gloves when putting hands in water/no swimming in contaminated water; **max 3**

3. (a) (i) mosquitoes transmit diseases such as malaria;
parasites are in the mosquito saliva which is injected when mosquitoes suck blood; **2**
(ii) female; Anopheline mosquito/*Anopheles*; **2**

(b) (i) so that the level of drug in the blood builds up/blood concentration takes time to build;
and is sufficient to kill the parasites as soon as the mosquitoes are encountered; **2**
(ii) parasites may still be in the liver after the holiday;
this part of the cycle must be allowed to complete its release of parasites to the blood; **2**

(c) all species of *Plasmodium* are not susceptible to all drugs;
specific species of *Plasmodium* must be targeted by specific drugs; **2**

(d) parasites in liver cells are more difficult to treat with drugs;
some may survive/become dormant and become activated causing attacks of malaria months or years later; **2**

4. proteases digest proteins in organic matter into amino acids;
bacteria can then deaminate the amino acids to ammonia, which can be oxidised to nitrates/ref nitrification;
cellulases digest cellulose cell walls in plant matter to simple sugars/glucose;
this liberates the protoplasm within plant cells for further digestion and recycling;
amylases/maltase digest starches to glucose;
lipases digest lipids to fatty acids and glycerol;
glucose/lipids/fatty acids/glycerol are absorbed by fungi and bacteria for use as respiratory substratethus liberating carbon dioxide;
ref to nitrates absorbed by plants for use in protein synthesis/carbon dioxide absorbed by plants for photosynthesis; **8**