ENTOMOLOGY II

INTRODUCTION

BIOL 356

Dr. (Mrs.) Sandra Abankwa Kwarteng
Department Theoretical and Applied Biology
College of Science

About This Course

- Course Objectives
- Course Content
- Required Textbooks
- Attendance
- Evaluation & Grading Policies
- Group Work / Term Paper

Course Objectives

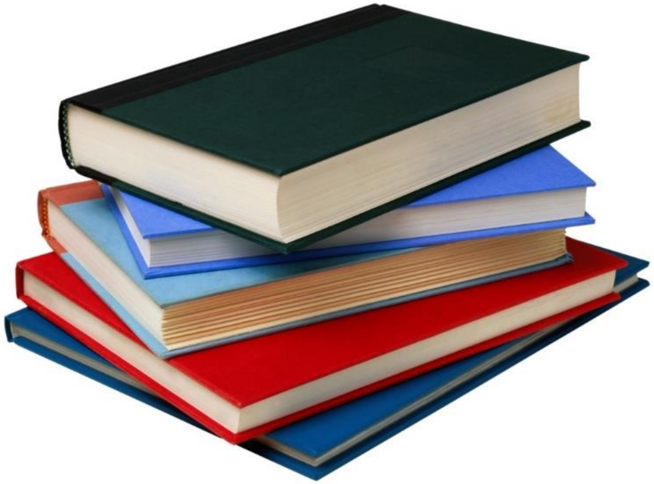
- To enable students understand the life cycles of selected insect vectors of human diseases and how to control these diseases.
- To make students understand and explain numerical changes in insect populations as well as gain a solid foundation on the principles and the practices used in the control of insect pests and the concept of integrated pest management.

Course Content

- Life cycles of selected insects of economic and medical importance.
- Insect vectors of human diseases: Black fly (*Simulium damnosum)*, Mosquitoes (*Anopheles*, *Aedes* and *Culex*), Tsetsefly (*Glossina*)
- Human diseases such as Malaria, Filariasis, Yellow fever, Onchocerciasis, Trypanosomiasis, Dengue fever.
- Mode of transmission, symptoms and treatment of vector borne diseases emphasizing control of the vectors.
- Methods of pest control and the concept of integrated pest management (IPM) discussed with respect to insect pests of agricultural importance.

Reading or Reference Material

- Ward, Richard D., Service M W. Medical entomology for students, 2008.
- Becker, Norbert, Dusan Petric, Marija Zgomba, Clive Boase, Minoo Madon, Christine Dahl, and Achim Kaiser. Mosquitoes and their control. Springer Science & Business Media, 2010.
- Van Emdem, H. F. and M. W Service. Pest and Vector control. Cambridge University Press. 349 Pp, 2004.



Attendance at Lectures

- Attendance at lectures is an integral part of the requirements of assessment for the course.
- If any student absents herself/himself for a cumulative total of three (3) lecture periods before mid-semester, she/he will not be eligible to write both the mid-semester and end of semester examinations or will not be eligible to write the end of semester examination if this occurs after the mid-semester examination.

Evaluation

1. Continuous assessment ➔ 30%
   - Assignment/Presentations/ Quizzes/Term paper/ Attendance & Participation in Lectures→ 10%
   - Mid-semester examination → 20%

2. Final Examination ➔ 70%

Grading

- 70 – 100 → A → Excellent
- 60 – 69 → B → Very Good
- 50 – 59 → C → Good
- 40 – 49 → D → Pass
- 0 – 39 → F → Fail
- I → Incomplete, could not write examination due to illness or other approved reasons.
- I* → Incomplete, examiner is yet to provide results, there is proof that students took part in examination

Economic Entomology

- The study of insects based on their relation to man, his domestic animals and his crops. They involve the prevention of harm to them.
- The practical methods by which the harm can be prevented and its repercussions.

Insect Vectors of Human Diseases

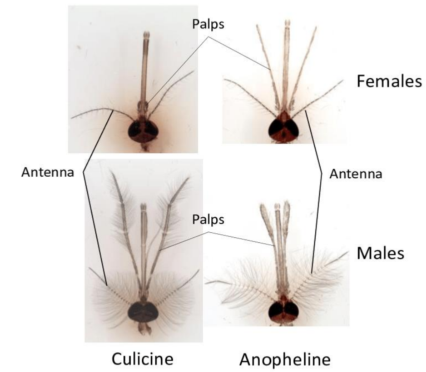



- The majority of insect vectors of human diseases are found in the Order of Diptera.
- Three Suborders are recognized in the Order Diptera

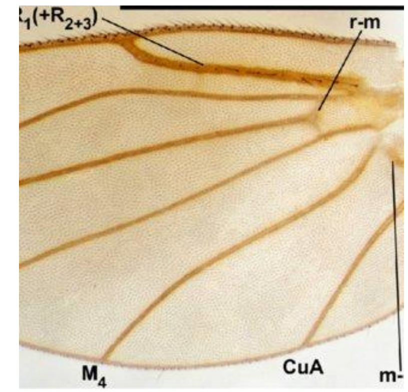
1. **Suborder Nematocera**
2. **Suborder Brachycera**
3. **Suborder Cyclorrhapha**

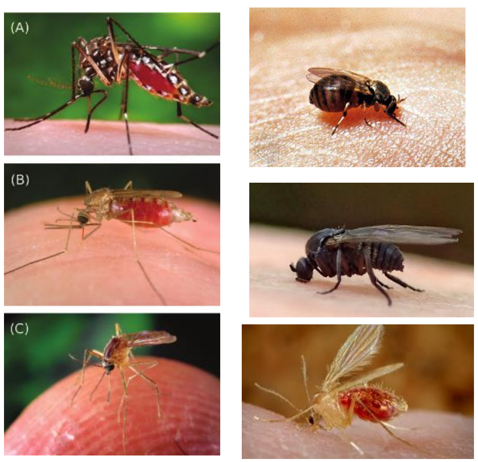



Suborder Nematocera

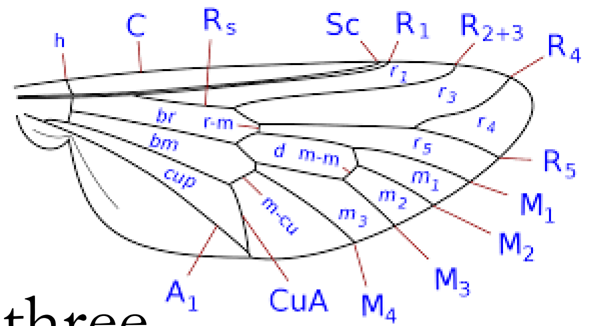


- Small, delicate flies.
- Have long filamentous, feathery antennae composed of many similar, freely articulated segments (more than six).
- The single pair of maxillary palps is three to five jointed.
- R_{2+3} often forked (never forked in other suborders).
- Include mosquitoes (Culicidae), black flies (Simuliidae), biting midges (Ceratopogonidae) and sand flies (Phlebotominae) as one subfamily of mothflies (Pschodidae).





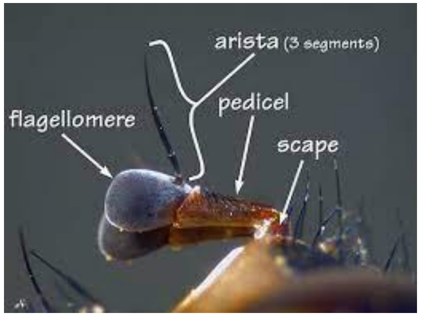
Suborder Brachycera



- Are small to large, stout bodied flies.
- Have short antennae, often composed of three segments and never more than six segments.
- Maxillary palps are one or two jointed.
- R_s usually 3- branched (R_{4+5} forked). Anal vein generally are long and in most cases closed and near the wing margin.
- Include horseflies (Family Tabanidae), soldier flies (Family Stratiomyidae), bee flies (Bombyliidae).

Suborder Cyclorrhapha

- Antennae 3-segmented, with an arista.
- Vein R_s 2-branched.
- Include; scuttle flies (Phoridae), flesh flies (Sarcophagidae), blow flies (Calliphoridae) and tse-tse (Glossinidae).



ENTOMOLOGY II

MOSQUITOES

BIOL 356

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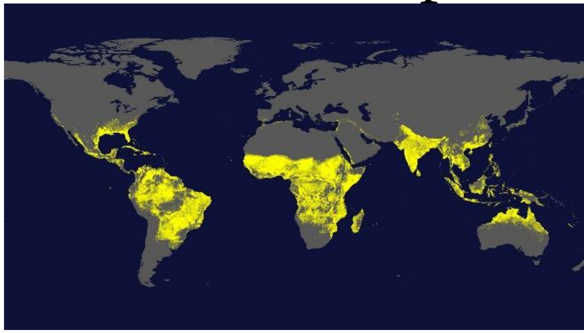
Family Culicidae

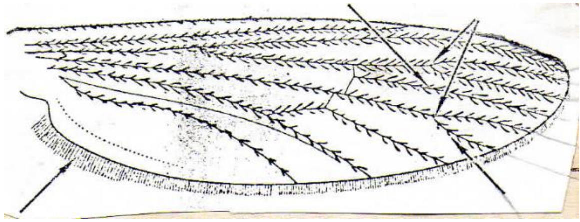
- About 3300 species of mosquitoes divided among 41 different genera have been described on a world wide basis.
- Mosquitoes are important as vectors of malaria, various forms of filariasis, and numerous arboviruses; the best known being dengue, yellow fever and West Nile Virus.

Characteristics of Mosquitoes

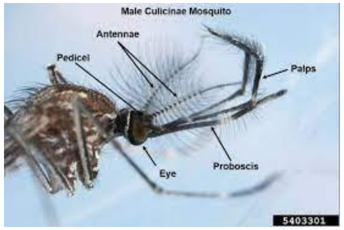


- Mosquitoes of the family Culicidae live worldwide, except in Antarctica, but require habitat with standing or slow moving fresh water for young to develop.
- The adults have a long forwardly directed proboscis, equal in length to head and thorax combined.

- They have various scales on the wing vein and wing margin, abdomen, thorax and legs.



Characteristics of Mosquitoes

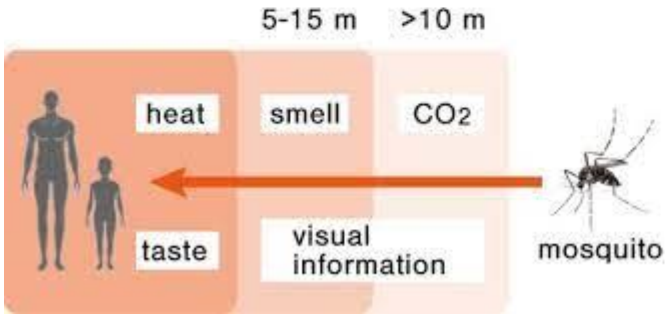


- Mosquitoes have thin, long bodies and three pairs of extremely long legs.
- Also have feathery or hairy antennae.
- Adult mosquitoes of both sexes feed on nectar juices and other fluids for flights energy.

- Anopheline and Culicine females also suck blood (haematophagy) from other animals such as mammals, birds, frogs, etc., each species of mosquito tending to have particular host preferences.

Characteristics of Mosquitoes

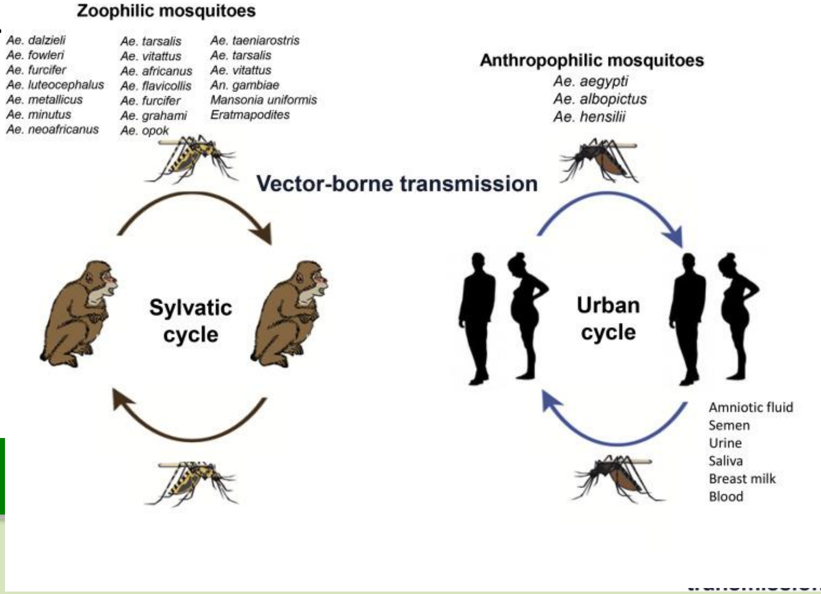
- Females do not require blood for their own survival but they do need supplemental substances such as protein and iron to develop eggs.
- Mosquitoes locate blood host by scent, sight and heat.
- Female mosquitoes hunt their blood host by detecting CO_2 and 1-octen-3-ol produced in breath and sweat.
- When a female mosquito senses CO_2 in the air, she flies upwind until she finds the source.
- The majority of mosquitoes hunt and feed at night although some do so by day.



- Sensilla on the palps and antennae serve to detect the host.

Characteristics of Mosquitoes

- Species showing strong attraction to man are said to be anthropophilic, as opposed to zoophilic or zoophagic species which bite other animals.
- Endophilic (endophagy) mosquitoes are those which favour houses or animal sheds for resting, whereas exophilic (exophagy) species prefer to remain outdoors.
- Male mosquitoes tend to be less endophilic than females of the same species, while non-biting species seldom go indoors at all.
- Few species of the mosquitoes have man as their principal host.



Breeding Areas

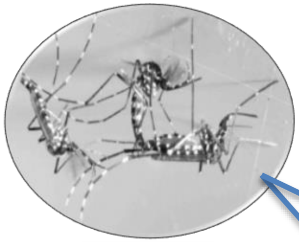
- Breeding places of mosquitoes are always in water.
- Mosquitoes will breed in practically any collection of water that stands longer than five to seven days.
- Different kinds of mosquitoes vary in their choice of breeding places.
  - Some mosquitoes like sunlit places where as others prefer shade.
  - Some prefer fresh water to stagnant water.
  - Others prefer the brackish water of salt marshes.

Breeding Areas

- Common breeding sites are ponds, pools, slow-moving streams, inland swamps and bogs, salt marshes, ditches, tree holes, rock holes and manmade containers of water.
- Man made containers include wells, cisterns, rain barrels, roof gutters, road gutters, cans, buckets, septic tanks, pit latrines and old tires that have been discarded.

Life Cycle

- Males and females mate during the first 3 to 5 days after they have emerged.
- Females mate only once.
- Males generally live for only a week while the female live longer than 1–2 weeks in nature.



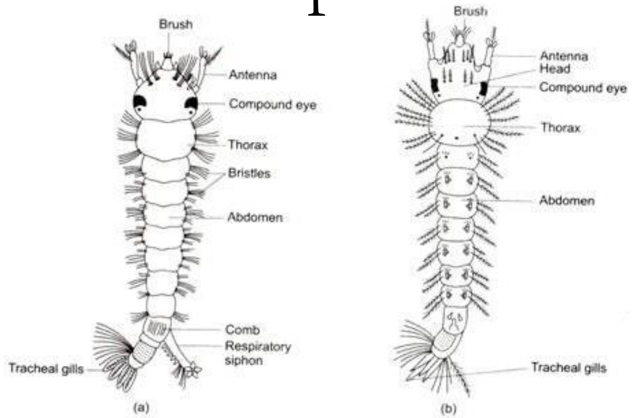
- Once a female has completely engorged, she flies to a shaded environment until her eggs are completely developed, usually 3 to 5 days.
- Once the eggs are developed the female is called a gravid female and she begins to search for a desirable place to lay her eggs.

Life Cycle

- Generally a female will only live long enough to lay 3 batches of eggs.
- The eggs of Aedini usually undergo diapauses to be able to withstand drought or winter.
- In other kinds of mosquitoes, eggs hatch within 1-2 days under optimal conditions after being laid.
- Presence of water and decreasing oxygen concentration trigger the hatching of eggs that have undergone diapauses.
- Larval development takes about a week for most tropical mosquitoes, but some temperate species over winter as larvae.

Life Cycle

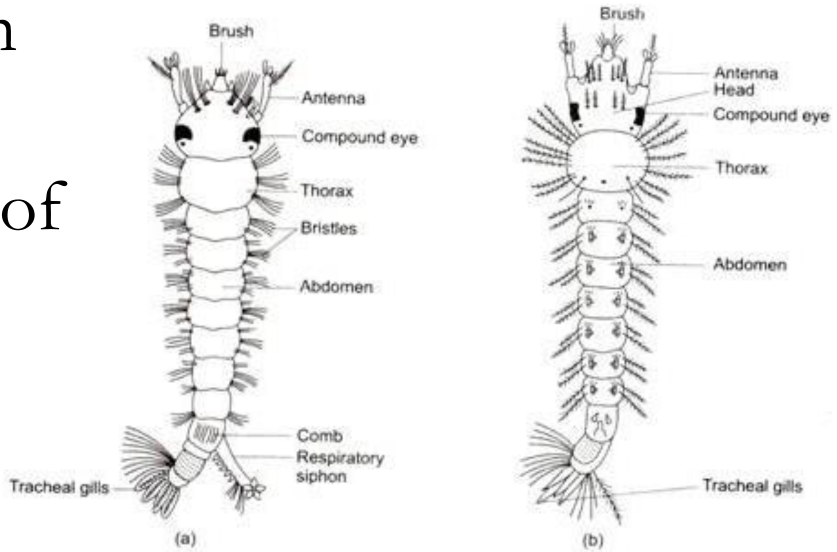
- Rates of mosquito larval growth are influenced by environmental factors as temperature, photoperiod, food supply and the degree of crowding.
- The fourth stage larva moults to the pupal stage, from which the adult mosquito emerges after a few days.
- Larvae breathe air via a pair of posterior dorsal spiracles located on a characteristic siphon which is not developed in Anophelinae.



Larvae of (a) *Culex* and (b) *Anopheles*

Life Cycle

- Larvae are distinguished from other aquatic insects by absence of legs, presence of a distinct head bearing mouth brushes and antennae.
- The larvae also have bulbous thorax that is wider than the head and abdomen; either a pair of respiratory openings (subfamily Anophelinae) or an elongate siphon (subfamily Culicinae) borne near the end of the abdomen.
- The larvae are filter feeders of organic particulates.



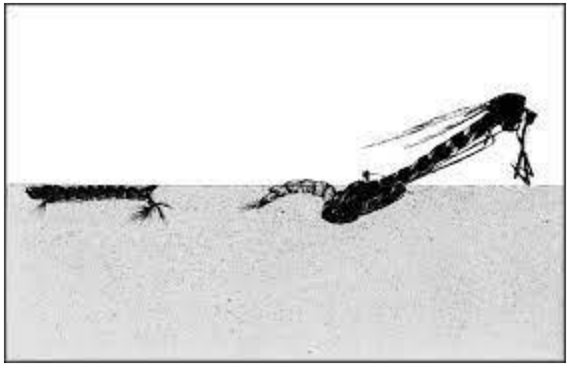
Larvae of (a) *Culex* and (b) *Anopheles*

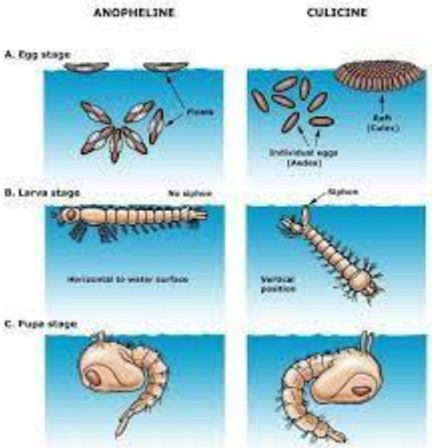
Life Cycle

- The majority of mosquito larvae have mouthparts adapted for filter feeding.
- The diet of most mosquito larvae comprises micro-organisms and detritus.
- Larvae develop through 4 stages, or instars, after which they metamorphose into pupae.
- At the end of each instar, the larvae molt, shedding their exoskeleton, or skin, to allow for further growth.
- The process from egg laying to emergence of the adult is temperature dependent, with a minimum time of 7 days.

Life Cycle

- The pupae rests beneath the surface preparing for metamorphosis.
- Pupae do not feed.
- Eventually the pupal case splits along the back and the adult mosquito works its way out onto the surface.
- Wings and legs become extended and the body cuticle begins to harden within half an hour of eclosion.





Subfamilies of Culicidae

- The family Culicidae is divided into three subfamilies:
  - Anophilinae,
  - Culicinae and
  - Toxorhynchitinae.
- The most important vector species belong to *Anopheles*, *Aedes*, and *Culex* which are distributed worldwide

Subfamilies of Culicidae

- Mosquitoes of the genus *Toxorhynchites* do not suck blood.
- *Toxorhynchites* and some culines produce eggs autogenously.
- Male and female of *Toxorhynchites* may well live for several weeks, feeding repeatedly, under natural conditions.
- Various anophilines and especially culicines transmit arboviruses and filariasis of man.
- The pathogens transmitted by mosquitoes include viruses (arboviruses), filarial worms (helminths) and protozoa.
- Mosquitoes also serve as the vectors of enzootic infections and some zoonotic diseases e.g yellow fever.

Control Measures

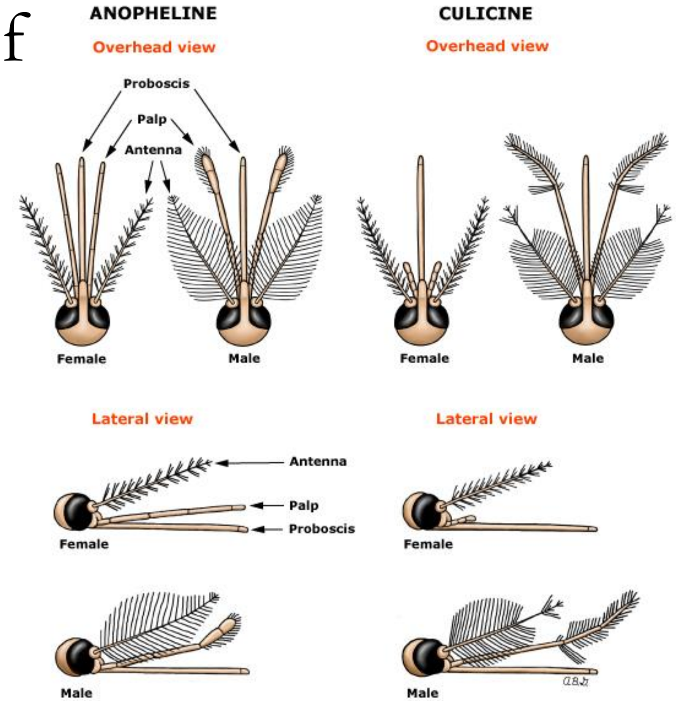
- Control measures against mosquitoes may be aimed at the larvae or at the adults.
- Measures aimed at larvae may involve the elimination or modification of larval habitats (for example drainage) or may involve the treatment of the larval habitat with insecticides.
- Measures aimed at the adults may be in the nature of preventives (the use of the protective clothing, screening and use of repellants) or insecticides (sprays or aerosols).

Subfamily Anophelinae

- The subfamily includes 478 formally recognized species.
- Anophelinae is divided into three genera: *Anopheles* (nearly worldwide distribution), *Bironella* (tropical Australia) and *Chagasia* (South American).
- Mosquitoes belonging to these genera are referred to as “anophelines”.
- *Anopheles* are medically important, being the sole vectors of malaria, and they play a substantial role in transmitting lymphatic filariasis due to *Wuchereria bancrofti.*
- *Bironella* and *Chagasia* are medically unimportant.
- Most species of *Anopheles* require large spaces for the mating flights, rendering it difficult to propagate them in captivity.

Characteristics

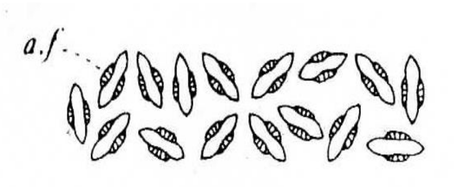
- Most species stand with proboscis, head and abdomen in almost a straight line, usually resting (on an upright surface) at an angle of about 45° to the surface and have dark and pale spots of scales on legs and margin of wings.
- The maxillary palps of both sexes are about as long as the proboscis (except *Bironella*).
- The maxillary palps are clubbed in the male.



Life Cycle of *Anopheles*

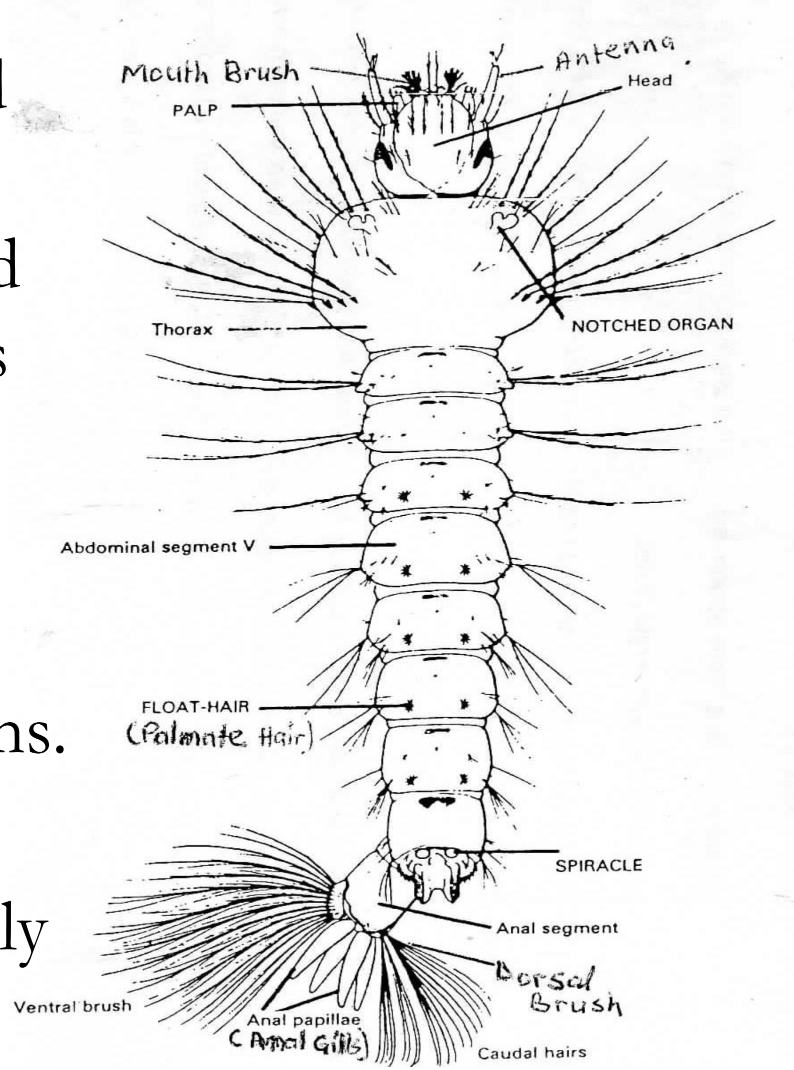
- At a temperature of 25-30°C, tropical *Anopheles* can be expected to suck blood and lay eggs regularly at intervals of 2 or 3 days.
- The female *Anopheles* mosquito lays a batch of 100 – 150 eggs usually at night on the surface of water.

- Eggs are 1mm in length and are laid singly and directly on water.
- They bear paired lateral air-filled floats which are air-filled spaces between the exochorion and endochorion of the egg shell to resist submersion



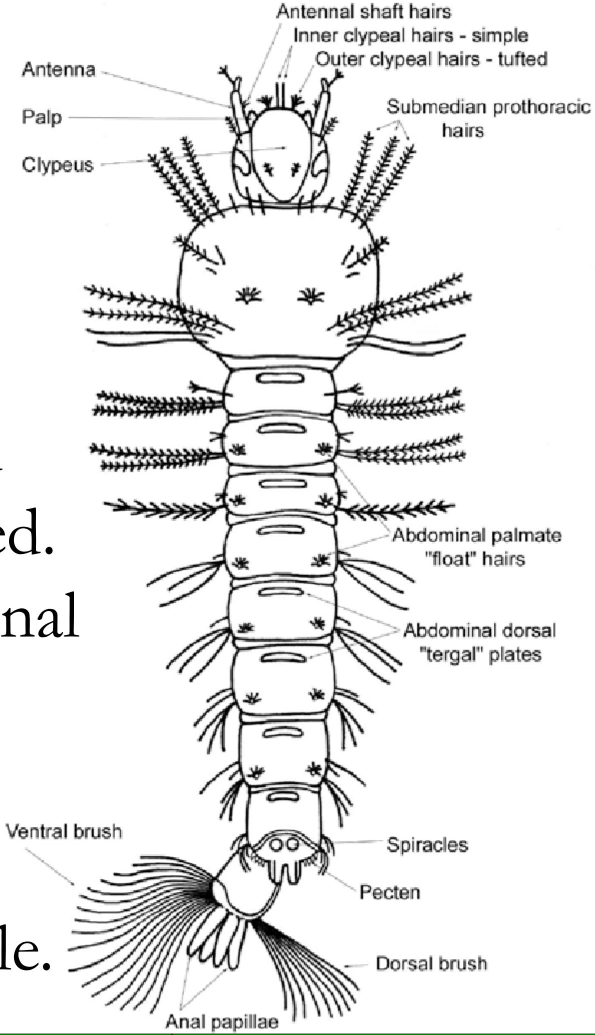
Anopheles Larvae

- Three regions can be differentiated in the body of the larva: a well developed sclerotised head, a broad thorax in which the three segments are fused; and a segmented abdomen.
- Its food consists of algae, bacteria protozoa, and other microorganisms.
- Palmate hairs are present on most abdominal segment and occasionally on the thorax.



Anopheles Larvae

- The head has a pair of short antennae, eyes, a pair of feeding brushes and preclypeal and clypeal hairs.
- The respiratory opening is composed of two dorsally placed spiracles located on the 8th abdominal segment and therefore must come to the surface frequently.
- Small glands secrete a waxy substance around the spiracles, which therefore cannot be wetted.
- The terminal segment is provided with four anal papillae (gills), which have respiratory and excretory functions, but are mainly used to absorb mineral salts.
- Respiration also takes place through the cuticle.



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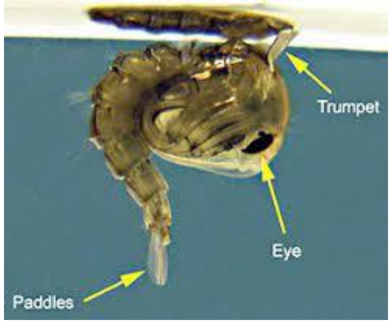
Anopheles Pupa

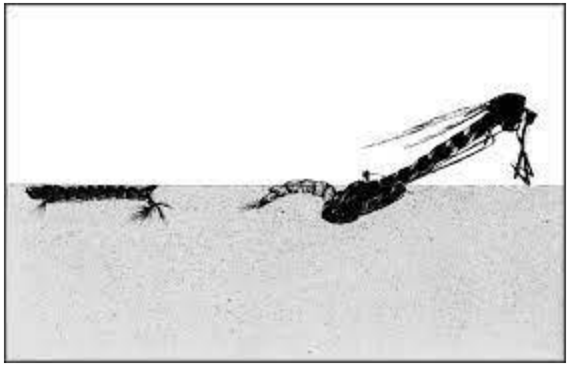
- The head and the thorax of the pupae combines into a simple division, the cephalothorax, which is joined posteriorly to a segmented abdomen.



- At rest, the pupa floats at the water surface with the abdomen reflected under the cephalothorax.
- The pupa does not feed but breathes through a pair of broad trumpets dorsally placed on the cephalothorax, i.e it is propneustic, and is susceptible to oil treatment.
- The ninth segment of the abdomen carries a pair of broad, flat plates, the paddles (for swimming).

Adult Emergence

- The pupal skin splits dorsally and the adult emerges gradually from the pupal exuviae.
- The newly emerged adult inflates rests whiles its exoskeleton hardens, its spreads its wings to dry before flying away.
- Their lifespan depends on temperature, humidity, and also their ability to successfully obtain a blood meal

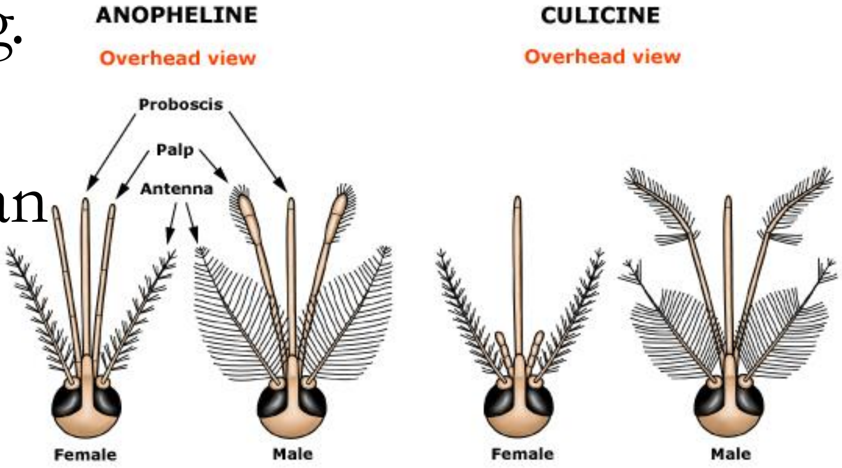


Subfamily Culicinae

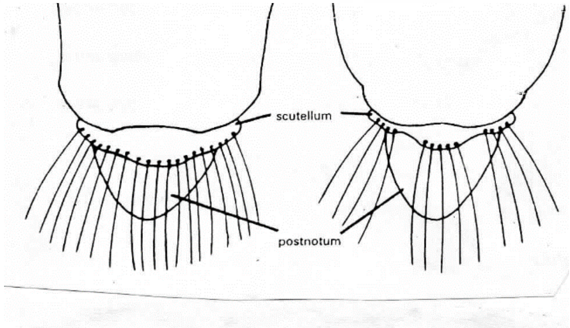
- By far the largest of the two subfamilies, containing almost 90% of the known world spp.
- Culicinae is the largest and heterogeneous subfamily of mosquitoes containing 3,047 species in 92 genera.
- Species belonging to the subfamily are referred to as "culicines", however, species of the tribe Aedini are sometimes referred to as "aedines".
- The main genera are *Aedes* and *Culex* and the medically important *Uranotaenia*.
- Members of the subfamily are found in all 200 geographic regions of the world, but the majority of species occur in tropical regions.

Characteristics

- Adult culicines stand with the body parallel to the surface on which they are resting.
- Females have maxillary palps that are usually much shorter than the proboscis and non-plumose antennae. Males have long palps with numerous long setae but they are not swollen apically like those of anophelines.



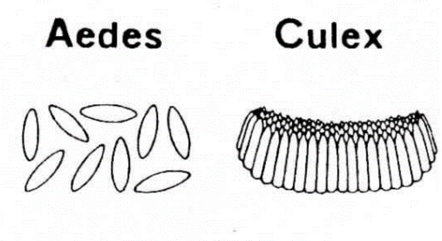
- The scutellum has three lobes with setae confined to each lobe.



Scutella of an *Anopheles* (left) and a Culicine (right)

Culicine Eggs

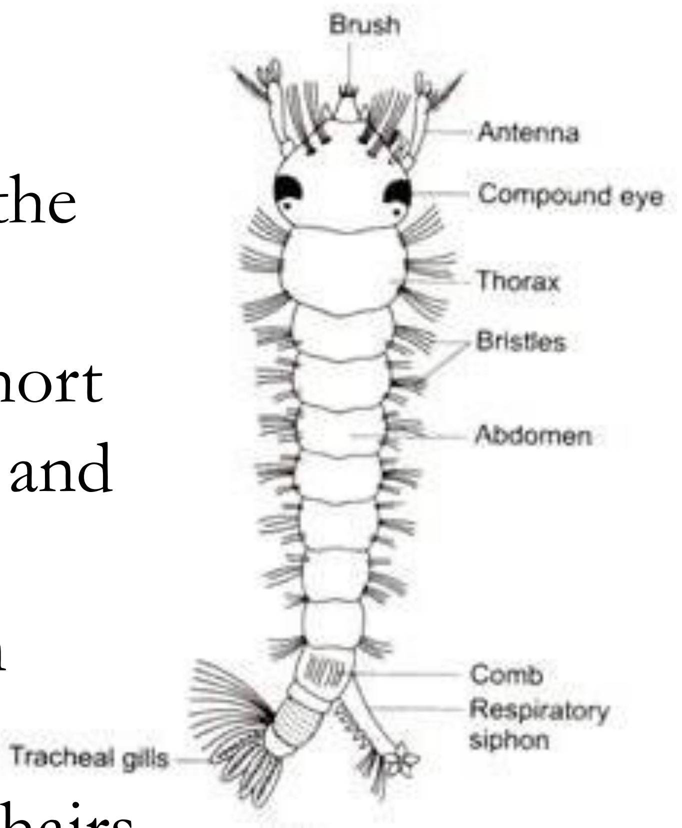
- They are laid either singly (e.g. *Aedes*) or in the form of egg rafts that float on the water surface (e.g. *Culex*), or are deposited as sticky masses glued to the underside of floating vegetation (e.g. *Masonia*)
- Culicine eggs never have floats.
- The rafts of *Culex* commonly measure



3-4 mm long and 2-3mm wide and cannot withstand desiccation and if dried, the eggs collapse and the embryos die.

Culicine Larvae

- All Culicinae larvae spiracles are situated at the tip of the tail-like siphon, projecting dorsally from the eighth abdominal segment.
- In *Aedes*, the siphon is typically short while in *Culex*, the siphon is long and slender.
- Culicines hang upside down at an angle from the water surface.
- There are no abdominal palmate hairs or tergal plates on Culicinae larvae.



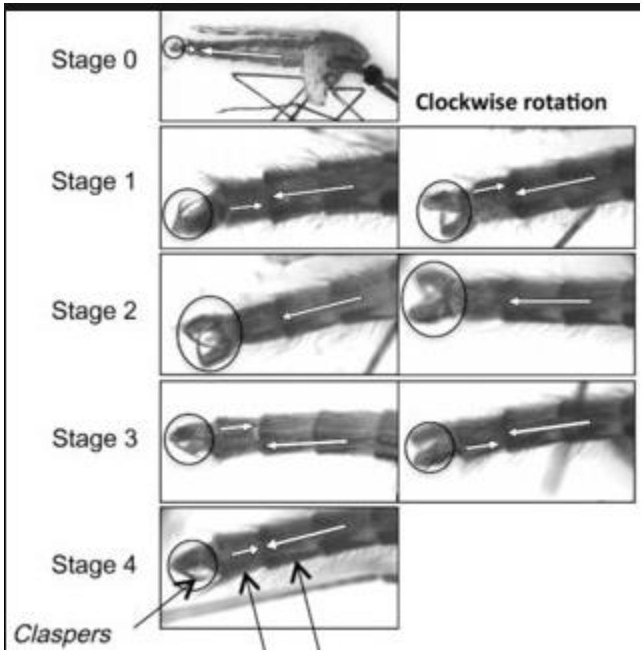
Culicine Pupa

- The length of the respiratory trumpets in Culicine pupae is variable, but they are generally longer and more cylindrical.
- Have narrower openings than in *Anopheles*.
- Abdominal segments 2-7 lack peg-like spines, although they have numerous setae.

Anopheles *Culex*

Adult Emergence

- When the progeny of any one egg batch emerge as adults, the males emerge first. The male terminalia have to rotate through 180^{o} before the male is ready for mating.
- This process takes about 24 hours so that by the time the females emerge the males are competent for mating.



Genus *Culex*

- About 800 species of *Culex* are known, being classified into 21 sub genera with many species acting as the vectors of enzootic arboviruses, protozoa and filariae.
- Larvae have several pairs of hair tufts on the siphon and the adult possess tarsal pulvilli and post spiracular bristles.
- The tip of the female abdomen is bluntly rounded.
- General body colouration of the adult is usually brown with wings plain and vein scales dark unlike Aedinae.
- The eggs cannot diapause so *Culex* breeding is continuous except when fertilized females hibernate.

Genus *Aedes*

- *Aedes* species are typical small mosquitoes.
- They usually have black and white stripe markings on their body and legs.
- In temperate countries, a high proportion of mosquitoes belong to the genus *Aedes* in which there are more than thousand known species.

Genus *Aedes*

- *Aedes* eggs are capable of withstanding desiccation.
- They are laid on damp surfaces such as soil or around a rim of water in a hole, in situations likely to be flooded causing the eggs to hatch after adequate rainfall.
- Most species of *Aedes* therefore breed seasonally in swamps and pools, with some groups adapted to smaller containers of water such as rock holes, root holes in trees, cut bamboo stumps, old snail shells, buckets and other artificial containers.
- It has been demonstrated that arboviruses can be passed transovariably in *Aedes*, i.e. from mother to progeny via the egg. This has been reported for Yellow fever.

Genus *Aedes*

- Presumably from this ancestral stock, man-biting populations have adapted to domestic breeding sites and become spread throughout the tropics between 35^{0} North and 35^{0} South.
- *Aedes aegypti* can be distinguished by its silvery white colouration on the thorax. It is the most widespread and dangerous species in this genus.
- In Africa forest, non anthropophilic populations known as *Aedes aegypti formosus* are distinguished by their lack of pale scales on the abdominal tergites
- Urban Yellow fever is also mainly transmitted by *Aedes aegypti* in central and South America and in West Africa.

Subfamily Toxorhynchitinae

- Toxorhynchitinae are very large metallic coloured mosquitoes which do not suck blood. They are larger than other mosquitoes.
- About 60 species are known, all classified in a single genus, *Toxorhynchites*, occurring mainly in the tropics and subtropics of the Oriental, Neotropical and Afrotropical.
- The scutellum is rounded and the palps of the female short.
- The basal part of the proboscis stout, the apical part is slender and decurved.
- The proboscis is suited only for imbibing nectar from plants or free fluids.

Life Cycle

- Breeding places are flooded tree-holes, rock-holes and artificial containers such as buckets and discarded tyres.
- Female *Toxorhynchites* scatter their rounded buoyant eggs onto water while flying. Larvae soon hatch and become predators with mouth brushes composed of six to ten strong recurved teeth on each side for grasping prey.
- Populations of some dangerous container-breeding Culicinae, notably *Aedes aegypti*, can be significantly reduced through predation by *Toxorhynchites*. *Toxorhynchites* adults are diurnally active.

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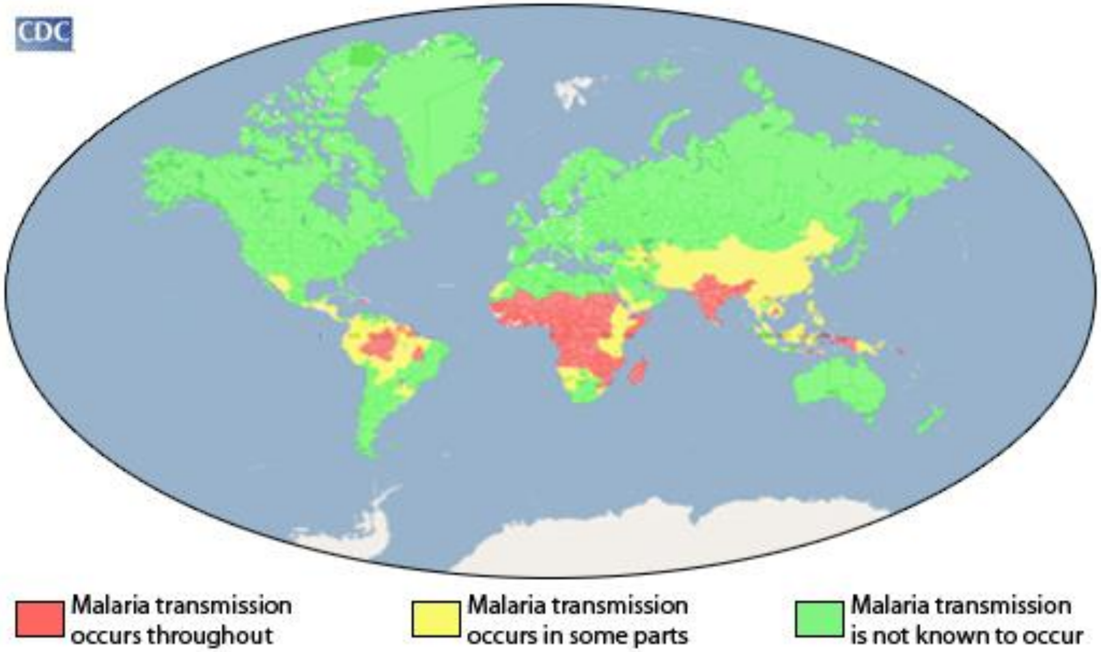
Malaria

- Malaria is a mosquito-borne infectious disease of humans and other animals caused by parasitic protozoans of the genus *Plasmodium*.
- It is transmitted via the bite of an infective female *Anopheles* mosquito.
- The primary malaria vectors in Africa are *Anopheles gambiae* and *Anopheles funestus*.
- They are strongly anthropophilic and, consequently, are 2 of the most efficient malaria vectors in the world.

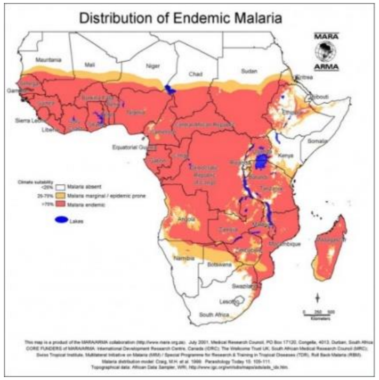
Malaria

- Malaria affects more people, more persistently throughout the world than other insect borne disease.
- It is widespread in tropical and subtropical regions, including parts of the Americas, many parts of Asia and much of Africa.



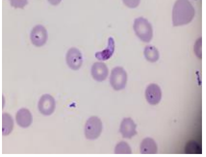
Distribution

- 90% of malaria-related deaths occur in Sub-Saharan Africa, with 60% of deaths being in young children under the age of five.
- Globally, 241 million cases were reported with 624,960 people dying of malaria in 2020.
- In Ghana, nearly 5.9 million (out of the overall 31 million total Ghanaian population) were diagnosed with malaria in 2020 with 92 out of every 1000 deaths being as a results of malaria.



Malaria Parasites (*Plasmodium*)

- More than a hundred species of *Plasmodium* have been described from vertebrates.
- About 20 species in other primates, a similar number in other mammals, and about 40 each in birds and reptiles.
- The vectors of the mammalian species of *Plasmodium* are species of *Anopheles* mosquitoes and those of bird plasmodia are most often Culicine mosquitoes.
- Five species of *Plasmodium* can infect and be transmitted by humans (*P. falciparum*, *P. vivax*, *P. malariae*, *P. ovale*, *P. knowlensi*).

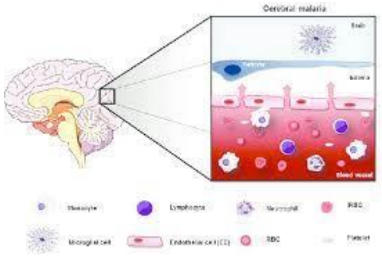


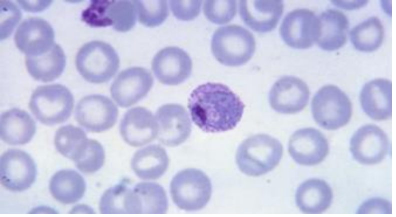
Plasmodium falciparum

- *P. falciparum* is the most common cause of infection and is responsible for about 80% of all malaria cases, and is also responsible for about 90% of the deaths of malaria.
- *P. falciparum* has a higher temperature threshold for development and is most common in warmest areas of the world.
- It may cause malignant tertian malaria fever.
- In the absence of treatment may kill up to 25% of non-immune adults within 2 weeks. Death rate is very high because the infected blood corpuscles tend to clump into masses, thus blocking up small blood vessels of internal organs such as brain, spleen, lungs among others.

Plasmodium falciparum

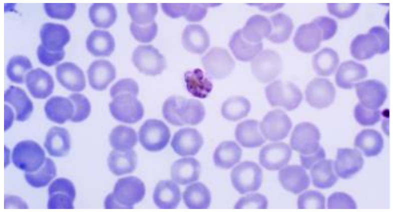
- Cerebral malaria is the most dangerous and frequent cause of mortality in children and non-immune adults
- It also causes renal failure.
- After the initial series of attacks have passed, malignant tertian fever may recur from the activation of latent erythrocytic forms.





Plasmodium vivax

- Causes benign tertian malaria.
- A less serious disease that rarely kills but is more persistent than *P. falciparum*.
- It is more widespread parasite than *P. falciparum* and has a wider temperature tolerance; extending as far as 16 degree Celsius and was therefore often the only species present in the cooler temperate regions.
- Recurrence of fever is every 48 hours.
- The disease may persist for up to 8 years causing relapses at intervals as short as 2 months.

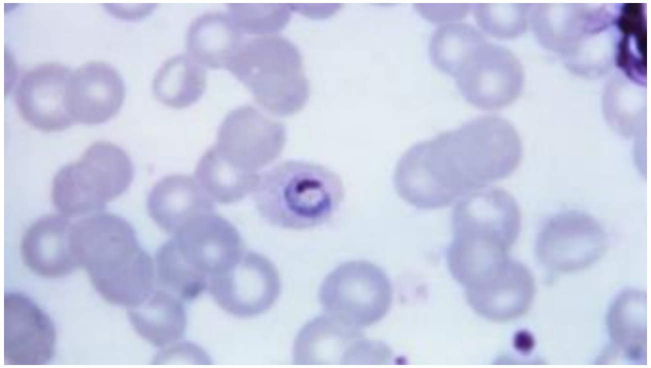


Plasmodium malariae

- Causes quartan malaria; recurrence of fever is at 72 hours.
- It is a widespread parasite but more rare than *P. falciparum* or *P. vivax*.
- It is next to *P. falciparum* in pathogenicity, with death resulting from kidney failure.
- It is persistent with relapses up to half a century after initial attack.

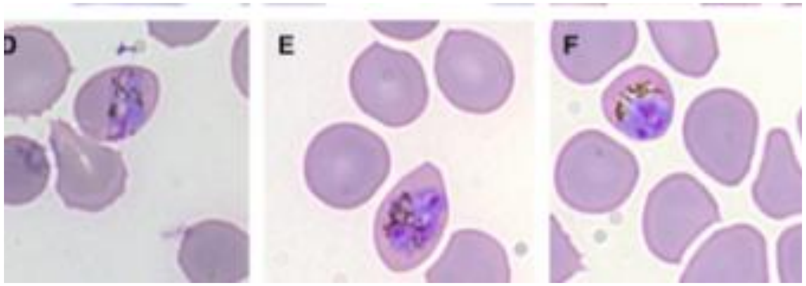
Plasmodium ovale

- *Plasmodium ovale* causes tertian malaria with limited pathenogenicity.
- It is the rarest of the human malaria parasites.
- Has a very long incubation period with relapse at three monthly intervals.



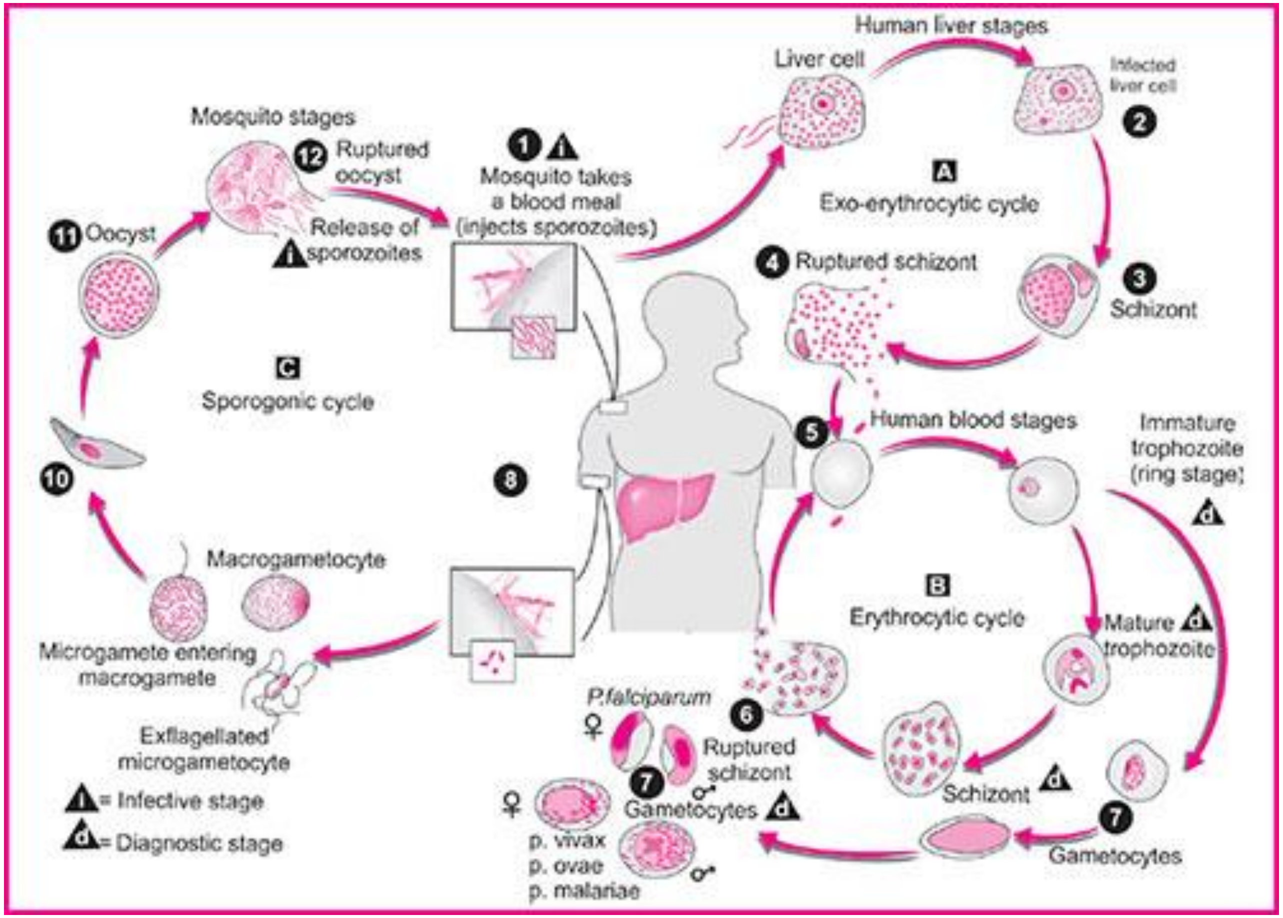
Plasmodium knowlesi

- Is the fifth major human malaria parasite.
- It may cause severe malaria as indicated by its asexual erythrocytic cycle of about 24 hours, with an associated fever that typically occurs at the same frequency (i.e. the fever is quotidian).
- It is a primate malaria parasite commonly found in Southeast Asia.
- It causes malaria in long-tailed macaques (*Macaca fascicularis*), but it may also infect humans, either naturally or artificially.



Life Cycle

Malaria parasites undergo three distinct replicative stages:

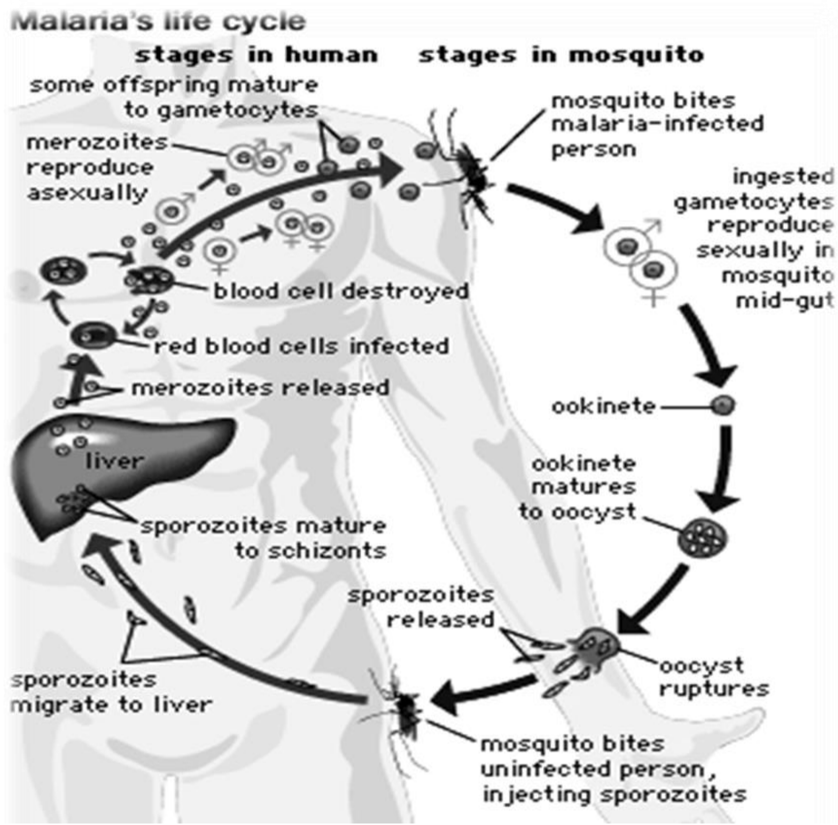


Life Cycle

- The malaria parasite exhibits a complex life cycle involving an insect vector (mosquito) and a vertebrate host (human).
- Female mosquitoes of the *Anopheles* genus are the primary, i.e. definitive hosts and act as transmission vectors.
- The parasite's secondary hosts are humans and other vertebrates.

Life Cycle

- Infection in humans begins with an infected female *Anopheles* mosquito taking a blood meal from a human host.
- As it feeds, it injects saliva contaminated with the sporozoite stage of the *Plasmodium* into the bloodstream of the host during feeding.



- The sporozoites are carried by the circulatory system to the liver which quickly invade the liver cells (hepatocytes).

Life Cycle

- In the liver, a pre-(or exo-) erythrocytic schizogonous cycle takes place in the parenchyma cells of the liver.
- This leads to formation of a large schizont, containing from 2000 to 4000 merozoites per the particular *Plasmodium* species.
- During the next 14 days in the case of *P. falciparum*, the liver-stage parasites differentiate and undergo asexual multiplication resulting in several merozoites which burst from the hepatoctye.

Life Cycle

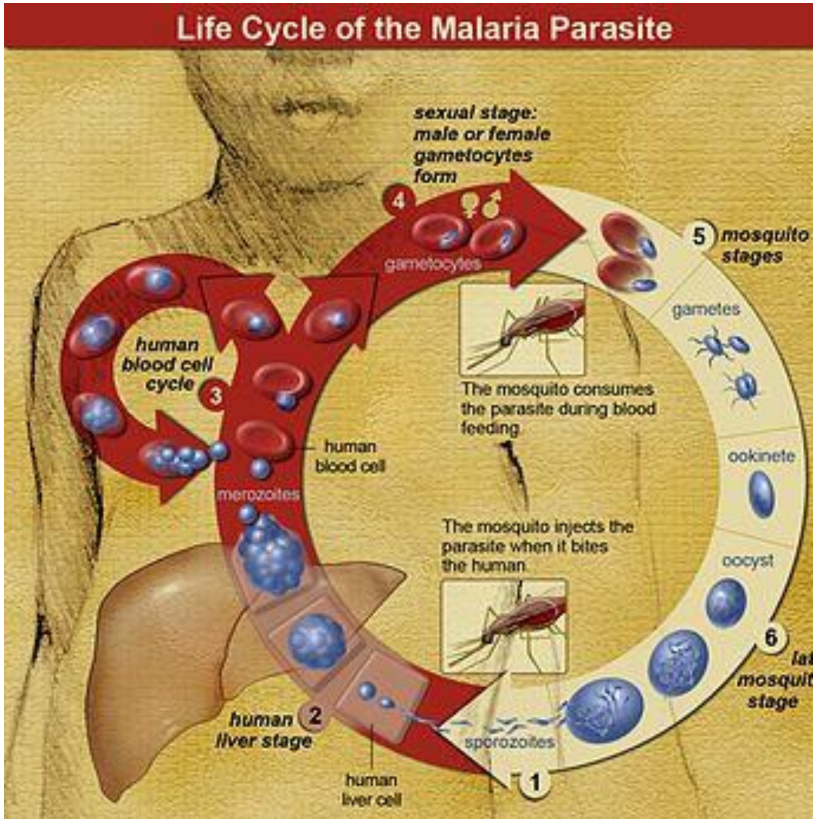
- The prepatent period of infection that started with an infective bite ends when the merozoites are released and either infects further liver cells or enters the bloodstream and invades the erythrocytes.
- In the red blood cells, they develop into ring forms, trophozoites and schizonts which in turn produce further merozoites.
- Trophozoite enlargement is accompanied by an active metabolism including the ingestion of host cytoplasm and the proteolysis of haemoglobin into amino acids.
- The end of the trophozoite period is manifested by multiple rounds of nuclear division resulting in a schizont.

Life Cycle

- The schizont releases from 6 to 16 merozoites which commence the repetition of the erythrocytic cycle.
- This synchronous release of merozoites from the erythrocytes liberates parasite products that stimulate the host's cells to release cytokines (a class of immunological mediators) which provoke the fever and illness of malaria attack.
- The length of this erythrocytic stage of the parasite life cycle depends on the parasite species: 48 hours for *P. falciparum*, *P. vivax*, and *P. ovale* (tertian malaria) and 72 hours for *P. malariae* (quartan malaria).

Life Cycle

- After several erythrocyte cycles (asexual phases), some trophozoites do not undergo division but differentiate to the sexual forms, male and female gametocytes (macro- or microgametocytes), a process that takes 8 days for *P. falciparum* but only 4 days for *P. vivax*.
- These gametocytes are taken up by a female *Anopheles* mosquito during a blood meal.



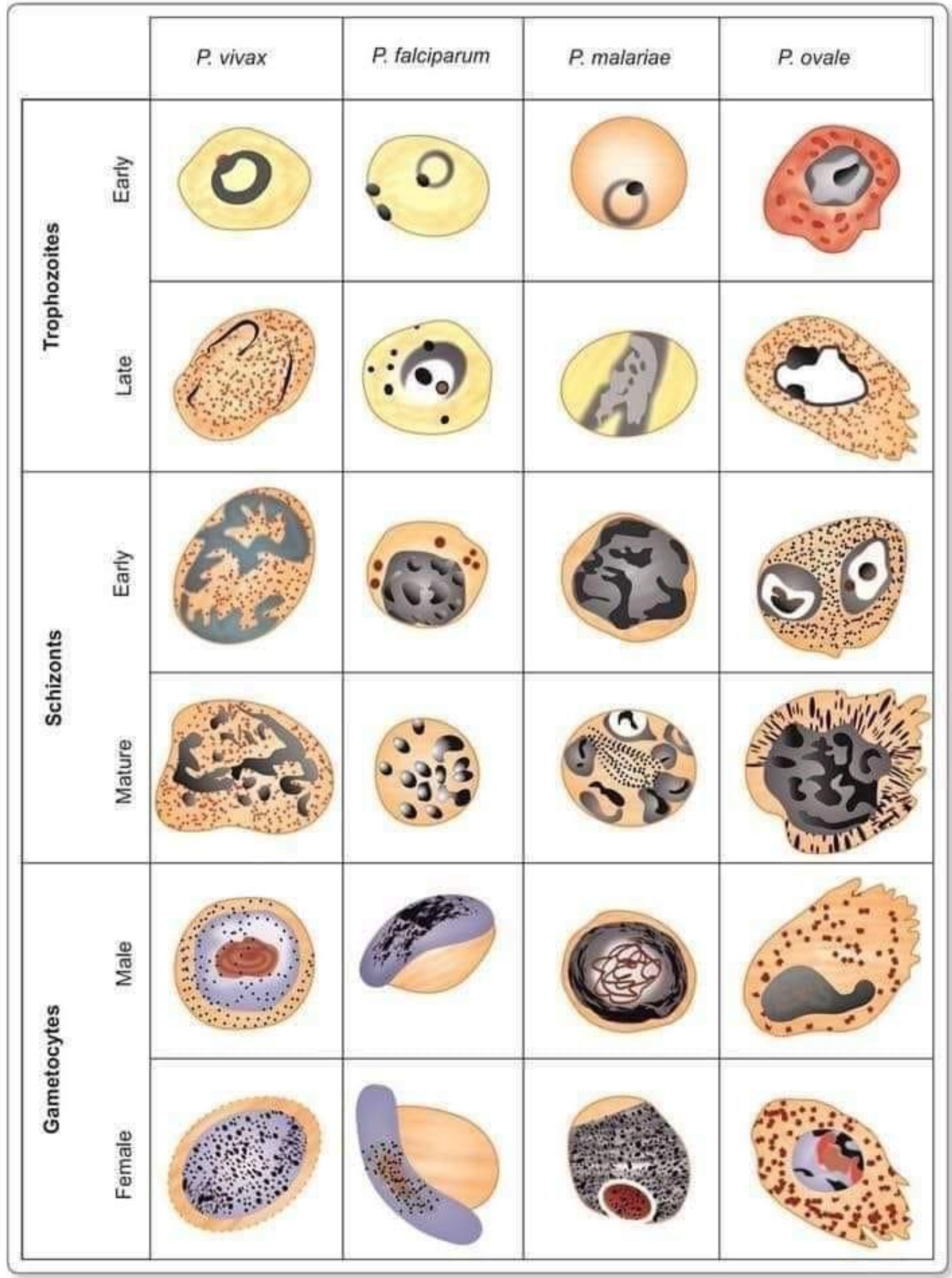
Life Cycles

- Within the mosquito midgut, the male gametocyte undergoes a rapid nuclear division, producing 8 flagellated microgamtes which fertilize the female macrogamete.
- The resulting ookinete traverses the mosquito gut wall and encysts on the exterior of the gut wall as a oocyst.
- The oocyst undergoes multiple rounds of asexual replication (sporogony) resulting in the production of sporozoites.

Life Cycle

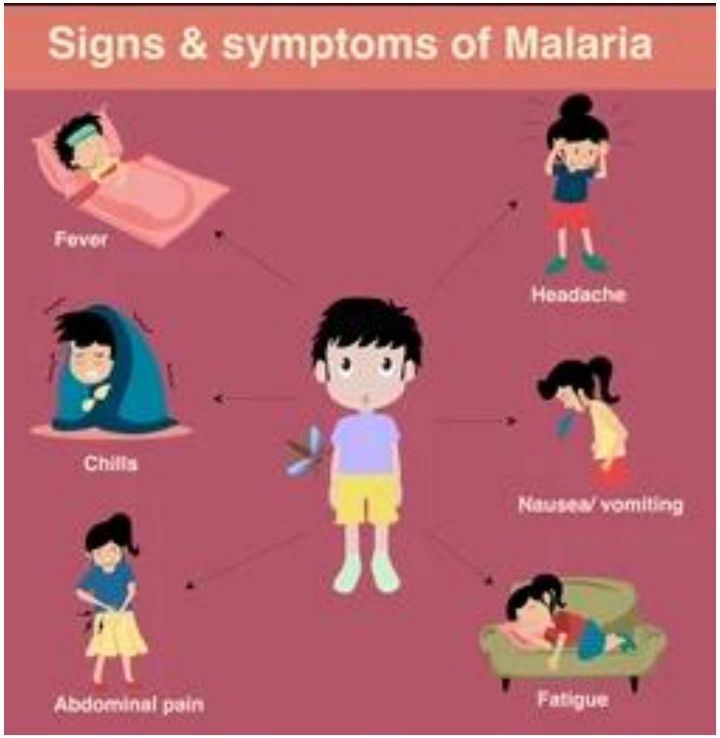
- Sporogony does not occur below 16 °C or above 33 °C which explains the temperature limitations for *Plasmodium* development.
- When the oocyst ruptures, it releases hundreds of sporozoites that migrate through the mosquito's body to the salivary glands, where they are then ready to infect a new human host.
- The time required for development in the mosquito (the extrinsic incubation period) ranges from 10–21 days, depending on the parasite species and the temperature.

Plasmodium species at the various stages of development



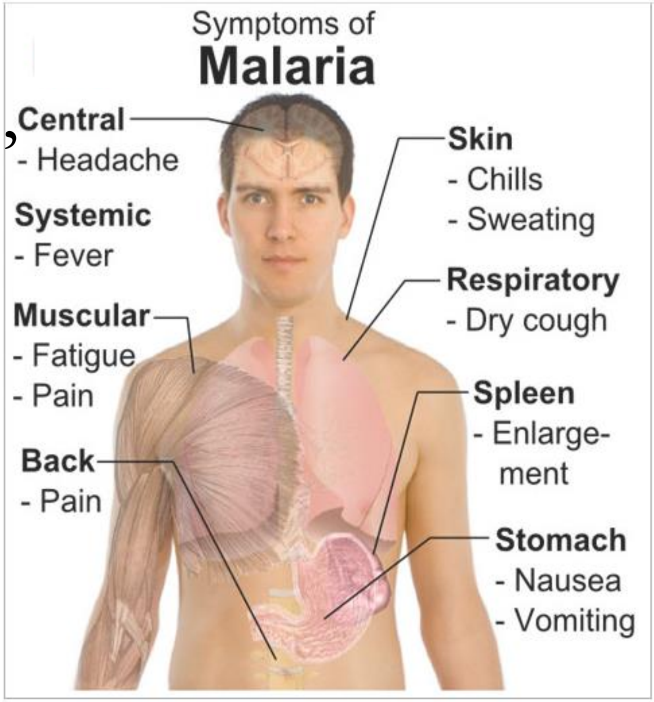
Signs and Symptoms of Malaria

- Malaria symptoms usually refer to various symptoms known to patient.
- Malaria signs may refer to those signs only noticeable by a doctor.
- Clinical symptoms of malaria are associated with the bursting of infected erythrocytes releasing merozoites and other debris into the blood stream.



Signs and Symptoms of Malaria

- People with malaria typically have fever, chills, muscle aches, arthralgia (joint pain), which turn within an hour into profuse sweating with headache, vomiting, dizziness and high temperature lasting for 2 to 6 hours, after which the temperature falls rapidly to normal and patient may feel well.



- Symptoms recur at intervals of 48hours to 72 hours.
- Symptoms usually appear between 10 and 15 days after the mosquito bite.

Signs and Symptoms of Malaria

- The result of an attack of malaria is anaemia with the possibility of oxygen deprivation to the tissues.
- The destruction of red blood cells can also cause jaundice.

Treatment of Malaria

1. Chemotherapy (use of antimalarial drugs)

- The antimalarial drugs are classified by their selective actions on different phases of the parasite's life cycle.
  - (a) Tissue schizonticides-eliminate developing tissue schizonts in the liver. e.g. Primaquine.
  - (b) Blood schizonticides(suppressive agents)- these drugs kill blood schizonts. e.g. Chloroquine , pyrimethamine, mefloquine, amodiaquine (amoquine), quinine, artesunate.

Treatment of Malaria

(c) Gametocytocides- prevent infection in mosquitoes by destroying gametocytes in the blood e.g. Primaquine for *P. falciparum* and chloroquine for *P. vivax*, *P. malariae* and *P. ovale*.

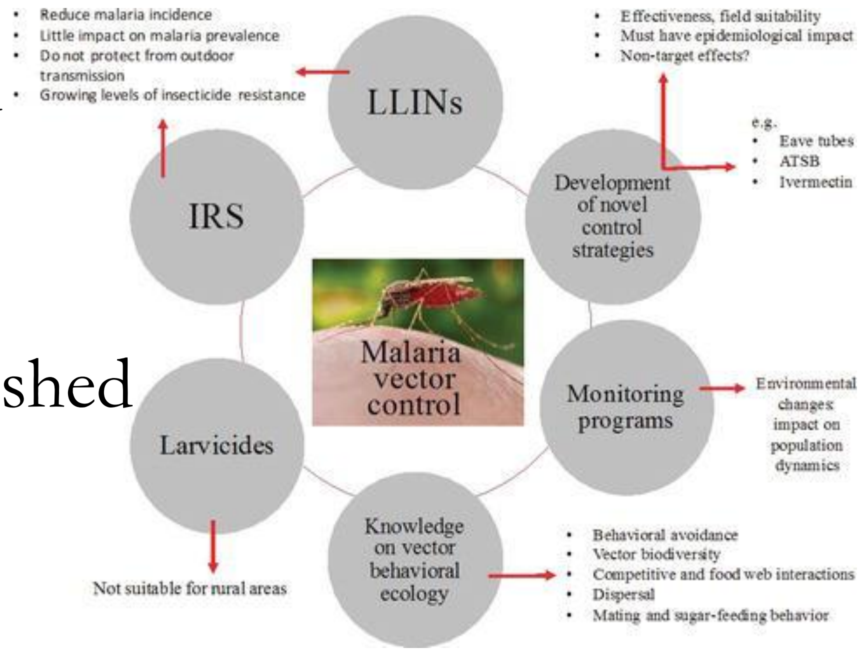
(d) Sporontocidal agents- these are drugs that render gametocytes non-infective in the mosquito e.g. pyrimethamine.

Treatment of Malaria

2. Chemoprophylaxis
   - Prevent attack of all forms of malaria. eg. Pyrimethamine and proguant prevent maturation of the early *P. falciparum* hepatic schizonts.

Vector Control

- Depending on the situation, source reduction, biocontrol, larviciding, or adulticiding may be used to manage mosquito populations.
- These techniques are accomplished using habitat modification, insecticides, biological-control agents, and trapping.



- Since many mosquitoes breed in standing water, source reduction can be as simple as emptying water from containers around the home

Biological Control

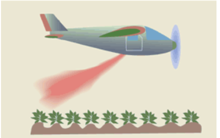
- Biological control or biocontrol is the use of natural enemies to manage mosquito (adult of larval) populations.
- There are several types of biological control including the direct introduction of pathogens and predators to target adult or larval mosquitoes.

Larviciding Using Biolarvicides

- Effective biocontrol agents include predatory fish that feed on mosquito larvae such as mosquitofish (*Gambusia affinis*) and some cyprinids (carps and minnows) and killifish. Tilapia will also consume mosquito larvae.

- Other predators include dragonfly naiads, which consume mosquito larvae in the breeding waters.
- Also used as biological control agent are the dead spores of varieties of the natural soil bacterium *Bacillus thuringiensis israelensis* (BTI) and *B. sphaericus*. They interfere in the digestion systems of larvae.

- It can be dispersed by hand or dropped by helicopter in large areas.



Larviciding Using Chemicals

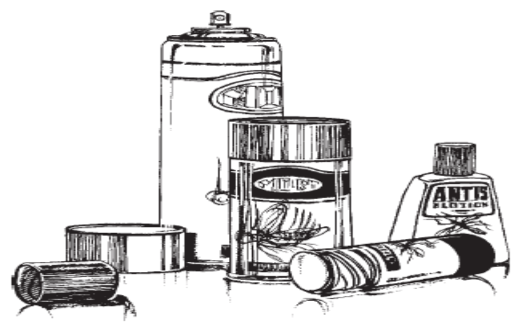
- Control of larvae can be accomplished through use of contact poisons, growth regulators, surface films and stomach poisons.

Adulticiding Using Biolarvicides

- Adult dragonflies eat adult mosquitoes.
- Like all animals, mosquitoes have their own set of diseases.
- Microbial pathogens of mosquitoes include viruses, bacteria, fungi, protozoa, nematodes, and microsproidia

Adulticiding Using Chemicals

- Chemical control of adult mosquitoes is the most familiar aspect of mosquito control to the public.
- It is accomplished by ground-based applications or via aerial application of chemical insecticides.
- Generally modern mosquito-control programs use low-volume applications of insecticides.



ENTOMOLOGY II

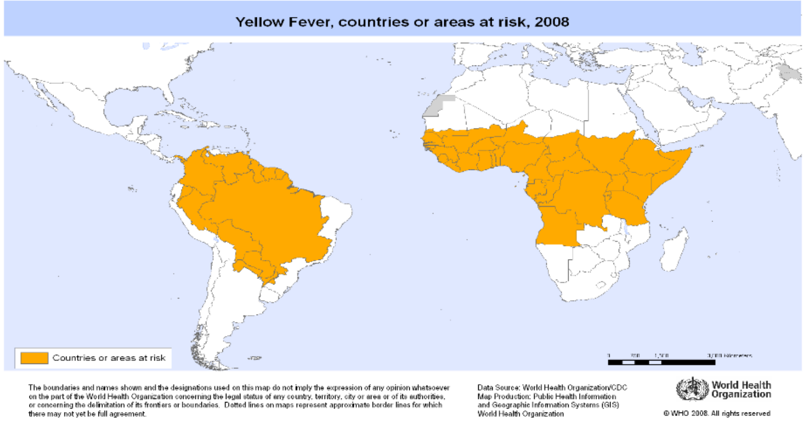
YELLOW FEVER

BIOL 356

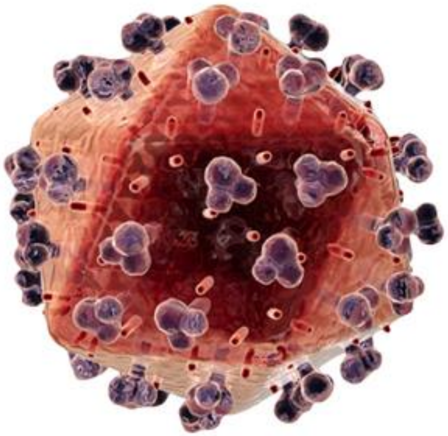
Dr. (Mrs.) Sandra Abankwa Kwarteng
Department Theoretical and Applied Biology
College of Science

Yellow Fever

- Yellow fever is common in West and Central Africa and parts of South America.



- Yellow fever is an acute, viral haemorrhagic disease which is transmitted to humans by infected female mosquitoes, *Aedes* or *Haemagogus* species .
- Mosquitoes that spread yellow fever usually bite during the day.
- The disease is caused by *Flavivirus* of the family Flaviviridae.



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Signs and Symptoms

- Once contracted, the virus incubates in the body for 3 to 6 days, followed by infection that can occur in one or two phases.
- 1st→ Causes fever, shivers, headache, nausea or vomiting, muscle pain, loss of appetite.
  - Most patients improve and their symptoms disappear after 3 to 4 days.
  - Often, the high fever is paradoxically associated with a slow pulse.

Signs and Symptoms

- 2^{nd} → 15% enter a 'toxic phase' within 24 hours.
  - Fever reappears and several body systems are affected.
  - The patient rapidly develops jaundice and complains of abdominal pain with vomiting.
  - Bleeding can occur from the mouth, nose, eyes and/or stomach. Blood appears in the vomit and faeces.
  - Kidney function deteriorates; this can range from abnormal protein levels in the urine (albuminuria) to complete kidney failure with no urine production (anuria).
  - Half of the patients in the 'toxic phase' die within 10-14 days. The remainder recover without significant organ damage.

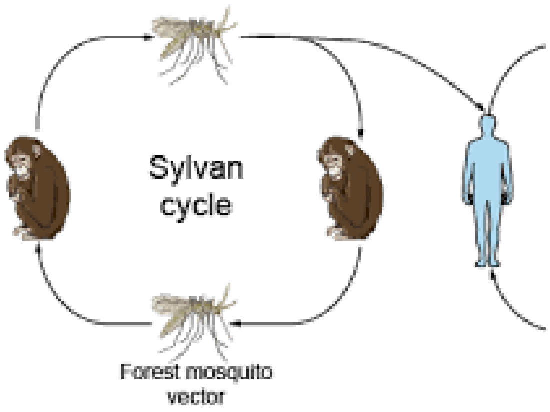
Signs and Symptoms

- Yellow fever is difficult to recognize, especially during the early stages.
- It can easily be confused with malaria, typhoid, other haemorrhagic viral fevers (e.g. lassa), other arboviral infections (e.g. dengue), viral hepatitis and poisoning (e.g. oral exposures to carbon tetrachloride).
- Blood tests (serology assays) can detect yellow fever antibodies that are produced in response to the infection.

Transmission

- The yellow fever virus is an arbovirus of the *flavivirus* genus, and the mosquito is the primary vector.
- The viral cycle in the mosquito is 12 days, after which the yellow fever virus reaches the mosquito's salivary glands and remains there for the rest of the mosquito's life.
- With every blood meal the female mosquito transmits virus contaminated saliva.
- The mosquitoes either breed around houses (domestic), in the jungle (wild) or in both habitats (semi-domestic).

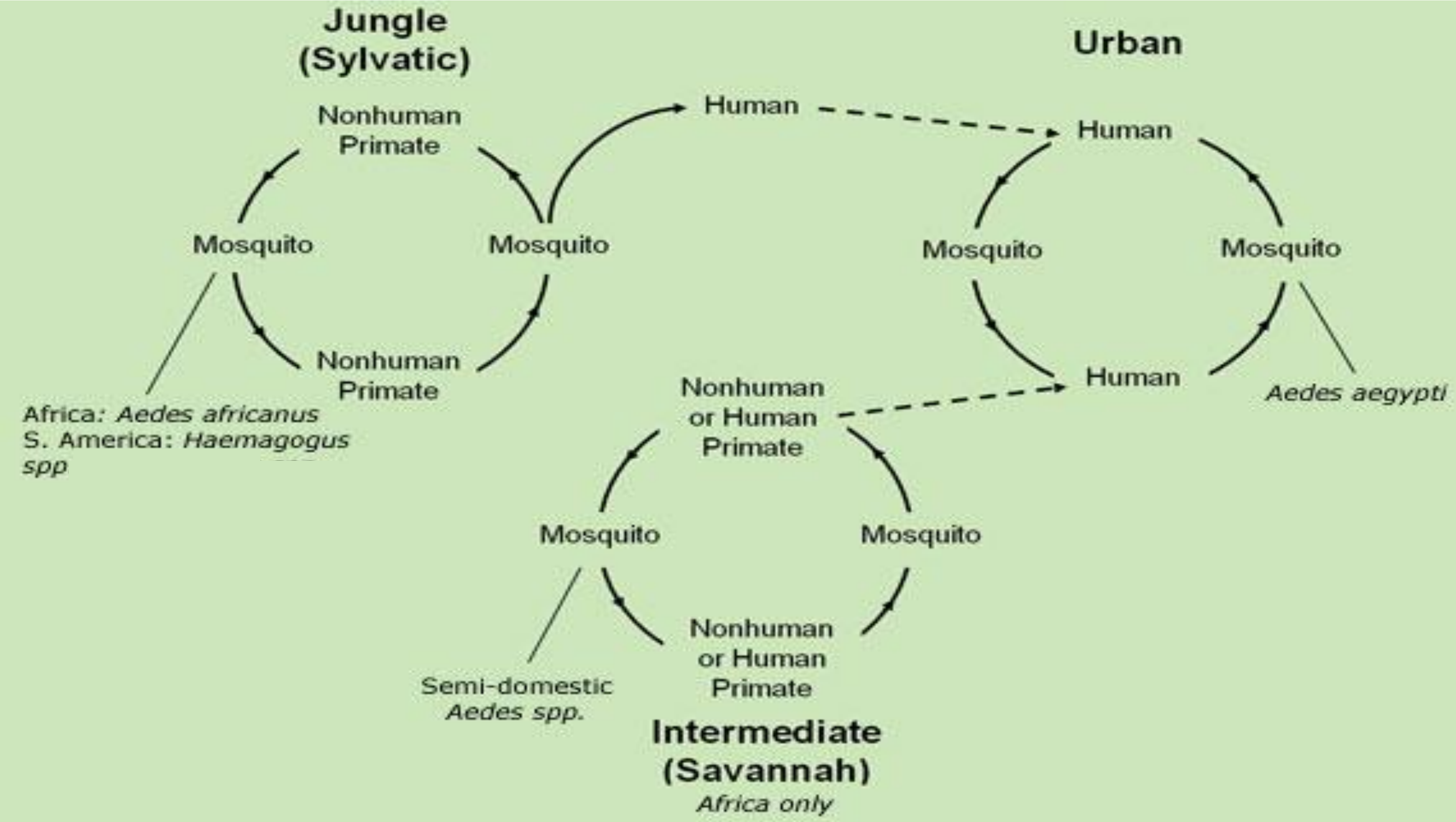
Transmission



There are 3 types of transmission cycles:

- Jungle (Sylvatic)
- Savannah (Intermediate)
- Urban

Life Cycle


Jungle
(Sylvatic)
Nonhuman Primate
Mosquito
Mosquito
Nonhuman Primate
Africa: *Aedes africanus*
S. America: *Haemagogus spp*
Human
Urban
Human
Mosquito
Mosquito
Human
Aedes aegypti
Nonhuman or Human Primate
Mosquito
Mosquito
Nonhuman or Human Primate
Semi-domestic *Aedes spp.*
Intermediate
(Savannah)
Africa only

Sylvatic (Jungle) Yellow Fever

- Jungle yellow fever is mainly a disease of monkeys.
- It is spread from infected mosquitoes to monkeys in the tropical rain forest.
- The infected monkeys then pass the virus to other mosquitoes that feed on them.
- At the forest edge, monkeys are likely to be bitten by *Aedes* mosquitoes which breeds in water-filled axils of certain strains of plants, or root holes in stems of plants.
- The infected mosquitoes bite humans entering the forest, resulting in periodic cases of yellow fever.

Sylvatic (Jungle) Yellow Fever

- People working and living among such forest edges in Africa are likely to become infected with yellow fever and other viruses transmitted from monkeys via *Ae. simpsoni*.
- Majority of the cases are young men working in the forest, or involved in logging, etc.
- Man to man transmission may then be continued by *Ae. aegypti*.

Intermediate yellow fever

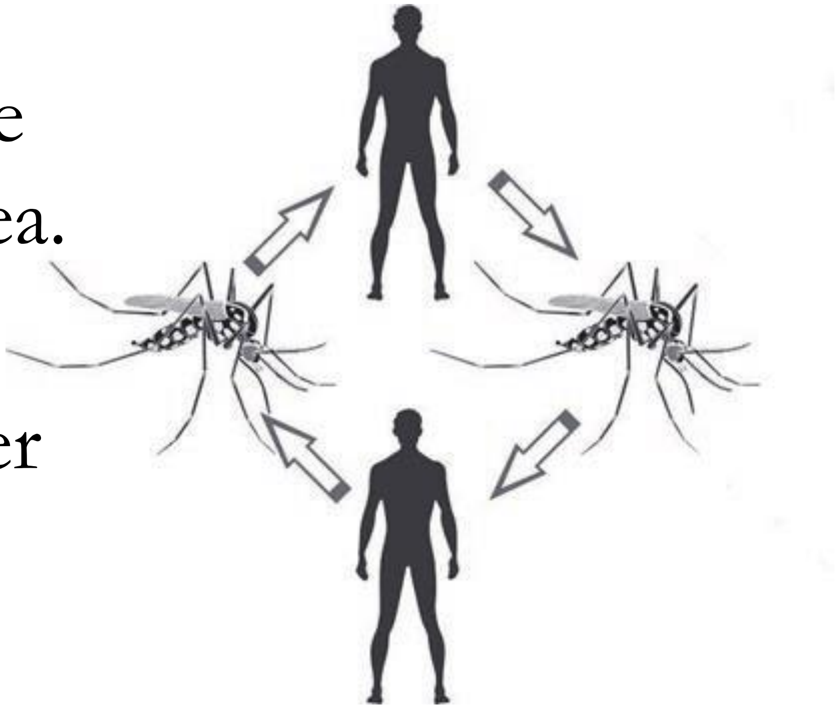
- In humid or semi-humid savannahs of Africa, restricted epidemics occur.
- Semi-domestic mosquitoes (that breed in the wild and around households) infect both monkeys and humans. This area is often called the "zone of emergence", where increased contact between man and infected mosquito leads to disease.
- This is the most common type of outbreak seen in recent decades in Africa.
- It can shift to a more severe urban-type epidemic if the infection is carried into a suitable environment (with the presence of domestic mosquitoes and unvaccinated humans).

Urban Yellow Fever

- Urban yellow fever is a disease of humans.
- It is spread by mosquitoes that have been infected by other people.
- *Aedes aegypti* is the type of mosquito that usually carries yellow fever from human to human. These mosquitoes have adapted to living among humans in cities, towns and villages.
- They breed in discarded tires, flower pots, oil drums, and water storage containers close to human dwellings.
- Large epidemics can occur when migrants introduce the virus into areas with high human population density.

Urban Yellow Fever

- These outbreaks tend to spread outwards from one source to cover a wide area.
- Urban yellow fever is the cause of most yellow fever outbreaks and epidemics.



Prevention

- Vaccination is the single most important measure for preventing yellow fever.
- In populations where vaccination coverage is low, vigilant surveillance is critical for prompt recognition to prevent epidemics and rapidly control of outbreaks.
- Mosquito control measures can be used to prevent virus transmission until vaccination has taken effect.
- WHO strongly recommends routine yellow fever vaccination for children in areas at risk for the disease.

Treatment

- There is no specific treatment for yellow fever.
- Dehydration and fever can be corrected with oral rehydration salts and paracetamol.
- Any superimposed bacterial infection should be treated with an appropriate antibiotic.
- Intensive supportive care may improve the outcome for seriously ill patients, but is rarely available in poorer, developing countries.

ENTOMOLOGY II

DENGUE

BIOL 356

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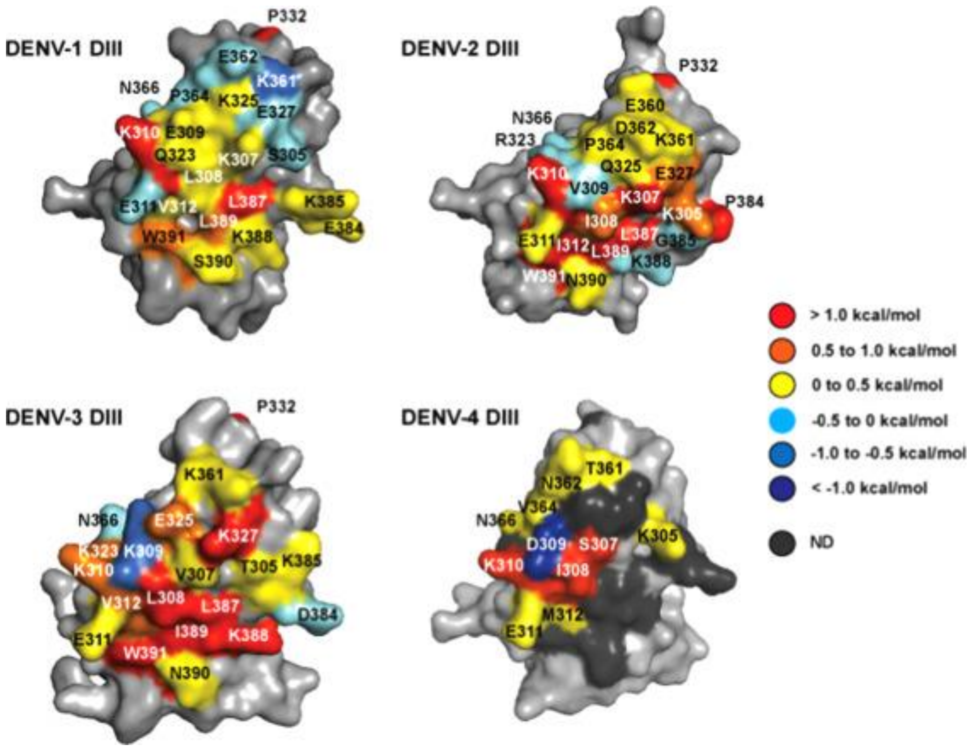
Dengue Fever

- Humans are the primary host of the virus, but it also circulates in nonhuman primates.
- Is an infectious tropical disease caused by the dengue virus that is spread by mosquitoes *Aedes aegypti*, which is found in tropical and subtropical regions. Other *Aedes* species that transmit the disease include *A. albopictus*, *A. polynesiensis* and *A. scutellaris*.

Transmission

- Dengue fever virus (DENV) is an RNA virus of the family Flaviviridae; genus *Flavivirus*.
- There are four strains of the virus, which are called serotypes, and these are referred to as DENV-1, DENV-2, DENV-3 and DENV-4.



Life Cycle of Dengue

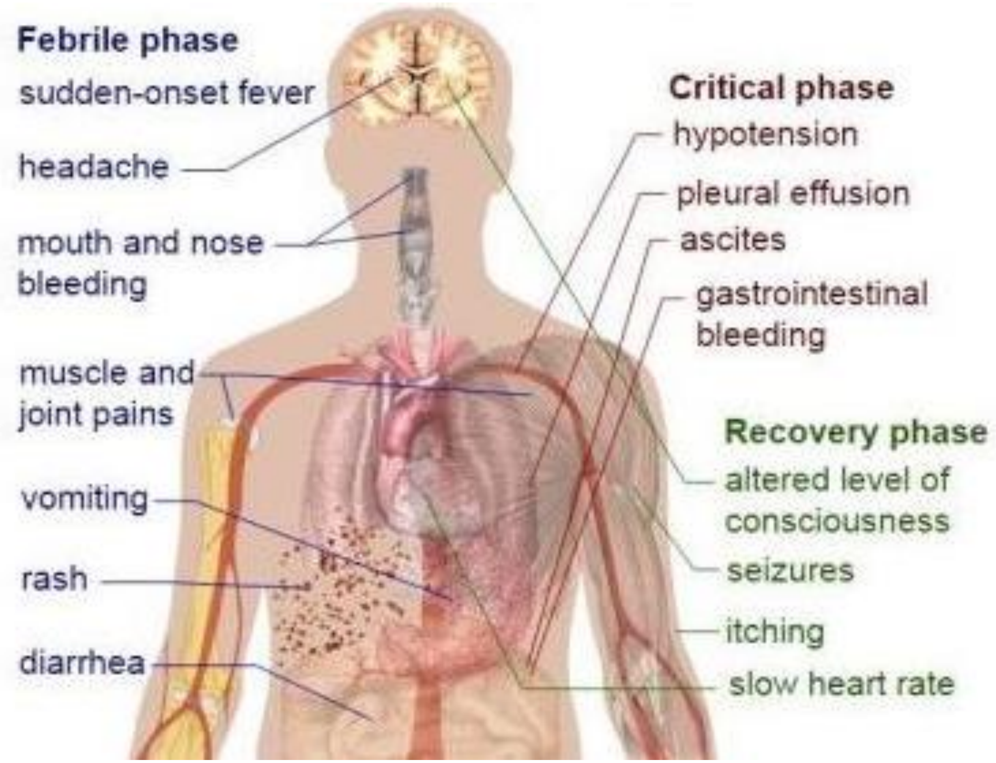
- An infection can be acquired via a single bite. A female mosquito that takes a blood meal from a person infected with dengue fever becomes itself infected with the virus in the cells lining its gut.
- About 8–10 days later, the virus spreads to other tissues including the mosquito's salivary glands and is subsequently released into its saliva.
- The virus seems to have no detrimental effect on the mosquito, which remains infected for life.
- Dengue can also be transmitted via infected blood products and through organ donation.

Symptoms

- Dengue fever begins with a sudden high fever 4 to 7 days after the infection.
- A flat, red rash may appear over most of the body 2 - 5 days after the fever starts.
- A second rash, which looks like the measles, appears later as the disease progresses.
- Infected people may have increased skin sensitivity which are very uncomfortable.

Symptoms

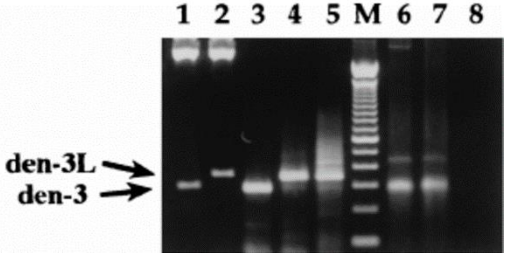
- Other symptoms include:
- Headache
- Fatigue
- Joint aches
- Muscle aches
- Nausea
- Swollen lymph nodes
- Vomiting



Diagnosis and tests

Tests that may be done to diagnose this condition include:

- Antibody titer for dengue virus types
- Rapid Test Kits
- Polymerase chain reaction (PCR) test for dengue virus types



Treatment and Prevention

- There is no specific treatment for dengue fever.
- You will need fluids if there are signs of dehydration.
- There are approved vaccines for the dengue virus, Dengvaxia for virus types 1, 2, 3 and 4.
- Prevention also depends on control of and protection from the bites of the mosquito that transmits it.

Dengue Field Studies

I am a Research Assistant at the entomology laboratory at the Navrongo Health Research Centre in Ghana

I have gathered a lot of experience in vector studies due to these collaborations and affiliations over the years.

MPhil candidate, Kwame Nkrumah University of Science and Technology (KNUST) in Ghana studying entomology

I have contributed several studies, including The Durability Studies of LifeNets in Ghana by the National Malaria Control Board in which we conducted fabric integrity tests and insecticide-resistant assays on Lifelong insecticide-treated nets in Ghana

Entomological assessment of the risk of dengue fever transmission in Northern Ghana

MPhil Entomology Studies

Story of Dengue in Ghana

- Dengue virus exposure among some blood donors in Ghana (2016).
- Detection of dengue virus in patients suspected of Ebola virus (2018).
- Dengue virus was detected among children with suspected malaria (2018).
- In 2022, dengue still persists in some neighbouring countries.

Problem Statement and Justification

- Evidence of dengue fever in Burkina-Faso in 2013 and 2017.
- Urbanization and proximity of Burkina-Faso to Kassena-Nankana districts (KNDs).
- Little is known about dengue fever and very little is known about *Aedes* mosquitoes.
- No profiling of *Aedes* mosquitoes, and little is known about *Aedes* in the district.
- Establish the risk of dengue fever transmission
- Knowledge of *Aedes* and dengue will inform public health officials on mitigation measures to put in place.

Field activities –Trap types

BG-Sentinel trap

CDC Light trap

Field activities

Inspection of water holding containers

Aedes larvae and pupae collection

Administration of questionnaires

Setting of light trap in a compound

Laboratory activities

Female *Aedes aegypti* mosquito under a microscope

Labelling and packaging of identified mosquitoes

ENTOMOLOGY II

FILARIASIS

BIOL 356

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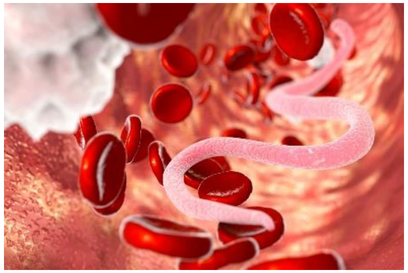
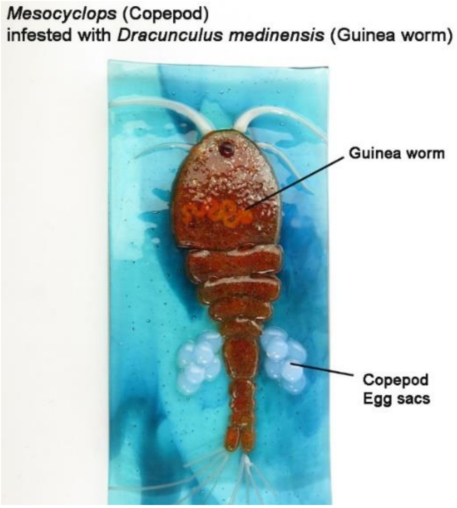
Filariasis

- Filariasis is a parasitic and infectious tropical disease, that is caused by thread-like filarial nematode worms.



- In all cases, the transmitting vectors are either blood sucking insects (fly or mosquito) or copepod crustaceans in the case of *Dracunculus medinensis*.



Filariasis

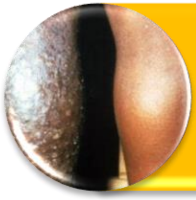
- There are 9 known filarial nematodes which use humans as the definitive host.

Parasite	Geographical distribution	Adult dwelling place in the body	Mf presence	Vector Involved	Disease symptoms
Wuchereria bancrofti	Africa, Pacifica, Asia, Americas	Lymphatics	Blood	*Cx. quinquefasciatus, Anopheles spp., Aedes spp.*	Lymphangitis Elephantiasis
Brugia malayi	Asia	Lymphatics	Blood	*Mansonia spp.*	Lymphangitis, Elephantiasis
Brugia timori	Indonesia	Lymphatics	Blood	*An. barbirostris*	Lymphangitis, Elephantiasis
Onchocerca volvulus	Africa, Central & South America, Yemen	Skin nodules, eye	Skin	*Simulium spp.*	Dermatitis, ocular lesions, blindness
Loa loa	Africa	Subcutaneous tisues	Blood	*Tabanus spp.*	Calabar swellings, eye irritations
*Mansonella ozzardi**	Central & South America	Mesentery of abdominal wall	Blood, skin	*Culicoides spp.*	Lymph node swelling, joint pain
*Mansonella perstans**	Africa, America	Perirenal tissues, pleural cavity, pericardium	Blood	*Culicoides spp.*	Skin itch, joint pain
*Mansonella streptocerca**	Africa	Subcutaneous tissues	Blood skin	*Culicoides spp.*	Skin itch, joint pain
Dracunculus medinensis	Subsaharan Africa	Subcutaneous tissue	Skin	*Cyclops*	Ulcers, Painful blister

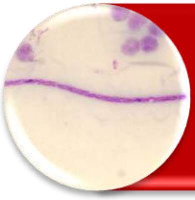
Filariasis

- Filarial nematodes are divided into 3 groups according to the part of the body that they occupy:

Lymphatic Filariasis



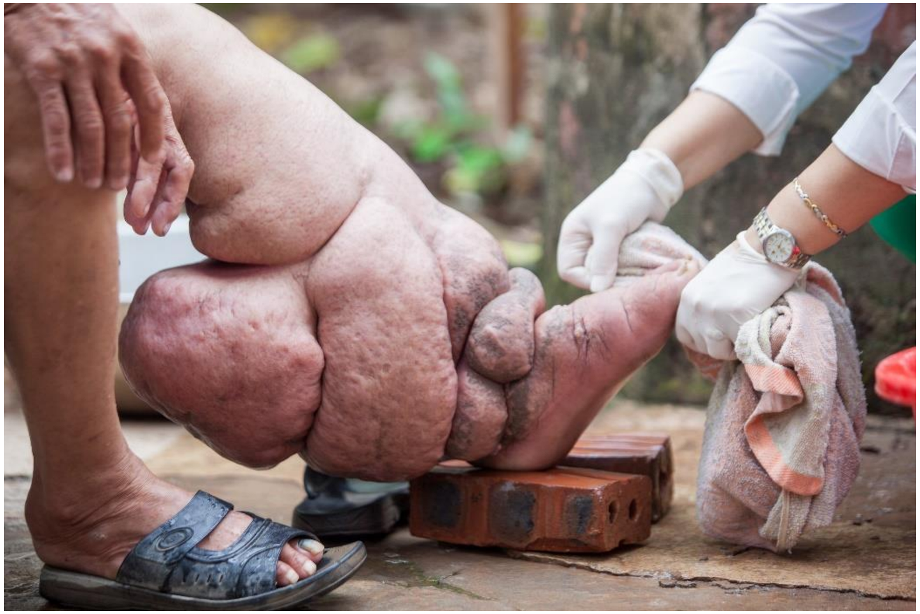
Subcutaneous Filariasis



Serous Cavity Filariasis

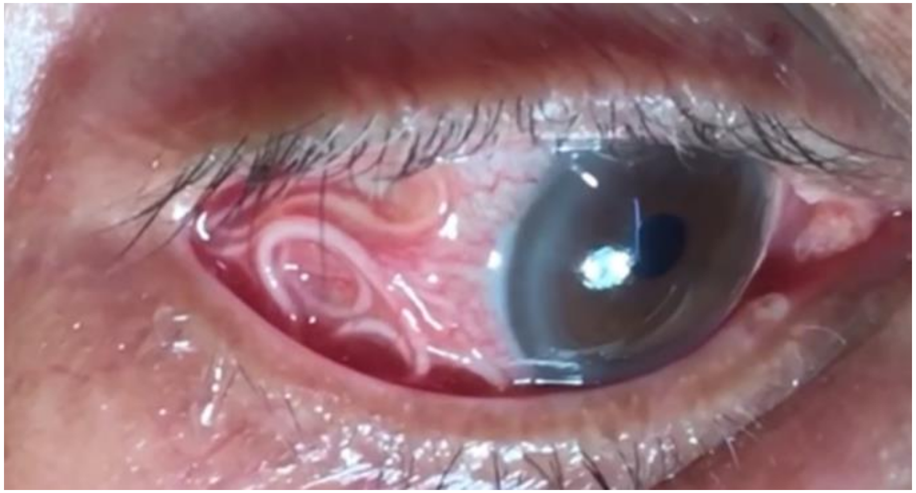
Lymphatic Filariasis

- Is caused by the worms *Wuchereria bancrofi*, *Brugia malayi*, and *Brugia timori*.
- These worms occupy the lymphatic system, including the lymph nodes, and in chronic cases these worms lead to the disease elephantiasis.



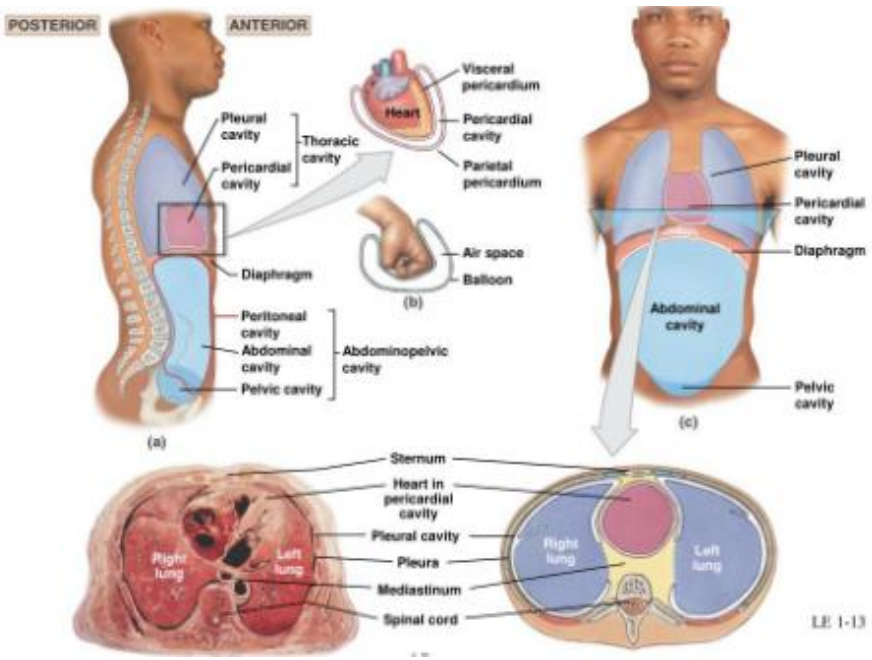
Subcutaneous Filariasis

- Is caused by *Loa loa* (the African eye worm), *Mansonella streptocerca, Onchocerca volvulus* and *Dracunculus medinensis*.
- These worms occupy the subcutaneous layer of our skin and our fat layer.



Serous Cavity Filariasis

- Serous Cavity Filariasis is caused by the worms *Mansonella perstans* and *Mansonella ozzardi*, which occupy the serous cavity of the abdomen.



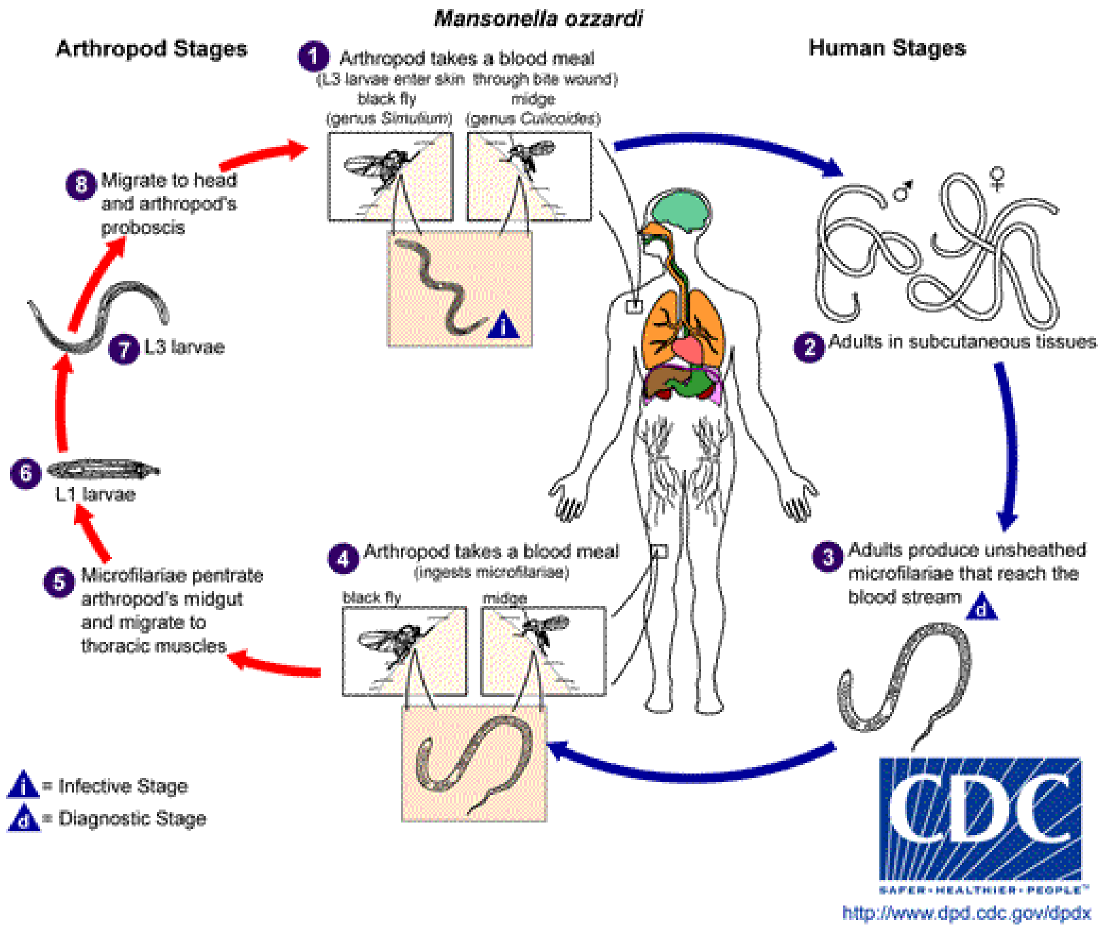
Life Cycle

Human filarial nematode worms have a complicated life cycle, which primarily consists of five stages.

- After the male and female worm mate, the female gives birth to thousands of live microfilariae.
- The microfilariae are taken up by the vector insect (intermediate host) during a blood meal.
- In the intermediate host, the microfilariae molt and develop into 3rd stage (infective) larvae in one to two weeks.
- Upon taking another blood meal the vector insect injects the infectious larvae into the dermis layer of our skin.

Life Cycle

- After approximately one year the larvae molt through 2 more stages, maturing into to the adult worm.



Onchocerciasis (River Blindness)

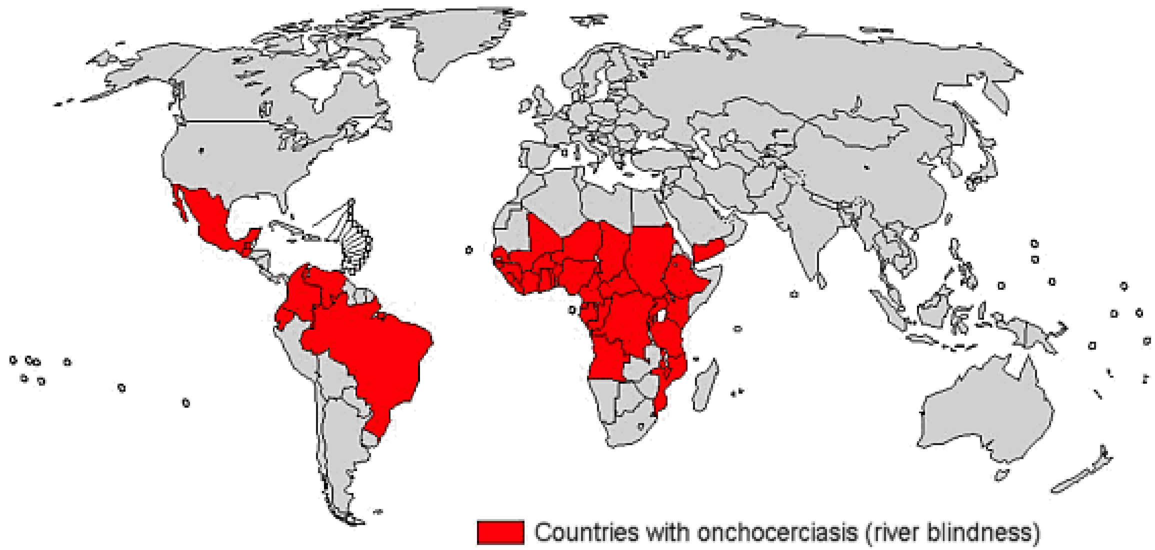
- Onchocerciasis is a parasitic disease caused by the filarial worm *Onchocerca volvulus* which is almost exclusively a parasite of man.
- *Onchocerca volvolus* adult male is 2-3 cm long while female is 60 cm long occurring in the subcutaneous tissues and in nodules.
- The microfilariae is 300 x 8 micrometer (0.24cm), 1000-3000 produced per day per adult female worm.
- Adult worms have a longevity of 10-15 years.

Onchocerciasis (River Blindness)

- It is often called "river blindness" because the blackfly, *Simulium damnosum*, which transmits the disease, abounds in fertile riverside areas.
- Onchocerciasis is the world's second leading infectious cause of blindness.

Distribution

- Onchocerciasis tends to be localized in distribution within its endemic areas.
- It occurs in 35 countries worldwide: 28 in tropical Africa, where 99% of infected people live. Isolated foci in Latin America (6 countries) and Yemen.



Life Cycle of *Onchocerca volvulus*

- *Onchocerca volvulus* has humans as the only definitive host and *Simulium* black flies are obligate intermediate hosts.
- Black flies feed on flower nectar.
- Females *Simulium* require blood meal for ovulation, and they can transmit infective-stage larvae as well as receive microfilariae during the blood meal. Fly's saliva acts as a chemoattractant for microfilariae in the surrounding subcutaneous tissues.

www.knust.edu.gh

Life Cycle of *Onchocerca volvulus*

- An infected blackfly bites a person and deposits *Onchocerca* larvae in the skin. The larvae then enter the bite wound
- The larvae move into the tissues under the skin (subcutaneous tissues) and form lumps (nodules).
- The larvae develop into adult worms in the nodules. Adult females may live up to about 15 years in these nodules.
- After mating, mature female worms produce eggs, which develop into immature forms of the worm called microfilariae. A worm may produce 1,000 microfilariae each day. The microfilariae typically live in the skin and the lymph vessels but are occasionally present in the bloodstream, urine, and sputum.

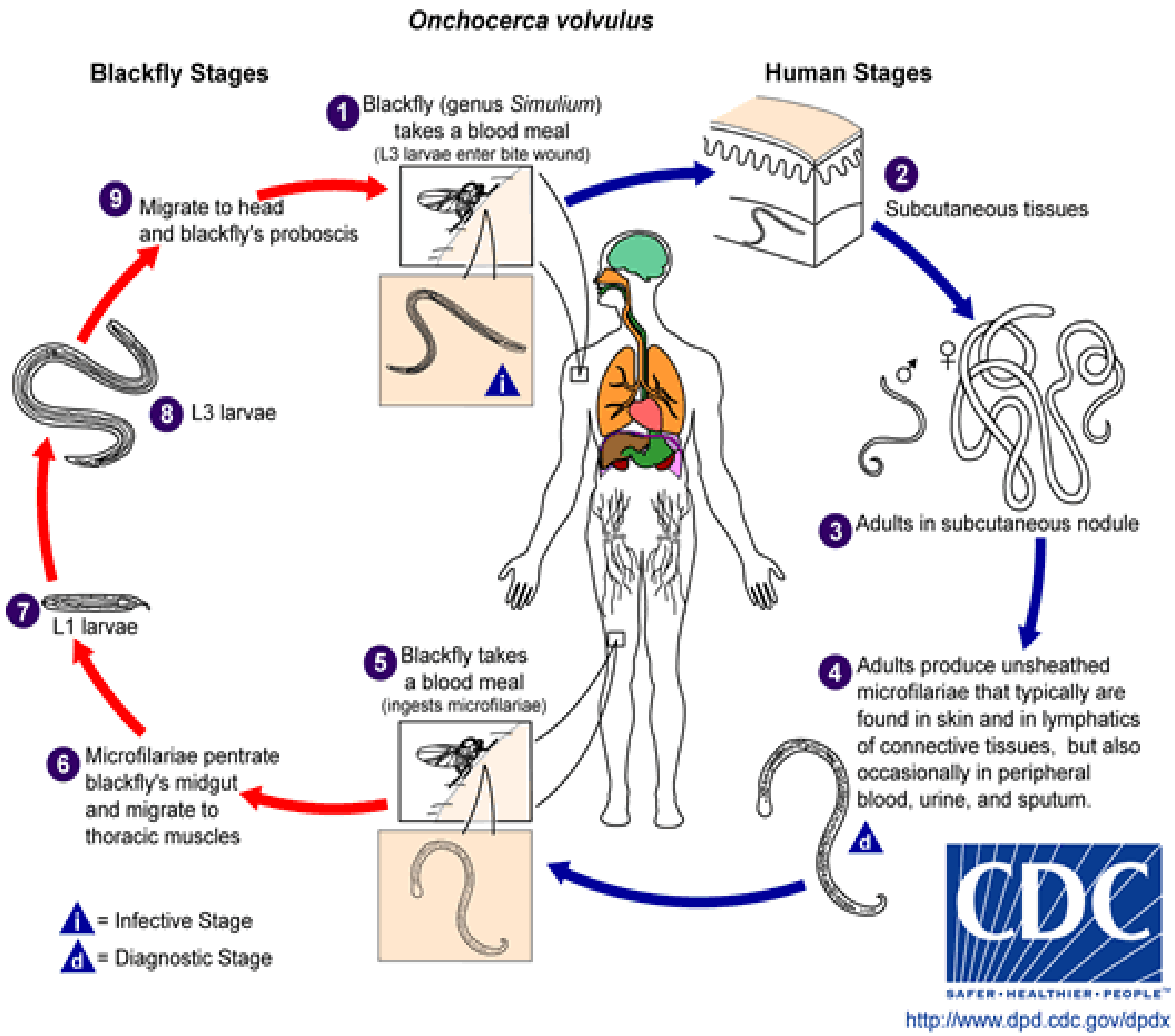
Life Cycle of *Onchocerca volvulus*

- In subcutaneous tissues the larvae moult from (L3) to L4 within 2 – 5 days. The final moult (L4 – L5) occurs at $1^1/_2 - 2^1/_2$ months after entry and develop into adult filariae, which commonly reside in nodules in subcutaneous connective tissues

- These move through the body and when they die cause variety of conditions including blindness, skin rashes, lesions, itching and skin depigmentation.

Life Cycle of *Onchocerca volvulus*

- The infection spreads when a blackfly bites an infected person and is infected with the microfilariae.
- After the microfilariae are ingested, they travel to the middle part of the fly's gut (midgut), then to muscles in its midsection (thoracic muscles).
- There, the microfilariae develop into larvae.
- Larvae travel to the fly's mouth parts (proboscis) and can be transmitted to other people when the fly bites them.


Onchocerca volvulus
Blackfly Stages
Human Stages
1 Blackfly (genus Simulium) takes a blood meal
(L3 larvae enter bite wound)
2 Subcutaneous tissues
3 Adults in subcutaneous nodule
4 Adults produce unsheathed microfilariae that typically are found in skin and in lymphatics of connective tissues, but also occasionally in peripheral blood, urine, and sputum.
5 Blackfly takes a blood meal
(ingests microfilariae)
6 Microfilariae pentrate blackfly's midgut and migrate to thoracic muscles
7 L1 larvae
8 L3 larvae
9 Migrate to head and blackfly's proboscis
i = Infective Stage
d = Diagnostic Stage
CDC
SAFER · HEALTHIER · PEOPLE
http://www.dpd.cdc.gov/dpdx

Prevention and Treatment

Control of insect through using of insecticides:

- Introduction of Onchocerciasis Control Programme in West Africa (OCP) was launched in 1974 in an area encompassing originally 7 countries in West Africa.
- In 1986, the programme was extended to include a further 4 countries. The total operational area was 1.23 million sq. km with a combined human population of 30 million.

Onchocerciasis Control Programme in West Africa (OCP)

- Vector control:
  - Insecticide spraying to control blackflies has proved successful in certain areas.
  - Temephos (Organophosphate) used as larvicide was effective but resistance developed in some areas

Prevention and Treatment

- Surgical treatment
- Biannual ivermectin treatment

NEGLECTED TROPICAL DISEASES (FILARIASIS AND SCHISTOSOMIASIS)

EXPERIENCES WITH ENDEMIC COMMUNITIES AND AFFECTED PERSONS

Fatima Amponsah Fordjour (Assistant Lecturer)
University for Development Studies, Tamale
Faculty of Biosciences, Department of Microbiology

Preparations for Field Work

Meeting with Endemic Communities and Affected Persons

Explanation of study procedures to affected persons

Screening of Endemic Communities

Focus Group Discussion with Affected Persons

Challenges faced by affected persons:

- Stigmatization
- Unemployment
- Life partner
- Mental health issues

Hydrocele of the scrotum

Lymphedema

Palpation for Onchocerciasis Nodules

Nodules

Onchodermat

Blindness

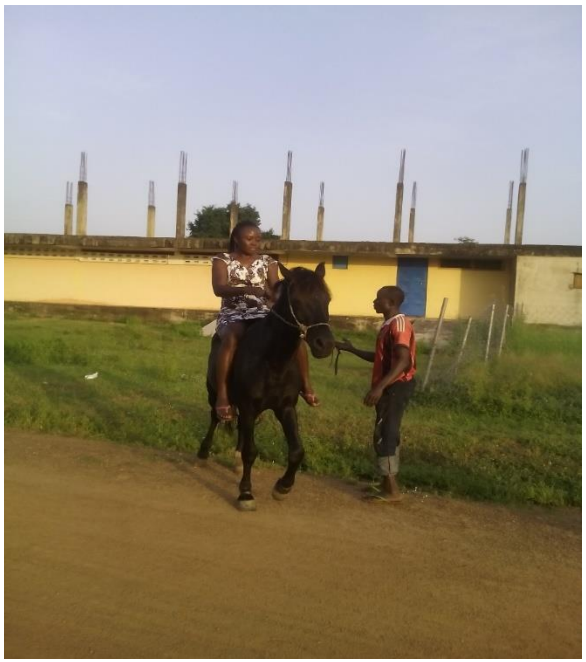
Depigmentatio
n

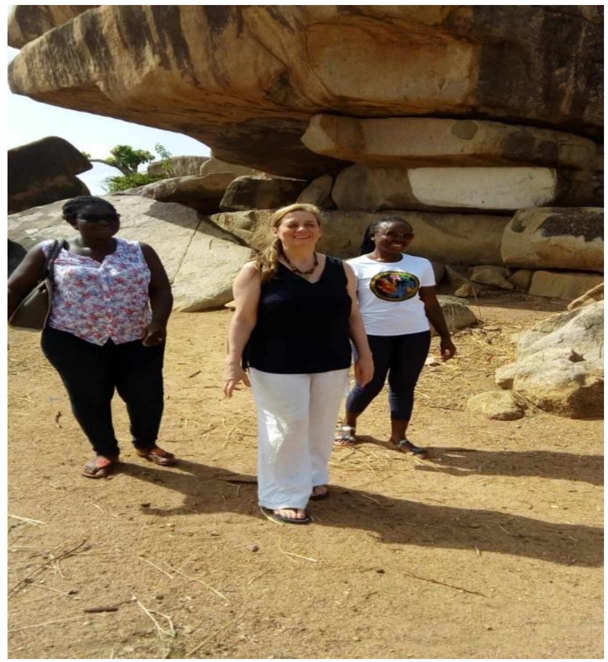
Atrop
hy

Stucked!!!

Nature of Roads Leading to Endemic Communities

Have fun no matter what happens





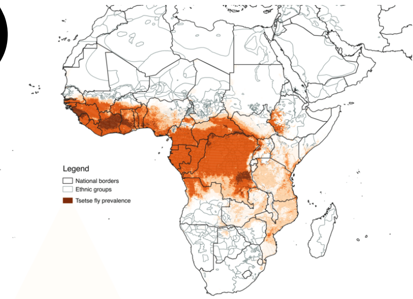
ENTOMOLOGY II

TRYPANOSOMIASIS

BIOL 356

Dr. (Mrs.) Sandra Abankwa Kwarteng
Department Theoretical and Applied Biology
College of Science

Family Glossinidae (Tsetseflies)



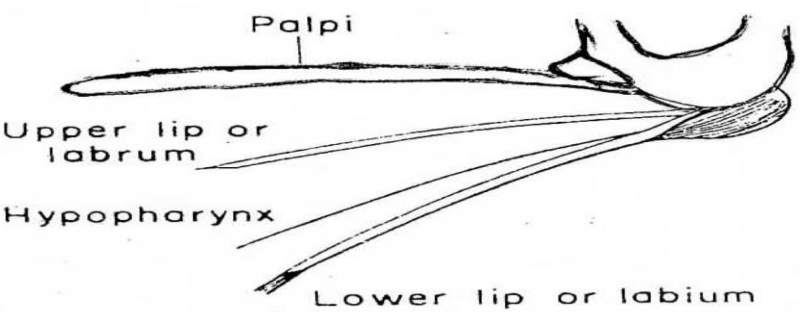
Distribution

- They are confined to tropical Africa.
- They are mainly found in vegetation by rivers and lakes, in gallery-forests and in vast stretches of wooded savannah.
- They occupy roughly half of the surface of the continent of Africa.
- Horizontally or inclined branches, 2-5 cm thick and 1-3 mm from the ground are favoured resting sites during the day (for most species).
- Resting flies are mostly along the edge of the thickets or margins of leaves and streams.

Family Glossinidae (Tsetseflies)

- Tsetse flies are large, brown to greyish, 6-15mm long.
- They are robust, sparsely bristled and usually larger than a housefly.

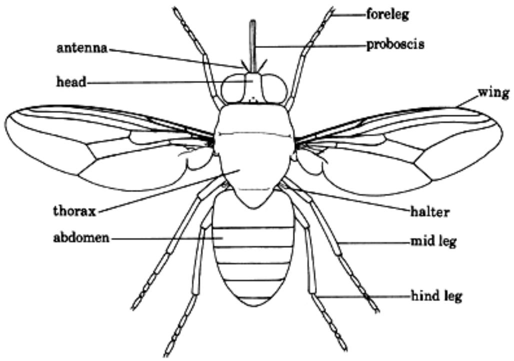
- The mouthparts consist of a horny labrum/upper lip, a slender hypopharynx / tongue (through which anticoagulant saliva is injected into the bite wound) and a stout ventral labium/lower lip.
- The unique viviparous genus *Glossina* contains some 30 species and sub species.



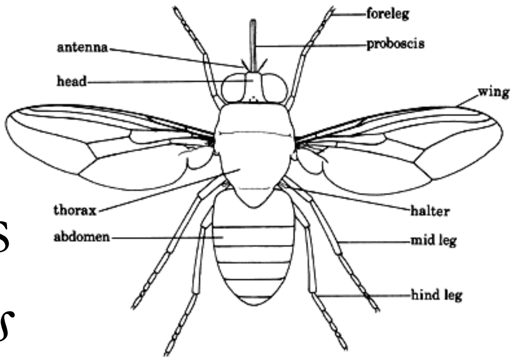
Mouthparts of *Glossina*.

Characteristics

- Proboscis is stout and projects well in front of the head.
- These parts enclose a food canal through which blood is sucked by muscular action.
- Male and female tsetse flies feed exclusively on the blood of vertebrates.
- There are some 10 species concerned with the transmission of African Trypanosomiasis.
- Of these species 4 are important: *G. palpalis*, *G. morsitans*, *G. tachinoides* and *G. swynnertonis.*

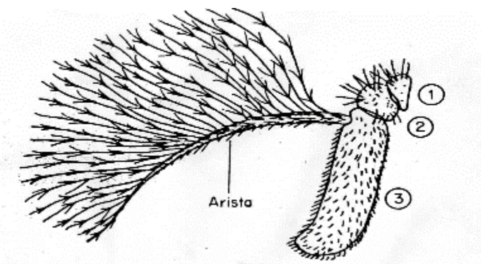


Characteristics

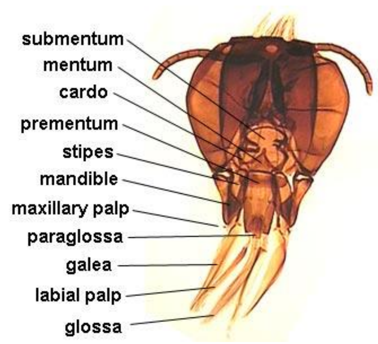


- Features which distinguish *Glossina* species from other biting flies such as *Tabanus* (horsefly), *Chrysops* (deerfly), *Stomoxys* (stable fly) , etc are:

1. Possession of long straight proboscis with a basal bulb.
2. The presence of branched hairs on the arista.
3. The labial palps as long as the proboscis .

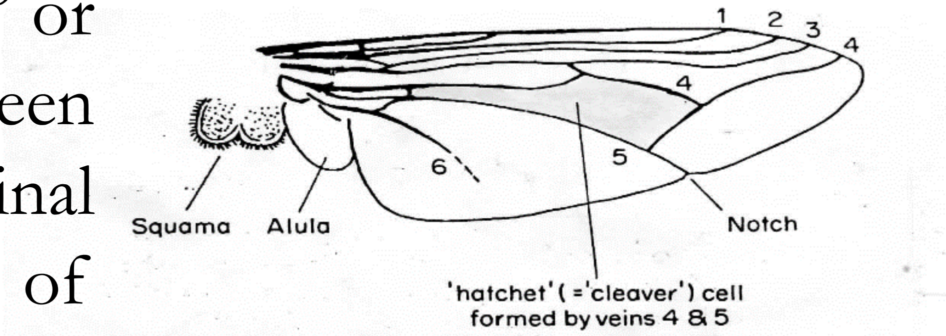


Antenna of Glossina showing the dorsal arista with branched hairs, which arises from the third antennal segment. In other flies the hairs of the arista are unbranched.



Characteristics

4. The presence of the 'hatchet' or 'cleaver' cell, enclosed between the fourth and fifth longitudinal wing veins is diagnostic of *Glossina*.

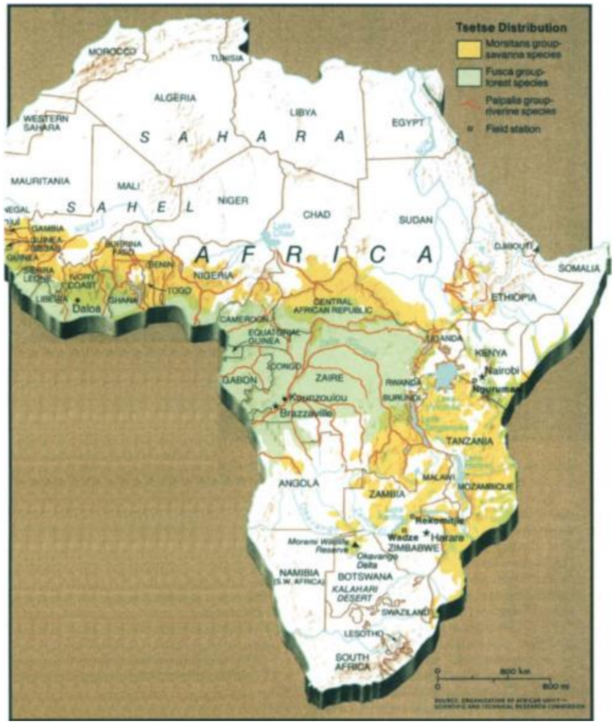


5. The wings are folded, scissors-like over the back of the resting fly.

Characteristics

- The genus *Glossina* is usually divided into three species groups based on a combination of ecological requirements, distributional, behavioral, molecular and morphological characteristics of the species.

  1. Fusca group
  2. Palpalis group
  3. Morsitans group



Fusca group

- *G. fusca, G. tabaniformis, G. medicorum, G. longipennis* and *G. brevipalpis* are members of the fusca group.
- Flies of the group include important vectors of trypanosomes (especially species of the *Trypanosoma vivax* group and *T. congolense* group) pathogenic to livestock.
- The flies of the fusca group are associated with dense, humid, tropical forests or forest edges that overlay most of the western and central African distribution of the palpalis group.
- They have never been associated with transmission of trypanosomiasis to man.

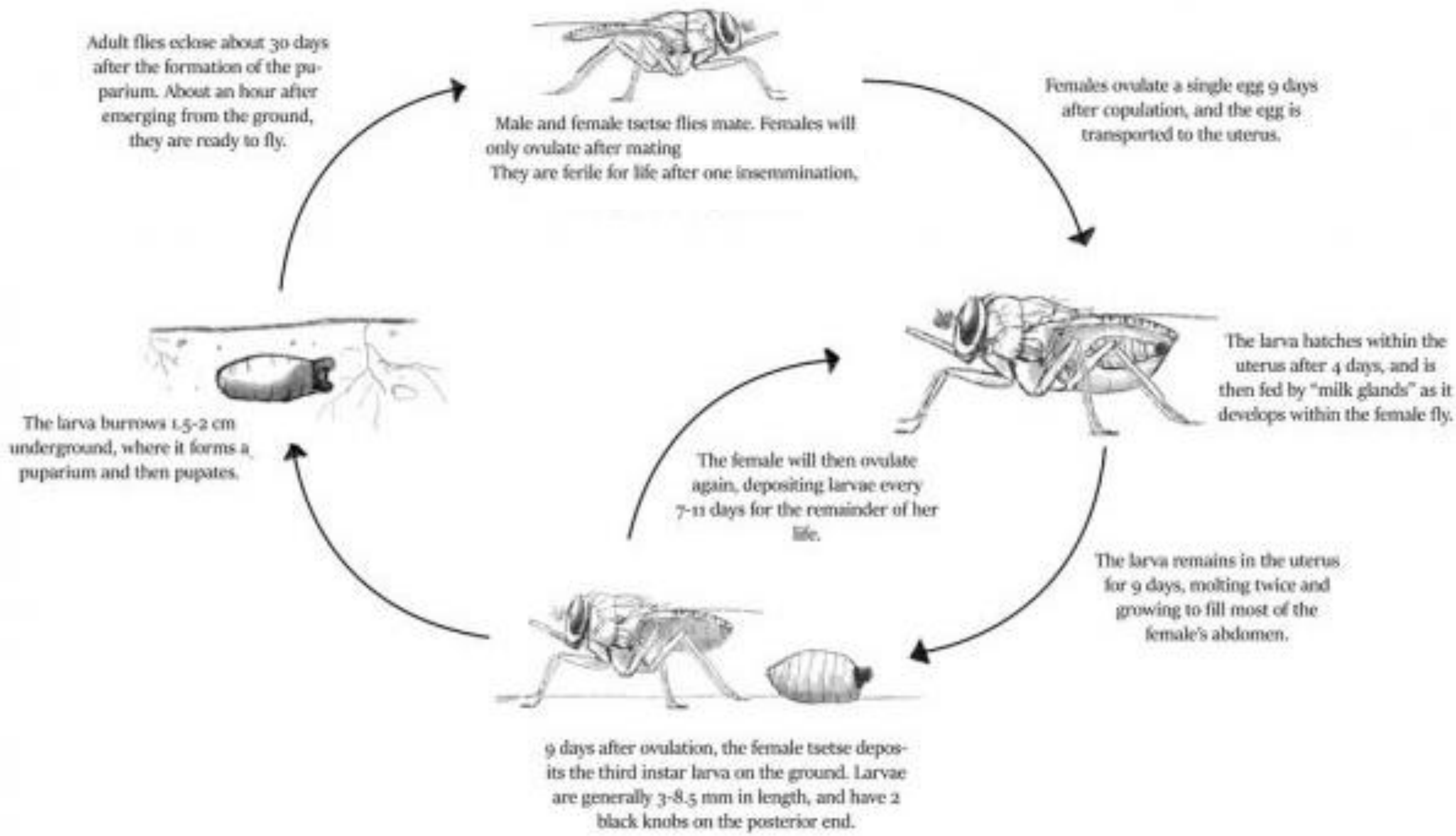
Palpalis group

- The palpalis group is found mostly in West Africa and the Congo basin. Members include *G. palpalis palpalis and G. palpalis gambiense, G. tachinoides, G. fuscipes.*
- The palpalis group are basically dependent on dense river line or lacustrine (associated with lake) vegetation.
- Species of these groups are active only during daylight hours and hunt their prey partly by sight; scent however becomes important at close range.
- *Trypanosoma brucei gambiense* is transmitted mostly by this tsetse fly species.
- Humans are the major host, although domestic animals such as pigs may also be a reservoir.

Morsitan group

- The Morsitan group (Eastern & Central Africa) are the least hygrophylic and occupy vast areas of bush land and thicket vegetation, often far from rivers and lakes – that is open forest land where mammalian game is plentiful.
- Morsitans group tsetse flies are thus mainly responsible for the transmission of *T. congolense* and *T. vivax*.
- Egs include *G. morsitans*, *G. pallidipes*, *G. longipalpis*, *G. swynnertoni*, and *G. austeni*
- Species of these groups are active only during daylight hours and hunt their prey partly by sight; scent however becomes important at close range.

Life Cycle of Tsetsefly



Life Cycle

- The tsetsefly has viviparous reproduction.
- During favourable conditions a female produces 20 larvae at intervals of about 11 days.
- The female tsetse mate just once and after 7 - 9 days she produces a single egg which develops and nourishes into a larva within her uterus. The female rears one larva at a time to the third instar larva.
- About 9-11 days later, the mother produces a larva which burrows into the ground where it pupates. The newly deposited larva then burrows into the soil to a depth of a few millimetres, using peristaltic movements.

Life Cycle

- Having reached a point below the surface where conditions are suitable, it becomes immobile and begins to pupariate (pupate) still within the third larval skin.
- The skin darkens and hardens.
- During emergence from the puparium, it uses a structure known as ptilinum. This is an eversible bladder extruded from the front of the head during the first few days of adult life; this bladder can still be everted while the body is still soft and soapy in texture.
- Flies in this stage, so far are referred to as teneral flies. Older flies are non-teneral flies – in which the head and the body are hardened and ptilinum can no longer be everted.

Life Cycle

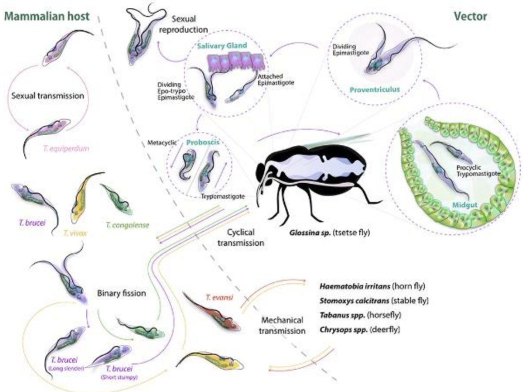
- The adult fly emerges from the pupa in the ground after about 30 days.
- After the quiescent/dormancy period, the young teneral flies seek for their first blood meal. Flies normally feed at intervals of three to four days. They die of starvation if deprived of blood meal for 10-12 days.
- Over a period of 12-14 days it matures, mates and, if it is a female, deposits its first larva.
- The average life span of female *Glossina* is 2-3 months: exceptionally for 6-7 months. Male tsetse fly adults may live two to three weeks.

Trypanosomes

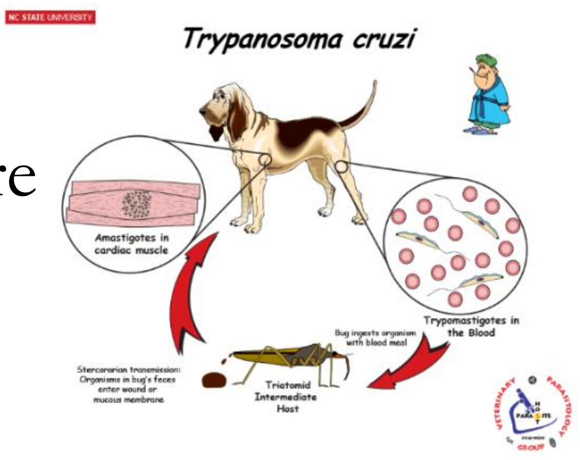
- **Salivarian trypanosomes (African trypanosomiasis)**
  - **Sleeping sickness**
    - **West African (Gambian)**
    - **East African (Rhodesian)**
- **Stercorarian Trypanosomes (South american trypanosomiasis)**
  - **Chag's disease**

Trypanosomes

Two major patterns are related to whether the trypanosome is belongs to the salivarian or stercorarian subgroups

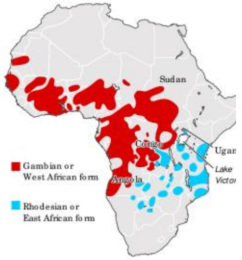


- The Salivaria are those trypanosomes that transmit from the "anterior station" of the insect host; i.e. they are in the saliva and are inoculated into the host during feeding.



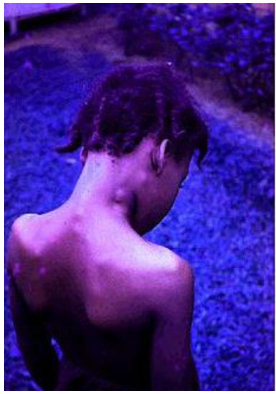
- The Stercoraria transmit from the "posterior station"; i.e. infective stages are passed in the feces of the insect during feeding.

African Trypanosomiasis



- Trypanosomiases are diseases of humans and livestock

- Sleeping sickness occurs in 36 sub-Saharan African countries.
- Rural populations living in regions where transmission occurs and which depend on agriculture, fishing, animal husbandry or hunting are the most exposed to the tsetse fly and therefore to the disease.



- Without treatment, the disease is considered fatal.
- The parasites concerned are protozoa belonging to the Genus *Trypanosoma*.
- They are mainly found in vegetation by rivers and lakes and in gallery-forests.

Forms of Human African Trypanosomiasis

West Africa Form

- *Trypanosoma brucei gambiense*

East Africa Form

- *Trypanosoma brucei rhodesiense*

Mode of Transmission

- Humans are reservoir for *T.b. gambiense*, whereas *T.b. rhodesiense* has reservoirs in both humans and domestic animals-(especially cattle), wild animals e.g antelopes.
- Riverine species of *Glossina palpalis*, *G. tachinoides* and *G. fascipes* transmit *T.b. gambiense;* whereas woodland species of *G. morsitans*, *G. pallidipes* and *G. swynnertorni* transmit *T.b. rhodesiense.*
- The tsetse fly does not become infective until 20-40 days after sucking infected blood meal.
- The fly is infectious throughout its lifetime.
- Tsetse transmit trypanosomes in two ways, mechanical and biological transmission.

Mechanical Transmission

- Mechanical transmission involves the direct transmission of the same individual trypanosomes taken from an infected host into an uninfected host.
- Mechanical transmission requires that tsetse feed on an infected host and acquire trypanosomes in the blood meal, and then, within a relatively short period, for tsetse to feed on an uninfected host and regurgitate some of the infected blood from the first blood meal into the tissue of the uninfected host. This type of transmission occurs most frequently when tsetse are interrupted during a bloodmeal and attempt to satiate themselves with another meal.

Mechanical Transmission

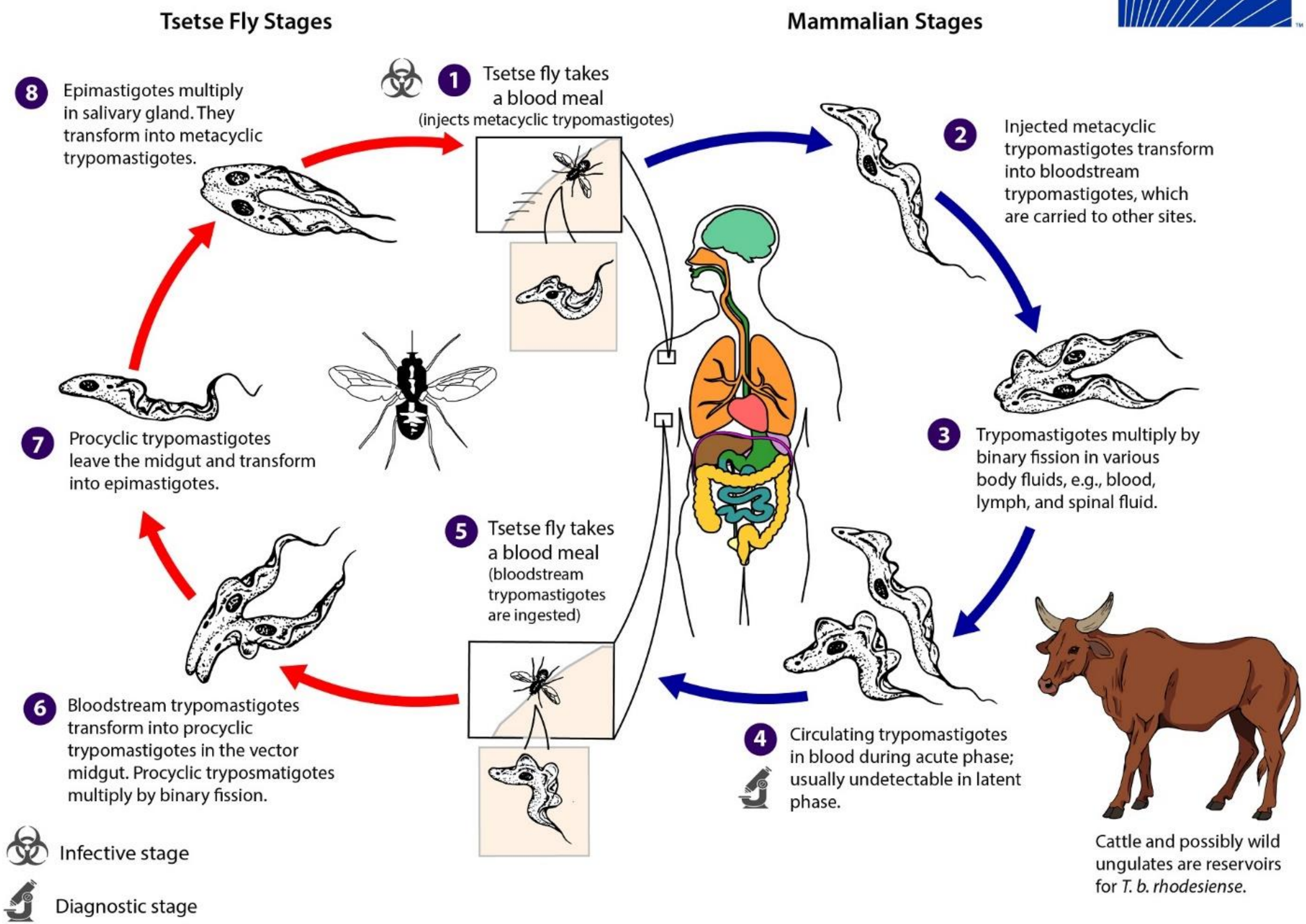
- Other flies, such as horse-flies(family Tabanidae) carry infective Trypanosomes on the proboscis where the organisms are capable of remaining alive for up to 24hrs.
- This can be transmitted to man during feeding.

Biological Transmission

- Biological transmission requires a period of incubation of the trypanosomes within the tsetse host.
- The term biological is used because trypanosomes must reproduce through several generations inside the tsetse host during the period of incubation, which requires extreme adaptation of the trypanosomes to their tsetse host.
- In this mode of transmission, trypanosomes reproduce through several generations, changing in morphology at certain periods.
- Trypanosomes are not passed between a pregnant tsetse and her offspring so all newly emerged tsetse adults are free of infection.

African Trypanosomiasis

Trypanosoma brucei gambiense & Trypanosoma brucei rhodesiense



Cycle of Transmission

In Human

- These trypanosomes, depending on the species, may move to a different part of the digestive tract, or migrate through the tsetse body into the salivary glands.
- When an infected tsetse bites a susceptible host, the fly may regurgitate part of a previous blood meal that contains trypanosomes, or may inject trypanosomes in its saliva.
- It is believed the inoculation must contain a minimum of 300 to 450 individual trypanosomes to be successful, and may contain up to 40,000 individuals.

Cycle of Transmission

In Humans

- A firm tender red nodule is formed at the site of inoculation, within a few days. At the site of inoculation in man, trypomastigote undergoes longitudinal division.
- They make their way, first into the lymphatic system, then into the bloodstream.
- In the blood stream, they differentiate into the blood stream forms and multiply to form trypomastigote and eventually into organs such as the brain and tissues (such as the muscle tissue) and throughout the body, including lymph and spinal fluid.

Cycle of Transmission

In Humans

- The disease causes the swelling of the lymph glands, and eventually leads to death.
- Uninfected tsetse may bite the infected animal/human prior to its death and acquire the disease, thereby closing the transmission cycle.

Cycle of Transmission

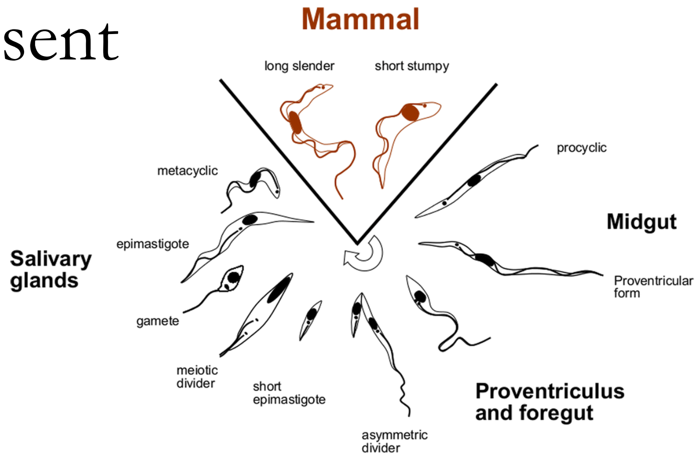
In Tsetsefly

- The 3 week life-cycle in the tsetse fly begins with the ingestion of trypomastigote in the blood meal from the reservoir host.
- They multiply in the insect's gut and form the procyclic stage and then migrate to the salivary glands.
- Here they are transformed into epimastigote.
- They multiply further and form metacyclic trypomastigotes, which are transmitted by the tsetse fly bite. The metacyclic trypomastigote in the saliva is injected into vertebrate skin when the fly feeds.

Polymorphism in Trypanosomes

- Development of *T. b gambiense* and *T.b. rhodesiense* is characterized by the occurrence of 3 main types of blood form:

  1. slender forms-long, thin and have free flagellum
  2. stumpy blood stream form-thick and short with no flagellum; a short one may be present
  3. intermediate forms: long , with moderately thick body and free flagellum of medium length.



Trypanosoma brucei gambiense (T.b.g.)

- It has a slower onset, found in West and Central Africa.
- This form represents more than 95% of reported cases of sleeping sickness and causes a chronic infection.
- A person can be infected for months or even years without major signs or symptoms of the disease.

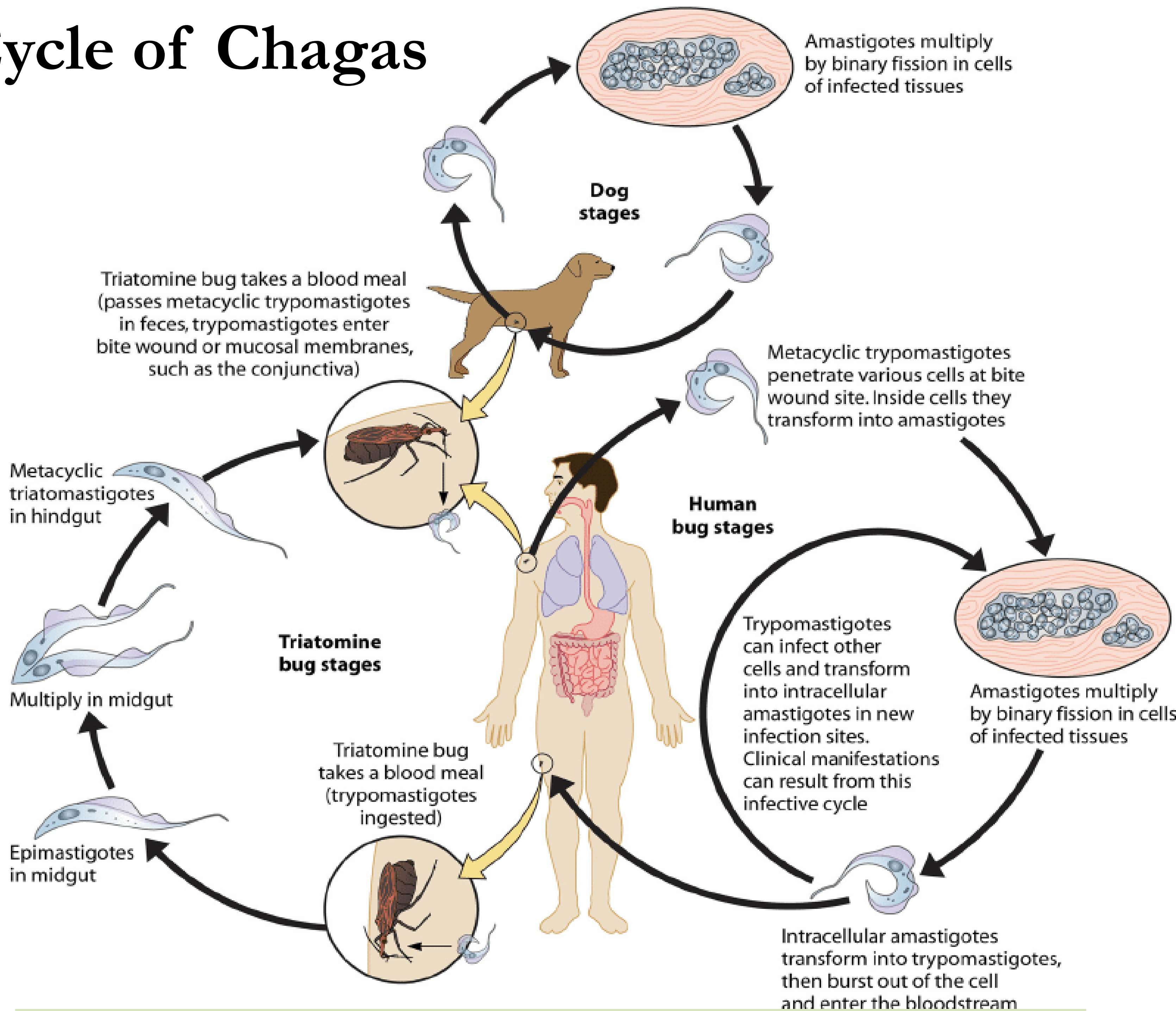
Trypanosoma brucei rhodesiense (T.b.r.)

- It refers to strains with a more rapid, virulent onset found in Eastern and Southern Africa.
- This form represents less than 10% of reported cases and causes an acute infection.
- First signs and symptoms are observed after a few months or weeks.
- The disease develops rapidly and invades the central nervous system.

Other Forms of Trypanosomiasis

- Occurs in 15 Central and South American countries but are not transmitted by tsetse fly.
- The most notable is American Trypanosomiasis known as Chagas disease which occurs in South America, caused by *Trypanosoma cruzi*, and transmitted by contact with faeces/urine of infected blood-sucking triatomine bugs/ kissing bug of Reduviidae.

Life Cycle of Chagas

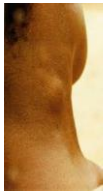


Animal Trypanosomiasis

- Animals can host the human pathogen parasites, especially *T.b. rhodesiense*. *T. brucei* multiplies in the blood of a range of animals including domestic animals and wild game as well humans.
- Domestic and wild animals are an important parasite reservoir.
- Examples of domestic animals that serve as reservoir are cattle, sheep, dogs, pigs, and goats and wild game – bushbuck (*Tragelaphus scriptus*).

Animal Trypanosomiasis

- When it occurs in bovine cattle or horses is called **Nagana-** *Trypanosoma congolense* and *Trypanosoma vivax*
- It is known as **Sura** when it occurs in domestic pigs- *Trypanosoma simiae*
- These diseases reduce the growth rate, milk productivity, and strength of farm animals, generally leading to eventual death of the infected animals.
- Certain species of cattle are called trypanotolerant because they can survive and grow even when infected with trypanosomes although they also have lower productivity rates when infected.



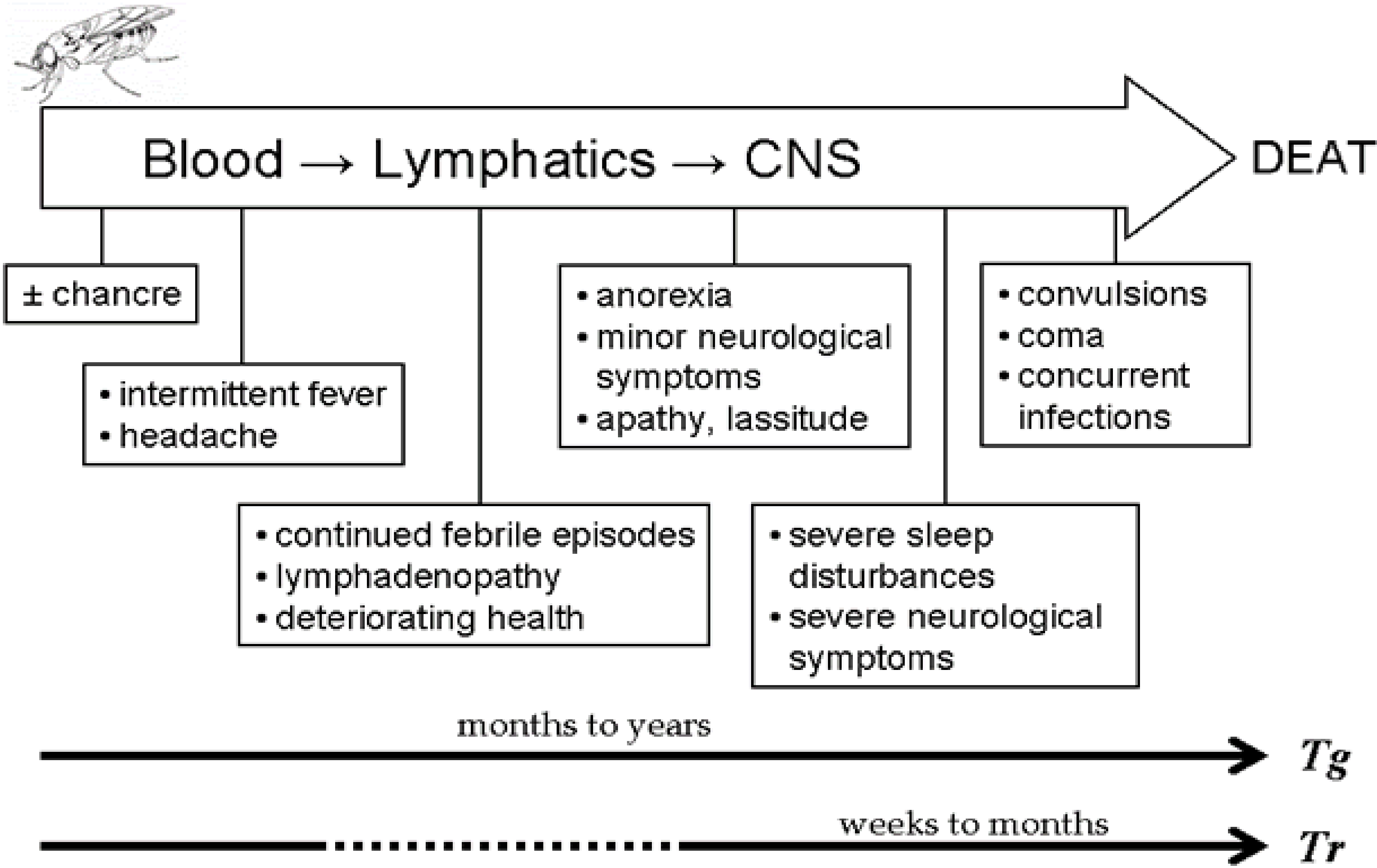
Clinical Symptoms

- Symptoms of East and West African trypanosomiasis are similar.
- Both forms begin with relatively minor signs, but they become increasingly severe if the infection persists and progresses throughout the body.
- The first sign of the disease is a painful sore from a tsetse fly bite that becomes red and otherwise visibly infected after 1-2 weeks. Followed by fever, severe headache, rash, irritability, general swelling around the eye and hands, extreme fatigue, swollen lymph nodes (especially at the back of the neck), aching muscles and joints, mood changes and weight loss occurs as the illness progress.

Symptoms

- If left untreated, the parasite infects central nervous system.
- Indeed, confusion, slurred speech, inability to concentrate, difficulty walking and talking, and seizures may occur in late stages of infection.
- Patients with advanced African trypanosomiasis often sleep during the day, while suffering insomnia at night.

Progression of Trypanosomiasis



Treatment

The type of treatment depends on the stage of the disease:

Stage	*T.b. gambiense*	*T.b. rhodesiense*
First stage	**Pentamidine** 4 mg/kg i.m. at 24 hourly intervals for 7 days i.m. (or as i.v. short infusion)	**Suramin** Test dose of 200 mg i.v. 20 mg/kg day 1, 3, 7, 14 and 21 [10]
Second stage	**Eflornithine** Intravenous eflornithine (100 mg/kg every 6 h) for 14 days Eflornithine/Nifurtimox combination Intravenous eflornithine (200 mg/kg every 12 h) for 7 days and oral nifurtimox (15 mg/kg per day, every 8 h) for 10 days **Melarsoprol** 2.2 mg/kg i.v 10 daily doses	**Melarsoprol** 2.2 mg/kg i.v 10 daily doses Pre-treatment with suramin Test dose of 4–5 mg kg^{-1} body weight at day 1

PEST CONTROL

ENTOMOLOGY II

BIOL 356

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Department: Theoretical and Applied Biology
College: Science


PEST
CONTROL

What is a Pest

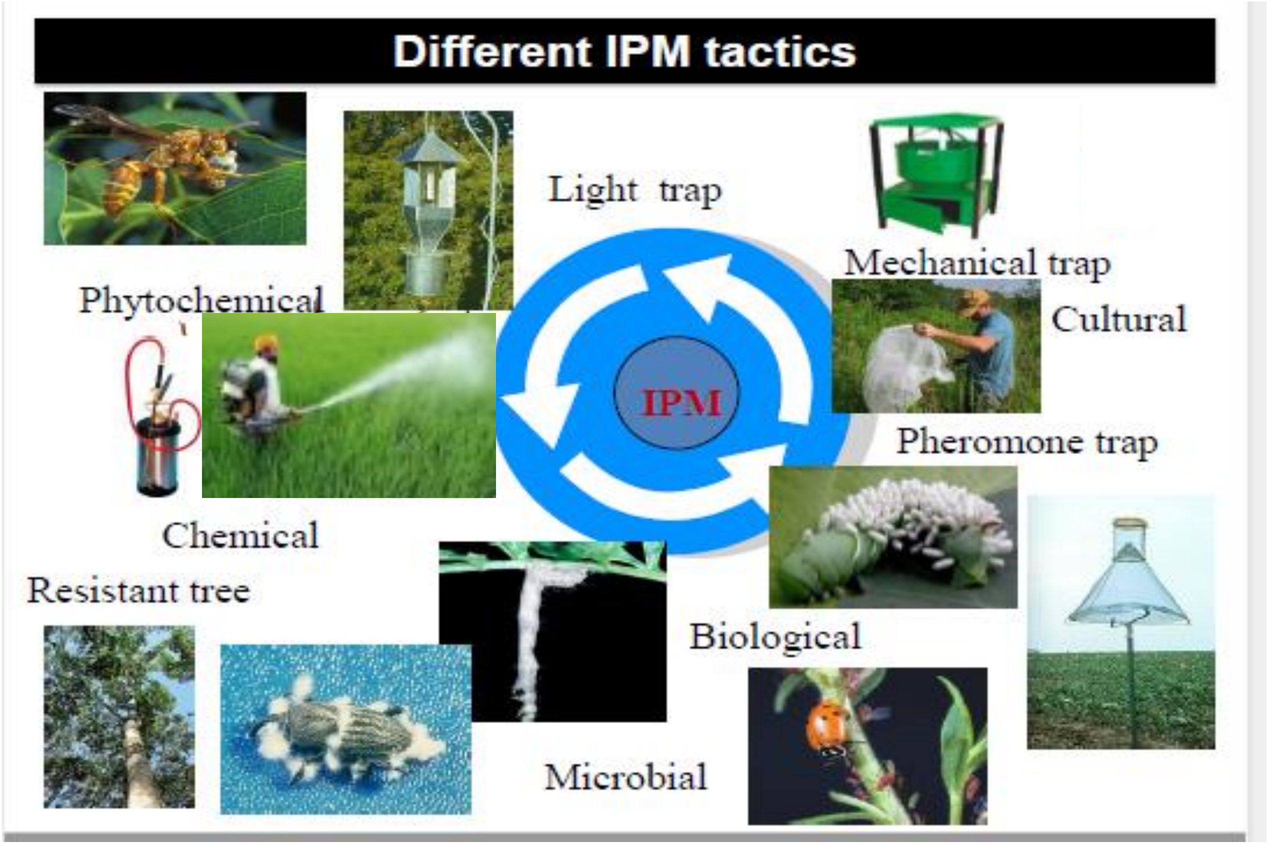
- A pest is anything that:
  - Competes with humans, animals, or desirable plants for their living conditions.
  - Injures humans, animals, desirable plants, structures, or possessions.
  - Spreads disease to humans, domestic animals, wildlife, or desirable plants.
  - Annoys or are a nuisance to humans or domestic animals.

Pest Control

- Various methods are available for the control of different pest infestations.
- These methods vary in their levels of sophistication and different pest situations may demand different control methods.

Integrated Pest Management (IPM)

What is Integrated Pest Management (IPM)?



Integrated pest management is a pest control system which utilizes all suitable control methods in combination either to reduce pest populations and/or maintain them at levels below those causing economic injury.

Goal of IPM

- The goal of an IPM system is to manage pests effectively as well as the environment to balance benefits of control costs, public health and environmental quality.
- IPM takes advantage of all appropriate pest management options.

The IPM System

- IPM is a combined and continuous system of controlling pests (weeds, insects and others) in which pests are identified, action thresholds are considered, all possible control options are evaluated and selected control(s) are implemented.
- Control options which include biological, chemical, cultural, genetic and mechanical methods are used to prevent or remedy unacceptable pest activity or damage.
- Choice of control option(s) is based on effectiveness, environmental impact, site characteristics, worker/public health and safety, and economic importantance.

The IPM System

- IPM systems rely on accurate determination of optimum control, timing and selection of appropriate method(s). Implementation requires current comprehensive information on pests and control options.
- The specific techniques used for integrated pest management vary with each situation, but there are fundamental principles that define IPM.

Fundamental Principles of IPM

- Monitor the site for presence of pests and natural controls. Use standardized, tested monitoring methods rather than basing decisions on haphazard observation.
- Identify the pest(s) that are the source of the problem and the level of infestation. Correct pest identification is required to identify optimum solutions. This monitoring and identification removes the possibility that pesticides will be used when they are not really needed or that the wrong kind of pesticide will be used.
- Understand the biology and economics of the pest and the system in which the pest exists. Learning the biology of the pest tells you how fast it reproduces, where it likes to live, what it likes to eat, and special things it can do.

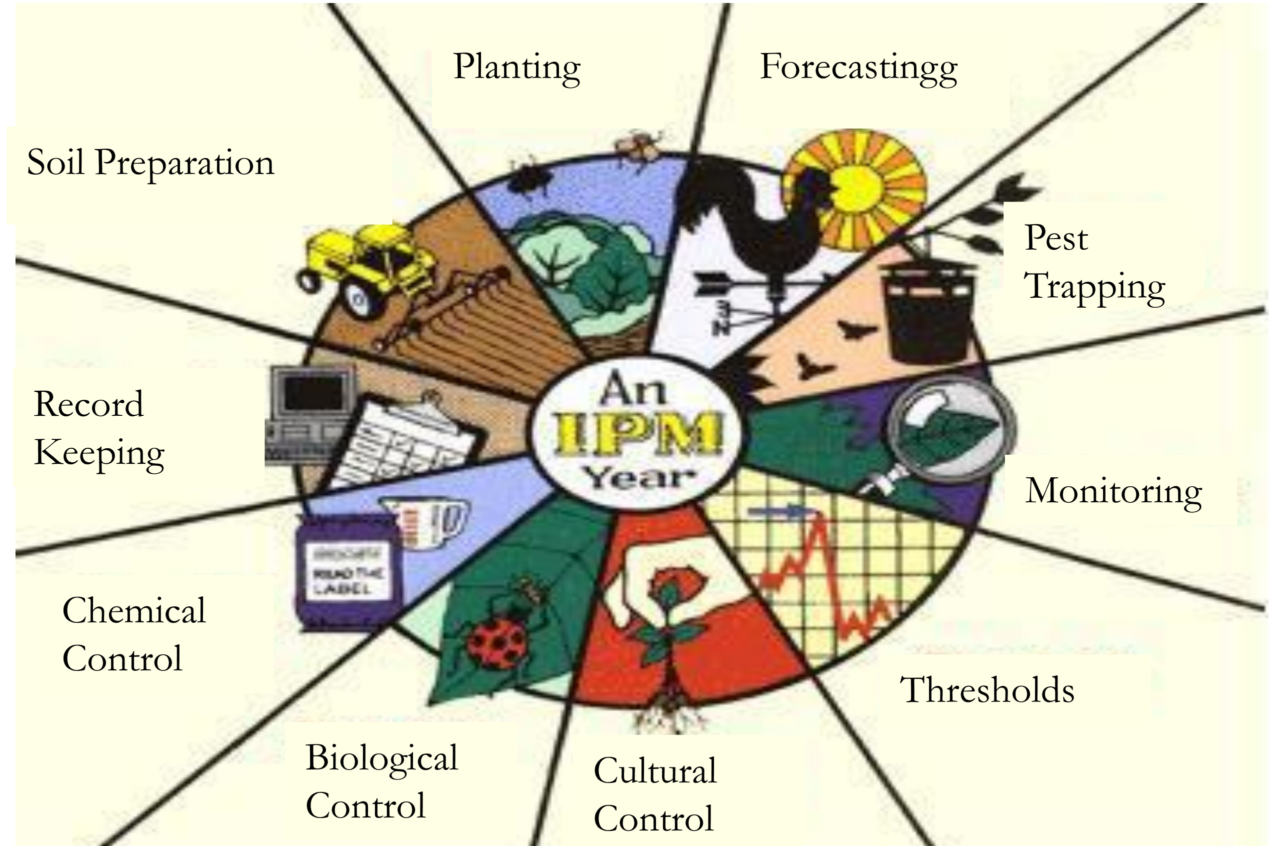
Fundamental Principles of IPM.

- You will use this information to choose the best ways to manage the pest.
- Set Action thresholds below which the pest can be tolerated. An Action threshold is a point at which pest populations or environmental conditions indicate that pest control action must be taken. Action thresholds are determined by factors such as severity of the problem caused by the pest, health or property concerns related to the pest, and user needs for the site where the pest is found. Actions are taken only when the potential damage is sufficient to justify action.
- The selected control method(s) of protection must balance considerations of safety, and potential hazards to property and the environment.

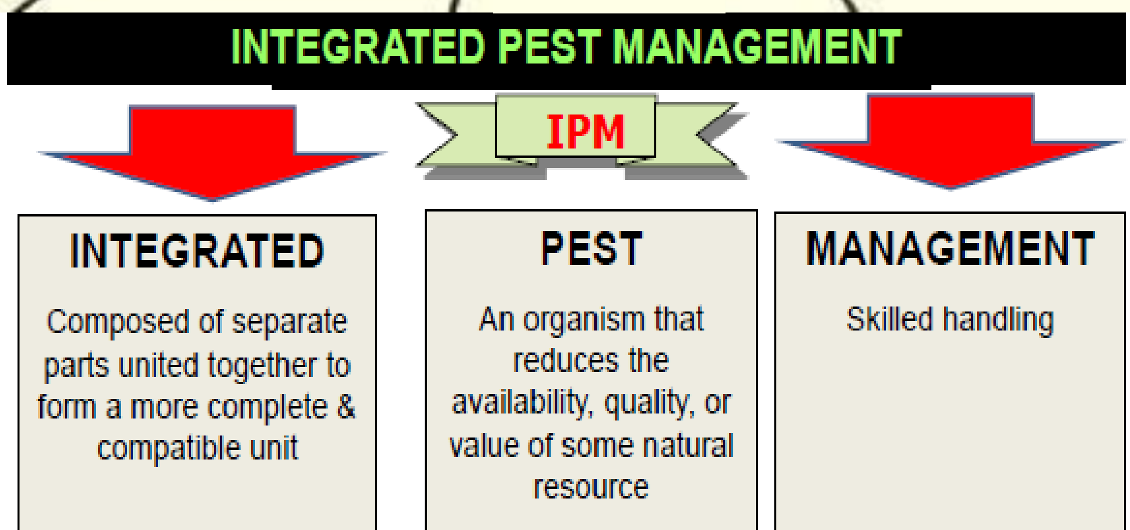
Fundamental Principles of IPM.

- Evaluate the pest management program and improve it when possible.
- This requires keeping records and reviewing them on a regular basis.

STEPS



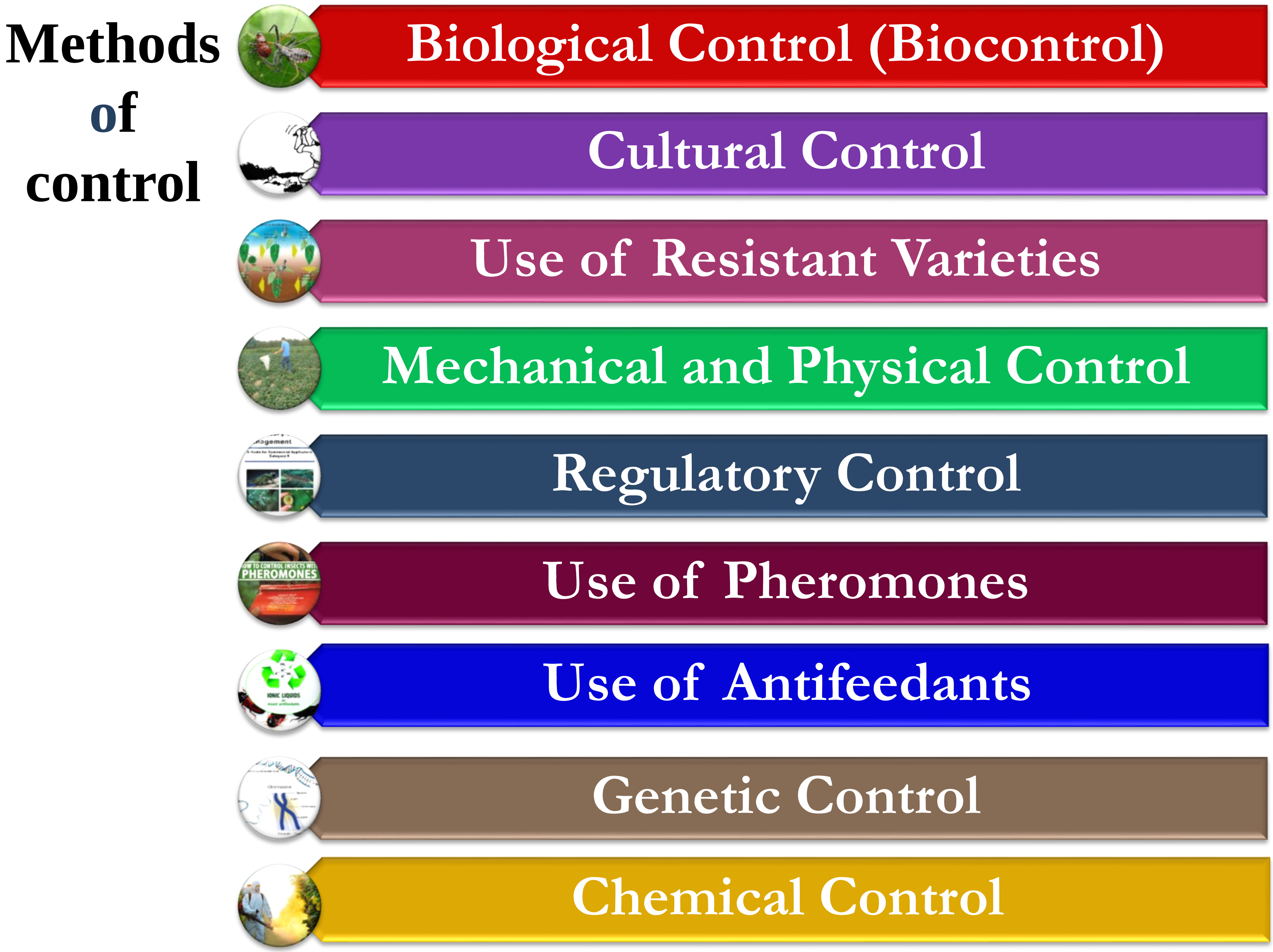
Planting
Forecastingg
Soil Preparation
Pest Trapping
An IPM Year
Record Keeping
Monitoring
Chemical Control
Thresholds
Biological Control
Cultural Control



INTEGRATED PEST MANAGEMENT
IPM
INTEGRATED
Composed of separate parts united together to form a more complete & compatible unit
PEST
An organism that reduces the availability, quality, or value of some natural resource
MANAGEMENT
Skilled handling

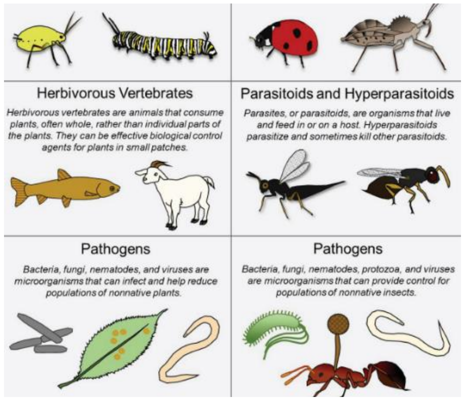
Advantages of Integrated Pest Management

- Promotes sustainable bio-based pest management alternatives.
- Reduces environmental risk associated with pest management by encouraging the adoption of more ecologically benign control tactics.
- Reduces the potential for air and ground water contamination


Methods of control
Biological Control (Biocontrol)
Cultural Control
Use of Resistant Varieties
Mechanical and Physical Control
Regulatory Control
Use of Pheromones
Use of Antifeedants
Genetic Control
Chemical Control

Biological Control (Biocontrol)

- Biological control refers to the deliberate introduction of predators, parasites and pathogens designed to reduce the pest population to a level at which it is no longer considered a pest.
- Insect pathogens such as viruses, fungi, bacteria, protozoa and nematodes.



- Predators - free-living animals that eat other animals. Some vertebrate predators have also been used, e.g. *Gambusia* have been used against mosquito larvae.

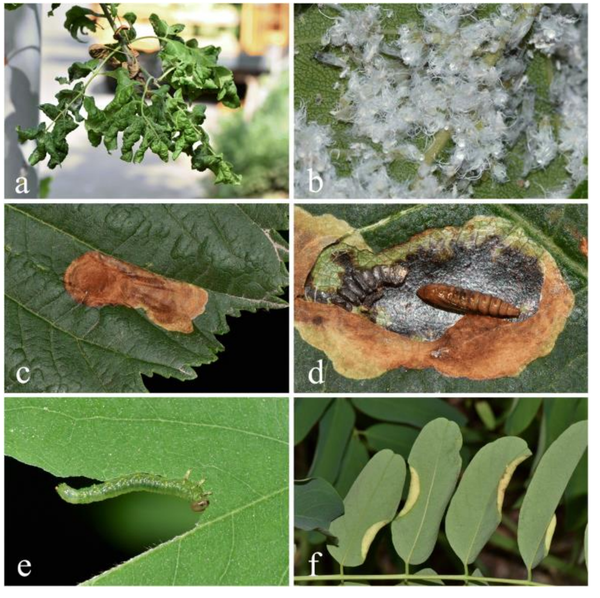
Biological Control Agents

- Biological Control Agents may be classified as follows:
- Entomophagous insects
  - Entomophagous insects are insects that consume other insects.

  - There are two main types:
    - Predators that prey on insects
    - Parasitoids that lay their eggs and develop in or on other insects.

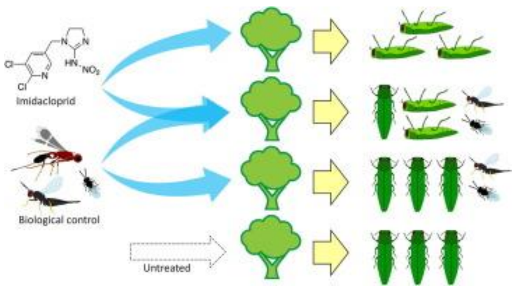
Biological Control Agents

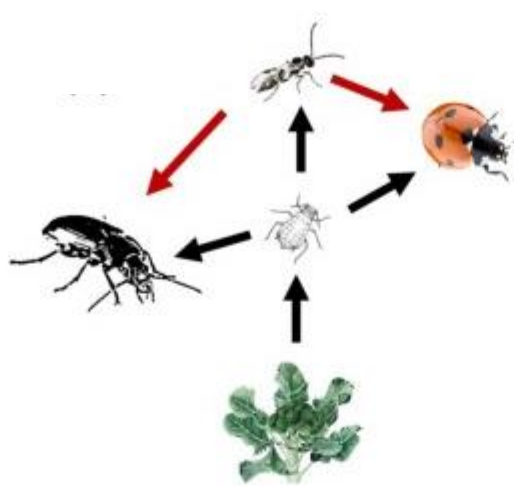
- Phytophagous insects
  - Phytophagous insects are generally considered to be those that feed on green plants. They include species that attack roots, stems, leaves, flowers, and fruits, either as larvae or as adults or in both stages.

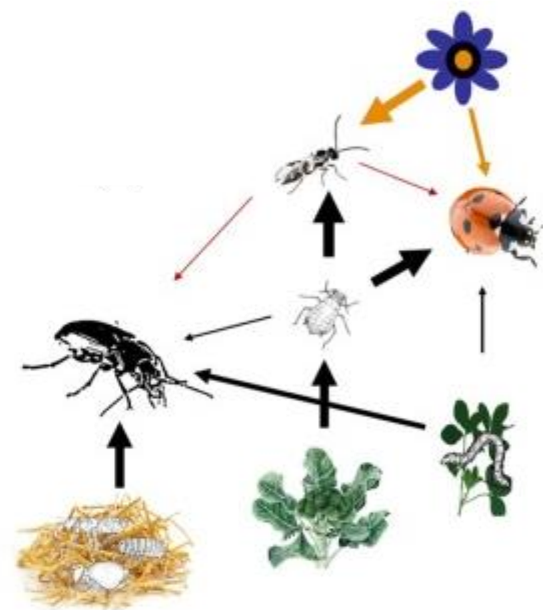


Techniques of Biological Control

- Classical biological control
- Augmentation biological control
- Conservation of natural enemy







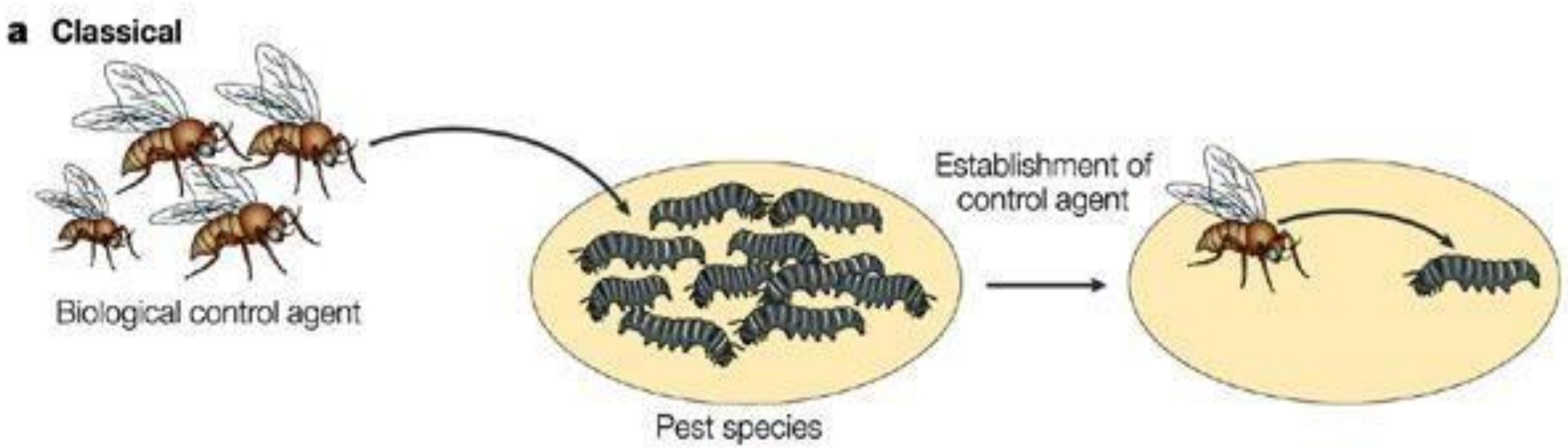
Classical Biological Control

- Classical biological control is the introduction of natural enemies to a new locality where they did not originate or do not occur naturally. It involves the introduction of suitable natural enemies of a pest.
- The idea is to lower permanently the equilibrium position of the pest to a non-economic level.
- Beneficial species released in sufficient number will successfully colonize and become an integral part of the ecosystem.
- This technique has yielded by far the best results and has been largely directed against exotic insect pests.

Classical Biological Control- Importation

Eg : Cottony cushion scale in California –

The introduction of the vedalia beetle, *Rodolia cardinali*, from Australia into California to control the cottony cushion scale, *Icerya purchasi* on citrus.

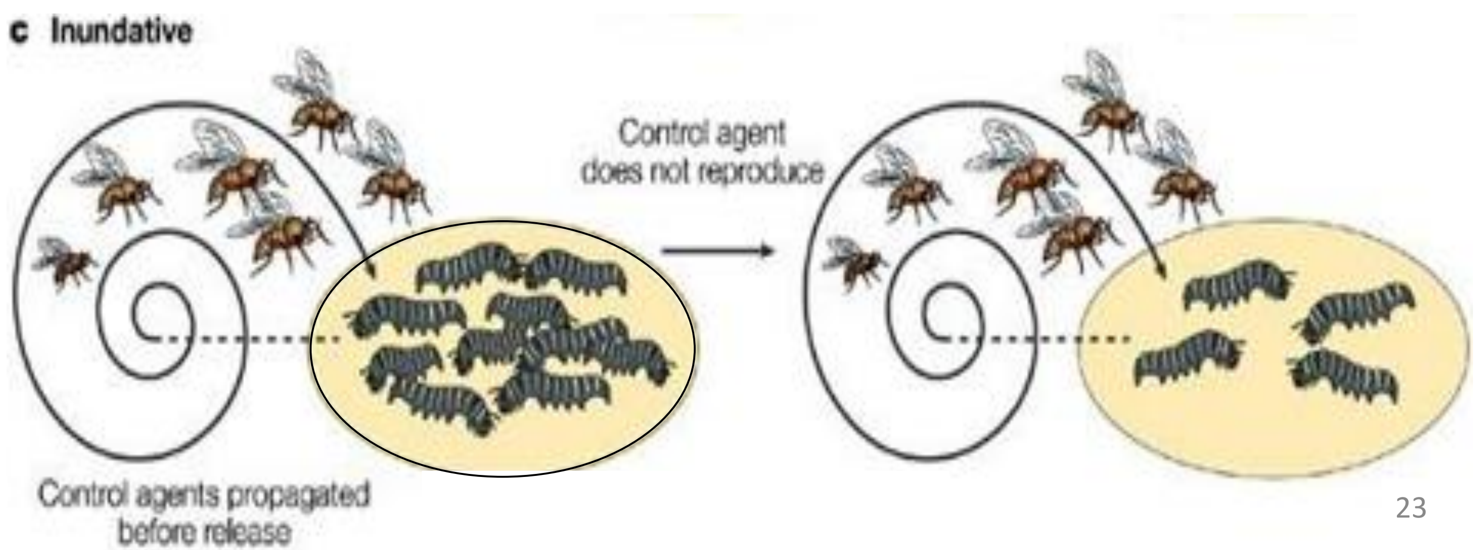


Augmentation - Inoculation

- The repeated release of relatively small numbers of a natural enemy for the purpose of building-up a population over generations for the control of future generations of pests.
- This approach has been used particularly, though not exclusively, for the control of imported pests.
- It has proved especially useful on perennials and against sedentary pests. Sedentary pests are pests that tunnel into the roots and establishing permanent feeding sites from which they do not move. They may protrude from roots as they grow.

Augmentation - Inundation

- Inundation: Large numbers of the natural enemy are reared in the laboratory and released to effect immediate high mortality in the pest population.
- Inundative release anticipates only control of the population and generation on which it is applied, with no expectation of long-term regulation.



Conservation of Natural Enemy

- This involves creating situations favorable to colonization of crops by resident natural enemies.
- A variety of management activities can be used to optimize the survival and/or effectiveness of natural enemies.
- Conservation activities might include reducing or eliminating insecticide applications to avoid killing natural enemies, prolonging harvest dates in adjacent fields or rows to ensure a constant supply of hosts (prey) or providing shelter or alternative food sources to improve survival of beneficial species.

Advantages of Biological Control

- Biological control is cheap. If successful, biological control is a very economical method.
- In classical biological control the only cost incurred is the initial one. This cost is, however, repaid many times over by the resulting benefits.
- The technique is selective with no side effects.
- Biological control agents tend to be fairly prey-specific and do not carry the kind of environmental dangers associated with insecticides.

Advantages of Biological Control

- Biological control agents are self-propagating and self-perpetuating. Ideally, once introduced, biological control agents will persist in time, and may spread over large areas from the points of release and reach targets that chemicals cannot.
- The development of resistance of pests to biological control is unlikely.
- Might reduce pest population below the level that causes economic damage.

Disadvantages of Biological Control

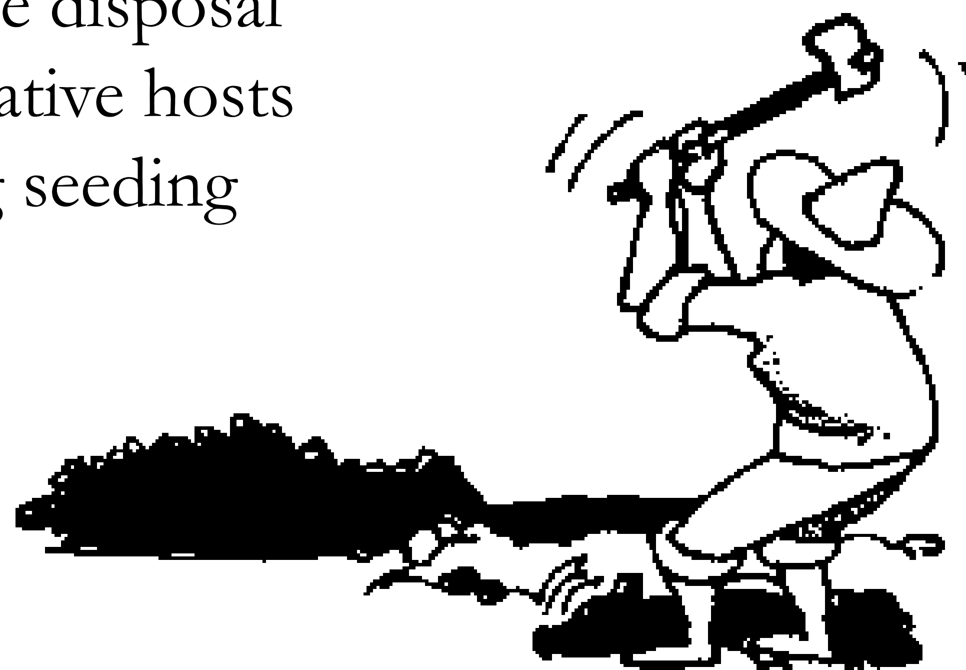
- Biological control acts slowly. It takes some time for biological control agents to spread from their point of release, to build up in numbers and to make their impact on the pest population.
- Biological control may be unpredictable: certainty of control is not always assured.
- In some cases, biological control can have unforeseen negative results that could outweigh all benefits. Example, when the mongoose was introduced to Hawaii in order to control the rat population, it predated on the endemic birds of Hawaii, especially their eggs, more often than it ate the rats.
- Biocontrol cannot meet the control of rapid growing weeds, particularly those competing with short-term crops. It is more suitable for perennial weeds (both terrestrial and aquatic).

Cultural Control

- Cultural control is the use of standard practices to reduce pest numbers or impact of their effects.
- Cultural practices can prevent an infection by altering;
  - the environment
  - the condition of the host
  - the behaviour of the pest.
- They disrupt the normal relationship between the pest and the host plant and make the pest less likely to survive, grow, or reproduce.

Cultural Control

- Common cultural practices include
  - Altering planting and harvesting dates
  - Crop rotation
  - Tillage operations that turn the soil and bury crop debris
  - Sanitation or residue disposal
  - Trap crops/ Alternative hosts
  - Cultivation; altering seeding rates/crop spacing



Planting Date (Time)

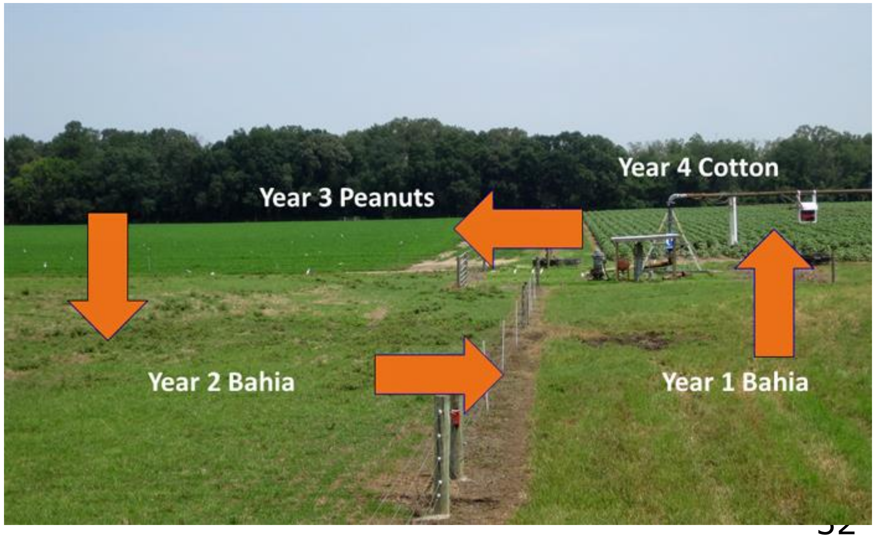
- Variation of sowing date can control pests, most of which show seasonal predictability, either by avoiding the egg-laying period of the pest or by allowing the plants to reach an age where they are resistant by the time the pest appears.

Time of Harvesting

- Prompt harvesting of maize and beans may prevent some crops from being infested by weevil (*Sitophilus zeamaise* and *Acanthoscelides obtectus* respectively).
- Both can infest the field crops from nearby storehouses.

Crop Rotation

- This method prevents continuous breeding of pests and therefore prevents build-up of pest populations and may hold them below numbers that will cause economic damage.
- Pests that are reduced in numbers effectively by rotation usually have a long life cycle, a limited host range and are relatively immobile in some stages of their development.
- Changing crops in a rotation system isolates such pests from their food supply.
- It is perhaps most useful in preventing build-up of soil pests such as plant parasitic nematodes.



Soil Tillage

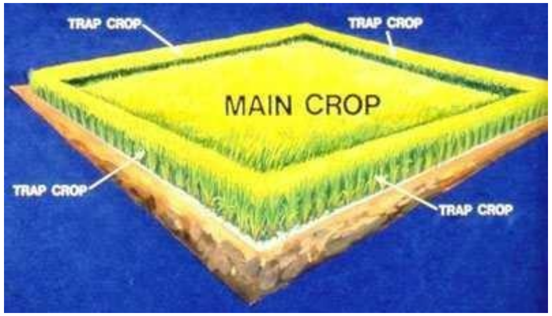
- Many insects live or hibernate in suitable temperature and humidity conditions relatively near the soil surface.
- These conditions can be distributed by ploughing, which creates temporary drought conditions in the upper soil layers.

Residue Disposal/Sanitation

- Farm hygiene often has a pest control purpose: Such as, the destruction of crop residues which removes residual pest populations (e.g. stem-boring larvae in maize) and elimination of plant debris on the soil surface in which many pests (e.g. flea beetles and whiteflies of brassicas) find shelter for hibernation.
- In South Africa removal of fallen oranges depletes the larval pool of the African false codling moth *Cryptophlebia leucotreta* making it easier for the parasitic natural enemy, *Trichogrammatoidea lutea*, to contain the remaining moth populations.

Trap Crops/ Alternative Hosts

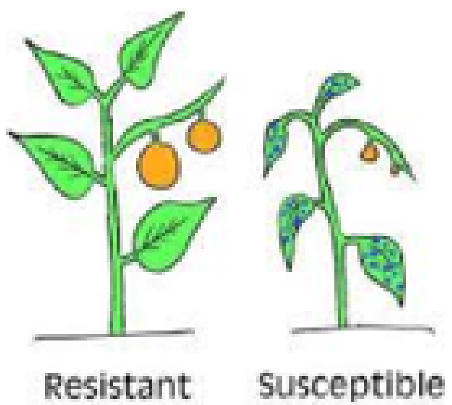
- Small plantings of a susceptible or preferred crop may be established near a major crop to act as a "trap".
- After the pest insect has been attracted to the trap crop, it is usually treated with insecticides e.g. in Uganda it has been shown that *Cissus* sp. is a very attractive trap plant for several crops.



- Many crop pests may develop on plants other than the crops.
- The destruction of these alternative host plants will also reduce the numbers of the pests concerned.

Use of Resistant Varieties

- Plant resistance represents the inherent ability of a crop variety to restrict, retard or overcome pest infestations.
- The resistant varieties of plants are less damaged or less infested by the pest than other varieties in the field under comparable environmental conditions and stage of growth.
- Plant resistance is one of the most effective and reliable methods of pest control.
- Its usually involves no extra expense to the farmer.



Use of Resistant Varieties

- This method however cannot be used against weed pests.
- Plant resistance may consists of three major types:

(a)Non-preference (Antixenosis), (b)Antibiosis and (c)Tolerance.

Non-Preference

- The presence of hairs, thorns, etc, by a plant may discourage oviposition (egg-laying) and/or feeding by an insect.
- Physical characteristics of plants such as height, colour, odour (smell) and leaf size may influence the attraction of insects to plants. After the insect arrives on the plant, factors like hairiness, leaf age, succulence (freshness), leaf size and stem diameter may influence feeding and egg-laying.
- High silica content in plants has been shown to discourage feeding in insects as the silica abrades the mandibles of the insects.

Antibiosis

- The tendency of a plant to resist insect injury often by injuring or destroying the insect.
- Antibiosis in plants interferes with the insect's life history, causing reduced life-span, fecundity or size, growth, development rate or increased mortality.
- Some plants actually produce ecdysones that act as insect anti-hormones, interfering with juvenile hormone production and so preventing successful metamorphosis.

Tolerance

- Tolerance is the term used when the resistant plant is capable of supporting a population of insects without loss of vigor.
- Tolerance is usually shown towards specific pests only.
- The ability of tolerant plants to survive infestations for a longer period permits a longer exposure of the insects to their natural enemies.

Disadvantages of Plant Resistance

- This method usually requires a long period of time to breed, multiply and distribute, especially with tree crops.
- It is possible for resistance to break down. Biotypes of pests may evolve which can damage previously resistant crop varieties.

Mechanical and Physical Control

- Mechanical control is the reduction of pest populations by using devices which affect them physically or alter their physical environment.
- Physical and mechanical methods of pest control differ from cultural techniques in that they are applied directly to the pest. For example, tomato hornworms may be hand-picked directly from tomatoes.

Mechanical and Physical Control

- Temperature and humidity control – temperature and humidity variations are best used against pests of stored products, such as grain, where 3 – 4 hours at 52 – 55^{o}C in a high frequency kills most pests.
- On living grain, pest destruction is more difficult since the grain must not also be destroyed.

Regulatory Control

- The objective of regulatory control is to prevent the entry and establishment of new pests in a country or area and to destroy or prevent further spread of those already present.
- Quarantine stations are established by law at a country's entry ports, and at times within the country, to inspect incoming plants, animals and commodities for the presence of new pests.
- If such pests are found, they are destroyed together with the commodity in which they are found.
- Laws are passed to prohibit the importation of plants and animals from countries or areas which are suspected to contain pests of quarantine significance

Use of Pheromones

- A pheromone is defined as a chemical or a mixture of chemicals that is released to the exterior by an organism and that causes one or more specific reactions in a receiving organism of the same species.
- Pheromones have particular advantages for pest control because they are usually highly species-specific, leave no undesirable residues in the environment and are effective in very minute quantities.
- Synthetic analogues of many major pests pheromones are now available and are often used to bait traps.
- The pheromones most used in pest control are the sex attractant pheromones usually produced by the female of the species.

Use of Antifeedants

- Antifeedants are defined as substances which when tasted, can induce cessation of feeding either temporarily or permanently, depending upon the potency.
- Antifeedants may not directly kill the pest; they prohibit feeding so that the pest starves to death.
- Substances which interfere with the feeding activity of a pest on the treated plant offer yet another novel approach to insect pest control.
- The use of antifeedants in pest control is not applicable to non-animal pests such as weeds and fungi.

Advantages and Disadvantages of Antifeedants

- Antifeedants have the advantage of not harming beneficial insects. They act only against insects which attack the crops, and even these are not necessarily killed.
- Antifeedants, however, have the disadvantage that only surface-feeding pests are affected; insects with piercing-sucking mouthparts are unaffected.

Genetic Control Methods

- Genetic control is a form of biological control of pest species which exploits the insect's mate-seeking expertise to introduce genetic abnormalities.
- Aim of genetic control strategies
  - population suppression; aiming at lowering the densities of natural target populations or eliminating them entirely.
  - population replacement; aiming at replacing natural pests with less damaging individuals.

Genetic Control Methods

- These methods may be discussed under the following:
  - Radiation sterilization release method: When ionizing radiation is used in sterilizing male pests so that mating with normal female will result in no progeny.

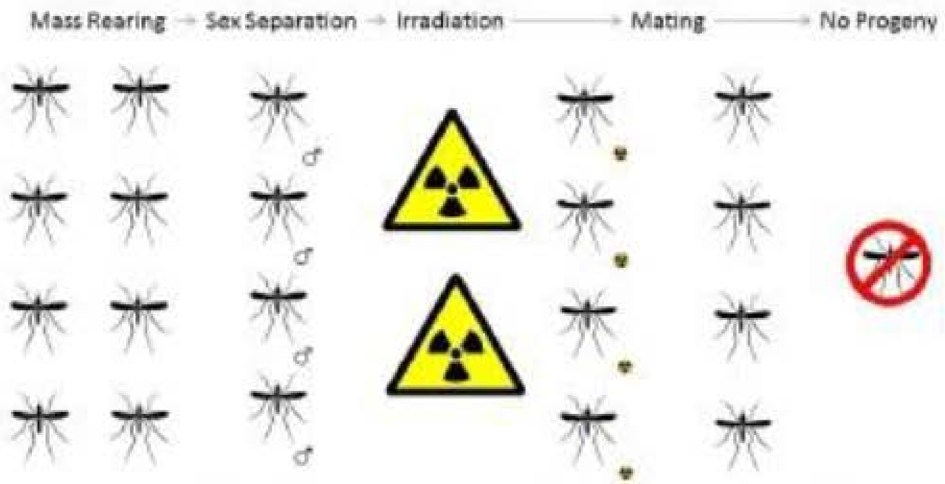
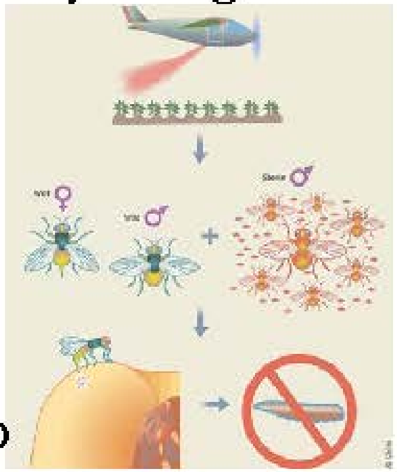


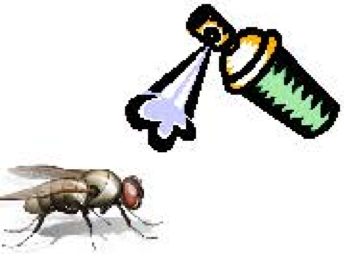
Fig. 1 - Conventional SIT schedule: mass rearing of mosquitoes followed by manual sex separation to assure that exclusively males are to be sterilized by ionizing radiation and further released to mate with wild females resulting in no progeny. This procedure must be repeated each and every time.

Genetic Control Methods

- Chemosterilants: any chemical compound used to control economically destructive or disease-causing pests by causing temporary or permanent sterility of one or both of the sexes or preventing maturation of the young to a sexually functional adult stage.

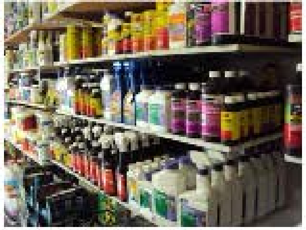


- Hybrid sterility- There is production of fertile females but sterile males among progeny or vice versa.
- Cytoplasmic incompatibility: Sterility is due to a cytoplasmic factor transmitted through the egg, which kills the sperm of male after its entry into the egg.



Chemical Control

- Chemical control involves the use of chemical insecticides to reduce pest population or to prevent pest injury.
- The chemicals used may poison the pest or repel them from specified areas.
- It is the best known and most commonly used pest control method.



Chemical Control
Types and Modes of Action

- Organochlorine and Pyrethroids:
  Most act on neurons preventing normal transmission of nerve impulses.
- Organophosphate and Carbamates:
  Cause acetylcholinesterase (AChE) inhibition leading to central nervous system effects.
- Quinazolines: Acts on the larval stages of most insect by inhibiting or blocking the synthesis of chitin in the exoskeleton.

Chemical Control
Types and Modes of Action

Synergists/Activators

- Synergists can counteract metabolic insecticide resistance by inhibiting detoxification enzymes.
- They prevent the degradation of toxicants, enhancing the activity of insecticides when used in concert; synergists and activators are not in themselves considered toxic or insecticidal.

Eg. Synergist nets combine pyrethroid and piperonyl-butoxide (PBO) to enhance potency against resistance

Chemical Control-Advantages & Disadvantages

Advantages

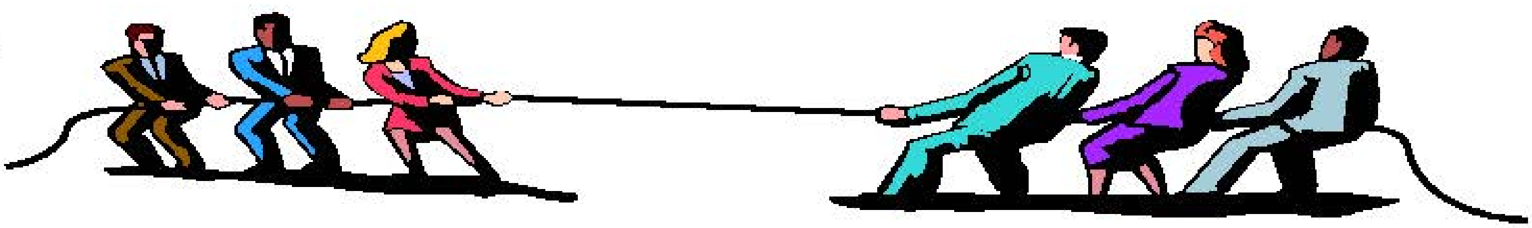
- Rapid eradication of pests – little delay.
- Low skill level needed to apply them.

Disadvantages

- Broad spectrum – non-target species also affected.
- Pest replacement
- Pest resurgence – seen when using broad spectrum pesticides – eradicates predator of pest and the pest, the pest may emerge without predators
- Bioaccumulation – may accumulate in food chains

Disadvantages of Pesticide Use

- Residues may have adverse effects on ecosystems by creating disequilibrium of food chains, insect-host relationships, insect-plant relationships.
- Frequent need for repeated pesticide applications may lead to resistance. In this case, the pests become unaffected by pesticides which formerly were effective in killing them.
- The problem of resistance causes a change over to new pesticides which further adds to the expense of chemical control.



Disadvantages of Pesticide Use

- Pesticides may have the grave disadvantage of posing a hazard to humans.
- As surely as pesticides will kill pests, they may also have negative effects on people who handle them carelessly.
- There are, in fact, many examples from different countries of human deaths resulting from careless handling of pesticides.

PEST CONTROL

ENTOMOLOGY II

BIOL 356

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Introduction to Toxicology

- It is the branch of science the deals with poisons and their harmful effects on living organisms. The study of the adverse effects of chemical agents on humans.
- Toxicant: a man-made agent that can produce an adverse effect/ deleterious response in a biological system, seriously damaging its structure or function or producing death.
- Toxin: usually is any naturally occurring poisonous substances of origins such as microbial and plants that reacts with specific cellular components to kill cells to alter growth or development, or kill the organism.

Introduction to Toxicology

- Toxicity: describes the degree to which a substance is poisonous or can cause injury.
- Toxic effects: This term refers to the health effects that occur due to exposure to a toxic substance; also known as a poisonous effect on the body. On the basis of toxic effects of a chemical, toxicity is subdivided into;
  - Acute effects: result due to short term exposure of few hours, days or weeks to a chemical. They are much severe in nature.
  - Chronic effects: related with exposure of smaller quantities over a prolonged period of time leading to toxic concentrations or long term exposures.

Factors Influencing Toxicity

- Exposure: is the actual contact of the chemical substance with the biological organism. The means by which an organism comes in contact with the substance is the route of exposure; in the air, water, soil, food, medication etc.
- Dose: is the total amount of a toxicant administered or taken by the organism at specific time intervals and may be quantified or estimated in a number of different ways.
- Response: is the organismal reaction to a toxic dose. It may be quantitative or qualitative. Response may be an all or none phenomenon such as mortality, or they may be graded effects such as growth or reproductive performance (fecundity).

Factors Influencing Toxicity

Types of Toxic Responses

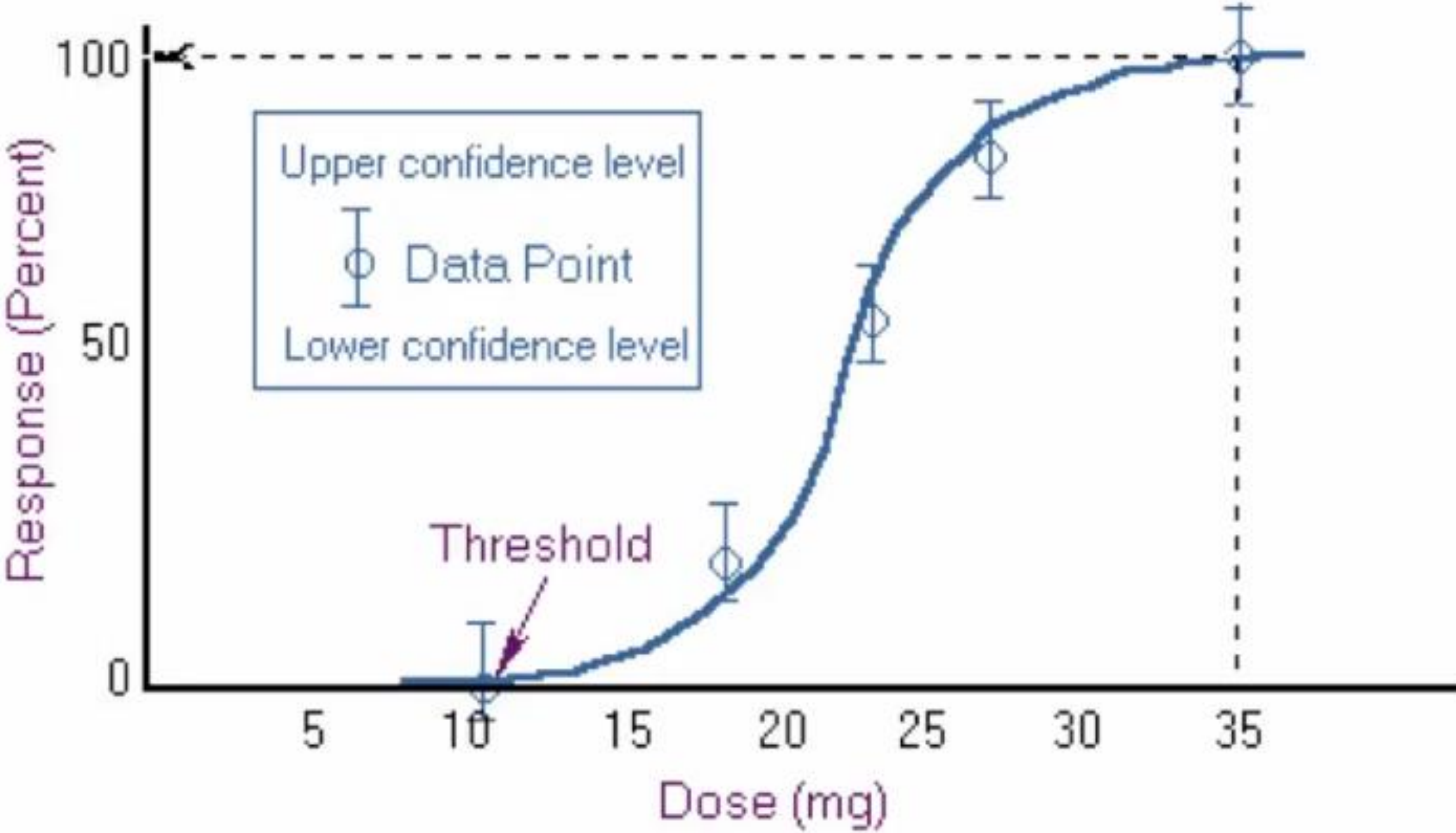
- Local: Effect at site of contact
- Systemic: Effect distant from exposure site
- Immediate: seconds to hours after a single exposure.
- Delayed: Days to years after exposure
- Reversible vs. Irreversible: Largely determined by the tissue involved, length of exposure and magnitude of toxicity involved.
  - Reversible: rapidly regenerating tissue: Liver, intestinal mucosa, blood cells.
  - Irreversible: CNS damage, carcinogenesis, mutagenesis, teratogenesis.

Factors Influencing Toxicity

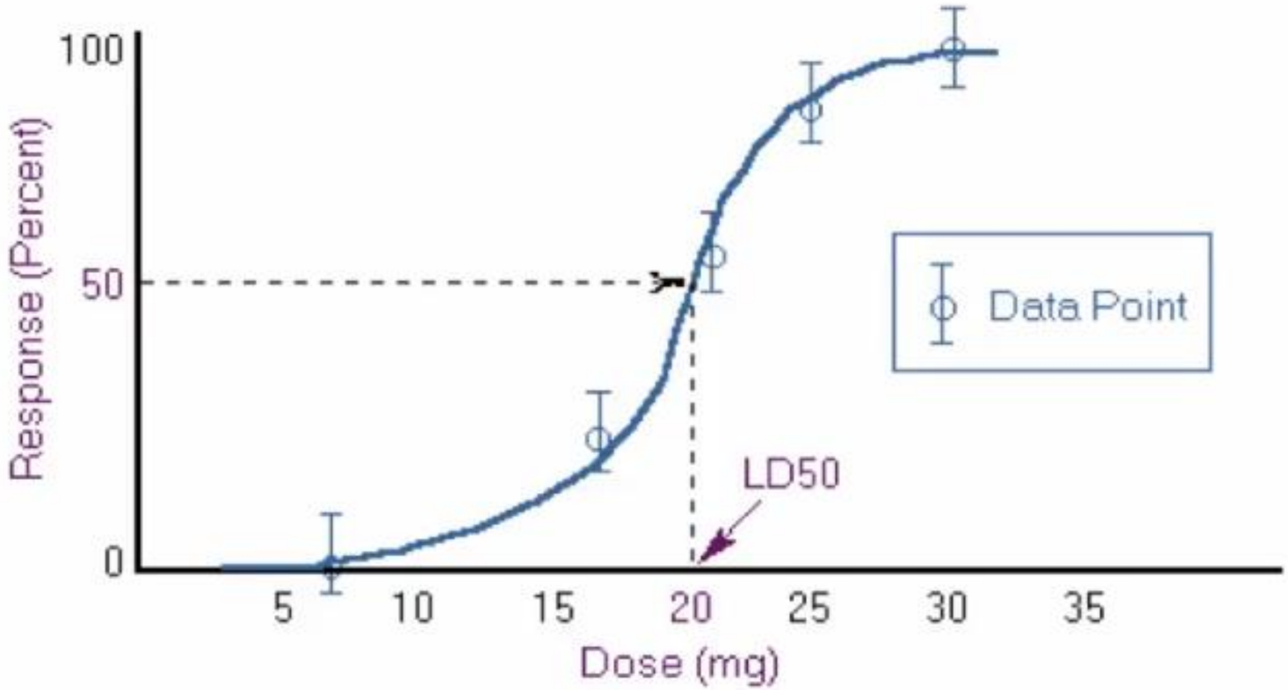
Dose-response

- A relationship between exposure and health effect, that can be established by measuring the response relative to an increasing dose.
- This relationship is important in determining the toxicity of a particular substance.
- It relies on the concept that a dose, or a time of exposure to a chemical, drug, or toxic substance, will cause an effect (response) on the exposed organism.
- Usually, the larger or more intense the dose, the greater the response, or the effect. This is the meaning behind the statement "the dose makes the poison."

Dose-Response Curve

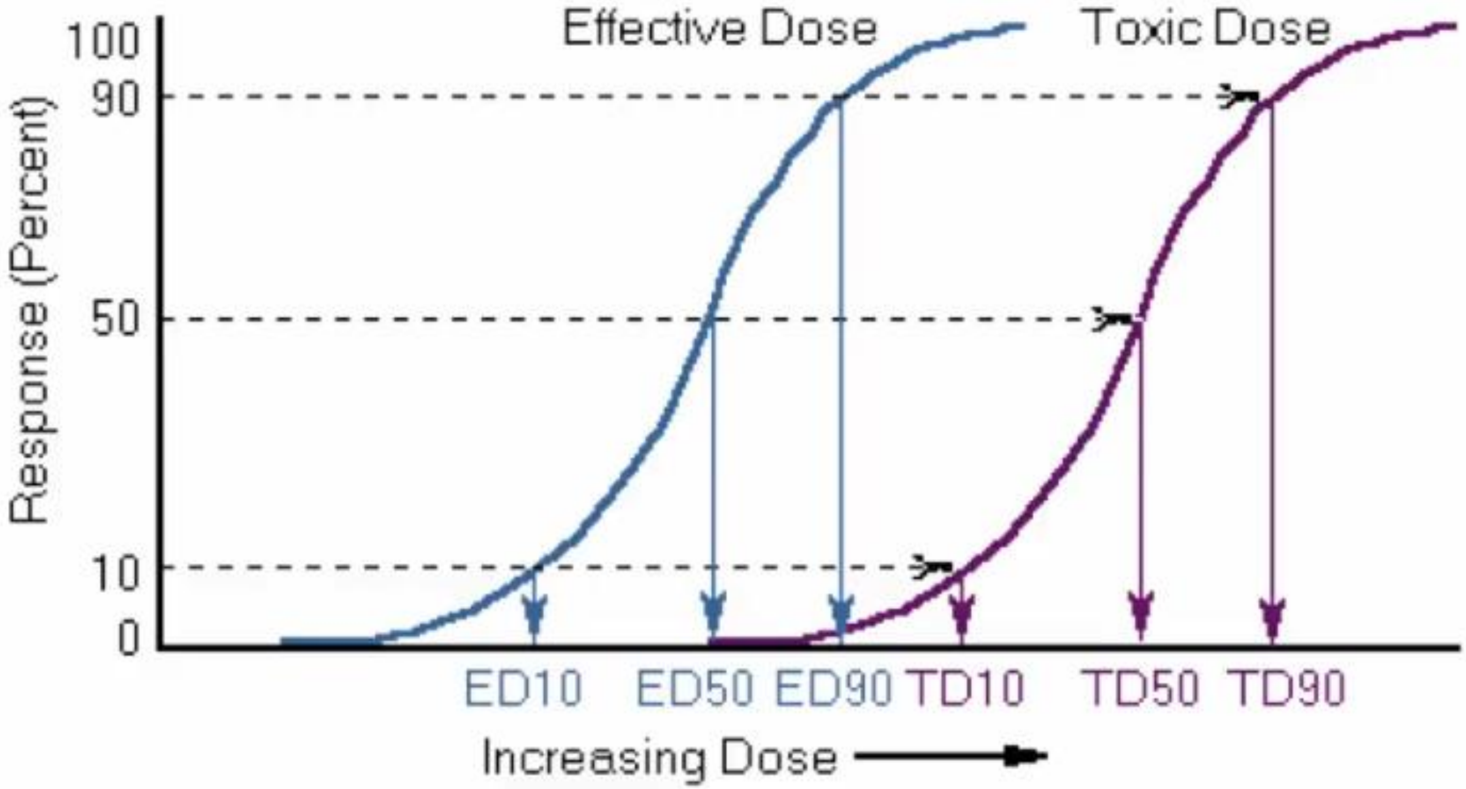


Dose Estimates of Toxic Effects



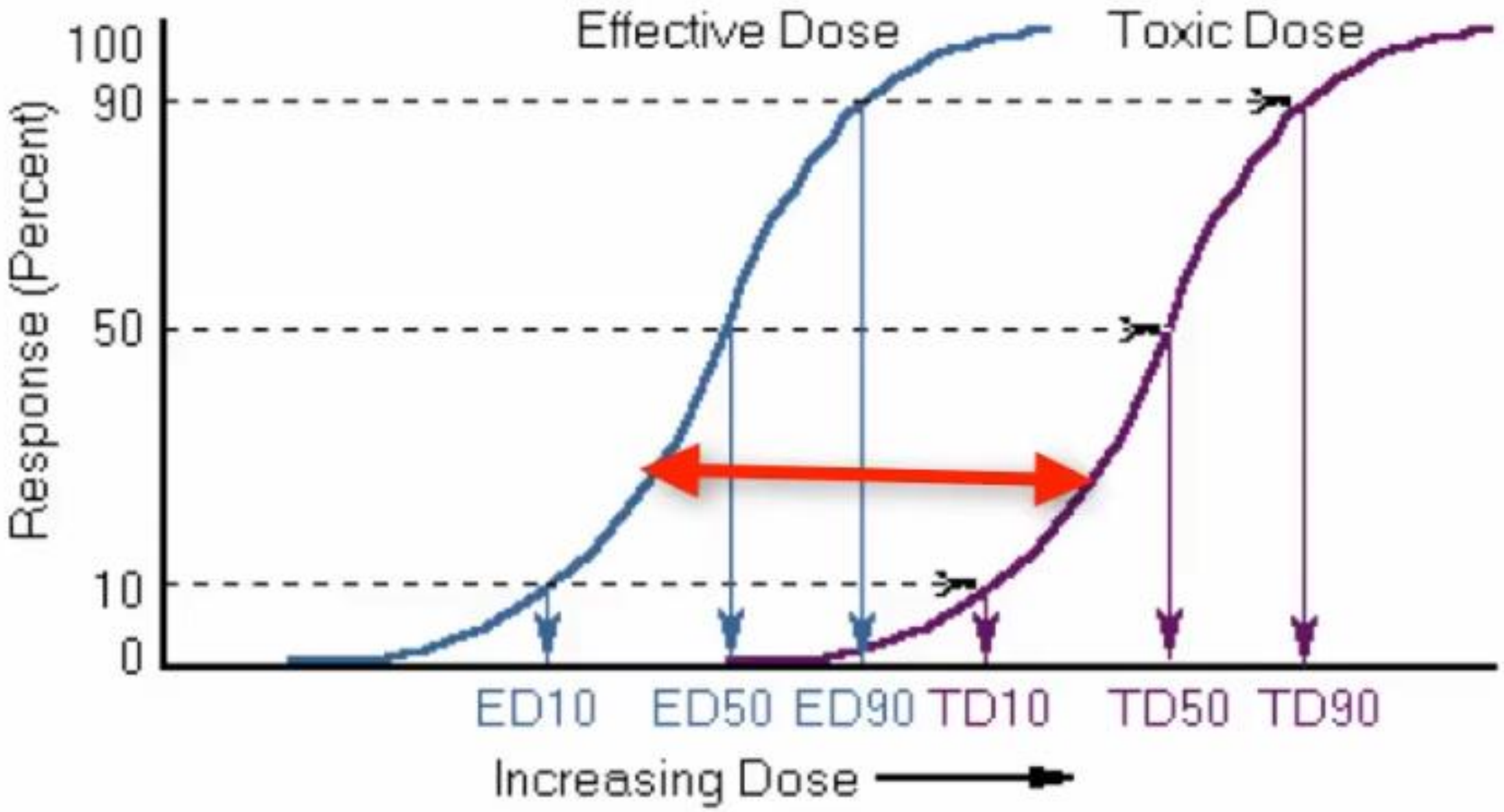
- The 50 in this expression refer to the dose of a given substance that kills 50% of the organisms exposed to.
- The LD 50 rating is usually expressed in milligrams of poison per kilogram of body weight.
- The higher the rating the less acutely poisonous.

Effective vs Toxic Doses

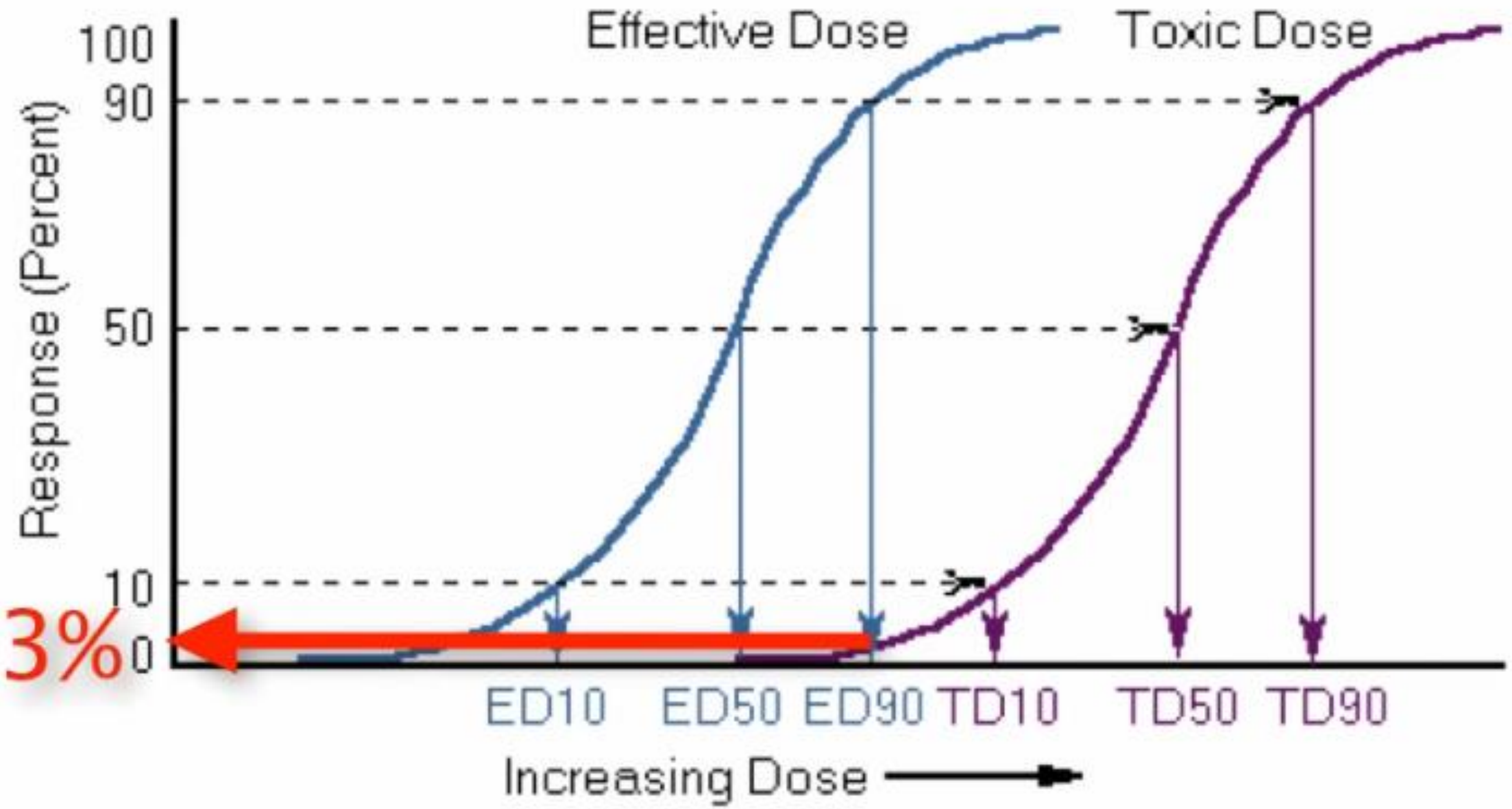


The knowledge of the effective and toxic dose levels aides the toxicologist and clinician in determining the relative safety of pharmaceuticals.

Effective vs Toxic Doses



Effective vs Toxic Doses

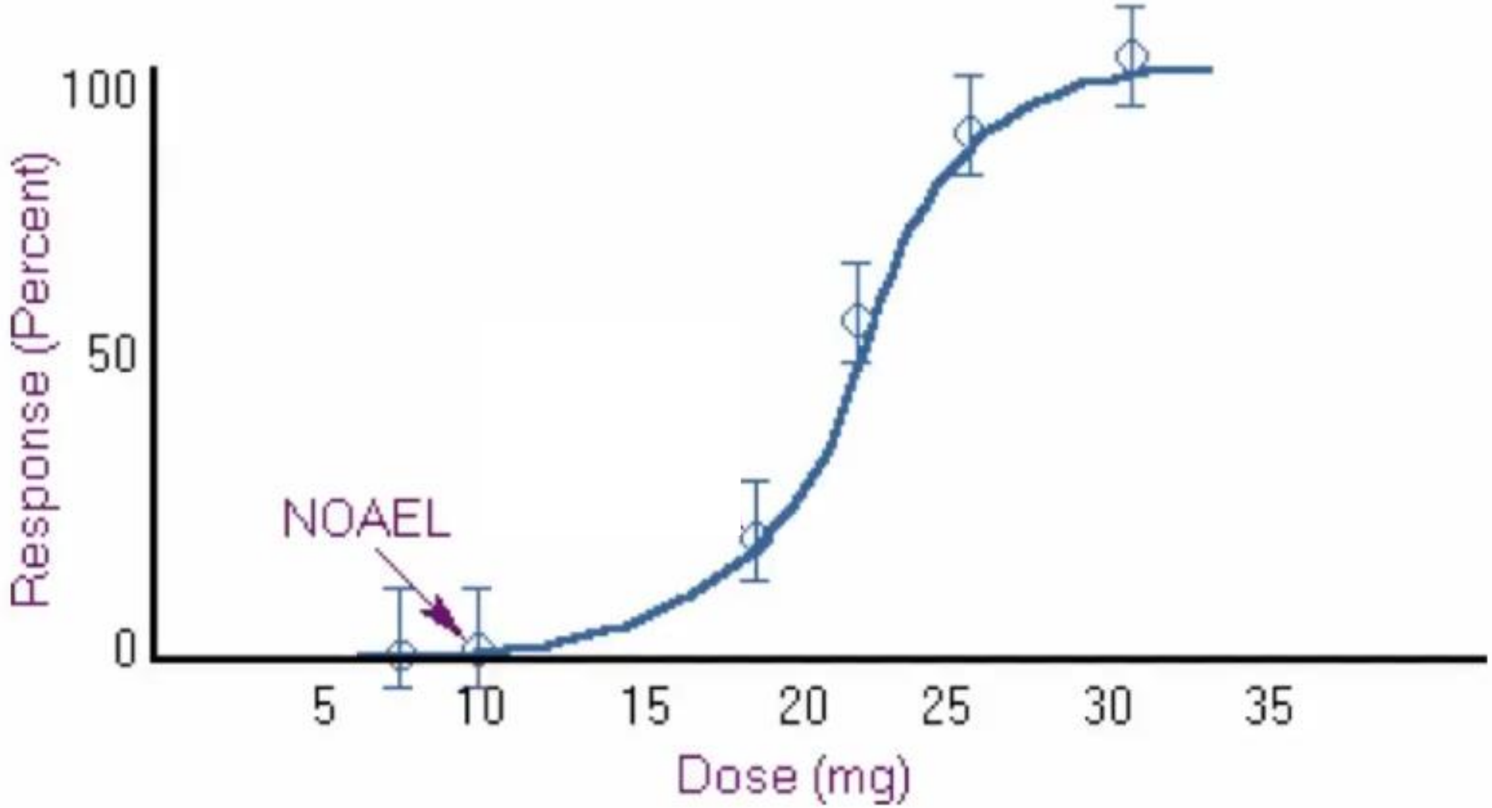


Factors Influencing Toxicity

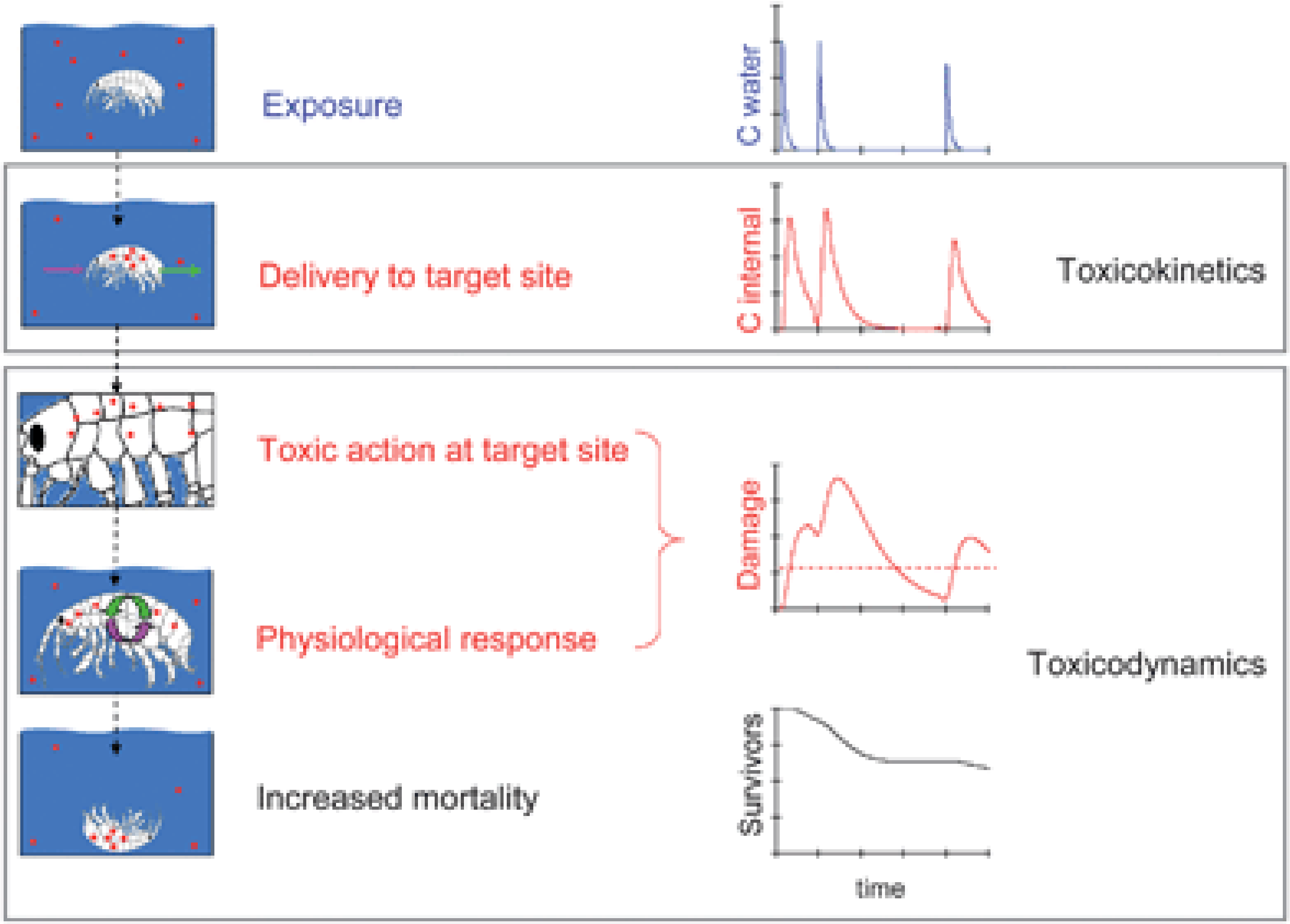
Threshold dose

- Given the idea of a dose-response, there should be a dose or exposure level below which the harmful or adverse effects of a substance are not seen in a population.
- That dose is referred to as the 'threshold dose'. This dose is also referred to as the no observed adverse effect level (NOAEL), or the no effect level (NEL).
- These terms are often used by toxicologists when discussing the relationship between exposure and dose. However, for substances causing cancer 16 (carcinogens), no safe level of exposure exists, since any exposure could result in cancer.

NOAEL



Three Phases of Toxicology



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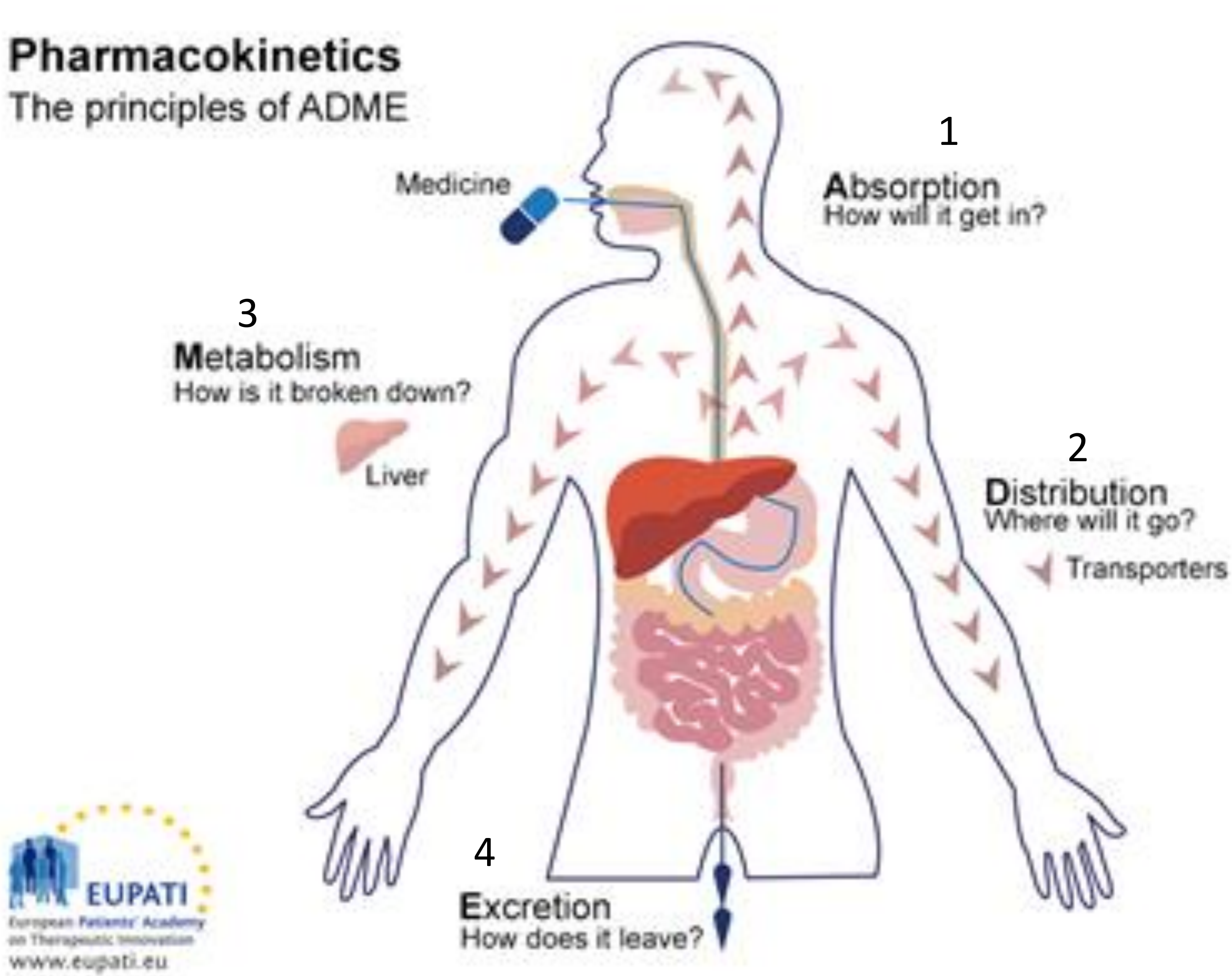
Exposure Phase

- It covers those factors that are responsible for determining the concentration of a toxic substance that effectively comes in contact with an organism.
- For absorption, a toxic substance must be present in a molecular form that can be dispensed and be relatively lipophilic to penetrate biological membranes.

Toxicokinetic Phase



Toxicokinetic Phase

- It involves all of the physiological processes and factors involved in absorption, distribution, metabolism and excretion of a toxicant.
- For the concentration of toxicant that is ingested by an organism, a fraction of the dose reaches the general circulation or becomes available systemically.
- The remaining dose is eliminated as waste in the feces. If the toxicant is ingested only once, availability will depend on the dose, rate of absorption, and rate of elimination.
- The amount of toxicant that reaches the target or receptor sites is designated as toxicologically available or bioavailable.
- However, the situation is complicated by the fact that toxicants may be converted to other products or metabolites.

Toxicodynamics

- It includes interactions of the toxic substance with its molecular site of action and the biochemical or biophysical events that finally lead to the toxic effects observed.

<u>Dose - Response Relationships</u>

Toxic Chemical

↓ *Key interaction*

Critical Target

↓

Modified Critical Target

↓ *Progression*

evident Biological Response or Effect

Divisions of Toxicology

Toxicologists fall into three main areas:

1. Descriptive toxicology.
2. Research/mechanistic toxicology.
3. Applied toxicology:
    - Forensic toxicology
    - Occupational toxicology
    - Clinical toxicology
    - Environmental toxicology

Division of Toxicology

Descriptive: is concerned with gathering toxicological information from animal experimentation. These types of experiments are used to establish how much of a chemical would cause illness or death. Regulatory bodies use information from these studies to set regulatory exposure limits.

Mechanistic: cellular, biochemical and molecular mechanisms by which chemicals cause toxic responses. It is to determine whether effects seen in animals can be expected in humans.

Forensic: is a multidisciplinary field involving the detection and interpretation of the presence of chemicals and other potentially toxic compounds in the tissues and fluids of the human body.

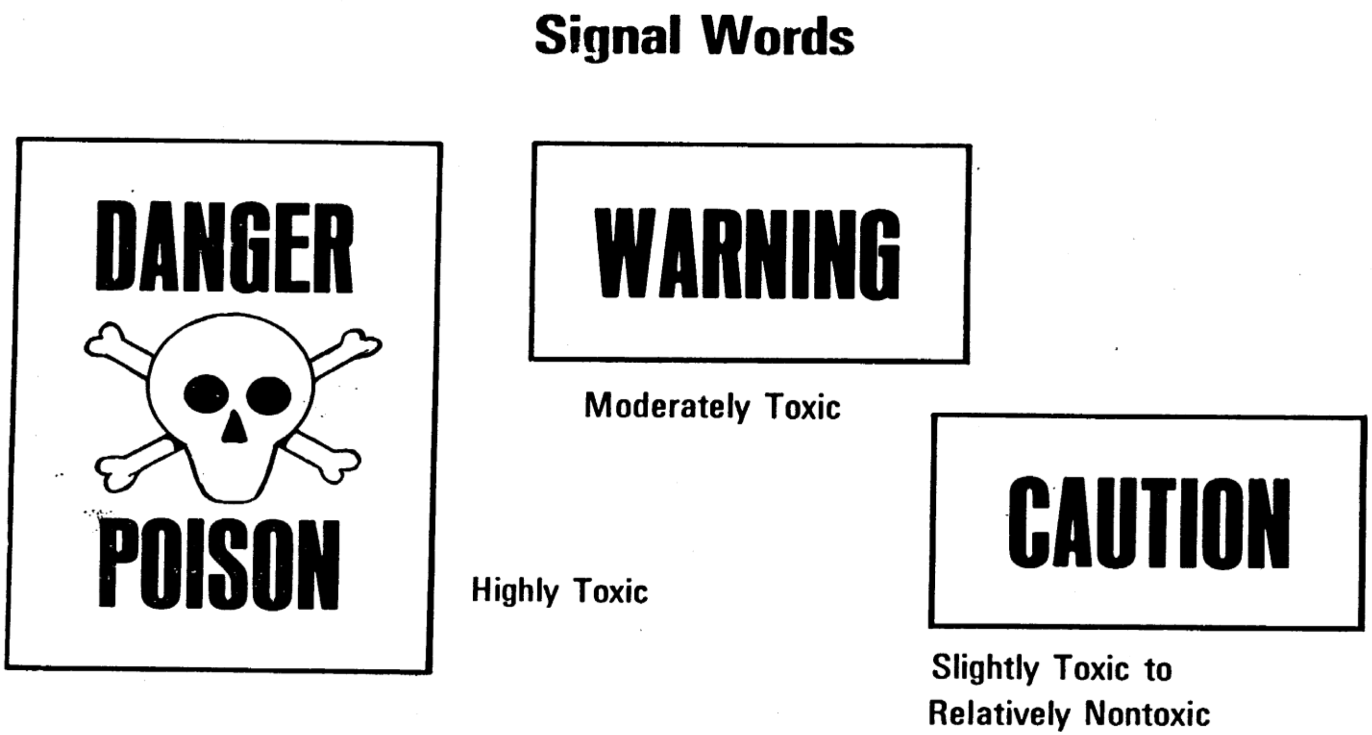
Division of Toxicology

Occupational: is concerned with health effects from exposure to chemicals in the workplace.

Clinical: is concerned with various types of diseases and illnesses associated with short term or long term exposure to toxic chemicals.

Environmental: is concerned with the study of chemicals that contaminate food, water, soil, or the atmosphere. It also deals with toxic substances that enter bodies of waters such as lakes, streams, rivers, and oceans. This sub-discipline addresses the question of how various plants, animals, and humans are affected by exposure to toxic substances.

Words on the Label



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