Protista

Introduction

All you need is a small puddle of water to be able to find some protista, which are very small microorganisms; commonly they may be found in the thin film of water covering particles of the ground.
There are a number of parasite species, some of which cause severe diseases in man, such as malaria; others live in symbiosis with other animals, for example in their intestines, and their action facilitates the digestive processes.

Protista knowledge

Small but fundamental

Protista are microscopic, mainly unicellular organisms, i.e. consisting of one cell only. Unlike Monera, which have no distinguished nucleus, Protista have a nucleus and this is why they are called eukaryotes. Their genetic material (DNA) is in the nucleus, wrapped in a membrane that separates it from the cytoplasm.
Protista are the kingdom with the highest degree of variability, which includes micro-organisms with very different shapes, structures and living conditions.
All Protista can reproduce asexually, i.e. they can duplicate without exchanging any genetic material. This is the most frequently used method to increase the number of individuals. But, in case of need, they can recombine their genetic inheritance, i.e. reproduce through “sexed” methods. All Protista have an aerobic metabolism, i.e. they need oxygen to live.
They consist of two large groups: autotrophic and heterotrophic protista.

Autotrophic protista

They can perform photosynthesis and mainly consist of unicellular algae. They can be divided into a number of systematic groups according to the shape of their cells and the type of photosynthetic pigments they use.

• **Chrysophyta or golden algae**: they live in both sea and freshwater; the most common ones are diatoms, which are equipped with a typical siliceous shell (SiO_2), consisting of two parts joined with each other like a box and a lid. The shell is provided with many small holes through which the cell communicates with the external environment. Diatoms usually live near the seabed.
• **Dinoflagellata**: they generally live in the sea and are also equipped with a shell, consisting of many cellulose plates. They have two flagella (resembling cilia, only longer) for covering small distances. They are among the most important components of the marine phytoplankton.
• **Euglenida**: they live in ponds and lakes. These organisms are provided with chloroplasts (cellular organelles containing chlorophyll, the pigment involved in the photosynthesis) and can therefore perform the photosynthesis; however, without light, they become heterotrophic and start therefore feeding on the organic substances they find in the surrounding environment. Their cell is equipped with two flagella and an eyespot, i.e. a concentration of light-sensitive pigments that allow Protista to move towards light.

Heterotrophic Protista

These Protista are also known as Protozoa, which means “first animals”; in fact, the term does not mean that all protozoa are the ancestors of the animals, but refers to the fact that they ingest food, which is typical of animals.
Some of these Protista are predators and feed on bacteria and other Protista, i.e. they feed on dead organic matter, while others are parasites that exploit the resources of several organisms.
They can be divided into three main groups depending on how they move:

• **Amoeboid protozoa**: they move with the aid of the pseudopodia, which means “false feet’, i.e. extensions of the cellular cytoplasm that allow the cell to move. The pseudopodia are also used to take in the food particles by phagocytosis (absorption of particles by a cell). This group includes amoebas: they have no external coatings, live in still water and damp soils and some species can be parasitic, such as Entamoeba histolityca, which transmits a disease, amoebic dysentery. On the contrary, Foraminiferida are provided with a calcareous coating with many holes, out of which protrude the pseudopodia, and always live in the sea. Heliozoia and Radiolaria, instead, differ from the others organisms for they have special props in their pseudopodia that keep them fairly stiff.
• **Flagellate protozoa**: they are equipped with between one and many flagella, through which they move. This group includes organisms that live on their own as well as parasitic ones, some of which transmit intestinal infections, such as the Trichomonas or Tripanosoma; this protozoan lives in Central Africa and moves from the body of the tsetse fly to the body of man or cattle, transmitting the serious sleeping sickness, which causes about 5,000 deaths a year. Other protozoa are symbionts, i.e. they benefit their hosts, such as the *Tryconimpha*, that lives in the stomach of termites, helping them digest the wood they feed on.
Sporozoa: they have no organs to move. They are all parasites of animals, of other protozoa and man. They can produce spores. This group includes the Plasmodium malariae, which causes the disease transmitted by the female Anopheles, and the Toxosplasma gondii, which transmits toxoplasmosis.
• **Ciliates**: they are considered the most developed group because of their complexity. They can live either in freshwater or salty water, and move with the aid of the cilia, that in some species cover all the cell, while in others they only cover some areas. In these protozoa, the food is not fed into any point of the cell, but in a specific area, the cytopharynx, near an opening between the cilia, which flutter to move in the food particles. This class includes the paramecium, the vorticella and the Balantidium coli, which causes intestinal lesions in man.

A long food chain

Even if protista are rather small in size (usually between few microns to a few millimetres), they are very important for natural organisation, given the important role that photosynthetic protozoa play in the food chain of the aquatic organisms.
They mainly feed on bacteria and thus play an essential role in the food chain, since they are the main producers on which all other organisms depend. The number of these organisms belonging to marine plankton can be huge; they have been found even as at 1,000 and 5,000 metres deep. This group includes, for instance, diatoms, which, as we said before, are equipped with a siliceous shell.
After the organism dies, it can fall and settle on the seabed, thus originating, especially in the coldest seas, some siliceous deposits that are called “infusorial earth”, used for instance to polish silver and to make toothpaste.
Diatoms are food for many forms of life, such as small crustaceans, called Copepoda, which in turn are food for the shoals of herrings.
Plankton is also composed of other protozoa, such as Radiolaria, large amounts of which lived in the past geological ages. After death, their shells settle on the seabed, building up a thick, hard rock, known as radiolarite, which, along with siliceous deposits from diatoms, compose the “infusorial earth”.

Together at all costs: the symbiosis

There are cases of symbiosis between animals and protozoa, in particular unicellular algae. The animals in which this phenomenon is most common are Radiolaria and Foraminifera (among protozoa), Coelenterata, Ctenophora, Platyhelminthes and molluscs (among Metazoa). In omnivore or herbivore species, such as, for instance, Radiolaria and Foraminifera, the algae adapt inside the cell by developing systems to resist the attack of some digestive enzymes of the host, especially cellulase. For instance, the zoochlorellae, even if they can also live on their own, can always be found in the *Convoluta* sp. Turbellaria (resembling a flat worm), where they get under the epidermis. They can invade the animal through the capsule of the egg, by which they are attracted. The Convoluta cannot live without these algae, because it needs the lipids they produce.

Zooxanthellae

Another case of symbiosis is the one between the mollusc *Tridacna*, which lives on the reefs of the Asian Pacific region, and the zooxanthellae. The latter live on the edge of the coating of the mollusc, which contains “hyaline bodies”, i.e. transparent bodies, that make it easier for light to penetrate; the zooxanthellae crowd around these bodies to perform the photosynthesis. The zooxanthellae are symbionts, also of Coelenterata, and reproduce through eggs. In the Mediterranean Sea, they live only in some sea anemones, but in the Tropical seas the symbionts live in very many species of Coelenterata, especially in the Madreporaria of the reefs. The polyp of the madrepores contains these algae that give it its brown-reddish colour. The algae supply the polyp with energy in the form of sugars and amino acids, produce oxygen and remove carbon dioxide (which could form carbonic acid and damage the calcareous skeleton of the polyps). In return, the polyps offer protection to these small algae. Every square centimetre of a madrepore contains approximately one million algae sp. *Zooxanthellae*.

Protistas’ ancestors

The most ancient fossil traces of the first eukaryote cells date back to approximately 1 and a half billion years ago. Prokaryotes had appeared two billion years earlier, and up to then they had been the only inhabitants: in the intervening time, the bacteria had had the opportunity to differentiate into two different lines of evolution. One of these originated the first eukaryotes, i.e. Protista, following the spread of bacteria that could perform the photosynthesis (cyanobacteria), enriching the atmosphere with oxygen. Since all Protista have an aerobic metabolism, they could not have developed before that time. It seems some bacteria may have started to form symbiotic associations with several bacteria, some of which could have evolved into cellular organelles (e.g. mitochondria and chloroplasts).

Man and Protista

Protista as disease-carriers

Protista live anywhere, provided there is even a little amount of water.
There are marine and freshwater species that live both floating on the water or on the seabed. A small water pond is enough for these micro-organisms to live; they can usually be found even in the thin film of water that covers the soil particles. Finally, there are many parasitic species, some of which transmit serious diseases to man. Here are some of the most important diseases that affect man:
• the sleeping sickness caused by trypanosomes, such as, for instance, the *Tripanosoma gambiense*, transmitted to man by some species of the tsetse fly
• toxoplasmosis, a disease affecting nearly 50% of the human population; harmless in itself, it becomes dangerous when it affects a pregnant woman since it is transmitted to the child, causing deformities
• malaria, transmitted to man by the anopheles, parasited by the Plasmodium. This disease still causes approximately 3 million victims a year, of whom one million are African children.

Cold beer that burns: Ciguatera

Intoxication from Ciguatera is caused by the fish that feed on plants or small fish, which in their turn have accumulated the toxin from Dinoflagellata, such as *Gambierdiscus toxicus*. The larger the fish, the higher the amount of accumulated toxin. The symptoms, that usually begin 15 to 30 minutes after eating contaminated fish, include abdominal pain, nausea, vomiting, diarrhoea, numbness of the tongue and pharynx, toothache, walking problems, blurred vision, rashes, itchiness, tears, weakness, muscle spasms, lack of motor co-ordination, sleeplessness and occasionally irregular breathing. A peculiar feature of Ciguatera is a reversed perception of temperature: a cold beer burns, a hot shower gives the shivers. In addition, drinking still water feels like drinking sparkling water or like an electric shock in the mouth.
The victims can be in very severe conditions, even shocked, a few minutes after the intoxication. Ciguatera is quite common in the Caribbean and in the Tropical areas of the Asian-Pacific Ocean and rarely lethal. It is estimated that the

cases of Ciguatera in the world are approximately 50,000 a year. Ciguatera cannot be prevented by testing fish or patients, and there are no standard treatments. Unfortunately, many of its most annoying, even if not dangerous, symptoms can last for weeks or months. The treatment is essentially symptomatic and no antidotes are known.

Protection of water

A fire-red lake

Lake Tovel, in the Trentino region, is known all over the world for the exceptional phenomenon of the "reddening of its waters". During the hottest hours of some summer days, large portions of the lake surface took a deep red colour, offering an incredible sight. The spectacular colour was due to the strong concentration of a unicellular alga of the group Dinoflagellata, the Glenodinium sanguineum (also known as Woloszynskya coronata). This alga, which is just 1/50 mm long, under specific stress conditions, stores special pigments, called carotenoids, which make it look completely red. 1964 was the last year in which the reddening phenomenon appeared as clearly as usual; since then, the alga, although still living in the lake, has not reached the concentration it takes to "inflame" the waters. Since 2001, the Provincia Autonoma di Trento has funded a research project for investigating the factors that are responsible for the missed reddening of the waters of Lake Tovel. The goal of the project is not to restore the conditions that in the past led to the flowering of the alga. The only purpose is to acquire all that information and details on the peculiarities of Lake Tovel that the local administrators need to make the best choices on the future of the lake. Lake Tovel is located in a lovely region, which attracts tourists and hikers, like many Alpine lakes, and is a precious water supply for the agriculture of the valley of the Trentino region, a reservoir of drinking water and, what's more, an added value given by the phenomenon of the reddening of its waters.

Man paints the sea red

Under favourable conditions, Dinoflagellata can rapidly proliferate and form large clusters. Red tides are the most conspicuous proofs of the massive presence of Dinoflagellata. In 1986, an increase in the Dinoflagellata population of the type Gymnodium brevi caused a significant red tide along the coasts of the Gulf of Texas. It extended 500 km along the coasts and caused the death of over 22 million fish in 2 months. Mollusc fishing was banned along 3/4 of the coast of the Gulf of Texas, south of Galveston, which caused a loss of oysters for a total of 1,4 million US dollars. Bivalvular molluscs are filter feeders, which feed on plankton and which, although storing the toxins contained in these Dinoflagellata, are only partly affected by their harmful effects. Nevertheless, under special circumstances, the amount of toxins that can concentrate in each single mollusc can be lethal even for man. In the same year, hundreds of tursiops dolphins died along the coasts of New Jersey and Maryland, when the red tide moved eastwards from the western coast of Florida after surviving a fairly mild winter. In Italy, algal proliferation phenomena took place in 1975 in the coastal area south of the mouth of the Po. Between 1975 and 1976, the algae caused the death of plenty of benthic animals (i.e. that live in contact with the seabed) and fish. It is assumed that the human impact on the coastal areas and in particular the gradual increase in the discharge of urban, industrial, agricultural and zoo-technical waste water into the sea may have boosted the development of these toxic algae.

Micro-organisms purify water

Before being discharged into rivers and lakes, waste waters must be purified. One of the systems used for this purpose is activated-sludge purification. This process utilises the water self-purification principle, in which the micro-organisms (bacteria, protozoa and metazoa) use the organic substances contained in the water, transform them and remove them from the water. The aerobic process is the most commonly used one, i.e. oxygen is supplied to trigger the biological processes in which the organic substances are oxidised. When this reaction is over, water is purified and flakes of biological material known as "activated sludge" are produced. This activated sludge consists of organic and inorganic components and different species of micro-organisms (especially bacteria). Ciliate protozoa play a very important role in the purification process. There is competition for food in the oxidisation tanks, i.e. the place in which purification takes place: bacteria are eaten by small predators (ciliate protozoa), which in their turn are eaten by larger organisms (carnivore protozoa or metazoa); so, bacteria need nutrients which consist of the organic matter contained in the waste water. The presence of ciliate protozoa in the activated sludge proves therefore that there are bacteria as well; if there are approximately 10 million individuals per litre, it means the purification plant works. By studying ciliate protozoa, used as bio-indicators, one can check if the plant works (low oxygen content, too many organic substances, excessive sludge extraction) and take corrective measures.

Water preservation

In the last decades is being undertaken a “biotechnological solution” which is capable of removing polluting agents from water: phytodepuration is based on the self-purification capacity of acquatic ecosystems through physical, chemical and biological processes carried out by vegetal organisms and bacteria. Plants involved are macro and microphytes which are specifically selected according to some characteristics as their capacity to adapt to the environment which needs to be decontaminated and their rapid growth with formation of biomass; in any case, the species employed for phytodepuration are water plants or hygrophilous plants which grow in moist environments. In particular, according to the type of phytodepuration system which is under construction, different types of floating, submerged and emergent microphytes are used alone or in group. Water depuration takes place thanks to the combined action of macrophytes and some associated micro-organisms: algae feed on a part of the existing pollutants and favour the development of bacteria capable of transforming harmful substances by metabolizing them. The type of installation of a phytodepuration system depends on the direction of the water flow. Surface flow systems consist of tanks or channels from 40 to 60 cm deep and recreate an ecosystem similar to ponds covered by floating hygrophilous plants. In sub-surface flow systems, instead, flowing water isn’t in contact with the atmosphere and an inert stand is inserted in the tanks where the roots of macrophytes will grow. Water flows under the inert stand to favour movement in the tank, which is 70-80 cm deep and is inclined. Phytodepuration systems are a valid alternative to wastewater treatment for small rural communities and seasonal sewers as those of camping sites, hotels and holiday villages or for the treatment of industrial wastewater, percolates coming from landfills and run-off water coming from roads and motorways. Construction costs are very variable but, anyhow, are never higher than those of conventional depuration plants whereas management costs are incredibly low as energy consumption can even be non existent.