# Unit 23 · Plasmodium vivax

STUDY NOTES

**WHAT NEB'S GRADE 11 EXAM ASKS**

- **CDC's grid (2077):** Faunal Diversity (Units 22–26 together): 19 of 75 marks, 1 MCQ, 2 short and 1 long; in one group with Evolutionary Biology, Units 18–21 (28 marks)
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **MCQ (1 mark)**
  - vector; where asexual and sexual phases happen
  - infective stage (sporozoite); paired organelles (lytic juice)
  - what causes fever and chills; site of pre-erythrocytic phase
  - who linked malaria and mosquito (Ross)
  - exflagellation (microgametocyte); ookinete; Schüffner's dots (amoeboid)
  - *Gambusia*; order of the sexual cycle; the diploid stage (zygote)
- **Short and long (in parts)**
  - schizogony and its kinds, **with diagrams**; liver schizogony **with diagrams**
  - **draw** a sporozoite, labeled
  - sexual cycle in the mosquito; encystment and sporogony
  - trophozoite vs sporozoite
  - erythrocytic schizogony and its stages (name the phase in a figure)
  - blackwater fever: *P. falciparum*
  - can malaria be prevented: control measures

## Key terms

**Digenetic**: needs two hosts to complete its life cycle.

**Primary (definitive) host**: where the **sexual** phase passes: female *Anopheles*.

**Secondary (intermediate) host**: where it multiplies **asexually**: human.

**Vector**: carries the parasite from one host to another: female *Anopheles*.

**Schizogony**: asexual multiple fission: nucleus divides many times, then cytoplasm splits round each; dividing cell = **schizont**, daughters = **merozoites**.

**Gametogony**: making gametes from gametocytes.

**Sporogony**: asexual multiplication in the oocyst making sporozoites.

**Syngamy**: fusion of male and female gametes (a process); **synkaryon**: nucleus from fused nuclei (a thing).

**Hemozoin**: yellowish brown **malarial pigment**: heme packed into harmless crystals.

**Pre-patent period**: bite → first parasites in blood; *P. vivax* **~8 days**.

**Incubation period**: entry of pathogen → first **symptom**; *P. vivax* **~14 days** (12–17).

**Hypnozoites**: sporozoites resting in liver cells (*P. vivax*, *P. ovale*) → **relapse**.

## Plasmodium vivax

- Protista · Protozoa · **Sporozoa** · *Plasmodium* · *vivax*; malarial parasite
- 200+ species; four in people:
  - *P. vivax*
  - *P. ovale*
  - *P. malariae*
  - *P. falciparum*
- (*P. knowlesi*, a monkey parasite, in Southeast Asia)
- warm temperate, subtropical, tropical; most of Nepal's malaria
- **intracellular** in humans (RBCs, liver cells); **extracellular** in the mosquito (gut, salivary glands)
- only females bite (blood for eggs); males drink nectar
- **tertian malaria**: fever every **48 hours** (*tertius*, third)
- *Anopheles* rests tilted at an angle; other mosquitoes parallel

**History**

- *mala aria*: "bad air" of marshes
- **Laveran** (**1880**, Algeria): parasite in RBCs; Nobel 1907
- **Manson** (**1894**): suggested mosquitoes
- **Ross** (**1897**, Secunderabad): cysts on *Anopheles* stomach; 1898, whole cycle in bird malaria; **proved** mosquitoes spread malaria; Nobel 1902

**Trophozoite** (feeding stage, in RBCs; Aikawa, 1966)

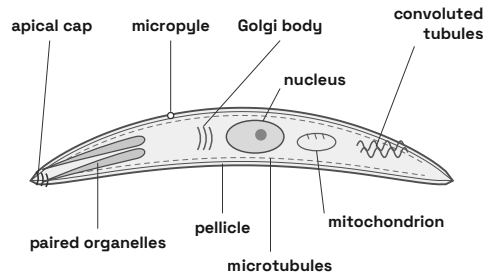
- round or amoeboid, **uninucleate**
- two-layered **plasmalemma** (in a parasitophorous vacuole)
- large **eccentric nucleus**, double membrane, nucleolus
- **food vacuoles** with **hemozoin**; feeds through a **cytostome**
- ER as vesicles; mitochondria with **peripheral cristae**; **concentric body**
- **no** locomotory organelles; **no** contractile vacuole

## Life cycle in a human (asexual)

**a. Inoculation of sporozoites**

- infective female *Anopheles*: **sporozoites** in **salivary glands** → injected with saliva
- saliva has **anticoagulants** (blood doesn't clot in the mouthparts)
- **sporozoite** (Garnham, 1966):
  - **sickle-shaped**, uninucleate; **12 μm × 1 μm** (RBC ~7.5 μm)
  - thin, firm, elastic **pellicle**
  - glides, wriggles by **contractile microtubules**
  - **apical cap + paired organelles** (rhoptries) → **lytic juice** → penetration

- **convoluted tubules**, central nucleus, mitochondrion, Golgi; **micropyle** (cytostome)

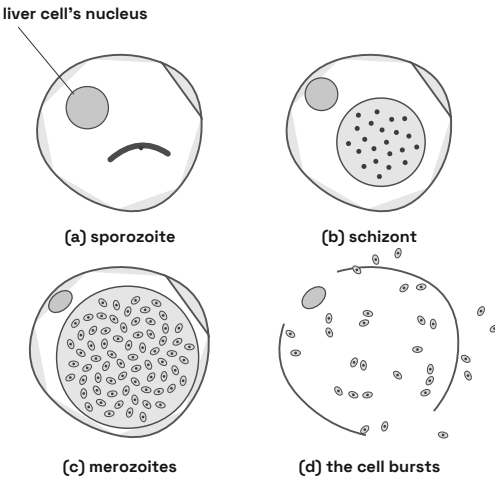



Sporozoite of *Plasmodium* (electron microscope).

| Trophozoite | Sporozoite |
|---|---|
| feeding, growing stage | **infective** stage |
| in human RBCs | in mosquito's oocysts, salivary glands |
| round or amoeboid | sickle-shaped |
| plasmalemma | pellicle, microtubules |
| no apical cap | apical cap, paired organelles |
| food vacuoles, hemozoin | none |
| doesn't move about | glides, wriggles |

**b. Liver schizogony**

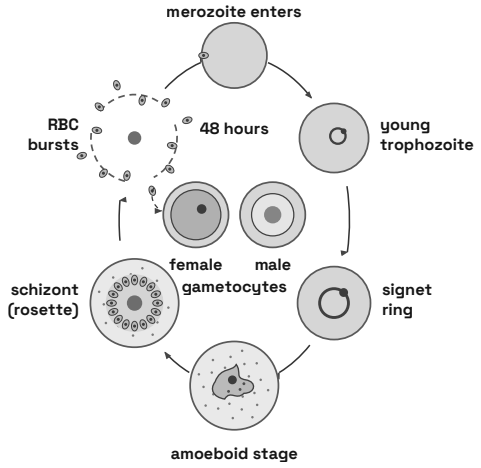
- within ~**half an hour**: sporozoites → **liver cells** (lytic juice)
- **pre-erythrocytic** (1st): sporozoite → **schizont** → thousands of **cryptomerozoites** → cell bursts → **sinusoids**
- **exo-erythrocytic** (2nd): cryptomerozoites → new liver cells → schizonts → **metacryptomerozoites**
  - **micro-metacryptomerozoites** (smaller, more): → **RBCs**
  - **macro-metacryptomerozoites** (larger, fewer): → fresh **liver cells**
- the two-cycle account: from 1940s bird malaria; use these terms in exams
- now known: one schizont per sporozoite → up to ~10,000 merozoites after ~a week; none go back to the liver
- **hypnozoites** (Krotoski, 1982) → relapses; **primaquine** kills them (chloroquine only blood stages)




Schizogony in a liver cell: (a) sporozoite enters; (b) schizont; (c) thousands of merozoites; (d) cell bursts.

**c. Erythrocytic schizogony** (in RBCs)

- i. **young trophozoite**: merozoite feeds, rounds, vacuole
- ii. **signet ring**: central non-contractile vacuole pushes nucleus to edge; hemoglobin → **globin** (food) + **heme** → **hemozoin**
- iii. **amoeboid stage**: pseudopodia; **Schüffner's dots** (red, eosinophilic); RBC **enlarged** (up to 2×), pale
- iv. **schizont** → mitosis → **12–24** merozoites round the edge: **rosette stage**
- RBC **bursts** → merozoites → fresh RBCs; one cycle **48 hours**
- **fever**: many RBCs burst together → merozoites, hemozoin in plasma → white cells release signals (TNF) → temperature up
- **post-erythrocytic schizogony** (old accounts): merozoites back to liver; now known not to happen




Erythrocytic schizogony of *P. vivax*, a 48-hour cycle.

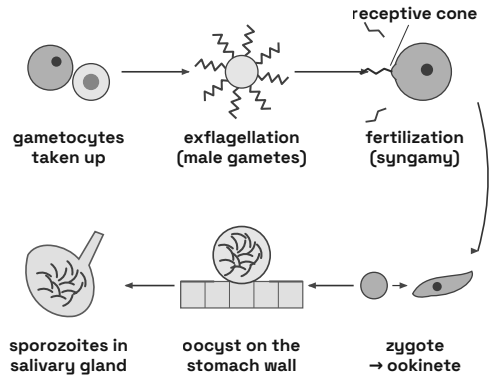
**d. Gametocytes**

- after several generations in RBCs, some merozoites grow slowly → **gametocytes** (plenty of hemozoin)
- **macrogametocytes** (female): larger, small compact nucleus, food-laden cytoplasm; usually **more numerous**
- **microgametocytes** (male): smaller, clear cytoplasm, large central nucleus
- develop no further in a person: die, or **sucked up** by female *Anopheles*
- build numbers first, so a mosquito's few drops hold both sexes

## Life cycle in the female Anopheles (sexual)

- **a.** blood sucked; all stages digested except **gametocytes**
- **b. gametogony**
  - male: **exflagellation**: triggered by **fall in temperature** and xanthurenic acid; nucleus → **8** haploid nuclei (6–8) → flagellum-like **male gametes**; **~15 minutes**
  - female: macrogametocyte → non-motile **female gamete** (ovum)
- **c. fertilization**: female gamete's **receptive cone**; many males, only **one** enters → **zygote** (**syngamy**)
  - zygote round, still (~24 hours) → motile, **vermiform ookinete** (vermicule), **15–20 μm × 3 μm**
- **d. encystment**: ookinete through **stomach wall** → rests beneath outer layer → **cyst wall** → **oocyst** (warts on the stomach)

- **sporogony**: many **mitoses** → spongy cytoplasm splits → spindle-shaped haploid **sporozoites**, **~10,000** per oocyst → oocyst bursts → **hemocoel** → **salivary glands** → out through the **hypopharynx** at the next bite
- blood meal → sporozoites in glands: **9–18 days**; longer in cold → malaria in the Terai, low valleys only
- **only the zygote is diploid** (Bano, 1959): meiosis follows at once (completed in the ookinete); all other stages haploid




Sexual phase in the female *Anopheles*: gametocytes → gametes → zygote → ookinete → oocyst → sporozoites → salivary gland.

- **sequence**: gametocytes → zygote → ookinete → oocyst → sporozoite

## Plasmodium falciparum

- tropics, subtropics; most deaths in Africa south of the Sahara
- **malignant tertian** (pernicious): fever almost continuous, or ~every 2 days; **most dangerous**
- sticky RBCs block brain vessels → **cerebral malaria** (confusion, fits, coma)
- RBCs of every age → severe **anemia**
- **blackwater fever**: RBCs burst in vessels → hemoglobin in urine (**hemoglobinuria**), dark
- high death rate; kills within days
- incubation **~12 days** (9–14); **no hypnozoites**, no relapse
- blood smear:
  - small rings at the RBC's **edge**, often **two chromatin dots**; two or more per RBC
  - schizont ~5 μm, **8–24** merozoites; older stages rarely in finger blood
  - hemozoin **black**
  - RBC **not enlarged**; **Maurer's dots**
  - **crescent** gametocytes (*falx*, sickle)

| | vivax | malariae | ovale | falciparum |
|---|---|---|---|---|
| malaria | benign tertian | quartan | ovale tertian | malignant tertian |
| incubation | ~14 days | 18–40 | ~14 | ~12 |
| cycle | 48 h | 72 h | 48 h | 36–48 h |
| relapses | yes | no | yes | no |
| RBC | enlarged, Schüffner's | Ziemann's dots | oval, Schüffner's | Maurer's dots |
| merozoites | 12–24 | 6–12 | 6–14 | 8–24 |

## Malaria: effects and control

- symptoms **~14 days** after the bite; each attack:
  - **cold stage**: shivering, chattering teeth (15 min–1 h)
  - **hot stage**: **40–41 °C**, headache (a few hours)
  - **sweating stage**: temperature falls; well till the next (48 h)
- also: **anemia**, **hemolysis**, **splenomegaly** (enlarged spleen)
- **Nepal**: cases down 96% (2014–2024); 37 local cases in 2024, ~1,000 in all, most **imported** (80%+ from India); aim: **eliminate by 2030** (3 years with no local case)
- **Tharu**: ~7× less malaria; **alpha-thalassemia** (natural selection); DDT from the 1950s opened the Terai

### Control measures

1. kill adult mosquitoes: traps, fumigation, **spray inside walls**
2. remove breeding places: swamps, stagnant water
3. cover open drains
4. remove tins, buckets, tyres that collect rain
5. clear bushes near houses
6. **oil, kerosene** on water: larvae can't breathe
7. **biological control**: larva-eating fish, *Gambusia*, trout, sticklebacks (*Gambusia* not native: harms native fish)
8. **insecticide-treated bed nets** (bites mostly at night)
9. cover arms, legs; repellents
10. **test quickly**; take the **full course**

- vaccines (falciparum, children): **RTS,S** (2021), **R21** (2023); none for *vivax*
- tests: **rapid diagnostic test** (15–20 min) or **blood smear**; free in Nepal's government facilities

**COMMON MISTAKES**

✗ Spherical, vacuolated adult form is a sporozoite
✓ that is the **trophozoite**; the sporozoite is sickle-shaped.

✗ Human is the primary host
✓ **mosquito** (sexual phase); human secondary.

✗ Laveran proved mosquitoes spread malaria
✓ he found the parasite; **Ross** proved the mosquito.

✗ Hemozoin is a toxin that causes fever
✓ harmless heme crystals; the body's defenses cause fever.

✗ Female gametocytes are fewer
✓ usually **more numerous**.

✗ Gametes are diploid
✓ only the **zygote** is diploid.

✗ Blackwater fever = hematuria
✓ dark urine from **hemoglobin** (hemoglobinuria).

✗ Quartan malaria is severe
✓ usually mild; can last years.