

# Irrigation and Drainage Engineering

(Soil Water Regime Management)

(ENV-549, A.Y. 2024-25)

4ETCS, Master option

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Platform of Hydraulic Constructions



Lecture 9-1. Impact of irrigation: water-borne diseases and sanitary impact

## 5. Sanitary impacts of irrigation networks

Extension of water-borne diseases: spread by vectors associated with water bodies and irrigation (malaria, schistosomiasis, onchocerciasis, etc.).



# Main water-related diseases

## Role of water

Carries the contaminating agent when ingested directly

Insufficient water

Favours the proliferation of vectors or intermediate hosts

## Type of disease

Dysentery, cholera, typhus, hepatitis, amoebiasis, arsenicosis, etc.

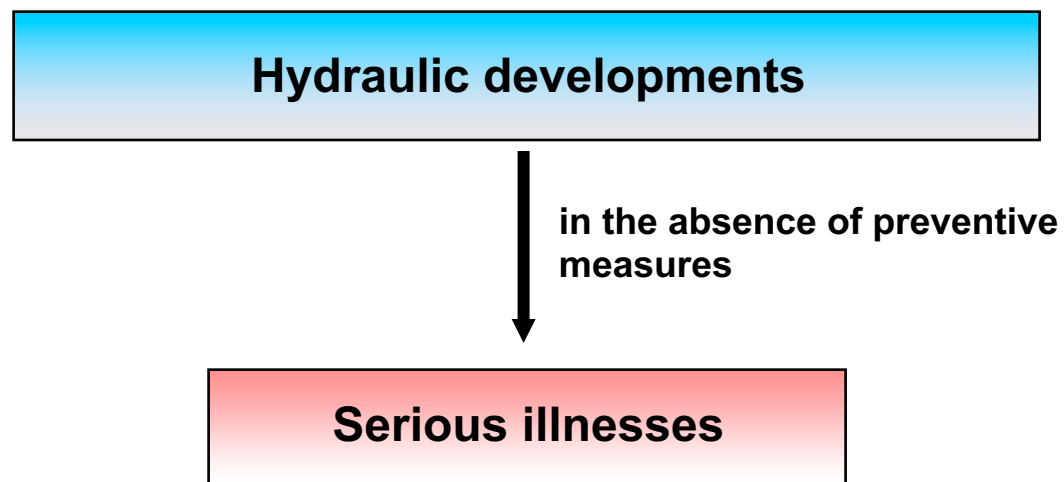
Leprosy, diarrhoea, conjunctivitis, etc.

Malaria, schistosomiasis, onchocerciasis, yellow fever, etc.



*According to the WHO, 80% of the world's diseases are directly or indirectly linked to water.*

**Solution:** build water supply systems that ensure hygiene and safety, efficient sanitation systems and appropriate hydraulic developments



- malaria
- schistosomiasis
- onchocerciasis
- etc.

Propagation is indirectly linked to water, which favours the creation of biotopes favourable to the proliferation of vectors or intermediate hosts.



## Vectors and intermediate hosts

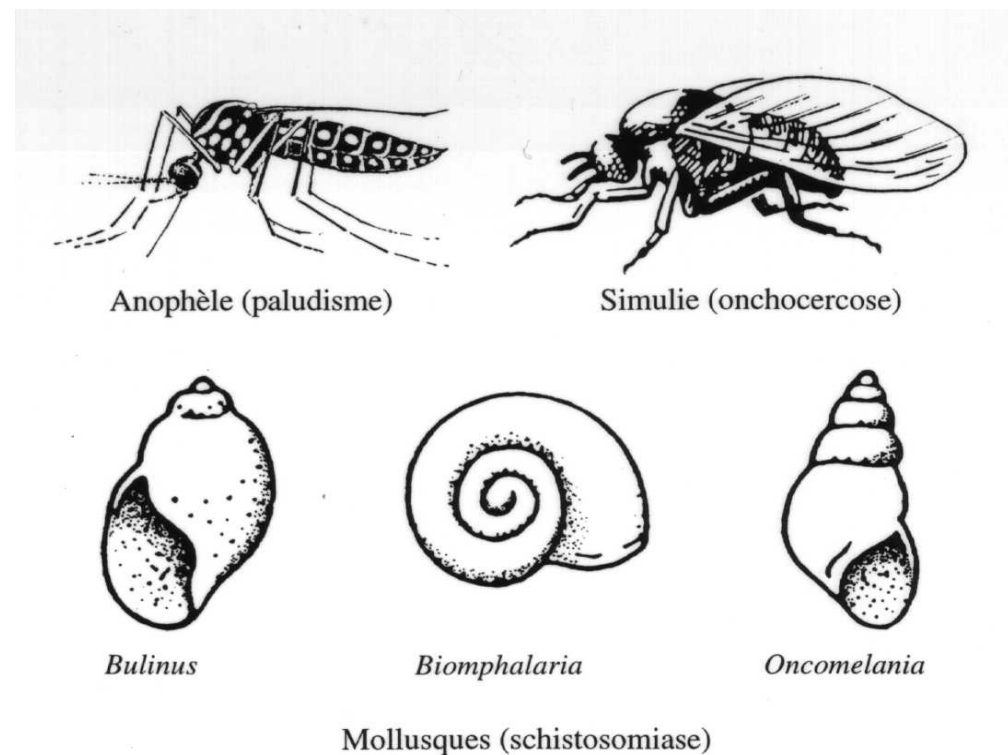
Animals that transmit or allow the development of the parasite that causes the disease. The parasite is the temporary host of the vector, where it generally undergoes evolution.

### Mosquitoes :

- **anopheles** vectors of **malaria**
- **simulium** (black fly) vectors of **onchocerciasis**

### Molluscs :

transmission of **schistosomiasis**.



Link to water: vectors live in water (molluscs) or require an aquatic environment at certain stages of their development (mosquitoes).



Anopheles



Simulium



Biomphalaria

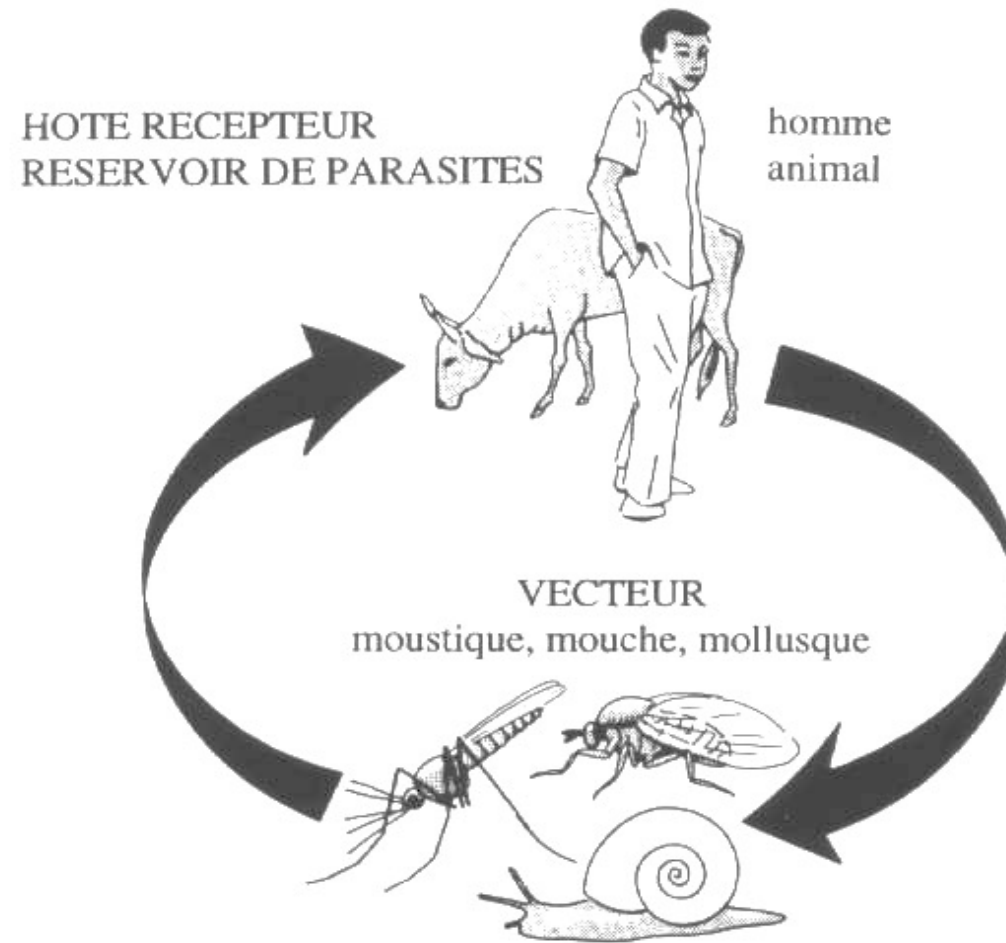


Bulinus



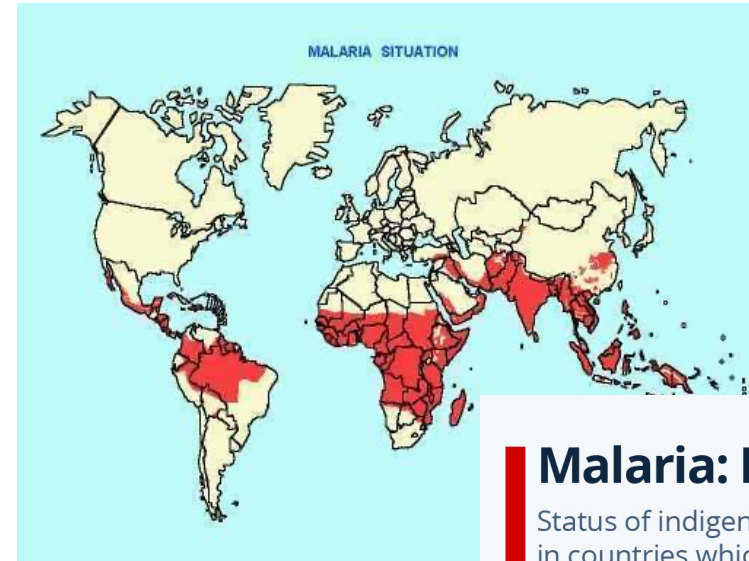
Oncomelania

## Spread of vector-borne diseases



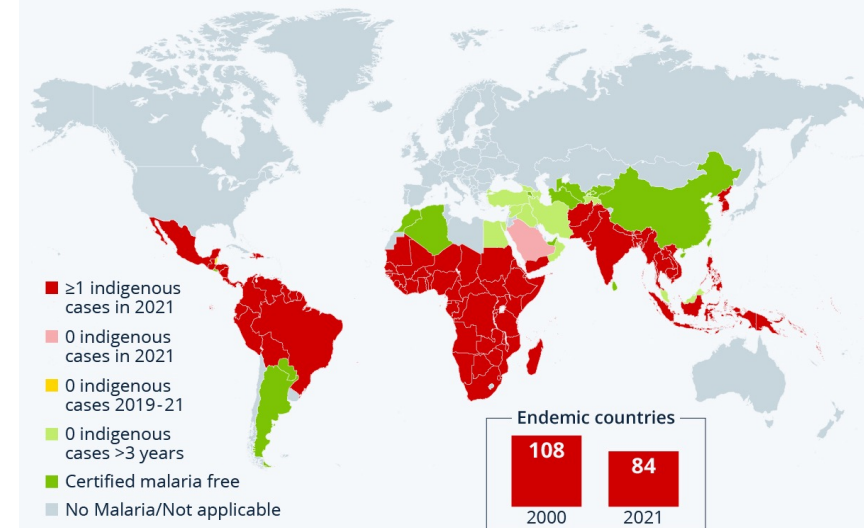
# Malaria

- is rife in more than 90 countries
- 40% of the world's population live in high-risk areas
- 300 to 500 million people affected by the disease
- more than 1 million deaths each year, mainly among children under the age of 5



## Malaria: Progress and Challenges

Status of indigenous malaria cases in 2021  
in countries which had at least one case in 2000



Source: World Health Organization

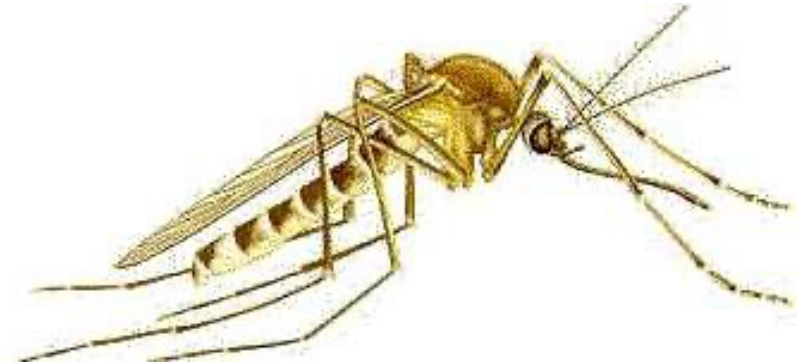




# Malaria

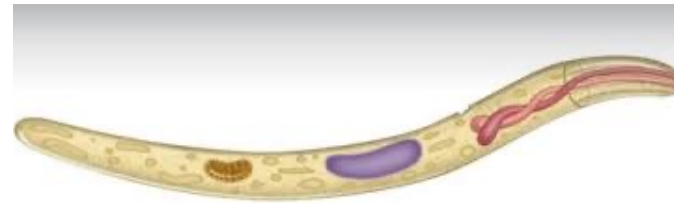
**Vector:** anopheles (mosquito)

**Link with water:** anopheles lays its eggs on the edges of bodies of water or liquid surfaces

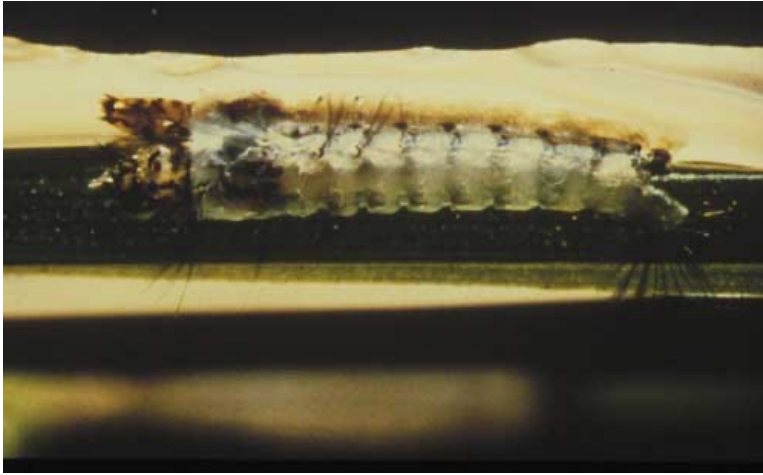


Anophèle

**Parasite:** Plasmodium (protozoa, unicellular eukaryota)



**Mode of action:** the parasites penetrate the red blood cells, multiply and burst them



**Anopheles larva  
(malaria vector)**

Anopheles lays its eggs on the edges of bodies of water or liquid surfaces; some species prefer fresh, clear water, while others prefer brackish or polluted water.



**Anopheles mosquito**



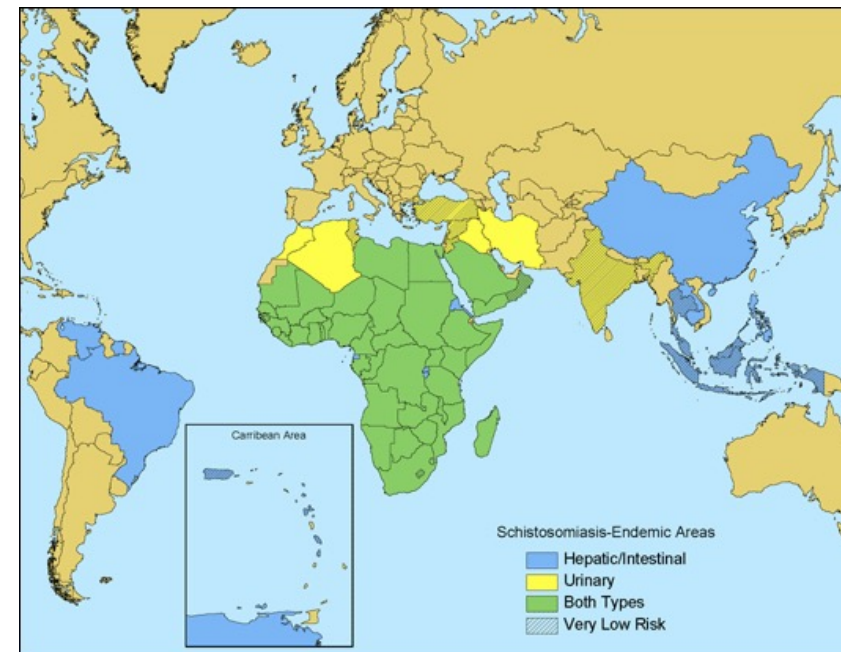
**Typical sites of Anopheles proliferation**





# Schistosomiasis

- 200 million people infected
- is rife in 74 tropical countries
- 500 to 600 million people live in high-risk areas



**Geographic distribution of schistosomiasis**



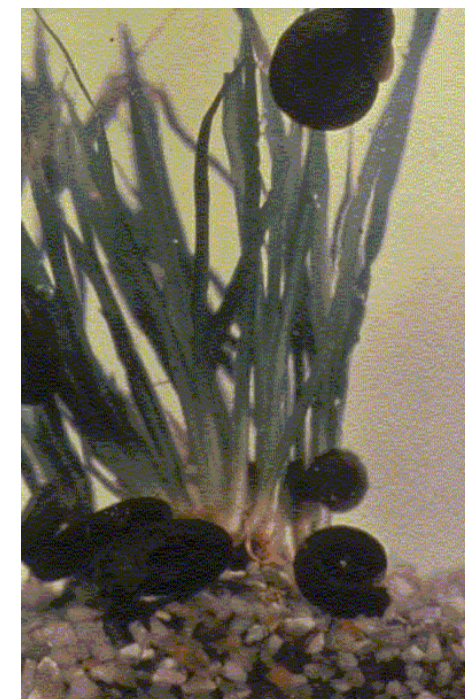
# Schistosomiasis

Intermediate hosts: molluscs

Link with water: molluscs live in shallow water (20 - 30 cm) with a slow current (< 70 cm/s), rich in aquatic plants\*.

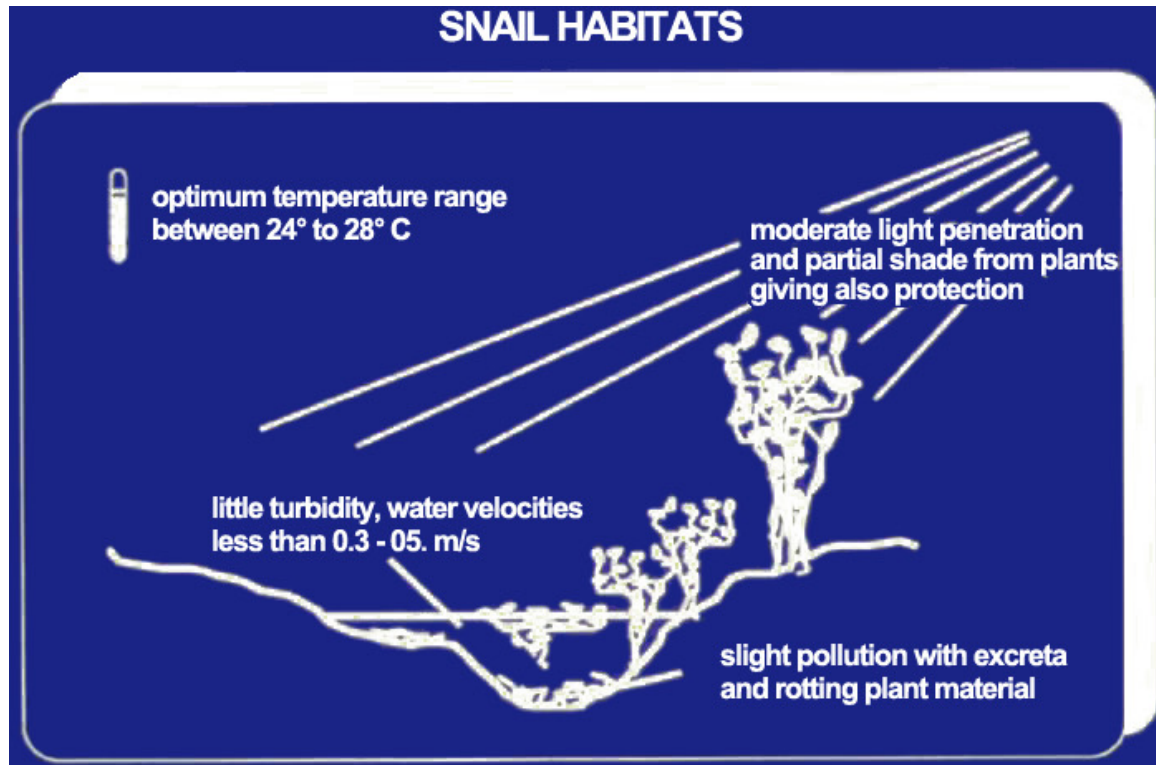
Parasite : schistosome

Mode of action: once in the ma-lad's circulatory system, schistosomes mate and migrate to the intestines or bladder. The females lay numerous eggs, which are expelled in the urine or faeces. If they come into contact with water, the eggs hatch. They develop in the presence of a mollusc, on which they remain for some time before being released and passing through human skin on contact with contaminated water.



\* ponds, banks of lakes and rivers, irrigation and drainage channels, rice fields, etc.

## SNAIL HABITATS

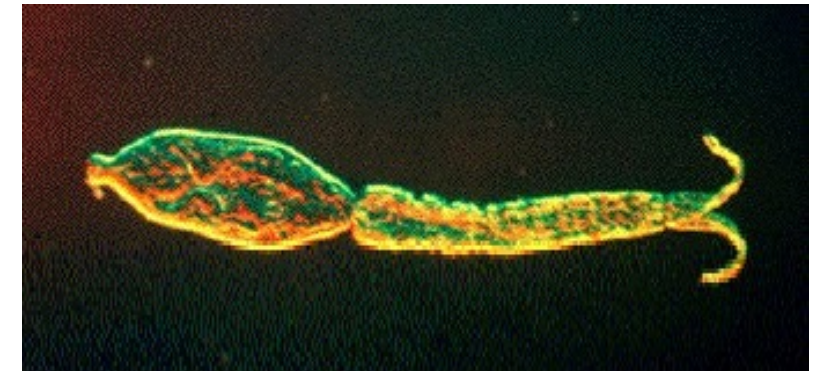
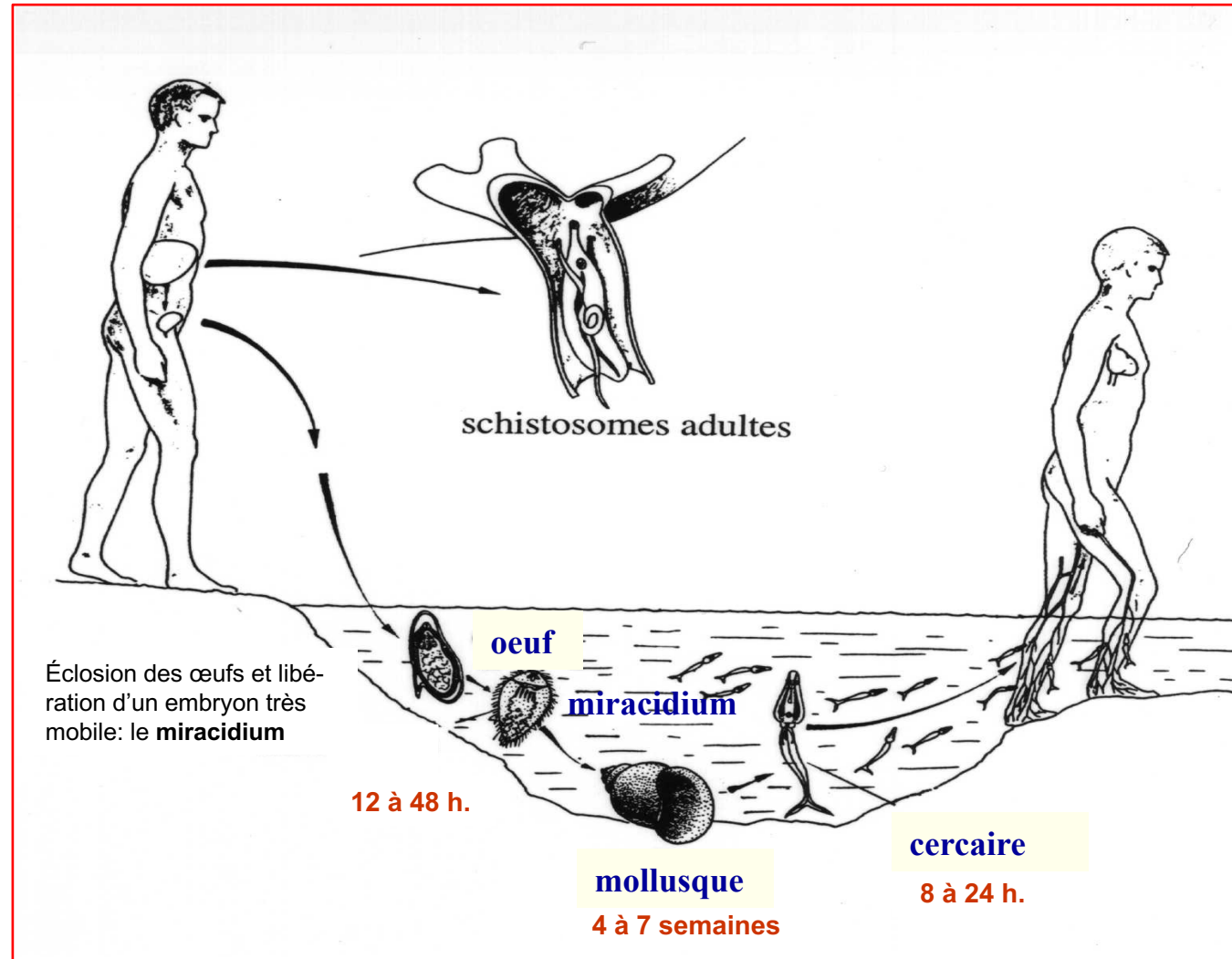


Habitats favourable to molluscs



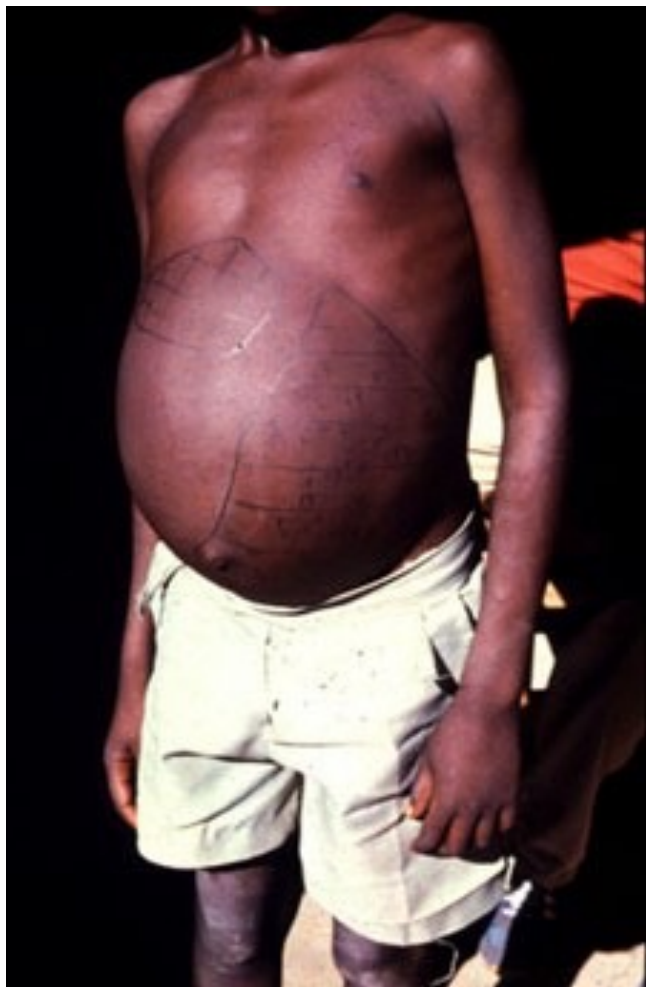
Mated adult schistosomes; the female, longer (20 mm) and thinner, lives permanently in the male's ventral gutter and lays between 30 and 3,000 eggs per day.

## Mode of transmission of schistosomiasis



Cercaria: larval form of the schistosome released by molluscs (approx. 1 mm)





**People exposed to schistosomiasis**



**Patients with schistosomiasis**



# Onchocerciasis

**Parasites** : filariae (thread-like worms living in nodules under the skin). The female lays 1000 to 3000 embryos (microfilariae) per day.

**Manifestations** : microfilariae move through the patient's dermis; when they reach the eye, they can cause blindness

**Vectors** : Simulium

**Link with water**: The simulium lays its eggs in fast flowing water ( $> 70$  cm/s), highly oxygenated and sunny





**Adult filaria (parasite)**



**Simulium (vector)**

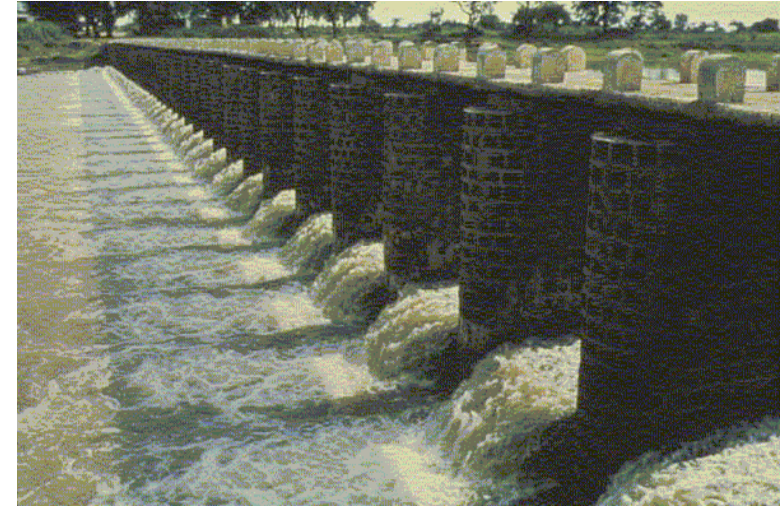


**Patients with  
onchocerciasis**



Photos tirées de: <http://www.icp.ucl.ac.be/~opperd/parasites/onch1.html>

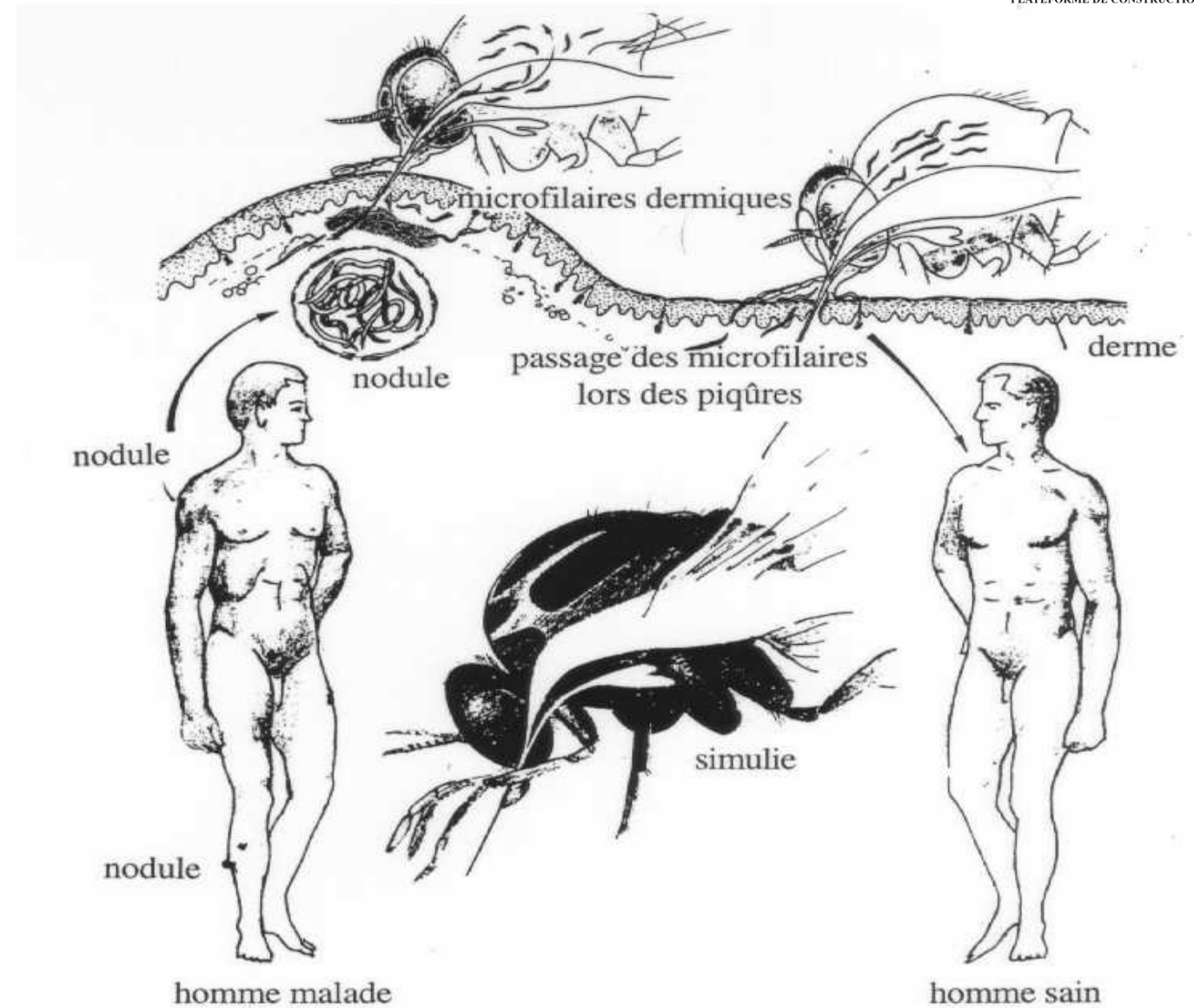




**Nesting sites for egg-laying simuliids  
(vectors of onchocerciasis)**



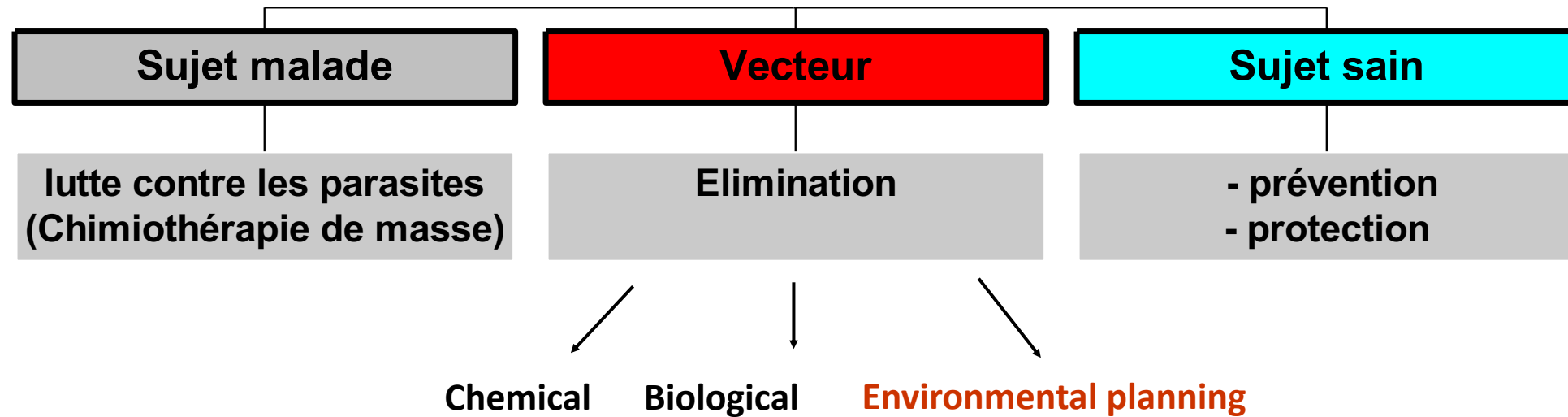
## Mode of transmission of onchocerciasis





# Fighting waterborne diseases transmission

Disease transmission = 3-component cycle



Distribution of ivermectin to treat onchocerciasis



Chemical treatment of a simulium larvae breeding site by helicopter

## Fighting against vectors

- **Chemical control (insecticides, larvicides, molluscicides)**
  - ✓ *Not always selective and biodegradable*
  - ✓ *Appearance of genetic resistance\**
- **Biological control**
  - ✓ *Use of vector predators (fish, birds, pathogens (bacteria, viruses), etc.)*
  - ✓ *Trapping of males, sterilising radiation, etc.*
- **Environmental planning**

\* by selection of resistant species or by mutations in previously susceptible species



## Biological control of aquatic weeds by fish



Grass carp: vegetarian fish



- Introduced in over 50 countries for this purpose
- Carp density needs to be carefully controlled; in excess, elimination of vital aquatic habitats → banned in some US states



## Biological control of aquatic weeds by insects



Charançons de la jacinthe d'eau (*N. eichhorniae*)



Coléoptère pour le contrôle de l'herbe à alligator



Jacinthes d'eau



Herbe à alligator



## Biological control of mosquito larvae by fish



**Mosquito fish**

**(Gambusia sauvage\*)**



\* 3 to 5 cm; can swallow up to 500 mosquito larvae a day

## Environmental planning

**General rule:** modify the environment to make it hostile to the hatching and development of vectors.

### Actions de base

- reduce the opportunity for vegetation to grow on bodies of water; if necessary, remove this vegetation
- remove shallow areas of stagnant water (marshes, ponds, etc.) and persistent puddles
- prevent the formation of turbulence and self aeration in exposed places: overflows, waterfalls, sluices, siphons, etc.







**Seepage and conveyance water losses**



**Canal side breakage due to animal burrowing**



**Weed growth and too closely sited settlement**



**Leaking tubing for sprinkler irrigation**