

# Chapter 7

## Protists: A Microbial Grab Bag

**Objectives:** After reading Chapter Seven, you should understand...

- The general features of protists, including their structures and physiology.
- The characteristics of the four groups of protozoa.
- Some of the diseases caused by protozoa.

**Protists** are a mixed group of microbes sometimes considered “taxonomic misfits”.

### The Five-Kingdom System of Classification

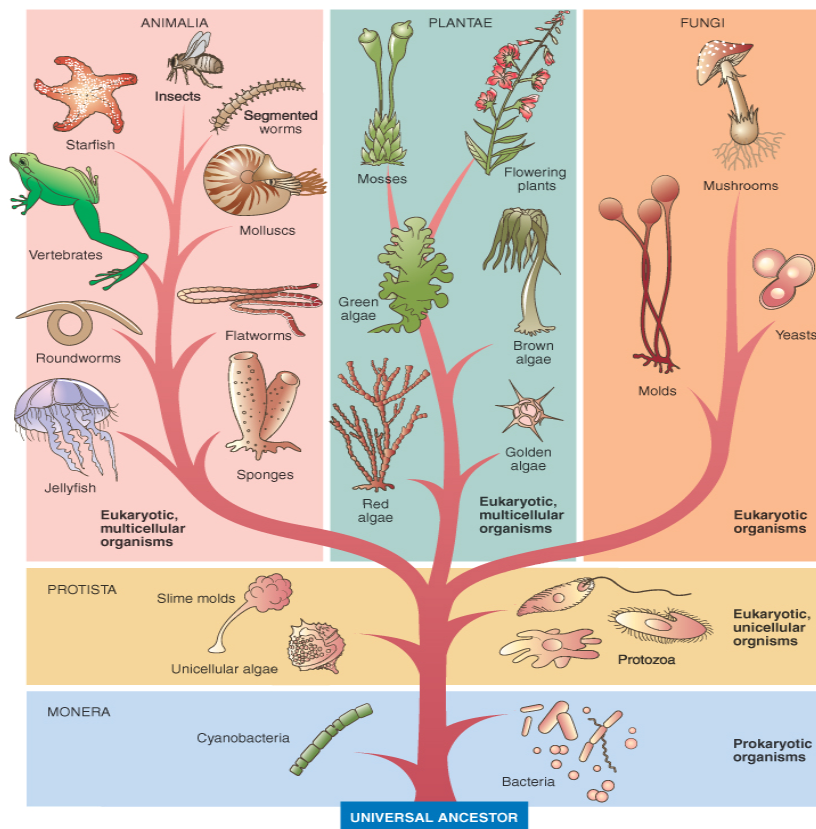


Figure 2.3

*Microbes and Society*  
I. Edward Alcamo  
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**Adaptation** to diverse environments exceeded only by bacteria...because they represent such a diverse group...

- All are **eukaryotic**.
- Most are microscopic, but some are as large as 1 mm in diameter/length.
- They have diverse modes of feeding.

*Phagocytosis* – engulf their food

*Absorption* – move food through the outer membrane.

- Some are parasitic.
- Some are photosynthetic.
- Some can move purposefully.
- Some are fungus-like, animal-like, or plant-like.
- Asexual reproduction is dominant, but sexual reproduction sometimes occurs.

We will focus on the **Protozoa** (also called **zooplankton** in marine and freshwater environments) and **single-celled algae**.

## PROTOZOA

Named such because they were **once** thought to be the first organisms on the planet.

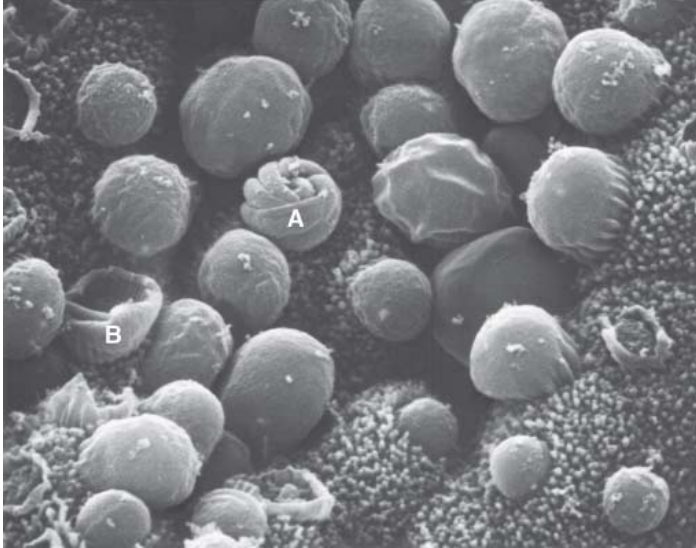
*proto* = **first, new**      *zoan* = **animal**

Most are found in **moist** environments.



Under **ideal conditions** they are found as feeding bodies called **trophozoites**.

Some form **cysts** (non-feeding bodies) to withstand environmental stress (like a spore).



**Cysts of *Cryptosporidium* spp. at the surface of intestinal tissue.  
From: Current, W.L. and Garcia, L.S.; Clin Microbiol Rev, 1991  
July; 4(3): 325-358.**

### **How to classify protozoa**

This is such a diverse group that many means of classification could be used.

e.g., mode of feeding, mode of reproduction, morphology, etc.

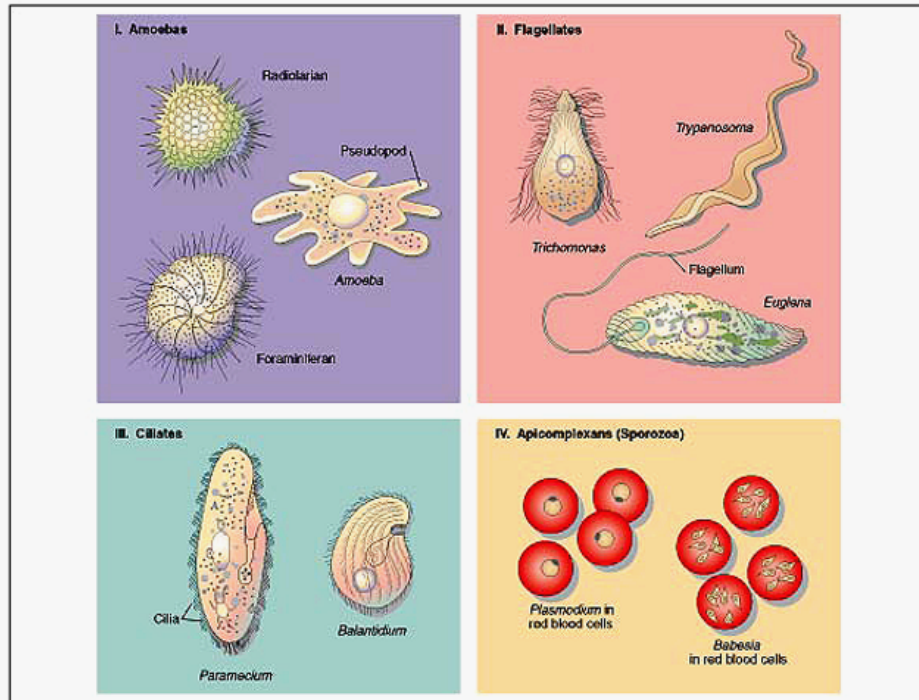
We will use the **means of locomotion** as a classification system.

Four major groups:

- 1. Amoeba** – protozoa that move by **pseudopodia**
- 2. Flagellates** – move by flagella
- 3. Ciliates** – move by cilia (will not discuss)
- 4. Sporozoa** – non-motile in the adult form

The Four Major Groups of Protozoa

Figure 5.3



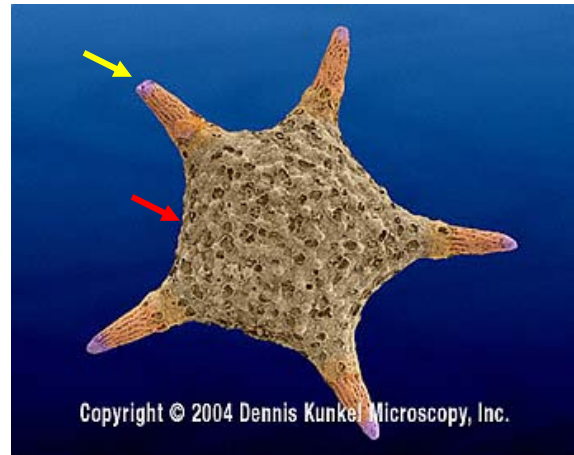
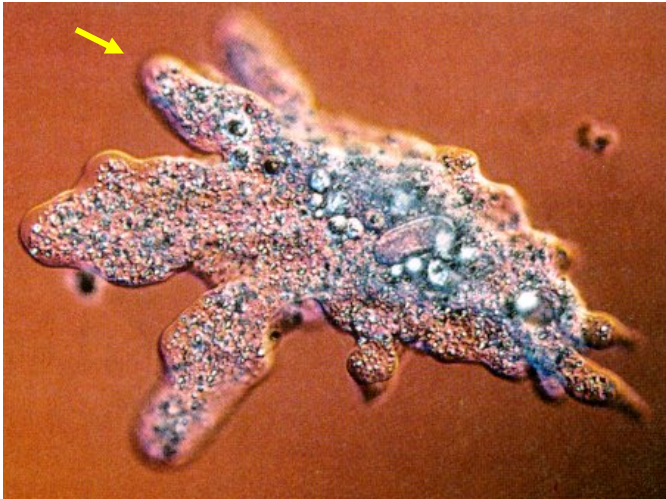
Amoeba

Known for their **plasticity**, as they change shape constantly.





The amoeba feature **pseudopodia** (yellow arrow) – temporary cellular extensions used for movement and feeding.



“Star sand” from Japan

Movement occurs as alternating liquid and gel states form within the cell.

Some amoeba form **tests** (red arrow), or shell-like castings.

The **foraminifera** are a **marine amoeba** that produce chalky shells with many pores through which pseudopodia move in and out as the organism feeds.

Can build up as dense deposits on the ocean floor.

The **White Cliffs of Dover** is the result of geologic uplifting of these deposits.

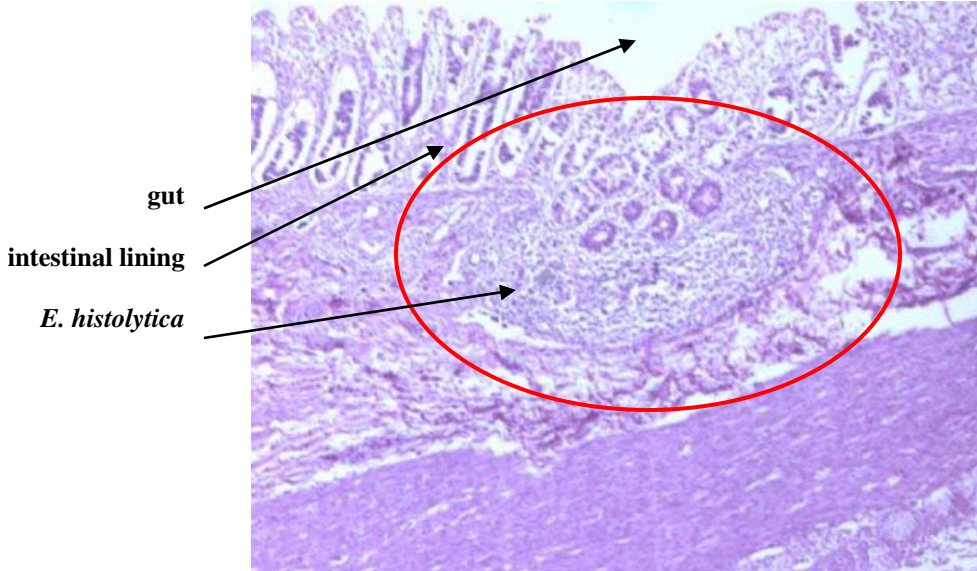


Since the foraminifera flourished at the same time as many **oil deposits** were being formed, they are useful as a depth marker for geologists drilling for oil.

**Pathogenic amoeba** - Relatively few exist, but some are important.

1. *Entamoeba histolytica* – causes **amoebiasis**

Transmitted by contaminated water and food containing cysts.



Responsible for ulcers and appendicitis-like pain.

Third leading cause of morbidity and mortality due to parasitic disease in humans (after malaria and schistosomiasis)

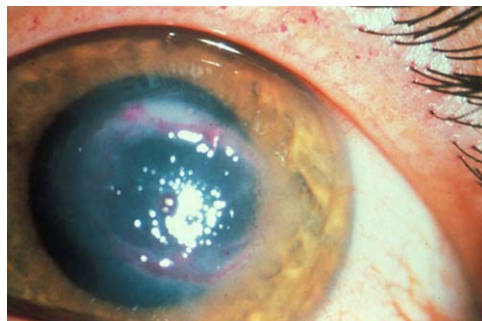
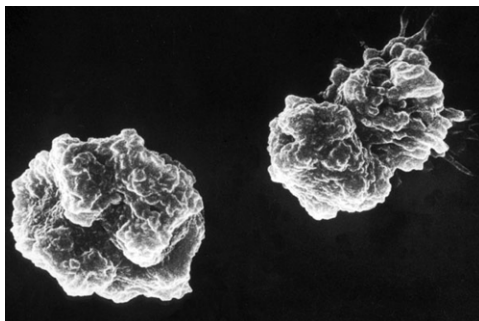
Causes between 50,000 and 100,000 deaths every year

2. *Acanthamoeba spp.* – commonly found in the environment.

Found in soil and dust, in fresh water sources such as lakes, rivers, and hot springs and in hot tubs.

Eye infections can result from contact lens cases becoming contaminated with *Acanthamoeba spp.* after improper cleaning and handling.

**Keratitis** - infection of the cornea (don't sleep in your contacts)



## Flagellates

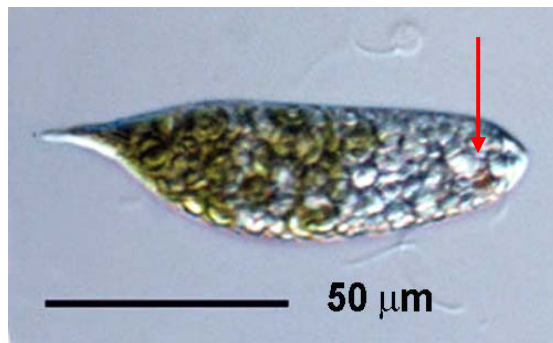
Distinguishing feature: All have **flagella** (from Latin *flagellum* = to “whip”)

In many ways, flagellates “**span the gap**” between *lower* and *higher* organisms.

1. ***Euglena spp.*** are well-adapted flagellates.

Live in fresh water and are especially common in warm seasons when they may form a green scum on the surfaces of small ponds or drainage ditches.

25 - 250  $\mu\text{m}$  long.



**In sunlight**, it can photosynthesize and create carbohydrates for energy.

**Plant-like**

**In the dark**, the photosynthetic pigments degrade and it feeds heterotrophically.

**Animal-like**

The *Euglena spp.* **eyespot** makes them more advanced than the organisms we have discussed thus far.

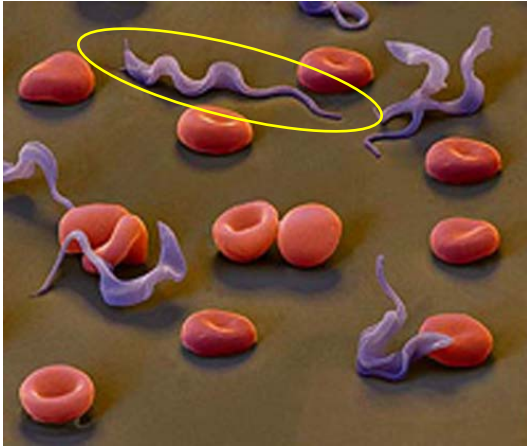
The eyespot is a light sensitive **organelle** that allows the euglena to sense light in its surroundings.

One problem: How does it know from which direction the light is coming?

A pigment covers **one** side of the organelle so that the *Euglena spp.* can determine from which direction the light is coming.

**Why would it want to know where the light is?**

2. *Trypanosoma* spp. – parasites that cause African and South American sleeping sickness.



*Trypanosoma* spp. with red blood cells



A triatomid bug

Commonly transmitted via the **tsetse fly** (Africa) bite or **triatomid bugs** (South America)

*Trypanosoma* spp. enter the bloodstream, and then invade brain tissue.

Causes a coma-like condition

South American sleeping sickness is often accompanied by severe **heart infection**.

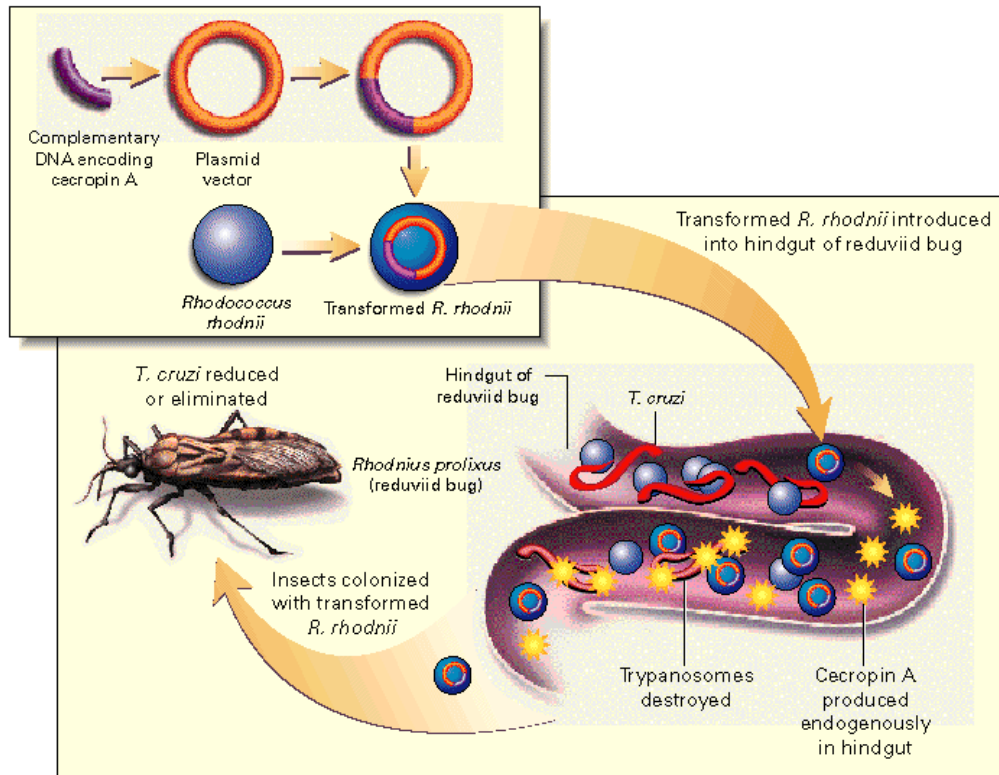
Despite some treatments, *Trypanosoma* spp. infections remain a real problem, but some measures can help to eliminate *Trypanosoma* spp. from the triatomid's gut.

*Rhodococcus rhodnii* is a **symbiont bacterium** of the triatomid.

Researchers have **genetically-altered** *R. rhodnii* to produce a protein that is extremely active against *Trypanosoma* spp.

Altered *R. rodnii* are then inoculated into triatomid bugs. When released into the wild, it is hoped that the transformed bugs will out-compete the wild-type triatomids.





From: Conte, 1997. *New England Journal of Medicine*. 337:785-786.

## Sporozoa

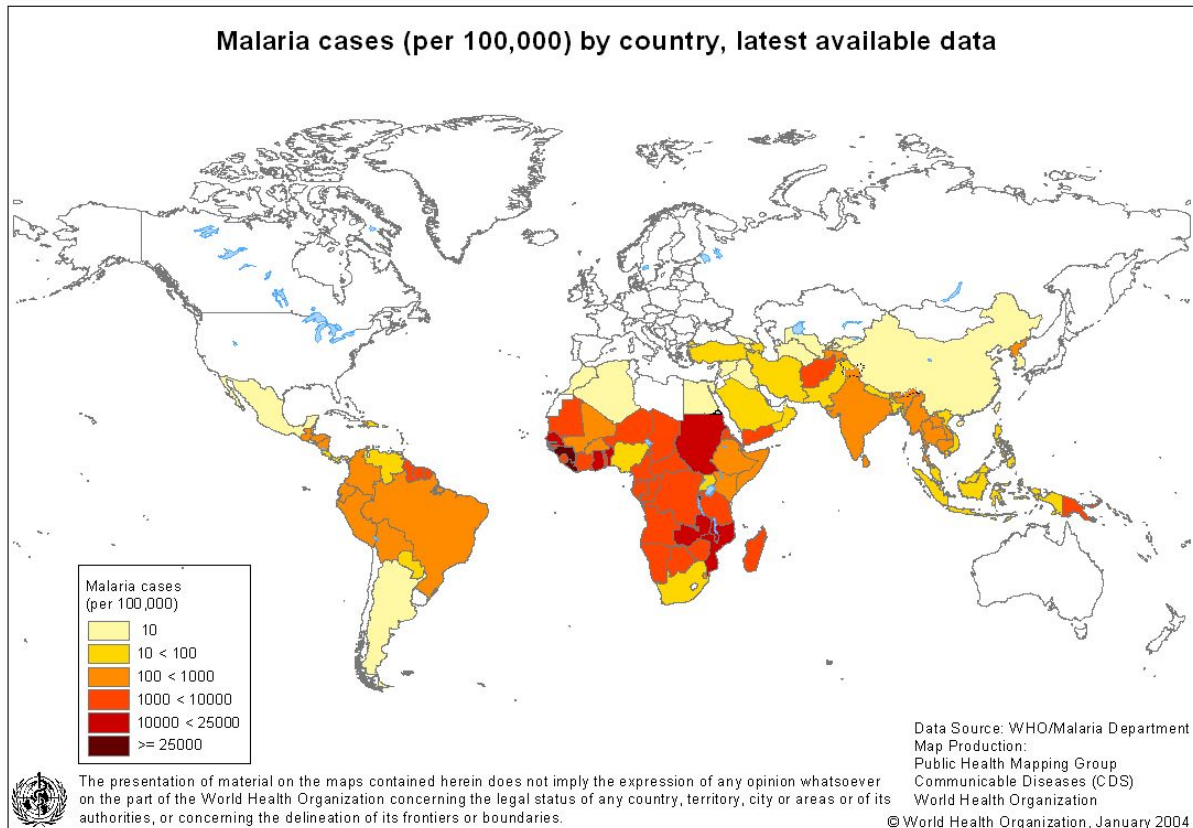
Distinguishing feature – at some stage of life cycle they will form a **spore-like** body.

Virtually all are parasitic and cause serious disease in humans and animals.

The most well known sporozoa are *Plasmodium spp.*, which cause **malaria**.

Most important health issue in the world.

The incidence of malaria in the world is estimated to be 300-500 million clinical cases annually and an estimated **1.5 to 2.7 million people** die of malaria each year.



## The malaria disease process

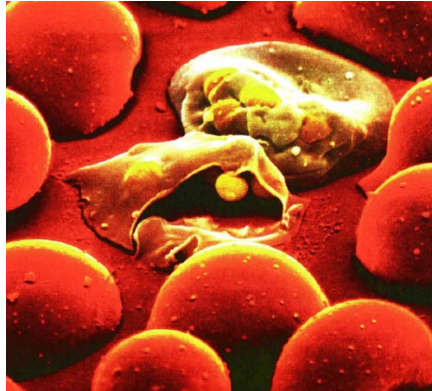
Malaria is blood-borne and transmitted by ????

After a single sporozoite (the parasite form inoculated by the female mosquito) of *Plasmodium falciparum* invades a liver cell, the parasite grows in 6 days and produces 30,000-40,000 daughter cells (merozoites).

The daughter cells are released into the blood when the liver cell ruptures.

In the blood, after a single merozoite invades a red blood cell, the parasite grows in 48 hours and produces 8-24 daughter cells, which are released into the blood when the red blood cell ruptures

Essentially, *Plasmodium spp.* causes severe **anemia** as it destroys red blood cells.



Red blood cells in the process of being destroyed by *Plasmodium spp.*

People in regions of the world (tropical) where malaria is prevalent have developed a means of **resistance to malaria**.

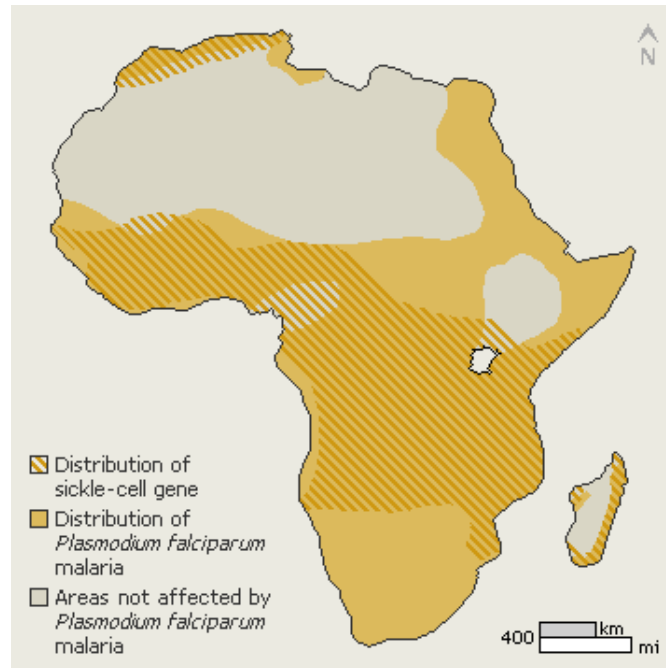
Red blood cells that assume a distorted shape can resist penetration by *Plasmodium spp.*

Identical to what we know as sickle cells.

Why can this sickle shape sometimes be a problem?



The geographical distribution of the **gene for hemoglobin S** (which causes the sickle shape) and the **distribution of malaria** in Africa virtually overlap.



Malaria (*Plasmodium* spp.) does not occur in the cooler, drier climates of the highlands, but rather in the tropical and subtropical regions of the world.

Thus, people indigenous to those highland regions of the continent do not display the high expression of the sickle hemoglobin gene like their lowland neighbors in the malaria belts.

The distribution of *Plasmodium* spp. primarily in Africa is the reason that sickle cell anemia is popularly known as a disease of people of African-American descent (**1 in 12 carry the gene**).

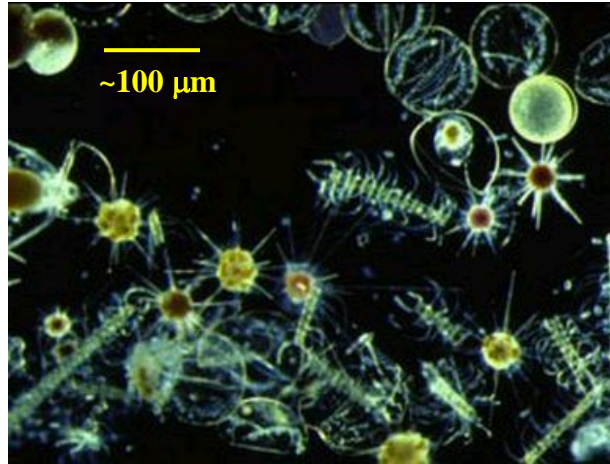
Malaria has, in essence, **selected** for sickle cell traits in that part of the world.



## UNICELLULAR ALGAE

Comprise the aquatic life known as **phytoplankton**.

Live near the ocean surface and generate energy through photosynthetic activity.



### **Are phytoplankton important?**

Three important unicellular algae groups:

#### **1. Pyrrophyta - the “fire” algae**

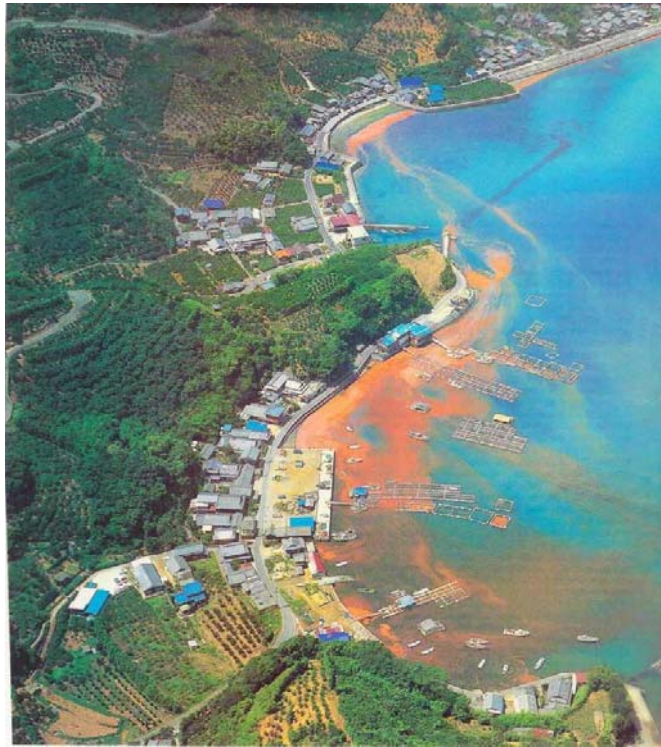
Bright red/orange pigments.

Responsible for “red tide”



From: [lifeinfreshwater.org.uk](http://lifeinfreshwater.org.uk)

Estuarine or marine algal bloom and is caused by a species of dinoflagellate called *Karenia brevis*.



Example of the red tide in Lake Tahoe. From: [http://ic.ucsc.edu/~flegal/etox80e/SpecTopics/AlgalBlooms/alg\\_p1.jpg](http://ic.ucsc.edu/~flegal/etox80e/SpecTopics/AlgalBlooms/alg_p1.jpg)

Blooms occur almost annually in waters along Florida's coast.

The density of *K. brevis* during a bloom can exceed **tens of millions of cells per liter** of seawater, which discolors the water a deep, reddish-brown hue.

*K. brevis* produces **brevetoxins** that after oral ingestion (from water directly or seafood) can cause a combination of gastrointestinal and neurologic disorders.

Toxin binds to nerve cells, leading to disruption of normal neurological processes and causing the illness clinically described as neurotoxic shellfish poisoning (NSP).

**What causes red tides?** No one really knows but several causes have been hypothesized.

1. Coastal water pollution
2. Increased water temperatures
3. Iron-rich dusts blown from the Sahara Desert

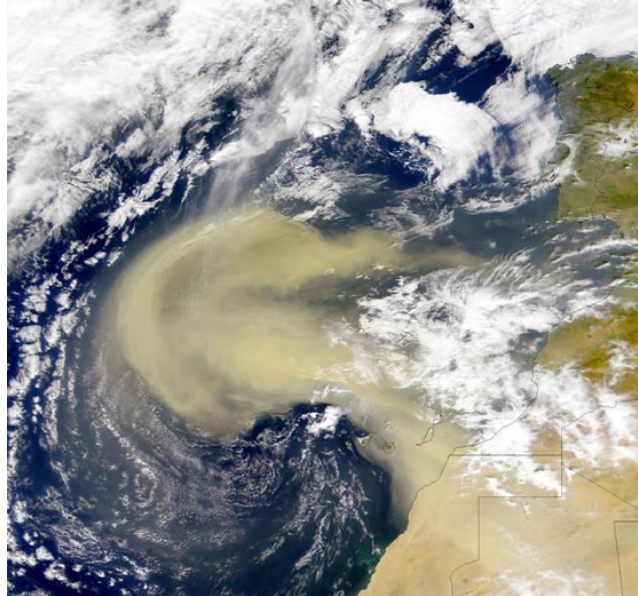


Image from NASA

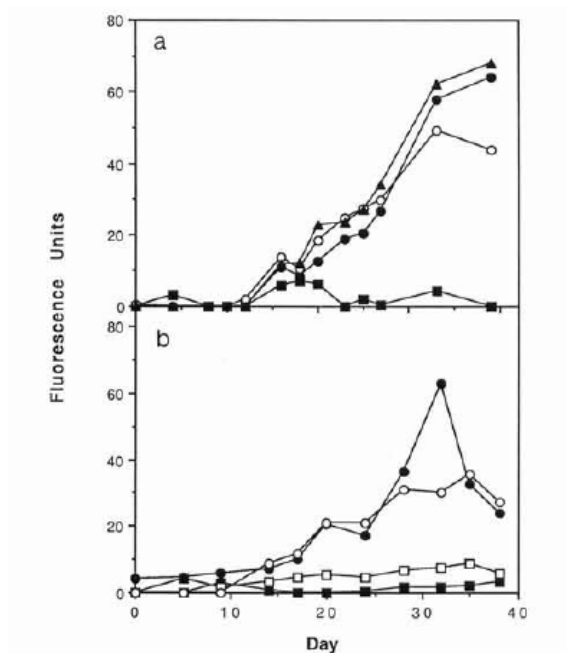


Fig. 2. *Alexandrium tamarense*. Growth response in sequential (a, b) batch cultures with added ferrihydrite. Fe additions: (■) no added Fe; (○) 5 nM ferrihydrite; (◊) 10 nM ferrihydrite; (△) 25 nM ferrihydrite; (▲) 50 nM ferrihydrite

From: Wells et al., *Mar. Ecol. Prog. Ser.* 69: 93-102, 1991



*Alexandrium tamarense*.  
From: [www.nefsc.noaa.gov](http://www.nefsc.noaa.gov)

## 2. Diatoms.

Intricate shells of silicon dioxide.

Major component of the phytoplankton and in the oceanic food chain.

**Diatomaceous earth** is made of fossilized diatoms.

Used as a filtering material for swimming pool- and aquarium filters.



## 3. Water molds

Diagnostic feature - **flagellated spores = zoospores.**

What advantage might the presence of a flagellum give to the zoospores vs. bacteria spores?

Downy mildews and powdery mildews are important economically (*Phytophthora spp.*).





**Phytophthora blight of peppers**

Water mold caused the Great Potato Blight in Ireland in the 1840s.

