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SCHOOL OF BIO AND CHEMICAL ENGINEERING

DEPARTMENT OF BIOTECHNOLOGY

UNIT – I – PHYCOLOGY AND MEDICAL PARASITOLOGY – SMB3104

UNIT 1 CLASSIFICATION

Algae in diversified habitats (terrestrial, fresh water, marine) thallus organization, cell ultrastructure, reproduction (vegetative, asexual, sexual) criteria for classification of algae: pigments, reserve food, flagella, modern classification.

Algae

From Wikipedia, the free encyclopedia

Algae (/ˈældʒi, ˈælɡi/; singular **alga** /ˈælɡə/) is an informal term for a large and diverse group of photosynthetic eukaryotic organisms. It is a polyphyletic grouping which includes species from multiple distinct clades. Included organisms range from unicellular microalgae, such as *Chlorella* and the diatoms, to multicellular forms, such as the giant kelp, a large brown alga which may grow up to 50 metres (160 ft) in length. Most are aquatic and autotrophic and lack many of the distinct cell and tissue types, such as stomata, xylem and phloem, which are found in land plants. The largest and most complex marine algae are called seaweeds, while the most complex freshwater forms are the Charophyta, a division of green algae which includes, for example, *Spirogyra* and stoneworts.

No definition of algae is generally accepted. One definition is that algae "have chlorophyll as their primary photosynthetic pigment and lack a sterile covering of cells around their reproductive cells".[2] Although cyanobacteria are often referred to as "blue-green algae", most authorities exclude all prokaryotes from the definition of algae.[3][4]

Algae constitute a polyphyletic group[3] since they do not include a common ancestor, and although their plastids seem to have a single origin, from cyanobacteria,[5] they were acquired in different ways. Green algae are examples of algae that have primary chloroplasts derived from endosymbiotic cyanobacteria. Diatoms and brown algae are examples of algae with secondary chloroplasts derived from an endosymbiotic red alga.[6]

Algae exhibit a wide range of reproductive strategies, from simple asexual cell division to complex forms of sexual reproduction.[7]

Algae lack the various structures that characterize land plants, such as the phyllids (leaf-like structures) of bryophytes, rhizoids in nonvascular plants, and the roots, leaves, and other organs found in tracheophytes (vascular plants). Most are phototrophic, although some are mixotrophic, deriving energy both from photosynthesis and uptake of organic carbon either by osmotrophy, myzotrophy, or phagotrophy. Some unicellular species of green algae, many golden algae, euglenids, dinoflagellates, and other algae have become heterotrophs (also called colorless or apochlorotic algae), sometimes parasitic, relying entirely on external energy sources and have limited or no photosynthetic apparatus.[8][9][10] Some other heterotrophic organisms, such as the apicomplexans, are also derived from cells whose ancestors possessed plastids, but are not traditionally considered as algae. Algae have photosynthetic machinery ultimately derived from cyanobacteria that produce oxygen as a by-product of photosynthesis, unlike other photosynthetic bacteria such as purple and green sulfur bacteria. Fossilized filamentous algae from the Vindhya basin have been dated back to 1.6 to 1.7 billion years ago.[11]

Etymology and study

The singular *alga* is the Latin word for 'seaweed' and retains that meaning in English.[12] The etymology is obscure. Although some speculate that it is related to Latin *algēre*, 'be cold',[13] no reason is known to associate seaweed with temperature. A more likely source is *alliga*, 'binding, entwining'.[14]

The Ancient Greek word for 'seaweed' was φῦκος (*phŷkos*), which could mean either the seaweed (probably red algae) or a red dye derived from it. The Latinization, *fūcus*, meant primarily the cosmetic rouge. The etymology is uncertain, but a strong candidate has long been some word related to the Biblical פוך (*pūk*), 'paint' (if not that word itself), a cosmetic eye-shadow used by the ancient Egyptians and other inhabitants of the eastern Mediterranean. It could be any color: black, red, green, or blue.[15]

Accordingly, the modern study of marine and freshwater algae is called either phycology or algology, depending on whether the Greek or Latin root is used. The name *fucus* appears in a number of taxa.

Classifications

The committee on the International Code of Botanical Nomenclature has recommended certain suffixes for use in the classification of algae. These are **-phyta** for division, -*phyceae* for class, -*phycideae* for subclass, -*ales* for order, -*inales* for suborder, -*aceae* for family, -*oidease* for subfamily, a Greek-based name for genus, and a Latin-based name for species.

Algal characteristics basic to primary classification

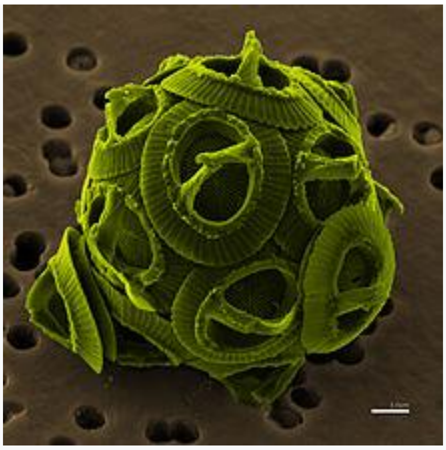
The primary classification of algae is based on certain morphological features. The chief among these are (a) pigment constitution of the cell, (b) chemical nature of stored food materials, (c) kind, number, point of insertion and relative length of the flagella on the motile cell, (d) chemical composition of cell wall and (e) presence or absence of a definitely organized nucleus in the cell or any other significant details of cell structure.

History of classification of algae

Although Carolus Linnaeus (1754) included algae along with lichens in his 25th class Cryptogamia, he did not elaborate further on the classification of algae.

Jean Pierre Étienne Vaucher (1803) was perhaps the first to propose a system of classification of algae, and he recognized three groups, Conferves, Ulves, and Tremelles. While Johann Heinrich Friedrich Link (1820) classified algae on the basis of the colour of the pigment and structure, William Henry Harvey (1836) proposed a system of classification on the basis of the habitat and the pigment. J. G. Agardh (1849–1898) divided algae into six orders: Diatomaceae, Nostochineae, Confervoideae, Ulvaceae, Floriadeae and Fucoideae. Around 1880, algae along with fungi were grouped under Thallophyta, a division created by Eichler (1836). Encouraged by this, Adolf Engler and Karl A. E. Prantl (1912) proposed a revised scheme of classification of algae and included fungi in algae as they were of opinion that fungi have been derived from algae. The scheme proposed by Engler and Prantl is summarised as follows:[16]

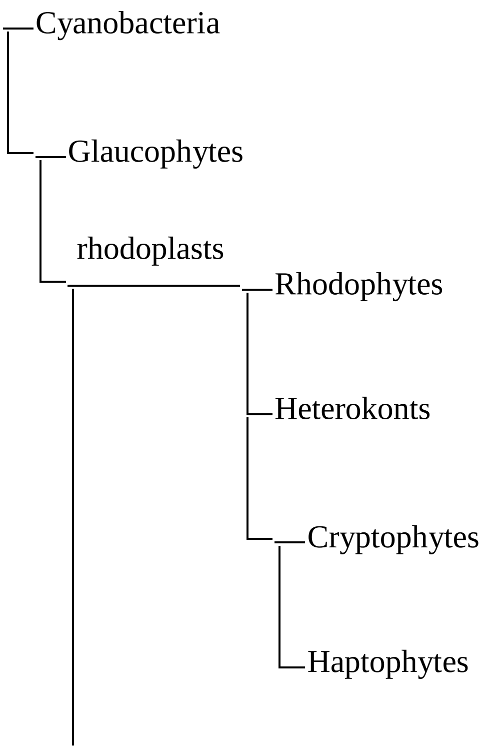
1. Schizophyta
2. Phytosarcodina
3. Flagellata
4. Dinoflagellata
5. Bacillariophyta
6. Conjugatae
7. Chlorophyceae
8. Charophyta
9. Phaeophyceae
10. Rhodophyceae
11. Eumycetes (Fungi)

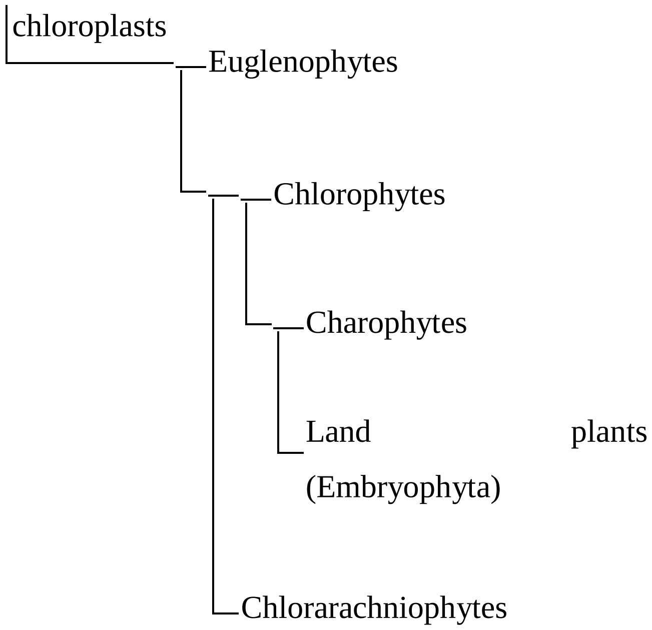


False-color scanning electron micrograph of the unicellular coccolithophore *Gephyrocapsa oceanica*

The algae contain chloroplasts that are similar in structure to cyanobacteria. Chloroplasts contain circular DNA like that in cyanobacteria and are interpreted as representing reduced endosymbiotic cyanobacteria. However, the exact origin of the chloroplasts is different among separate lineages of algae, reflecting their acquisition during different endosymbiotic events. The table below describes the composition of the three major groups of algae. Their lineage relationships are shown in the figure in the upper right. Many of these groups contain some members that are no longer photosynthetic. Some retain plastids, but not chloroplasts, while others have lost plastids entirely.

Phylogeny based on plastid[17] not nucleocytoplasmic genealogy:





Supergroup affiliation	Members	Endosymbiont	Summary
Primoplantae / Archaeplastida	• Chlorophyta • Rhodophyta • Glaucophyta	Cyanobacteria	These algae have "primary" chloroplasts, i.e. the chloroplasts are surrounded by two membranes and probably developed through a single endosymbiotic event. The chloroplasts of red algae have chlorophylls *a* and *c* (often), and phycobilins, while those of green algae have chloroplasts with chlorophyll *a* and *b* without phycobilins. Land plants are pigmented similarly to green algae and probably developed from them, thus the Chlorophyta is a sister taxon to the plants; sometimes the Chlorophyta, the Charophyta, and land plants are grouped together as the Viridiplantae.
Excavata and Rhizaria	• Chlorarachniophytes	Green algae	These groups have green chloroplasts containing chlorophylls *a* and *b*.[18] Their

	• Euglenids		chloroplasts are surrounded by four and three membranes, respectively, and were probably retained from ingested green algae. **Chlorarachniophytes**, which belong to the phylum Cercozoa, contain a small nucleomorph, which is a relict of the algae's nucleus. **Euglenids**, which belong to the phylum Euglenozoa, live primarily in fresh water and have chloroplasts with only three membranes. The endosymbiotic green algae may have been acquired through myzocytosis rather than phagocytosis.[19]
Chromista and Alveolata	• Heterokonts • Haptophyta • Cryptomonads • Dinoflagellates	Red algae	These groups have chloroplasts containing chlorophylls *a* and *c*, and phycobilins. The shape varies from plant to plant; they may be of discoid, plate-like, reticulate, cup-shaped, spiral, or ribbon shaped. They have one or more pyrenoids to preserve protein and starch. The latter chlorophyll type is not known from any prokaryotes or primary chloroplasts, but genetic similarities with red algae suggest a relationship there.[20] In the first three of these groups (Chromista), the chloroplast has four membranes, retaining a nucleomorph in cryptomonads, and they likely share a common pigmented ancestor, although other evidence casts doubt on whether the heterokonts, Haptophyta,

			and cryptomonads are in fact more closely related to each other than to other groups.[21][22] The typical dinoflagellate chloroplast has three membranes, but considerable diversity exists in chloroplasts within the group, and a number of endosymbiotic events apparently occurred.[5] The Apicomplexa, a group of closely related parasites, also have plastids called apicoplasts, which are not photosynthetic, but appear to have a common origin with dinoflagellate chloroplasts.[5]

Linnaeus, in *Species Plantarum* (1753),[23] the starting point for modern botanical nomenclature, recognized 14 genera of algae, of which only four are currently considered among algae.[24] In *Systema Naturae*, Linnaeus described the genera *Volvox* and *Corallina*, and a species of *Acetabularia* (as *Madrepora*), among the animals.

In 1768, Samuel Gottlieb Gmelin (1744–1774) published the *Historia Fucorum*, the first work dedicated to marine algae and the first book on marine biology to use the then new binomial nomenclature of Linnaeus. It included elaborate illustrations of seaweed and marine algae on folded leaves.[25][26]

W. H. Harvey (1811–1866) and Lamouroux (1813)[27] were the first to divide macroscopic algae into four divisions based on their pigmentation. This is the first use of a biochemical criterion in plant systematics. Harvey's four divisions are: red algae (Rhodospermae), brown algae (Melanospermae), green algae (Chlorospermae), and Diatomaceae.[28][29]

At this time, microscopic algae were discovered and reported by a different group of workers (e.g., O. F. Müller and Ehrenberg) studying the Infusoria (microscopic organisms). Unlike macroalgae, which were clearly viewed as plants, microalgae were frequently considered animals because they are often motile.[27] Even the nonmotile (coccoid) microalgae were sometimes merely seen as stages of the lifecycle of plants, macroalgae, or animals.[30][31]

Although used as a taxonomic category in some pre-Darwinian classifications, e.g., Linnaeus (1753), de Jussieu (1789), Horaninow (1843), Agassiz (1859), Wilson & Cassin (1864), in further classifications, the "algae" are seen as an artificial, polyphyletic group.

Throughout the 20th century, most classifications treated the following groups as divisions or classes of algae: cyanophytes, rhodophytes, chrysophytes, xanthophytes, bacillariophytes, phaeophytes, pyrrhophytes (cryptophytes and dinophytes), euglenophytes, and chlorophytes. Later, many new groups were discovered (e.g., Bolidophyceae), and others were splintered from older groups: charophytes and glaucophytes (from chlorophytes), many heterokontophytes (e.g., synurophytes from chrysophytes, or eustigmatophytes from xanthophytes), haptophytes (from chrysophytes), and chlorarachniophytes (from xanthophytes).

With the abandonment of plant-animal dichotomous classification, most groups of algae (sometimes all) were included in Protista, later also abandoned in favour of Eukaryota. However, as a legacy of the older plant life scheme, some groups that were also treated as protozoans in the past still have duplicated classifications (see ambiregnal protists).

Some parasitic algae (e.g., the green algae *Prototheca* and *Helicosporidium*, parasites of metazoans, or *Cephaleuros*, parasites of plants) were originally classified as fungi, sporozoans, or protistans of *incertae sedis*,[32] while others (e.g., the green algae *Phyllosiphon* and *Rhodochytrium*, parasites of plants, or the red algae *Pterocladiophila* and *Gelidiocolax mammillatus*, parasites of other red algae, or the dinoflagellates *Oodinium*, parasites of fish) had their relationship with algae conjectured early. In other cases, some groups were originally characterized as parasitic algae (e.g., *Chlorochytrium*), but later were seen as endophytic algae.[33] Some filamentous bacteria (e.g., *Beggiatoa*) were originally seen as algae. Furthermore, groups like the apicomplexans are also parasites derived from ancestors that possessed plastids, but are not included in any group traditionally seen as algae.

Relationship to land plants

The first land plants probably evolved from shallow freshwater charophyte algae much like *Chara* almost 500 million years ago. These probably had an isomorphic alternation of generations and were probably filamentous. Fossils of isolated land plant spores suggest land plants may have been around as long as 475 million years ago.[34][35]

Morphology

The kelp forest exhibit at the Monterey Bay Aquarium: A three-dimensional, multicellular thallus

A range of algal morphologies is exhibited, and convergence of features in unrelated groups is common. The only groups to exhibit three-dimensional multicellular thalli are the reds and browns, and some chlorophytes.[36] Apical growth is constrained to subsets of these groups: the florideophyte reds, various browns, and the charophytes.[36] The form of charophytes is quite different from those of reds and browns, because they have distinct nodes, separated by internode 'stems'; whorls of branches reminiscent of the horsetails occur at the nodes.[36] Conceptacles are another polyphyletic trait; they appear in the coralline algae and the Hildenbrandiales, as well as the browns.[36]

Most of the simpler algae are unicellular flagellates or amoeboids, but colonial and nonmotile forms have developed independently among several of the groups. Some of the more common organizational levels, more than one of which may occur in the lifecycle of a species, are

- Colonial: small, regular groups of motile cells
- Capsoid: individual non-motile cells embedded in mucilage
- Coccoid: individual non-motile cells with cell walls
- Palmelloid: nonmotile cells embedded in mucilage
- Filamentous: a string of nonmotile cells connected together, sometimes branching
- Parenchymatous: cells forming a thallus with partial differentiation of tissues

In three lines, even higher levels of organization have been reached, with full tissue differentiation. These are the brown algae,[37]—some of which may reach 50 m in length (kelps)[38]—the red algae,[39] and the green algae.[40] The most complex forms are found among the charophyte algae (see Charales and Charophyta), in a lineage that eventually led to the higher land plants. The innovation that defines these nonalgal plants is the presence of female reproductive organs with protective cell layers that protect the zygote and developing embryo. Hence, the land plants are referred to as the Embryophytes.

Physiology

Many algae, particularly members of the Characeae species,[41] have served as model experimental organisms to understand the mechanisms of the water permeability of membranes, osmoregulation, turgor regulation, salt tolerance, cytoplasmic streaming, and the generation of action potentials.

Phytohormones are found not only in higher plants, but in algae, too.[42]

Symbiotic algae

Some species of algae form symbiotic relationships with other organisms. In these symbioses, the algae supply photosynthates (organic substances) to the host organism providing protection to the algal cells. The host organism derives some or all of its energy requirements from the algae. Examples are:

Lichens

Lichens are defined by the International Association for Lichenology to be "an association of a fungus and a photosynthetic symbiont resulting in a stable vegetative body having a specific structure".[43] The fungi, or mycobionts, are mainly from the Ascomycota with a few from the Basidiomycota. In nature they do not occur separate from lichens. It is unknown when they began to associate.[44] One mycobiont associates with the same phycobiont species, rarely two, from the green algae, except that alternatively, the mycobiont may associate with a species of cyanobacteria (hence "photobiont" is the more accurate term). A photobiont may be associated with many different mycobionts or may live independently; accordingly, lichens are named and classified as fungal species.[45] The association is termed a morphogenesis because the lichen has a form and capabilities not possessed by the symbiont species alone (they can be experimentally isolated). The photobiont possibly triggers otherwise latent genes in the mycobiont.[46]

Trentepohlia is an example of a common green alga genus worldwide that can grow on its own or be lichenised. Lichen thus share some of the habitat and often similar appearance with specialized species of algae (*aerophytes*) growing on exposed surfaces such as tree trunks and rocks and sometimes discoloring them.

Coral reefs]

Floridian coral reef

Coral reefs are accumulated from the calcareous exoskeletons of marine invertebrates of the order Scleractinia (stony corals). These animals metabolize sugar and oxygen to obtain energy for their cell-building processes, including secretion of the exoskeleton, with water and carbon dioxide as byproducts. Dinoflagellates (algal protists) are often endosymbionts in the cells of the coral-forming marine invertebrates, where they accelerate host-cell metabolism by generating sugar and oxygen immediately available through photosynthesis using incident light and the carbon dioxide produced by the host. Reef-building stony corals (hermatypic corals) require endosymbiotic algae from the genus *Symbiodinium* to be in a healthy condition.[47] The loss of *Symbiodinium* from the host is known as coral bleaching, a condition which leads to the deterioration of a reef.

Sea sponges

Endosymbiontic green algae live close to the surface of some sponges, for example, breadcrumb sponges (*Halichondria panicea*). The alga is thus protected from predators; the sponge is provided with oxygen and sugars which can account for 50 to 80% of sponge growth in some species.[48]

Lifecycle

Rhodophyta, Chlorophyta, and Heterokontophyta, the three main algal divisions, have lifecycles which show considerable variation and complexity. In general, an asexual phase exists where the seaweed's cells are diploid, a sexual phase where the cells are haploid, followed by fusion of the male and female gametes. Asexual reproduction permits efficient population increases, but less variation is possible. Commonly, in sexual reproduction of unicellular and colonial algae, two specialized, sexually compatible, haploid gametes make physical contact and fuse to form a zygote. To ensure a successful mating, the development and release of gametes is highly synchronized and regulated; pheromones may play a key role in these processes.[49] Sexual reproduction allows for more variation and provides the benefit of efficient recombinational repair of DNA damages during meiosis, a key stage of the sexual cycle.[*citation needed*] However, sexual reproduction is more costly than asexual reproduction.[50] Meiosis has been shown to occur in many different species of algae.[51]

Numbers

Algae on coastal rocks at Shihtiping in Taiwan

The *Algal Collection of the US National Herbarium* (located in the National Museum of Natural History) consists of approximately 320,500 dried specimens, which, although not exhaustive (no exhaustive collection exists), gives an idea of the order of magnitude of the number of algal species (that number remains unknown).[52] Estimates vary widely. For example, according to one standard textbook,[53] in the British Isles the *UK Biodiversity Steering Group Report* estimated there to be 20,000 algal species in the UK. Another checklist reports only about 5,000 species. Regarding the difference of about 15,000 species, the text concludes: "It will require many detailed field surveys before it is possible to provide a reliable estimate of the total number of species ..."

Regional and group estimates have been made, as well:

- 5,000–5,500 species of red algae worldwide
- "some 1,300 in Australian Seas"[54]
- 400 seaweed species for the western coastline of South Africa,[55] and 212 species from the coast of KwaZulu-Natal.[56] Some of these are duplicates, as the range extends across both coasts, and

the total recorded is probably about 500 species. Most of these are listed in List of seaweeds of South Africa. These exclude phytoplankton and crustose corallines.

- 669 marine species from California (US)[57]
- 642 in the check-list of Britain and Ireland[58]

and so on, but lacking any scientific basis or reliable sources, these numbers have no more credibility than the British ones mentioned above. Most estimates also omit microscopic algae, such as phytoplankton.

The most recent estimate suggests 72,500 algal species worldwide.[59]

Distribution

The distribution of algal species has been fairly well studied since the founding of phytogeography in the mid-19th century.[60] Algae spread mainly by the dispersal of spores analogously to the dispersal of Plantae by seeds and spores. This dispersal can be accomplished by air, water, or other organisms. Due to this, spores can be found in a variety of environments: fresh and marine waters, air, soil, and in or on other organisms.[60] Whether a spore is to grow into an organism depends on the combination of the species and the environmental conditions where the spore lands.

The spores of freshwater algae are dispersed mainly by running water and wind, as well as by living carriers.[60] However, not all bodies of water can carry all species of algae, as the chemical composition of certain water bodies limits the algae that can survive within them.[60] Marine spores are often spread by ocean currents. Ocean water presents many vastly different habitats based on temperature and nutrient availability, resulting in phytogeographic zones, regions, and provinces.[61]

To some degree, the distribution of algae is subject to floristic discontinuities caused by geographical features, such as Antarctica, long distances of ocean or general land masses. It is, therefore, possible to identify species occurring by locality, such as "Pacific algae" or "North Sea algae". When they occur out of their localities, hypothesizing a transport mechanism is usually possible, such as the hulls of ships. For example, *Ulva reticulata* and *U. fasciata* travelled from the mainland to Hawaii in this manner.

Mapping is possible for select species only: "there are many valid examples of confined distribution patterns."[62] For example, *Clathromorphum* is an arctic genus and is not mapped far south of there.[63] However, scientists regard the overall data as insufficient due to the "difficulties of undertaking such studies."[64]

Ecology

Phytoplankton, Lake Chūzenji

Algae are prominent in bodies of water, common in terrestrial environments, and are found in unusual environments, such as on snow and ice. Seaweeds grow mostly in shallow marine waters, under 100 m (330 ft) deep; however, some such as *Navicula pennata* have been recorded to a depth of 360 m (1,180 ft).[65] A type of algae, *Ancylonema nordenskioeldii*, was found in Greenland in areas known as the 'Dark Zone', which caused an increase in the rate of melting ice sheet.[66] Same algae was found in the Italian Alps, after pink ice appeared on parts of the Presena glacier.[67]

The various sorts of algae play significant roles in aquatic ecology. Microscopic forms that live suspended in the water column (phytoplankton) provide the food base for most marine food chains. In very high densities (algal blooms), these algae may discolor the water and outcompete, poison, or asphyxiate other life forms.

Algae can be used as indicator organisms to monitor pollution in various aquatic systems.[68] In many cases, algal metabolism is sensitive to various pollutants. Due to this, the species composition of algal populations may shift in the presence of chemical pollutants.[68] To detect these changes, algae can be sampled from the environment and maintained in laboratories with relative ease.[68]

On the basis of their habitat, algae can be categorized as: aquatic (planktonic, benthic, marine, freshwater, lentic, lotic),[69] terrestrial, aerial (subaerial),[70] lithophytic, halophytic (or euryhaline), psammon, thermophilic, cryophilic, epibiont (epiphytic, epi zoic), endosymbiont (endophytic, endozoic), parasitic, calcifilic or lichenic (phycobiont).[71]

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UNIT – II – PHYCOLOGY AND MEDICAL PARASITOLOGY – SMB3104

UNIT 2 CLASSFICATIONS & APPLICATIONS

Salient features of protochlorophyta, chlorophyta, charophyta, xanthophyta, Bacillariophyta, phaeophyta and Rhodophyta with special reference to Microcystis, Hydrodictyon, Chara, Drapernaldiopsis, Sargassum, Dictyota, Batrachospermum. Algal blooms, algal biofertilizers; algae as food, feed and use in industry.

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7 Major Types of Algae

Regina Bailey

Updated September 12, 2018

Pond scum, seaweed, and giant kelp are all examples of algae. **Algae** are protists with plant-like characteristics, that are typically found in aquatic environments. Like plants, algae are eukaryotic organisms that contain chloroplasts and are capable of photosynthesis. Like animals, some algae possess flagella, centrioles, and are capable of feeding on organic material in their habitat. Algae range in size from a single cell to very large multicellular species, and they can live in various environments including salt water, freshwater, wet soil, or on moist rocks. The large algae are generally referred to as simple aquatic plants. Unlike angiosperms and higher plants, algae lack vascular tissue and do not possess roots, stems, leaves, or flowers. As primary producers, algae are the foundation of the food chain in aquatic environments. They are a food source for many marine organisms including brine shrimp and krill, which in turn serve as the nutrition basis for other marine animals.

Algae can reproduce sexually, asexually or by a combination of both processes through alternation of generations. The types which reproduce asexually divide naturally (in the case of single-celled organisms) or release spores which may be motile or non-motile. Algae that reproduce sexually are generally induced to produce gametes when certain environmental stimuli – including temperature, salinity, and nutrients – become unfavorable. These algae species will produce a fertilized egg or zygote to create a new organism or a dormant zygospore that activates with favorable environmental stimuli.

Algae can be categorized into seven major types, each with distinct sizes, functions, and color. The different divisions include:

- Euglenophyta (Euglenoids)
- Chrysophyta (Golden-brown algae and Diatoms)
- Pyrrophyta (Fire algae)
- Chlorophyta (Green algae)
- Rhodophyta (Red algae)
- Paeophyta (Brown algae)
- Xanthophyta (Yellow-green algae)

Euglenophyta

Euglena are fresh and salt water protists. Like plant cells, some euglenoids are autotrophic. They contain chloroplasts and are capable of photosynthesis. They lack a cell wall, but instead are covered by a protein-rich layer called the pellicle. Like animal cells, other euglenoids are heterotrophic and feed on carbon-rich material found in the water and other unicellular organisms. Some euglenoids can survive for some time in darkness with suitable organic material. Characteristics of photosynthetic euglenoids include an eyespot, flagella, and organelles (nucleus, chloroplasts, and vacuole).

Due to their photosynthetic capabilities, *Euglena* were classified along with algae in the phylum *Euglenophyta*. Scientists now believe that these organisms have acquired this ability due to endosymbiotic relationships with photosynthetic green algae. As such, some scientists contend that Euglena should not be classified as algae and be classified in the phylum *Euglenozoa*.

Chrysophyta

Golden-brown algae and diatoms are the most abundant types of unicellular algae, accounting for around 100,000 different species. Both are found in fresh and salt water environments. Diatoms are much more common than golden-brown algae and consist of many types of plankton found in the ocean. Instead of a cell wall, diatoms are encased by a silica shell, known as a frustule, that varies in shape and structure depending on the species. Golden-brown algae, though fewer in number, rival the productivity of diatoms in the ocean. They are usually known as nanoplankton, with cells only 50 micrometers in diameter.

Pyrrophyta (Fire Algae)

Fire algae are unicellular algae commonly found in oceans and in some fresh water sources that use flagella for motion. They are separated into two classes: dinoflagellates and cryptomonads. **Dinoflagellates** can cause a phenomenon known as a red tide, in which the ocean appears red due to their large abundance. Like some fungi, some species of *Pyrrophyta* are bioluminescent. During the night, they cause the ocean to appear to be aflame. Dinoflagellates are also poisonous in that they produce a neurotoxin that can disrupt proper muscle function in humans and other organisms. Cryptomonads are similar to dinoflagellates and may also produce harmful algal blooms, which cause the water to have a red or dark brown appearance.

Chlorophyta (Green Algae)

Green algae mostly abide in freshwater environments, although a few species can be found in the ocean. Like fire algae, green algae also have cell walls made of cellulose, and some species have one or two flagella. Green algae contain chloroplasts and undergo photosynthesis. There are thousands of unicellular and multicellular species of these algae. Multicellular species usually group in colonies ranging in size from four cells to several thousand cells. For reproduction, some species produce non-motile aplanospores that rely on water currents for transport, while others produce zoospores with one flagellum for swimming to a more favorable environment. Types of green algae include sea lettuce, horsehair algae, and dead man's fingers.

Rhodophyta (Red Algae)

Red algae are commonly found in tropical marine locations. Unlike other algae, these eukaryotic cells lack flagella and centrioles. Red algae grow on solid surfaces including tropical reefs or attached to other algae. Their cell walls consist of cellulose and many different types of carbohydrates. These algae reproduce asexually by monospores (walled, spherical cells without flagella) that are carried by water currents until germination. Red algae also reproduce sexually and undergo alternation of generations. Red algae form a number of different seaweed types.

Paeophyta (Brown Algae)

Brown algae are among the largest species of algae, consisting of varieties of seaweed and kelp found in marine environments. These species have differentiated tissues, including an anchoring organ, air pockets for buoyancy, a stalk, photosynthetic organs, and reproductive tissues that produce spores and gametes. The life cycle of these protists involves alternation of generations. Some examples of brown algae include sargassum weed, rockweed, and giant kelp, which can reach up to 100 meters in length.

Xanthophyta (Yellow-Green Algae)

Yellow-green algae are the least prolific species of algae, with only 450 to 650 species. They are unicellular organisms with cell walls made of cellulose and silica, and they contain one or two flagella for motion. Their chloroplasts lacks a certain pigment, which causes them to appear lighter in color. They usually form in small colonies of only a few cells. Yellow-green algae typically live in freshwater, but can be found in salt water and wet soil environments.

Key Takeaways

- Algae are protists with characteristics that resemble those of plants. They are most commonly found in aquatic environments.
- There are seven major types of algae, each with distinct characteristics.
- Euglenophyta (Euglenoids) are fresh and salt water protists. Some euglenoids are autotrophic while others are heterotrophic.
- Chrysophyta (Golden-brown algae and Diatoms) are the most abundant types of single-celled algae (approximately 100,000 different species).
- Pyrrophyta (Fire algae) are single-celled algae. They are found in both the oceans and in fresh water. They use flagella to move around.
- Chlorophyta (Green algae) typically live in freshwater. Green algae have cell walls made of cellulose and are photosynthetic.
- Rhodophyta (Red algae) are mostly found in tropical marine environments. These eukaryotic cells do not have flagella and centrioles, unlike other types of algae.
- Paeophyta (Brown algae) are among the largest species. Examples include both seaweed and kelp.
- Xanthophyta (Yellow-green algae) are the least common species of algae. They are single-celled and both cellulose and silica make up their cell walls.

Uses

Harvesting algae

Agar

Agar, a gelatinous substance derived from red algae, has a number of commercial uses.[72] It is a good medium on which to grow bacteria and fungi, as most microorganisms cannot digest agar.

Alginates

Alginic acid, or alginate, is extracted from brown algae. Its uses range from gelling agents in food, to medical dressings. Alginic acid also has been used in the field of biotechnology as a biocompatible medium for cell encapsulation and cell immobilization. Molecular cuisine is also a user of the substance for its gelling properties, by which it becomes a delivery vehicle for flavours.

Between 100,000 and 170,000 wet tons of *Macrocystis* are harvested annually in New Mexico for alginate extraction and abalone feed.[73][74]

Energy source

To be competitive and independent from fluctuating support from (local) policy on the long run, biofuels should equal or beat the cost level of fossil fuels. Here, algae-based fuels hold great promise,[75][76] directly related to the potential to produce more biomass per unit area in a year than any other form of biomass. The break-even point for algae-based biofuels is estimated to occur by 2025.[77]

Fertilizer

Seaweed-fertilized gardens on Inisheer

For centuries, seaweed has been used as a fertilizer; George Owen of Henllys writing in the 16th century referring to drift weed in South Wales:[78]

This kind of ore they often gather and lay on great heapes, where it heteth and rotteth, and will have a strong and loathsome smell; when being so rotten they cast on the land, as they do their muck, and thereof springeth good corn, especially barley ... After spring-tydes or great rigs of the sea, they fetch it in sacks on horse backes, and carie the same three, four, or five miles, and cast it on the lande, which doth very much better the ground for corn and grass.

Today, algae are used by humans in many ways; for example, as fertilizers, soil conditioners, and livestock feed.[79] Aquatic and microscopic species are cultured in clear tanks or ponds and are either harvested or used to treat effluents pumped through the ponds. Algaculture on a large scale is an important type of aquaculture in some places. Maerl is commonly used as a soil conditioner.

Nutrition

Dulse, a type of edible seaweed

Naturally growing seaweeds are an important source of food, especially in Asia. They provide many vitamins including: A, B_1, B_2, B_6, niacin, and C, and are rich in iodine, potassium, iron, magnesium, and calcium.[80] In addition, commercially cultivated microalgae, including both algae and cyanobacteria, are marketed as nutritional supplements, such as spirulina,[81] *Chlorella* and the vitamin-C supplement from *Dunaliella*, high in beta-carotene.

Algae are national foods of many nations: China consumes more than 70 species, including *fat choy*, a cyanobacterium considered a vegetable; Japan, over 20 species such as *nori* and *aonori*;[82] Ireland, dulse; Chile, cochayuyo.[83] Laver is used to make laver bread in Wales, where it is known as *bara lawr*; in Korea, *gim*. It is also used along the west coast of North America from California to British Columbia, in Hawaii and by the Māori of New Zealand. Sea lettuce and badderlocks are salad ingredients in Scotland, Ireland, Greenland, and Iceland. Algae is being considered a potential solution for world hunger problem.[84][85][86]

The oils from some algae have high levels of unsaturated fatty acids. For example, *Parietochloris incisa* is very high in arachidonic acid, where it reaches up to 47% of the triglyceride pool.[87] Some varieties of algae favored by vegetarianism and veganism contain the long-chain, essential omega-3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). Fish oil contains the omega-3 fatty acids, but the original source is algae (microalgae in particular), which are eaten by marine life such as copepods and are passed up the food chain.[88] Algae have emerged in recent years as a popular source of omega-3 fatty acids for vegetarians who cannot get long-chain EPA and DHA from other vegetarian sources such as flaxseed oil, which only contains the short-chain alpha-linolenic acid (ALA).

Pollution control

- Sewage can be treated with algae,[89] reducing the use of large amounts of toxic chemicals that would otherwise be needed.
- Algae can be used to capture fertilizers in runoff from farms. When subsequently harvested, the enriched algae can be used as fertilizer.
- Aquaria and ponds can be filtered using algae, which absorb nutrients from the water in a device called an algae scrubber, also known as an algae turf scrubber.[90][91][92][93]

Agricultural Research Service scientists found that 60–90% of nitrogen runoff and 70–100% of phosphorus runoff can be captured from manure effluents using a horizontal algae scrubber, also called an algal turf scrubber (ATS). Scientists developed the ATS, which consists of shallow, 100-foot raceways of nylon netting where algae colonies can form, and studied its efficacy for three years. They found that algae can readily be used to reduce the nutrient runoff from agricultural fields and increase the quality of water flowing into rivers, streams, and oceans. Researchers collected and dried the nutrient-rich algae from the ATS and studied its potential as an organic fertilizer. They found that cucumber and corn seedlings grew just as well using ATS organic fertilizer as they did with commercial fertilizers.[94] Algae scrubbers, using bubbling upflow or vertical waterfall versions, are now also being used to filter aquaria and ponds.

Polymers

Various polymers can be created from algae, which can be especially useful in the creation of bioplastics. These include hybrid plastics, cellulose based plastics, poly-lactic acid, and biopolyethylene.[95] Several companies have begun to produce algae polymers commercially, including for use in flip-flops[96] and in surf boards.[97]

Bioremediation

The alga *Stichococcus bacillaris* has been seen to colonize silicone resins used at archaeological sites; biodegrading the synthetic substance.[98]

Pigments

The natural pigments (carotenoids and chlorophylls) produced by algae can be used as alternatives to chemical dyes and coloring agents.[99] The presence of some individual algal pigments, together with specific pigment concentration ratios, are taxon-specific: analysis of their concentrations with various analytical methods, particularly high-performance liquid chromatography, can therefore offer deep insight into the taxonomic composition and relative abundance of natural algae populations in sea water samples.[100][101]

Stabilizing substances

Carrageenan, from the red alga *Chondrus crispus,* is used as a stabilizer in milk products.

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DEPARTMENT OF BIOTECHNOLOGY

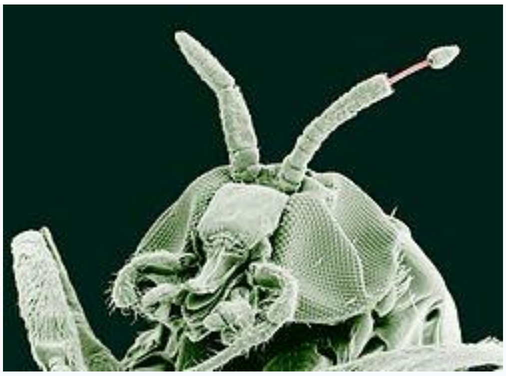
UNIT – III – PHYCOLOGY AND MEDICAL PARASITOLOGY – SMB3104

UNIT 3 PARASITOLOGY

Parasitology – General Concepts – Introduction to Parasitology, Classification – Host parasite relationship. Laboratory techniques in parasitology-Blood –Thick and thin smear, Faeces – Examination for ova and cyst.

Parasitology

From Wikipedia, the free encyclopedia



Adult black fly (*Simulium yahense*) with *Onchocerca volvulus* emerging from the insect's antenna. The parasite is responsible for the disease known as river blindness in Africa. Sample was chemically fixed and critical point dried, then observed using conventional scanning electron microscopy. Magnified 100×.

Parasitology is the study of parasites, their hosts, and the relationship between them. As a biological discipline, the scope of parasitology is not determined by the organism or environment in question but by their way of life. This means it forms a synthesis of other disciplines, and draws on techniques from fields such as cell biology, bioinformatics, biochemistry, molecular biology, immunology, genetics, evolution and ecology.

Fields

The study of these diverse organisms means that the subject is often broken up into simpler, more focused units, which use common techniques, even if they are not studying the same organisms or diseases. Much research in parasitology falls somewhere between two or more of these definitions. In general, the study of prokaryotes falls under the field of bacteriology rather than parasitology.

Medical

The Italian Francesco Redi, considered to be the father of modern parasitology, was the first to recognize and correctly describe details of many important parasites.[1]

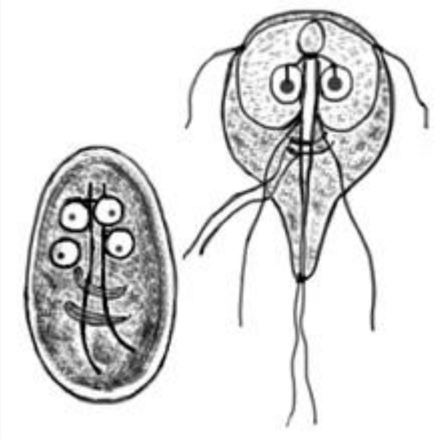
The parasitologist F.E.G. Cox noted that "Humans are hosts to nearly 300 species of parasitic worms and over 70 species of protozoa, some derived from our primate ancestors and some acquired from the animals we have domesticated or come in contact with during our relatively short history on Earth".[2]

One of the largest fields in parasitology, medical parasitology is the subject that deals with the parasites that infect humans, the diseases caused by them, clinical picture and the response generated by humans against them. It is also concerned with the various methods of their diagnosis, treatment and finally their prevention & control. A parasite is an organism that live on or within another organism called the host. These include organisms such as:

- *Plasmodium* spp., the protozoan parasite which causes malaria. The four species infective to humans are *P. falciparum*, *P. malariae*, *P. vivax* and *P. ovale*.
- *Leishmania*, unicellular organisms which cause leishmaniasis
- *Entamoeba* and *Giardia*, which cause intestinal infections (dysentery and diarrhoea)
- Multicellular organisms and intestinal worms (helminths) such as *Schistosoma* spp., *Wuchereria bancrofti*, *Necator americanus* (hookworm) and *Taenia* spp. (tapeworm)
- Ectoparasites such as ticks, scabies and lice

Medical parasitology can involve drug development, epidemiological studies and study of zoonoses.

History



Cyst and imago of *Giardia lamblia*, the protozoan parasite that causes giardiasis. The species was first observed by Antonie van Leeuwenhoek in 1681.

Antonie van Leeuwenhoek observed and illustrated *Giardia lamblia* in 1681, and linked it to "his own loose stools". This was the first protozoan parasite of humans that he recorded, and the first to be seen under a microscope.[4]

A few years later, in 1687, the Italian biologists Giovanni Cosimo Bonomo and Diacinto Cestoni published that scabies is caused by the parasitic mite *Sarcoptes scabiei*, marking scabies as the first disease of humans with a known microscopic causative agent.[5] In the same publication, *Esperienze Intorno alla Generazione degl'Insetti* (*Experiences of the Generation of Insects*), Francesco Redi also described ecto- and endoparasites, illustrating ticks, the larvae of nasal flies of deer, and sheep liver fluke. His earlier (1684) book *Osservazioni intorno agli animali viventi che si trovano negli animali viventi* (*Observations on Living Animals found in Living Animals*) described and illustrated over 100 parasites including the human roundworm.[6] He noted that parasites develop from eggs, contradicting the theory of spontaneous generation.[7]

Modern parasitology developed in the 19th century with accurate observations by several researchers and clinicians. In 1828, James Annersley described amoebiasis, protozoal infections of the intestines and the liver, though the pathogen, *Entamoeba histolytica*, was not discovered until 1873 by Friedrich Lösch. James Paget discovered the intestinal nematode *Trichinella spiralis* in humans in 1835. James McConnell described the human liver fluke in 1875. A physician at the French naval hospital at Toulon, Louis Alexis Normand, in 1876 researching the ailments of French soldiers returning from what is now Vietnam, discovered the only known helminth that, without treatment, is capable of indefinitely reproducing within a host and causes the disease strongyloidiasis.[8] Patrick Manson discovered the life cycle of elephantiasis, caused by nematode worms transmitted by mosquitoes, in 1877. Manson further predicted that the malaria parasite, *Plasmodium*, had a mosquito vector, and persuaded Ronald Ross to investigate. Ross confirmed that the prediction was correct in 1897–1898. At the same time, Giovanni Battista Grassi and others described the malaria parasite's life cycle stages in *Anopheles* mosquitoes. Ross was controversially awarded the 1902 Nobel prize for his work, while Grassi was not.[4]

Disease*	**Parasite**	**Insect (vector)**
African trypanosomiasis (sleeping sickness)	*Trypanosoma brucei gambiense*, *Trypanosoma brucei rhodesiense*	Tsetse flies
Babesiosis	*Babesia microti* and other species	*Babesia microti: Ixodes* (hard-bodied) ticks
Chagas disease	*Trypanosoma cruzi*	Triatomine (“kissing”) bugs
Leishmaniasis	*Leishmania* species	Phlebotomine sand flies
Malaria	*Plasmodium* species	*Anopheles* mosquitoes

Diagnosis of Parasitic Diseases

How are parasitic diseases diagnosed?

Many kinds of lab tests are available to diagnose parasitic diseases. The kind of test(s) your health care provider will order will be based on your signs and symptoms, any other medical conditions you may have, and your travel history. Diagnosis may be difficult, so your health care provider may order more than one kind of test.

What kinds of tests are used to diagnose parasitic diseases?

See below for a list of some commonly used tests your health care provider may order.

- **A fecal (stool) exam, also called an ova and parasite test (O&P)** This test is used to find parasites that cause diarrhea, loose or watery stools, cramping, flatulence (gas) and other abdominal illness. CDC recommends that three or more stool samples, collected on separate days, be examined. This test looks for ova (eggs) or the parasite.Your health care provider may instruct you to put your stool specimens into special containers with preservative fluid. Specimens not collected in a preservative fluid should be refrigerated, but not frozen, until delivered to the lab or the health care provider's office.Your health care provider may request that the lab use special stains or that special tests be performed to look for parasites not routinely screened for.

- **Endoscopy/Colonoscopy**

  Endoscopy is used to find parasites that cause diarrhea, loose or watery stools, cramping, flatulence (gas) and other abdominal illness.This test is used when stool exams do not reveal the cause of your diarrhea.This test is a procedure in which a tube is inserted into the mouth (endoscopy) or rectum (colonoscopy) so that the doctor, usually a gastroenterologist, can examine the intestine.This test looks for the parasite or other abnormalities that may be causing your signs and symptoms.

- **Blood tests**

  Some, but not all, parasitic infections can be detected by testing your blood. Blood tests look for a specific parasite infection; there is no blood test that will look for all parasitic infections. There are two general kinds of blood tests that your doctor may order:

  - *Serology*This test is used to look for antibodies or for parasite antigens produced when the body is infected with a parasite and the immune system is trying to fight off the invader.This test is done by your health care provider taking a blood sample and sending it to a lab.
  - *Blood smear*This test is used to look for parasites that are found in the blood. By looking at a blood smear under a microscope, parasitic diseases such as filariasis, malaria, or babesiosis, can be diagnosed.This test is done by placing a drop of blood on a microscope slide. The slide is then stained and examined under a microscope.

- **X-ray, Magnetic Resonance Imaging (MRI) scan, Computerized Axial Tomography scan (CAT)**These tests are used to look for some parasitic diseases that may cause lesions in the organs.

Transmission of Parasitic Diseases

- Animals (Zoonotic)
- Blood
- Food
- Insects

- Water

Animals (Zoonotic)

Pets can carry parasites and pass parasites to people. Proper handwashing can greatly reduce risk.

A zoonotic disease is a disease spread between animals and people. Zoonotic diseases can be caused by viruses, bacteria, parasites, and fungi. Some of these diseases are very common. For zoonotic diseases that are caused by parasites, the types of symptoms and signs can be different depending on the parasite and the person. Sometimes people with zoonotic infections can be very sick but some people have no symptoms and do not ever get sick. Other people may have symptoms such as diarrhea, muscle aches, and fever.

Foods can be the source for some zoonotic infection when animals such as cows and pigs are infected with parasites such as *Cryptosporidium* or *Trichinella*. People can acquire cryptosporidiosis if they accidentally swallow food or water that is contaminated by stool from infected animals. For example, this can happen when orchards or water sources are near cow pastures and people consume the fruit without proper washing or drink untreated water. People can acquire trichinellosis by ingesting undercooked or raw meat from bear, boar, or domestic pigs that are infected with the *Trichinella* parasite.

Pets can carry and pass parasites to people.

Some dog and cat parasites can infect people. Young animals, such as puppies and kittens, are more likely to be infected with roundworms and hookworms.

Wild animals can also be infected with parasites that can infect people. For example, people can be infected by the raccoon parasite *Baylisascaris* if they accidentally swallow soil that is contaminated with infected raccoon feces.

Regular veterinary care will protect your pet and your family.

There are simple steps you can take to protect yourself and your family from zoonotic diseases caused by parasites.

- Make sure your pet is under a veterinarian's care to help protect your pet and your family from possible parasite infections.
- Practice the four Ps: Pick up Pet Poop Promptly, and dispose of properly. Be sure to wash your hands after handling pet waste.
- Wash your hands frequently, especially after touching animals, and avoid contact with animal feces.
- Follow proper food-handling procedures to reduce the risk of transmission from contaminated food.
- For people with weakened immune systems, be especially careful of contact with animals that could transmit these infections.

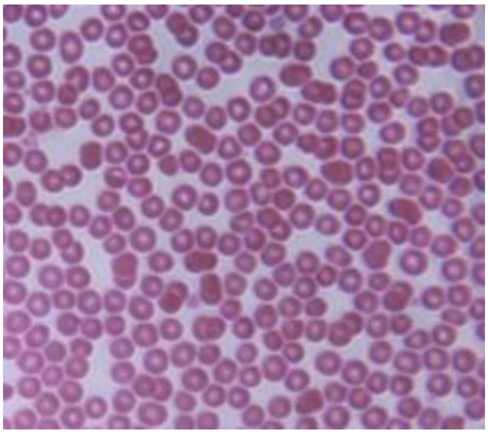
Blood

Some parasites can be bloodborne. This means

1. the parasite can be found in the bloodstream of infected people; and
2. the parasite might be spread to other people through exposure to an infected person's blood (for example, by blood transfusion or by sharing needles or syringes contaminated with blood).

Examples of parasitic diseases that can be bloodborne include African trypanosomiasis, babesiosis, Chagas disease, leishmaniasis, malaria, and toxoplasmosis. In nature, many bloodborne parasites are spread by insects (vectors), so they are also referred to as vector-borne diseases. *Toxoplasma gondii* is not transmitted by an insect (vector).

In the United States, the risk for vector-borne transmission is very low for these parasites except for some *Babesia* species.



Microscopic red blood cells

Blood Transfusions

Many factors affect whether parasites that can be found in the bloodstream might be spread by blood transfusion. Examples of some of the factors include

- how much of the parasite's life cycle is spent in the blood;
- how many parasites might be found in the blood (in other words, the concentration or level of the parasite);

- how long the parasite stays in the body, in treated and untreated people; and
- how the parasite affects people. For example, if infected people feel sick, they might not want to donate blood or they might be deferred (turned away).

Some parasites spend most or all of their life cycle in the bloodstream, such as *Babesia* and *Plasmodium* species. Parasites, such as *Trypanosoma cruzi*, might be found in the blood early in an infection (the acute phase) and then at much lower levels later (the chronic phase of infection). Other parasites only migrate (travel) through the blood to get to another part of the body.

There may be cases of transfusion-transmitted parasites that go undetected and unreported, but the risk for infection is very low compared with the number of blood transfusions. In the United States since 1980, there have been published reports of cases of transfusion-associated babesiosis (>150), malaria (~50), and Chagas disease (~5). Since 1965, there have been published reports of transfusion-associated toxoplasmosis (~4).

Blood Donor Screening

Potential blood donors are asked if they have had babesiosis or Chagas disease. If the answer is "yes," the person is deferred from donating blood.

Potential blood donors are also asked about their recent international travel. People who traveled to an are where malaria transmission occurs are deferred from donating blood for 1 year after their return to the United States. Former residents of areas where malaria transmission occurs will be deferred for 3 years. People diagnosed with malaria cannot donate blood for 3 years after treatment, during which time they must have remained free of symptoms of malaria.

Donated blood is tested for a number of infectious agents. Currently, most of the U.S. blood supply is screened for *Trypanosoma cruzi* (the parasite that causes Chagas disease). If the results are positive, the blood center will try to notify the donor. People who test positive should consult a health care provider. Health care providers may contact CDC for confirmatory testing and management information, including treatment.

Food

Numerous parasites can be transmitted by food including many protozoa and helminths. In the United States, the most common foodborne parasites are protozoa such as *Cryptosporidium* spp., *Giardia intestinalis*, *Cyclospora cayetanensis*, and *Toxoplasma gondii*; roundworms such as *Trichinella spp.* and *Anisakis* spp.; and tapeworms such as *Diphyllobothrium* spp. and *Taenia* spp.

Many of these organisms can also be transmitted by water, soil, or person-to-person contact. Occasionally in the U.S., but often in developing countries, a wide variety of helminthic roundworms, tapeworms, and flukes are transmitted in foods such as

- undercooked fish, crabs, and mollusks;
- undercooked meat;
- raw aquatic plants, such as watercress; and
- raw vegetables that have been contaminated by human or animal feces.

Some foods are contaminated by food service workers who practice poor hygiene or who work in unsanitary facilities.

Symptoms of foodborne parasitic infections vary greatly depending on the type of parasite. Protozoa such as *Cryptosporidium* spp., *Giardia intestinalis*, and *Cyclospora cayetanensis* most commonly cause diarrhea and other gastrointestinal symptoms. Helminthic infections can cause abdominal pain, diarrhea, muscle pain, cough, skin lesions, malnutrition, weight loss, neurological and many other symptoms depending on the particular organism and burden of infection. Treatment is available for most of the foodborne parasitic organisms.

Insects

Triatomine bugs are the vectors for Chagas disease.
Credit: CDC

An insect that transmits a disease is known as a vector, and the disease is referred to as a vector-borne disease. Insects can act as mechanical vectors, meaning that the insect can carry an organism but the insect is not essential to the organism's life cycle, such as when house flies carry organisms on the outside of their bodies that cause diarrhea in people. Insects can also serve as obligatory hosts where the disease-causing organism must undergo development before being transmitted (as in the case with malaria parasites).

Vector-borne transmission of disease can take place when the parasite enters the host through the saliva of the insect during a blood meal (for example, malaria), or from parasites in the feces of the insect that defecates immediately after a blood meal (for example, Chagas disease). Parasites transmitted by insects often circulate in the blood of the host, with the parasite residing in and damaging organs or other parts of the body.

Disease*	**Parasite**	**Insect (vector)**
African trypanosomiasis (sleeping sickness)	*Trypanosoma brucei gambiense*, *Trypanosoma brucei rhodesiense*	Tsetse flies
Babesiosis	*Babesia microti* and other species	*Babesia microti: Ixodes* (hard-bodied) ticks
Chagas disease	*Trypanosoma cruzi*	Triatomine ("kissing") bugs
Leishmaniasis	*Leishmania* species	Phlebotomine sand flies
Malaria	*Plasmodium* species	*Anopheles* mosquitoes

* These diseases are listed in alphabetical order.

In developing countries where insect control is less common, the frequency of diseases is usually greater than in areas with the resources to effectively reduce the populations of disease vector insects. In the United States, the risk for vector-borne transmission is very low for these parasites except for some *Babesia* species.

It is important to remember that while some species of insects are capable of transmitting disease, the majority of insects are beneficial to people and the environment.

Water

Parasites can live in natural water sources. When outdoors, treat your water before drinking it to avoid getting sick.

Water is an essential resource for life. Water is used by everyone, every day. Not only do all people need drinking water to survive, but water plays an important role in almost every aspect of our lives – from recreation to manufacturing computers to performing medical procedures. When water becomes contaminated by parasites, however, it can cause a variety of illnesses.

Globally, contaminated water is a serious problem that can cause severe pain, disability and even death. Common global water-related diseases caused by parasites include Guinea worm, schistosomiasis, amebiasis, cryptosporidiosis (Crypto), and giardiasis. People become infected with these diseases when they swallow or have contact with water that has been contaminated by certain parasites. For example, individuals drinking water contaminated with fecal matter containing the ameba *Entamoeba histolytica* can get amebic dysentery (amebiasis). An individual can get Guinea worm disease when they drink water that contains the parasite *Dracunculus medinensis*. If an infected person with an open Guinea worm wound enters a pond or well used for drinking water, they can spread the parasite into the water and continue the cycle of contamination and infection. Schistosomiasis can be spread when people swim in or have contact with freshwater lakes that are contaminated with *Schistosoma* parasites.

Americans traveling abroad should take the necessary precautions to protect themselves from waterborne illness if they plan on being in countries with unsafe drinking water or recreational water. Individuals spending time in the wilderness should also follow the appropriate steps to ensure the safety of their water.

Follow the 6 Steps for Healthy Swimming to avoid recreational water illnesses (RWIs).

Parasites are also a cause of waterborne disease in the United States. Both recreational water (water used for swimming and other activities) and drinking water can become contaminated with parasites and cause illness. Recreational water illnesses (RWIs) are diseases that are spread by swallowing, breathing, or having contact with contaminated water from swimming pools, hot tubs, lakes, rivers, or the ocean.

The most commonly reported RWI is diarrhea caused by parasites, such as *Cryptosporidium* and *Giardia intestinalis*. *Giardia intestinalis* is also a common parasite found in drinking water. Both *Cryptosporidium* and *Giardia intestinalis* are found in the fecal matter of an infected person or animal. These parasites can be spread when someone swallows water that has been contaminated with fecal matter from an infected person or animal. Individuals with compromised immune systems who come into contact with these parasites can also be at greater risk for serious illness.

Proper sanitation and hygiene are also essential to preventing waterborne illness. Globally, CDC works to provide access to clean and safe water through a variety of programs and projects. In the United States, CDC educates the public on how to develop healthy swimming habits and protect their private well water from parasites.

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DEPARTMENT OF BIOTECHNOLOGY

UNIT – IV – PHYCOLOGY AND MEDICAL PARASITOLOGY – SMB3104

UNIT 4 PROTOZOOLOGY.

Protozoology: Pathogenic mechanisms, Disease transmissions, their life cycles and Lab Diagnosis of the following – *Entamoeba histolytica, Plasmodium vivax, Plasmodium falciparum, Leishmania donovani, Giardia lamblia, Trichomonas vaginalis, Balantidium coli, Toxo plasmagondii* and *Cryptosporidium parvum.*

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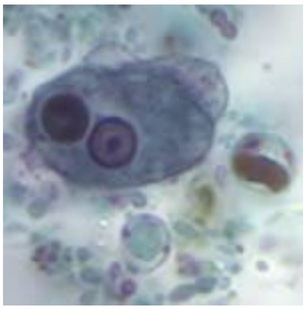
Protozoa

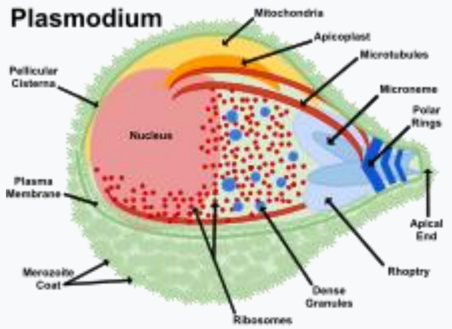


Entamoeba histolytica is a protozoan. A microscope is necessary to view this parasite. Credit: CDC. Protozoa are microscopic, one-celled organisms that can be free-living or parasitic in nature. They are able to multiply in humans, which contributes to their survival and also permits serious infections to develop from just a single organism. Transmission of protozoa that live in a human's intestine to another human typically occurs through a fecal-oral route (for example, contaminated food or water or person-to-person contact). Protozoa that live in the blood or tissue of humans are transmitted to other humans by an arthropod vector (for example, through the bite of a mosquito or sand fly).

The protozoa that are infectious to humans can be classified into four groups based on their mode of movement:

- Sarcodina – the ameba, e.g., *Entamoeba*
- Mastigophora – the flagellates, e.g., *Giardia*, *Leishmania*
- Ciliophora – the ciliates, e.g., *Balantidium*
- Sporozoa – organisms whose adult stage is not motile e.g., *Plasmodium*, *Cryptosporidium*
- **Protozoan infections** are parasitic diseases caused by organisms formerly classified in the Kingdom Protozoa. They are usually contracted by either an insect vector or by contact with an infected substance or surface and include organisms that are now classified in the supergroups Excavata, Amoebozoa, SAR, and Archaeplastida.[1]

- Protozoan infections are responsible for diseases that affect many different types of organisms, including plants, animals, and some marine life. Many of the most prevalent and deadly human diseases are caused by a protozoan infection, including African Sleeping Sickness, amoebic dysentery, and malaria.
- The species originally termed "protozoa" are not closely related to each other and only have superficial similarities (eukaryotic, unicellular, motile, though with exceptions). The terms "protozoa" (and protist) are usually discouraged in the modern biosciences. However, this terminology is still encountered in medicine. This is partially because of the conservative character of medical classification and partially due to the necessity of making identifications of organisms based upon morphology.
- Within the taxonomic classification, the four protist supergroups (Amoebozoa, Excavata, SAR, and Archaeplastida) fall under the Domain Eukarya. Protists are an artificial grouping of over 64,000 different single-celled life forms. This means that it is difficult to define protists due to their extreme differences and uniqueness. Protists are a *polyphyletic* [(of a group of organisms) derived from more than one common evolutionary ancestor or ancestral group and therefore not suitable for placing in the same taxon][2] a collection of organisms and they are unicellular, which means that they lack the level of tissue organization which is present in more complex eukaryotes. Protists grow in a wide variety of moist habitats and a majority of them are free-living organisms. In these moist environments, plankton and terrestrial forms can also be found. Protists are *chemoorganotrophic* [organisms which oxidize the chemical bonds in organic compounds as their energy source][3] and are responsible for recycling nitrogen and phosphorus. Parasites also are responsible for causing disease in humans and domesticated animals.
- Protozoa are *chemoorganotrophic* protists and have three different ways of acquiring nutrients. The first method of acquiring nutrients is through saprotrophic nutrition. In saprotrophic nutrition, nutrients are obtained from dead organic matter through enzymatic degradation. The second method of acquiring nutrients is through osmotrophic nutrition. In osmotrophic nutrition, nutrients are obtained through absorbing soluble products. The third method of acquiring nutrients is through holozoic nutrition. In holozoic nutrition, solid nutrients are absorbed through phagocytosis.[1]
- Some protozoa are *photoautotrophic* protists. These protists include strict aerobes, and use photosystems I and II in order to carry out photosynthesis which produces oxygen.[1]



- **Diagram of *Plasmodium* structure**

- *Mixotrophic* protists obtain nutrients through organic and inorganic carbon compounds simultaneously.[1]
- All cells have a plasma membrane. In a protist, the plasma membrane is also known as the plasmalemma. Just below the plasma membrane, and in the inner fluid region, cytoplasm can be found. The pellicle structure in the protist is a thin layer of protein that helps provide the cell with some support and protection. In addition to the plasma membrane, protists contain two different types of vacuoles. Contractile vacuoles help to maintain osmoregulation, and phagocytic vacuoles allow select protists to ingest food. In some protists, flagella and/or cilia may be present to help with motility and nutrient intake. The flagella/cilia create water currents that assist in feeding and respiration. Energy intake is necessary for protists' survival. Aerobic chemoorganotrophic protists produce energy through the use of their mitochondria. The mitochondria then generates energy for the protist to keep up with cellular life functions. Photosynthetic protists produce energy through the use of their mitochondria and chloroplasts. Finally, anaerobic chemoorganotrophs produce energy through the use of hydrogenosomes, which is a membrane enclosed organelle that releases molecular hydrogen (H_2).[1]
- Encystment is when a protist becomes a dormant cyst with a cell wall; during encystment, the cyst has decreased complexity and metabolic activity relative to the protist. Encystment protects the protist from environmental changes, the cyst can be a site for nuclear reorganization and cell division, and it can act as a host cell in order to transfer parasitic species. Excystment is when a return to favorable conditions may cause a cyst to return to its original state. In parasitic protists, excystment may occur when the cyst is ingested by a new host.[1]
- Protists reproduce asexually or sexually. If the protists reproduce asexually, they do so through binary fission, multiple fission, budding, and fragmentation. If the protists reproduce sexually, they do so through a syngamy process where there is a fusion of the gametes. If this

occurs in an individual it is recognized as autogamy. If this occurs between individuals, it is known as conjugation.[1]

Entamoebida

Entamoebida lack mitochondria and possess mitosomes. *Entamoeba histolytica* is a pathogenic parasite known to cause amoebiasis, which is the third leading cause of parasitic deaths.[20] It is diagnosed by the assessment of stool samples.[21] Amoebiasis is caused by the ingestion of food or water contaminated with feces or other bodily wastes of an infected person, which contain cysts, the dormant form of the microbe. These cysts on reaching the terminal ileum region of the gastrointestinal tract give rise to a mass of proliferating cells, the trophozoite form of the parasite, by the process of excystation.[22] Symptoms of this infection include diarrhea with blood and mucus, and can alternate between constipation and remission, abdominal pain, and fever. Symptoms can progress to ameboma, fulminant colitis, toxic megacolon, colonic ulcers, leading to perforation, and abscesses in vital organs like liver, lung, and brain. Amoebiasis can be treated with the administration of anti-amoebic compounds, this often includes the use of Metronidazole, Ornidazole, Chloroquine, Secnidazole, Nitazoxanide and Tinidazole. Tinidazole may be effective in curing children.[23] The usage of conventional therapeutics to treat amoebiasis if often linked with substantial side effects, a threat to the efficacy of these therapeutics, further worsened by the development of drug resistance in the parasite.[20] Amoebic meningoencephalitis and keratitis is a brain-eating amoeba caused by free-living *Naeglaria* and *Acanthomoeba.* One way this pathogen can be acquired is by soaking contact lenses in water instead of contact solution. This will result in progressive ulceration of the cornea.[24] This pathogen can be diagnosed by demonstration of amoebae in clinical specimens. There is currently no drug therapy available for amoebic meningoencephalitis and keratitis.

Protozoan organisms

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Source/Transmission (Reservoir/Vector)
Granulomatous amoebic encephalitis and *Acanthamoeba* keratitis (eye infection)	*Acanthamoeba* spp.	eye, brain, skin	culture	worldwide	contact lenses cleaned with contaminated tap water
Granulomatous amoebic encephalitis	*Balamuthia mandrillaris*	brain, skin	culture	worldwide	via inhalation or skin lesion
Babesiosis	*Babesia B. divergens*, *B. bigemina*, *B. equi*, *B. microfti*, *B. duncani*	red blood cells	Giemsa-stained thin blood smear	New England (different species have worldwide distribution)	tick bites, e.g. *Ixodes scapularis*
Balantidiasis	*Balantidium coli*	intestinal mucosa,	stool (diarrhea		ingestion of cyst, zoonotic infection

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Source/Transmission (Reservoir/Vector)**
		may become invasive in some patients	=ciliated trophozoite; solid stool=large cyst with horseshoe shaped nucleus)		acquired from pigs (feces)
Blastocystosis	*Blastocystis* spp.	intestinal	direct microscopy of stool (PCR, antibody)	• worldwide: one of the most common human parasites[1][2] • Developing regions: infects 40–100% of the total	eating food contaminated with feces from an infected human or animal

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Source/Transmission (Reservoir/Vector)**
				populations[1][2][3]	
Cryptosporidiosis	*Cryptosporidium* spp.	intestines	stool	widespread	ingestion of oocyst (sporulated), some species are zoonotic (e.g. bovine fecal contamination)
Cyclosporiasis	*Cyclospora cayetanensis*	intestines	stool	United States	ingestion of oocyst thru contaminated food
Dientamoebiasis	*Dientamoeba fragilis*	intestines	stool	up to 10% in industrialized countries	ingesting water or food contaminated with feces
Amoebiasis	*Entamoeba histolytica*	intestines (mainly colon, but can cause liver failure if	stool (fresh diarrheic stools have amoeba, solid	areas with poor sanitation, high population density and	fecal-oral transmission of cyst, not amoeba

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Source/Transmission (Reservoir/Vector)
		not treated)	stool has cyst)	tropical regions	
Giardiasis	*Giardia lamblia*	lumen of the small intestine	stool	worldwide?	ingestion of water containing deer or beaver feces
Isosporiasis	*Isospora belli*	epithelial cells of small intestines	stool	worldwide – less common than *Toxoplasma* or *Cryptosporidium*	fecal oral route – ingestion of sporulated oocyst
Leishmaniasis	*Leishmania* spp.	cutaneous, mucocutaneous, or visceral	visual identification of lesion or microscopic stain with Leishman's or Giemsa's stain	visceral leishmaniasis – worldwide; cutaneous leishmaniasis – Old World; mucocutaneous	*Phlebotomus*, *Lutzomyia* – bite of several species of phlebotomine sandflies

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Source/Transmission (Reservoir/Vector)
				leishmaniasis – New World	
Primary amoebic meningoencephalitis (PAM)[4][5]	*Naegleria fowleri*	brain	culture	unknown, but infection is rare	nasal insufflation of contaminated warm fresh water, poorly chlorinated swimming pools, hot springs, soil
Malaria	*Plasmodium falciparum* (80 % of cases), *Plasmodium vivax*, *Plasmodium ovale curtisi*, *Plasmodium ovale wallikeri*, *Plasmodium malariae*, *Plasmodium knowlesi*	red blood cells, liver	blood film	tropical – 250 million cases/year	*Anopheles* mosquito

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Source/Transmission (Reservoir/Vector)**
Rhinosporidiosis	*Rhinosporidium seeberi*	nose, naso pharynx	biopsy	India and Sri Lanka	nasal mucosa came into contact with infected material through bathing in common ponds
Sarcocystosis	*Sarcocystis bovihominis,Sarcocystis suihominis*	intestine, muscle	muscle biopsy	widespread	ingestion of uncooked/undercooked beef/pork with *Sarcocystis* sarco cysts
Toxoplasmosis (Acute and Latent)	*Toxoplasma gondii*	eyes, brain, heart, liver	blood and PCR	worldwide: one of the most common human parasites; estimated to infect between 30–50% of the global	ingestion of uncooked/undercooked pork/lamb/goat with *Toxoplasma* brad yzoites, ingestion of raw milk with *Toxoplasma* tach yzoites, ingestion of contaminated water food or soil with oocysts in cat feces that is more than one day old

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Source/Transmission (Reservoir/Vector)**
				population.[6][7]	
Trichomoniasis	*Trichomonas vaginalis*	female urogenital tract (males asymptomatic)	microscopic examination of genital swab	worldwide	sexually transmitted infection – only trophozoite form (no cysts)
Sleeping sickness	*Trypanosoma brucei*	brain and blood	microscopic examination of chancre fluid, lymph node aspirates, blood, bone marrow	50,000 to 70,000 people; only found in Africa	tsetse fly, day-biting fly of the genus *Glossina*
Chagas disease	*Trypanosoma cruzi*	colon, esophagus, heart,	Giemsa stain – blood	Mexico, Central America,	*Triatoma*/Reduviidae – "kissing bug" insect vector, feeds at night

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Source/Transmission (Reservoir/Vector)
		nerves, muscle and blood		South America – 16–18 million	

SCHOOL OF BIO AND CHEMICAL ENGINEERING

DEPARTMENT OF BIOTECHNOLOGY

UNIT – V – PHYCOLOGY AND MEDICAL PARASITOLOGY – SMB3104

UNIT 5 HELMINTHOLOGY

Helminthology: Classification, Cestodes – *Taeniasolium,T. saginata, T.echinococcus,* trematodes – *Schistosomahaematobium,Fasciola hepatica,* Nematodes – ***Ascaris, Anchylostoma, Trichuris, Enterobius* and *Wuchereria*- their life cycle , Transmission, pathogenicity and Lab Diagnosis**

Helminths

An adult *Ascaris lumbriocoides* worm. They can range from 15 to 35 cm. Credit: CDC.

Helminths are large, multicellular organisms that are generally visible to the naked eye in their adult stages. Like protozoa, helminths can be either free-living or parasitic in nature. In their adult form, helminths cannot multiply in humans. There are three main groups of helminths (derived from the Greek word for worms) that are human parasites:

- Flatworms (platyhelminths) – these include the trematodes (flukes) and cestodes (tapeworms).
- Thorny-headed worms (acanthocephalins) – the adult forms of these worms reside in the gastrointestinal tract. The acanthocephala are thought to be intermediate between the cestodes and nematodes.
- Roundworms (nematodes) – the adult forms of these worms can reside in the gastrointestinal tract, blood, lymphatic system or subcutaneous tissues. Alternatively, the immature (larval) states can cause disease through their infection of various body tissues. Some consider the helminths to also include the segmented worms (annelids)—the only ones important medically are the leeches. Of note, these organisms are not typically considered parasites.

Helminths (worms)

Helminth organisms (also called helminths or intestinal worms) include:

Tapeworms

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Transmission/ Vector
Tapeworm – Tapeworm infection	*Cestoda*, *Taenia multiceps*	intestine	stool	rare worldwide	
Diphyllobothriasis – tapeworm	*Diphyllobothrium latum*	intestines, blood	stool (microscope)	Europe, Japan, Uganda, Peru, Chile	ingestion of raw fresh water fish
Echinococcosis – tapeworm	*Echinococcus granulosus*, *Echinococcus multilocularis*, *E. vogeli*, *E. oligarthrus*	liver, lungs, kidney, spleen	imaging of hydatid cysts in the liver, lungs, kidney and spleen	Mediterranean countries	as intermediate host, ingestion of material contaminated by feces from a carnivore; as definite host, ingestion of uncooked meat (offal) from a herbivore

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Transmission/ Vector
Hymenolepiasis[8]	*Hymenolepis nana*, *Hymenolepis diminuta*				ingestion of material contaminated by flour beetles, mealworms, cockroaches
Beef tapeworm	*Taenia saginata*	Intestines	stool	worldwide distribution	ingestion of undercooked beef
Cysticercosis-Pork tapeworm	*Taenia solium*	Brain, muscle, Eye (Cysts in conjuntiva/anterior chamber/sub-retinal space)	stool, blood	Asia, Africa, South America, Southern Europe, North America.	ingestion of undercooked pork
Bertielliasis	*Bertiella mucronata*, *Bertiella studeri*	Intestines	stool	rare	contact with non-human primates

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Transmission/ Vector
Sparganosis	*Spirometra erinaceieuropaei*				ingestion of material contaminated with infected dog or cat feces (humans: dead-end host)

Flukes[edit]

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Transmission/Vector
Clonorchiasis	*Clonorchis sinensis*; *Clonorchis viverrini*	gall bladder ducts and inflammation of liver		East Asia	ingestion of under prepared freshwater fish
Lancet liver fluke	*Dicrocoelium dendriticum*	gall bladder		rare	ingestion of ants

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Transmission/Vector**
Liver fluke – Fasciolosis[9]	*Fasciola hepatica*, *Fasciola gigantica*	liver, gall bladder	stool	*Fasciola hepatica* in Europe, Africa, Australia, the Americas and Oceania; *Fasciola gigantica* only in Africa and Asia, 2.4 million people infected by both species	freshwater snails
Fasciolopsiasis – intestinal fluke[10]	*Fasciolopsis buski*	intestines	stool or vomitus (microscope)	East Asia – 10 million people	ingestion of infested water plants or water (intermediate host:amphibic snails)

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Transmission/Vector
Metagonimiasis – intestinal fluke	*Metagonimus yokogawai*		stool	Siberia, Manchuria, Balkan states, Israel, Spain	ingestion of undercooked or salted fish
Metorchiasis	*Metorchis conjunctus*			Canada, US, Greenland	ingestion of raw fish
Chinese liver fluke	*Opisthorchis viverrini*, *Opisthorchis felineus*, *Clonorchis sinensis*	bile duct		1.5 million people in Russia	consuming infected raw, slightly salted or frozen fish
Paragonimiasis, lung fluke	*Paragonimus westermani*; *Paragonimus africanus*; *Paragonimus caliensis*; *Paragonimus kellicotti*; *Paragonimus*	lungs	sputum, feces	East Asia	ingestion of raw or undercooked freshwater crabs crayfishes or other crustaceans

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Transmission/Vector**
	skrjabini; *Paragonimus uterobilateralis*				
Schistosomiasis – bilharzia, bilharziosis or snail fever (all types)	*Schistosoma* sp.			Africa, Caribbean, eastern South America, east Asia, Middle East – 200 million people	skin exposure to water contaminated with infected freshwater snails
intestinal schistosomiasis	*Schistosoma mansoni* and *Schistosoma intercalatum*	intestine, liver, spleen, lungs, skin, rarely infects the brain	stool	Africa, Caribbean, South America, Asia, Middle East – 83 million people	skin exposure to water contaminated with infected *Biomphalaria* freshwater snails

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Transmission/Vector**
urinary blood fluke	*Schistosoma haematobium*	kidney, bladder, ureters, lungs, skin	urine	Africa, Middle East	skin exposure to water contaminated with infected *Bulinus* sp. snails
Schistosomiasis by *Schistosoma japonicum*	*Schistosoma japonicum*	intestine, liver, spleen, lungs, skin	stool	China, East Asia, Philippines	skin exposure to water contaminated with infected *Oncomelania* sp. snails
Asian intestinal schistosomiasis	*Schistosoma mekongi*			South East Asia	skin exposure to water contaminated with infected *Neotricula aperta* – freshwater snails
Echinostomiasis	*Echinostoma echinatum*	small intestine		Far East	ingestion of raw fish, mollusks, snails
Swimmer's itch	*Trichobilharzia regenti*, Schistosomatidae			worldwide	skin exposure to contaminated water

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Prevalence	Transmission/Vector
					(snails and vertebrates)

Roundworms[edit]

Disease caused	Latin name (sorted)	Habitat in definite host	Prevalence	Vector or intermediate host	Mode of transmission
Ancylostomiasis /Hookworm	*Ancylostoma duodenale*, Necator americanus	lungs, small intestine, blood	stool	common in tropical, warm, moist climates	penetration of skin by L3 larva
Angiostrongyliasis	*Angiostrongylus*	intestine	stool		ingestion of infected faeces or infected slugs
Anisakiasis[11]	*Anisakis*	allergic reaction	biopsy	incidental host	ingestion of raw fish, squid, cuttlefish, octopus

Disease caused	Latin name (sorted)	Habitat in definite host	Prevalence	Vector or intermediate host	Mode of transmission
Roundworm – Parasitic pneumonia	*Ascaris* sp. *Ascaris lumbricoides*	Intestines, liver, appendix, pancreas, lungs, Löffler's syndrome	stool	common in tropical and subtropical regions	
Roundworm – Baylisascariasis	*Baylisascaris procyonis*	Intestines, liver, lungs, brain, eye		rare: North America	stool from raccoons
Roundworm-lymphatic filariasis	*Brugia malayi*, *Brugia timori*	lymph nodes	blood samples	tropical regions of Asia	arthropods
Dioctophyme renalis infection	*Dioctophyme renale*	kidneys (typically the right)	urine	rare	ingestion of undercooked or raw freshwater fish

Disease caused	Latin name (sorted)	Habitat in definite host	Prevalence	Vector or intermediate host	Mode of transmission
Guinea worm – Dracunculiasis	*Dracunculus medinensis*	subcutaneous tissues, muscle	skin blister/ulcer	South Sudan (eradication ongoing)	
Pinworm – Enterobiasis	*Enterobius vermicularis*, *Enterobius gregorii*	intestines, anus	stool; tape test around anus	widespread; temperate regions	
Gnathostomiasis [12]	*Gnathostoma spinigerum*, *Gnathostoma hispidum*	subcutaneous tissues (under the skin)	physical examination	rare – Southeast Asia	ingestion of raw or undercooked meat (e.g., freshwater fish, chicken, snails, frogs, pigs) or contaminated water
Halicephalobiasis	*Halicephalobus gingivalis*	brain			soil-contaminated wounds

Disease caused	**Latin name (sorted)**	**Habitat in definite host**	**Prevalence**	**Vector or intermediate host**	**Mode of transmission**
Loa loa filariasis, Calabar swellings	*Loa loa filaria*	connective tissue, lungs, eye	blood (Giemsa, haematoxylin, eosin stain)	rain forest of West Africa – 12–13 million people	Tabanidae – horsefly, bites in the day
Mansonelliasis, filariasis	*Mansonella streptocerca*	subcutaneous layer of skin			insect
River blindness, onchocerciasis	*Onchocerca volvulus*	skin, eye, tissue	bloodless skin snip	Africa, Yemen, Central and South America near cool, fast flowing rivers	*Simulium*/black fly, bites during the day
Strongyloidiasis – Parasitic pneumonia	*Strongyloides stercoralis*	intestines, lungs, skin (Larva currens)	stool, blood		skin penetration
Thelaziasis	*Thelazia californiensis*,	eyes	ocular examination	Asia, Europe	*Amiota (Phortica) variegata*, *P*

Disease caused	**Latin name (sorted)**	**Habitat in definite host**	**Prevalence**	**Vector or intermediate host**	**Mode of transmission**
	Thelazia callipaeda				*hortica okadai*
Toxocariasis	*Toxocara canis*, *Toxocara cati*, *Toxascaris leonina*	liver, brain, eyes (*Toxocara canis* – visceral larva migrans, ocular larva migrans)	blood, ocular examination	worldwide distribution	pica, unwashed food contaminated with *Toxocara* eggs, undercooked livers of chicken
Trichinosis	*Trichinella spiralis*, *Trichinella britovi*, *Trichinella nelsoni*, *Trichinella nativa*	muscle, periorbital region, small intestine	blood	more common in developing countries due to improved feeding practices in developed countries.	ingestion of undercooked pork

Disease caused	Latin name (sorted)	Habitat in definite host	Prevalence	Vector or intermediate host	Mode of transmission
Whipworm	*Trichuris trichiura*, *Trichuris vulpis*	large intestine, anus	stool (eggs)	common worldwide	accidental ingestion of eggs in dry goods such as beans, rice, and various grains or soil contaminated with human feces
Elephantiasis – Lymphatic filariasis	*Wuchereria bancrofti*	lymphatic system	thick blood smears stained with hematoxylin.	tropical and subtropical	mosquito, bites at night

Other organisms[edit]

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Transmission/Vector**
Acanthocephaliasis	Archiacanthocephala, *Moniliformis moniliformis*	Gastrointestinal tract, peritoneum, eye	Faeces, parasite itself	worldwide	ingestion of intermediate hosts
Halzoun syndrome	*Linguatula serrata*	nasopharynx	physical examination	Mid East	ingestion of raw or undercooked lymph nodes (e.g., meat from infected camels and buffaloes)
Myiasis	Oestroidea, Calliphoridae, Sarcophagidae	dead or living tissue			
Screwworm, Cochliomyia	*Cochliomyia hominivorax* (family Calliphoridae)	skin and wounds	visual	North America (eradicated), Central America, North Africa	direct contact with fly

Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Prevalence**	**Transmission/Vector**
Chigoe flea	*Tunga penetrans*	Subcutaneous tissue	physical examination	Central and South America, Sub-Saharan Africa	
Human botfly	*Dermatobia hominis*	Subcutaneous tissue	physical examination	Central and South America	mosquitoes and biting flies