Plasmodium vivax

[Malarial Parasite]

Systematic Position: -

Kingdom – Animalia

Phylum – Protozoa

Sub-Phylum – Plasmodroma

Class – Sporozoa

Genus – *Plasmodium*

Species – *vivax*

About **60 species** of plasmodium are known to cause malaria in reptiles, birds & mammals. Among which **four species** are common in human beings. They are:

1. **P.vivax**: -
   This causes benign **tertian fever**. The fever occurs after every 48 hours or on every third day.
2. **P.malariae**: -
   This causes **quartan fever**. The fever occurs after every 72 hours or on every fourth day.
3. **P.falciparum**: -
   This causes **malignant malaria or aestivo-automnal malaria** (Fatal malaria) or, **black water fever**. Fever occurs irregularly.
4. **P.ovale**: -
   It causes mild or **ovale malaria**. Fever occurs after every 48 hours.

Malaria means bad air [**mala (Italian word) = bad, aria = air**]. In ancient time people thought that malaria is caused by bad air. But, now we know that the causative agent of malaria is a parasitic protozoa of genus Plasmodium.

*Organisms that live on or in other organisms & obtain their food from living body are called **parasites**.

*The organisms on or in which parasites live are called hosts.

Plasmodium is a **digenetic parasite**, it means, it completes its life cycle into two hosts of two different species which are human beings (**primary or definitive host**) & anopheles mosquito (**secondary or intermediate host**).

* Monkeys have malarial parasites in their blood but themselves don't suffer from malaria, hence they act as reservoir host.

*Occurrence: -

- Malaria parasites are found widely spread from **4^{o} S to 63^{o} N** latitudes.
- P.**vivax** is the most widespread or in temperate region.
- **P.falciparum** is confined to the warmer countries only.
- **P.malariae** occurs in sub-tropical zone
- While **P.ovale** the rarest of the four, has been reported from Philippines & the east and west America, especially all Nigeria.

Habits & Habitat: -

The parasites live in RBC and parenchyma cells of liver of human beings & other vertebrates and in the alimentary canal & salivary glands of mosquitoes.

*History: -

- **Lancisi** first of all suspected a connection between the **abundance of mosquitoes** and the **occurrence of disease**.
- **Charles Laveran** (1880), a French army physician in Algeria first discovered **Plasmodium** in the blood of malarial patient.

- **Golgi & Celli** (1885) observed that **Plasmodium** always occurs in RBC.
- In 1892, a German doctor, **Richard Pfeiffer**, suggested that plasmodium is introduced in human blood through some blood sucking animals.
- In 1894, **Monson** suggested the possible role of mosquito in the spread of malarial parasite to **Sir Ronald Ross**.
- On his suggestion, **Sir Ronald Ross**, an Indian Army Doctor, set to work in 1895 & after 2 years, on **29th August, 1897** he discovered the **oocysts of plasmodium** on the stomach of an Anopheline mosquito.
- In 1898, **Grassi & his Italian Co-workers** worked out the complete life cycle of the **P.vivax** in the female **Anopheles**.

Life-Cycle of Plasmodium Vivax: -

P.vivax completes its life cycle in two stages that are asexual in human beings & sexual in **Anopheles** mosquito.

Asexual Cycle in Human Being: -

Infection or Transmission: -

❖ While feeding the mosquitoes puncture the skin of man by its beak like proboscis & injects some saliva to check the clotting of blood, as it contains an anti-coagulant.

❖ Along with saliva, thousands of sporozoites are also inoculated into human blood at a single bite.

❖ This method of infection is called inoculative method.

Infection by bitting of mosquito

Transfusion Malaria –

- ❖ Through blood transfusion.

Congenital Malaria –

- ❖ Through mother's blood through foetus due to some placental defect.

Therapeutic Malaria –

- ❖ It can be induced artificially, for treatment of neurosyphilis.

Accidental Malaria –

- ❖ By the use of same syringe.

Sporozoite: -

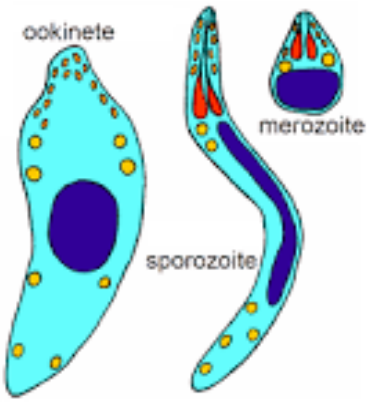
- ❖ Infective stage of plasmodium is called sporozoite.

*Structure of Sporozoite: -

- ❖ It is minute, slightly curved or sickle shaped organisms, tapering at the both ends.
- ❖ They are motile creatures performing vibratory and gliding movements.
- ❖ Each sporozoite is about 14 µ long & 1 µ broad and covered with firm, elastic but non-resistant, thin cuticle, which helps to maintain more or less definite shape.
- ❖ Nucleus is present at its thicker part or in centre.

*Ultrastructure of Sporozoite: -

- ❖ According to Garnham, Bird & Baker (1963), the external covering or pellicle consists of three layers and contains longitudinally arranged hollow peripheral fibrils or microtobules which may be contractile & responsible for wriggling movements of the body. [11 in ***P.vivax***, 13 in ***P.ovale*** and 15 in ***P.falciparum***]



- ❖ Anterior end bears a cup like depression, the apical cup, with concentric rings (probably 3).
- ❖ A pair of long narrow organelles opens into the apical cup.
- ❖ These probably secrete a proteolytic enzymes to facilitate the sporozoite's penetration of host cell.
- ❖ Many convoluted tubules of unknown function, occur throughout the length of the body.
- ❖ The cytoplasm contains many mitochondria and a nucleus.

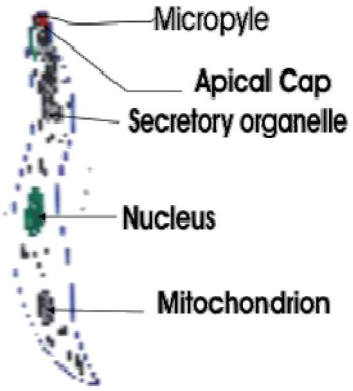


Fig - Sporozoite

Short and Garnham (1848 & 1954) have shown that in about half an hour after infection, the sporozoites disappear from blood & appeared in reticuloendothelial cells of capillaries of liver.

The life cycle in human beings can be studied under three headings: -

1. Pre-erythrocytic Cycle (8 days)
2. Exo-erythrocytic Cycle
3. Erythrocytic Cycle

Pre-erythrocytic Cycle: -

- ❖ The sporozoites enter into liver cells & feed on glycogen of liver.

- ❖ It divides by multiple fission into about 12000 small elongated structures called cryptozoites or cryptomerozoites.
- ❖ Inside the liver cell it becomes a spherical and non-pigmented trophozoite termed a cryptozoite.
- ❖ Its nucleus divides several times & within eight or nine days it grows into a multimucleate schizont.
- ❖ The rupture of which liberates a vast number of tiny uninucleate cryptomerozoites into the liver sinusoids.
- ❖ They may either pass into the blood circulation to attach to RBC or enter fresh liver cells so as to continue exo-erythrocytic cycle.

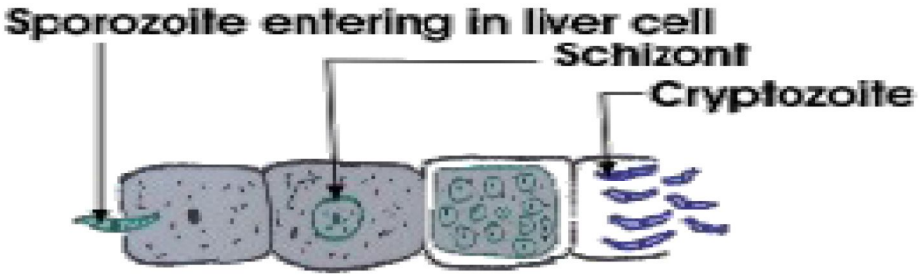


Fig - **Pre - erythrocytic cycle**

Pre-patent period: -

The duration between the initial (sporozoite) infection & the first appearance of the parasites in the blood is termed the pre-patent period. It is 8 days in ***P.vivax***.

Exo-erythrocytic Cycle: -

- ❖ After re-entering a liver cell, each cryptomerozoite becomes a trophozoite known as a metacryptozoite or phanerozoite.
- ❖ As a result of schizogony it may produce several thousand metacryptomerozoites.
- ❖ Of these some are smaller in size but more numerous and called as the micro-metacryptomerozoites.
- ❖ They enter the RBC to start erythrocytic cycle.

- Others are larger in size but less numerous and called as mega-metacryptomerozoites which attack fresh liver cells to continue exo-erythrocytic cycle.
- This phase is absent in ***P.falciparum***.

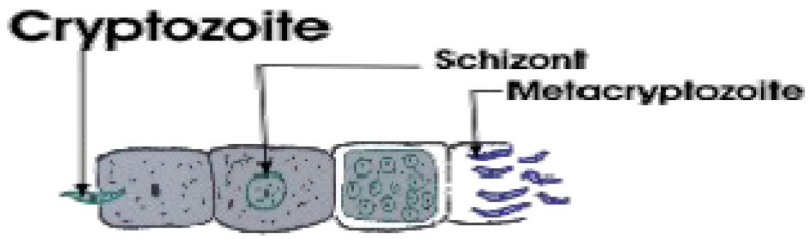


fig:- **Exo - erythrocytic cycle**

Erythrocytic Cycle: -

This cycle in man, is also known as the **cycle of Golgi**.

This cycle begins when RBC is attacked either by crypto-merozoites or meta-cryptomerozoites.

- Each merozoites burrows in a RBC and assumes a rounded disc like shape with a single large nucleus.
- It is the trophozoite stage which grows at the expense of the hemoglobin of blood corpuscles.
- so, it is also called vegetative stage or nutritive stage.
- A vacuole appears in the parasites and gradually increases in size, pushing the nucleus to one side. This stage is called **signet-ring stage**.
- The ingested hemoglobin of the blood corpuscleis decomposed into amino acid and haematin.
- These amino acids are used by the parasite to synthesize its own proteins, for which energy is obtained from the breakdown of glucose.
- The unused haematin forms the yellowish brown or black, toxic, malarial pigment called **haemozoin**.

Amoeboid Stage:-

With further growth, the vacuole disappears and the parasite becomes amoeboid in appearance.

The corpuscles becomes larger (double) and slightly paler due to loss of its haemoglobin & on its surface develop numerous fine and characteristics granules, the **Schuffner's dots**.

Full grown mature trophozoite most completely fills the enlarged corpuscle and now become a schizont, ready to multiply asexually by a process called **erythrocytic schinzogony or merogony.**

Rosette Stage:-

- The nucleus of the Schizont divides by multiple fission into 6 to 24.
- These nuclei come to lie on the periphery, while the haemozoin granules accumulate at the centre.
- All nuclei are bounded by a membrane with little amount cytoplasm.
- These cells are called erythrocytic merzoites or schizoites.
- This stage is known as **Rosette stage**.

After sometime, the cell membrane of RBC bursts and the merozoites with haemozoin are set free in blood. This cycle is completed in 48 hours in P.vivax, P.ovale & P.falciparum and in 72 hours in P.malariae.

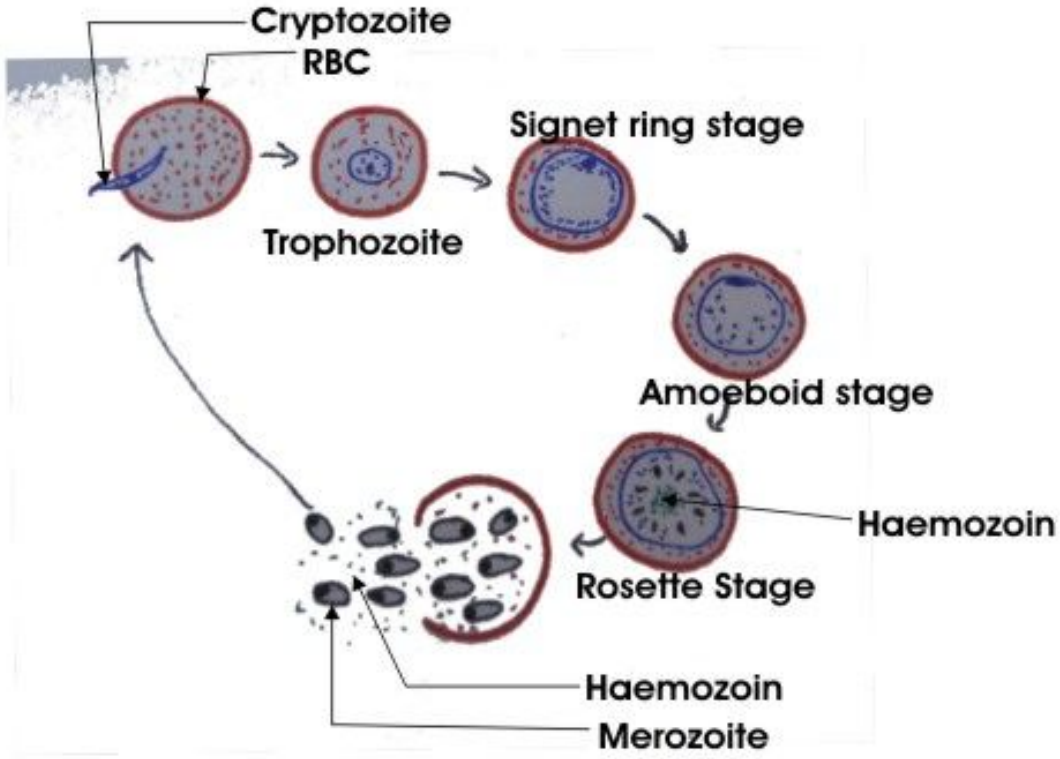


Fig:- **Erythrocytic cycle**

Incubation period: -

The time period between infection and first appearance of signs and symptoms is called incubation period.

It is 14 days in P.vivax.

Formation of gametocytes: -

- The released merozoites attack the RBC or continue erythrocytic cycle.
- Whereas some merozoites enter into RBC and grow into compact rounded bodies known as gametocytes or gamonts.

The gametocytes are of two distinct types: -

1. Male or micro-gametocytes: -

They are smaller in size (9 – 10 and less numerous. Large, laterally placed, diffuse nucleus.

2. Female or mega-gametocytes: -

They are large in size (10 – 12 and more numerous. Small, peripherally placed and compact nucleus

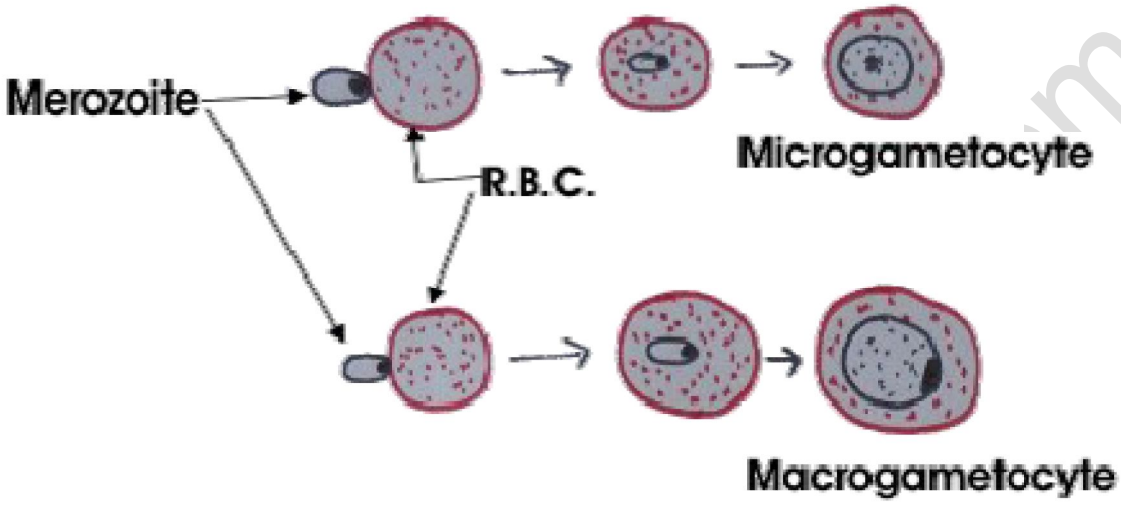


Fig:- Formation of gametocyte

Sexual Cycle of P.vivax in mosquito: -

Transfer to Mosquito: -

- The gametocytes don't develop further in the vertebrate host.
- They don't survive for more than a week in human blood if not taken up by the insect host.
- When a female Anopheles sucks the blood of an infected person, it ingests the RBC containing the gametocytes.
- The rupture of RBC sets free the gametocytes which develop into gametes.

- **Micro-gametes: -**
  - The nucleus of micro-gametocytes divide mitotically into 6 to 8 nuclei which migrate to the periphery.
  - At the same time 6 to 8 flagellum like long threads of cytoplasm push out from the surface of the gametocyte into each of which a daughter nucleus passes.

❖These nucleated threads are made gametes or micro-gametes and each measures 20 – 25 in length.

❖The formation of the micro-gametes is so sudden & violent or explosive that this process is called **exflagellation** which is stimulated by low temperature.

- **Macro-gametes or mega-gametes: -**

Macro-gametocytes undergo mitosis to form a polar body and gives out a small cytoplasmic projection, the cones of reception or Fertilization cone.

Fertilization: -

Micro-gametes penetrate the macro-gametes through their fertilization cone & fertilization or, **syngamy** takes place. As a result, zygote having a single **diploid nucleus** or **synkaryon**.

OOkinete: -

❖The zygote remains rounded and motionless for some time, but soon it becomes elongated and motile.

❖ It shows movement and is known as **vermicule** or **ookinete** (active egg).

❖ It measures about 15 – 22 µ in length and 3 in width.

❖By its tapered end it pierces through the epithelial lining of mosquito stomach and rests against the basement membrane of stomach.

❖Here, it stops to move, becomes spherical and begins to encyst.

Oocyst: -

❖The cyst is thin, membranous and elastic, secreted by the ookinete and partly derived from the stomach tissues of the mosquito.

❖The encysted zygote is called the **oocyst** or **sporont**.

❖It grows in size from 6 – 60 in diameter.

❖A single infected mosquito may contain 50 – 500 such **oocysts** bulging as tiny nodules form the outer wall of the stomach in the haemocoel.

Sporogony: -

❖Oocyst now enters upon a phase of asexual reproduction known as **sporogony**.
❖ First division is **meiosis** and then **mitosis** is repeated.
❖ At the same time some elongated vacuoles are developed.
❖The daughter nuclei arrange themselves along the free margins of the cytoplasm.
❖Later slender finger like processes are given out from these cytoplasmic bodies and a daughter nucleus migrates into each of them.
❖In this way about 10,000 sporozoites are formed from each oocyst.
❖ The full grown **sporozoites** become separated from the residual cytoplasm and liberated into the haemocoel after breaking the oocyst.
❖They move to different organs in the body of the mosquito, but many of them penetrate into the salivary glands.
❖This cycle is completed in 2 to 4 weeks.

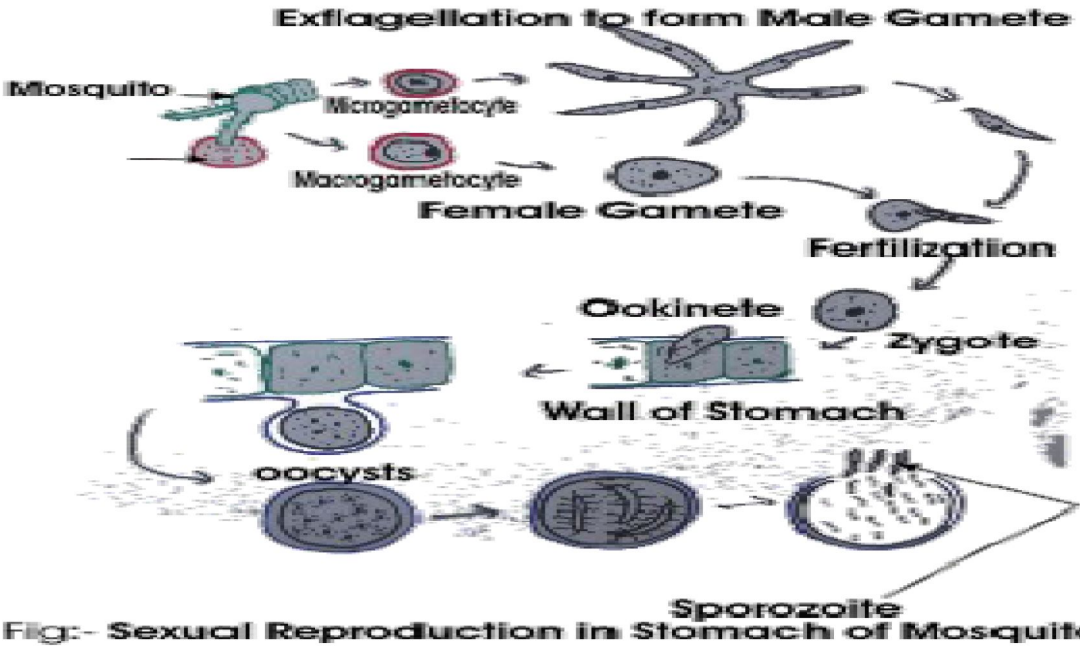


Fig:- Sexual Reproduction in Stomach of Mosquito

The

salivary glands of infected mosquito may contain as many as 2 lacks of sporozoites.

Pathogenicity: -

Effect on mosquito: -

It is non-pathogenic.

Effect on man: -

In man, infection with ***Plasmodium*** causes intermittent fever which are known as malaria. Each attack of fevers shows three successive stages: -

1. **Cold Stage:** -
   Patient becomes nauseous, suffers from headache and severe chills with acute shivering.
2. **Hot Stage**: -
   Pulse rate goes up, respiration becomes quick and the temperature rises as high as 160^{o} F.
3. **Sweating Stage**: -
   Patient sweats profusely and the fever comes down.

Control of Malaria: -

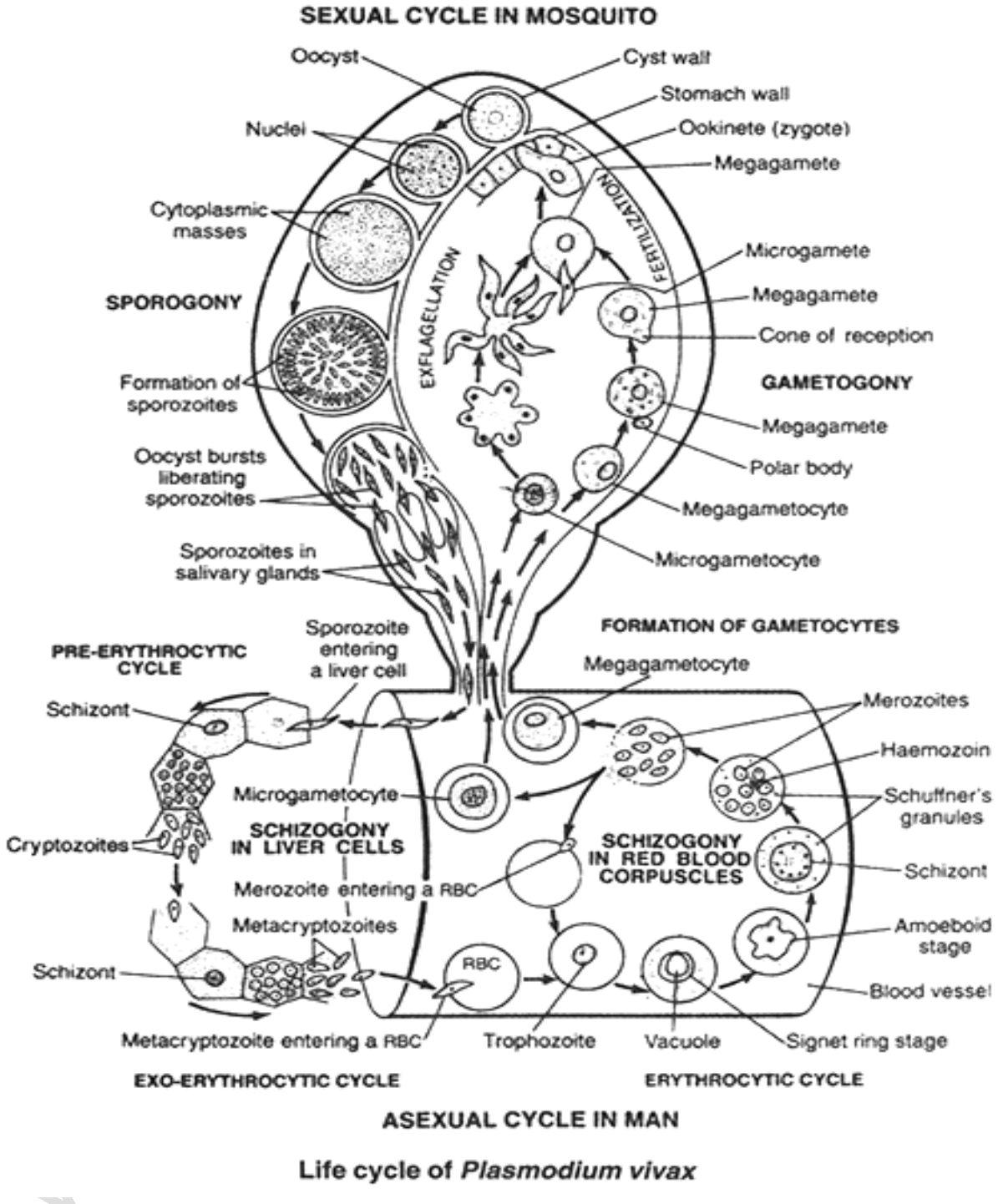
The flight for eradication of malaria is practically worldwide. All the control measures fall under the following three categories: -

1. **Elimination or destruction of vector i.e. female anopheles.**
2. **Prophylaxis i.e. prevention of infection.**
3. **Therapy i.e. treatment of infection in the patient.**

1. Elimination of Anopheles: -

It is achieved by using the following methods: -

A. Elimination of breeding places: -



Life cycle of *Plasmodium vivax*

a) Water should not be allowed to stand

b) Open drains should be closed or made underground

c) Bushes and shrubs should be cleared off.

B. Destruction of larvae and pupae and adult: -

a) By spreading kerosene oil.

b) By biological method.
c) By chemicals.

2. **Prophylaxis: -**

Protection of healthy person in malariom areas from being infected can be done through the use of insect repellant, nets, gloves, chemicals etc.

3. **Therapy: -**

Various synthetic drugs such as quinine, arabrin, camoquin, chloroquin etc are used as suppressants of various stages of the parasites.

Note:- **Starred Points are not necessary to write in notes for examination.**