BioMEDIA ASSOCIATES LL.C.
LIFE FROM LIGHT

Study Guide

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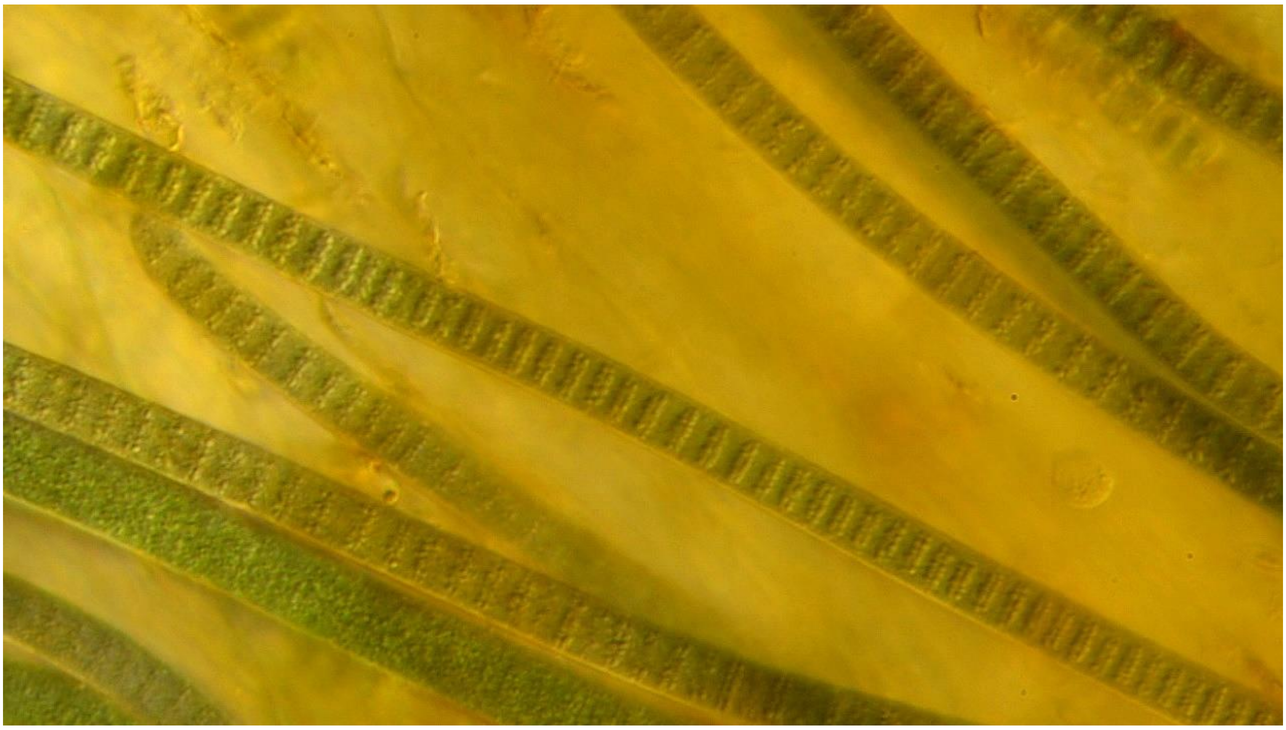
Supplement to Video Program



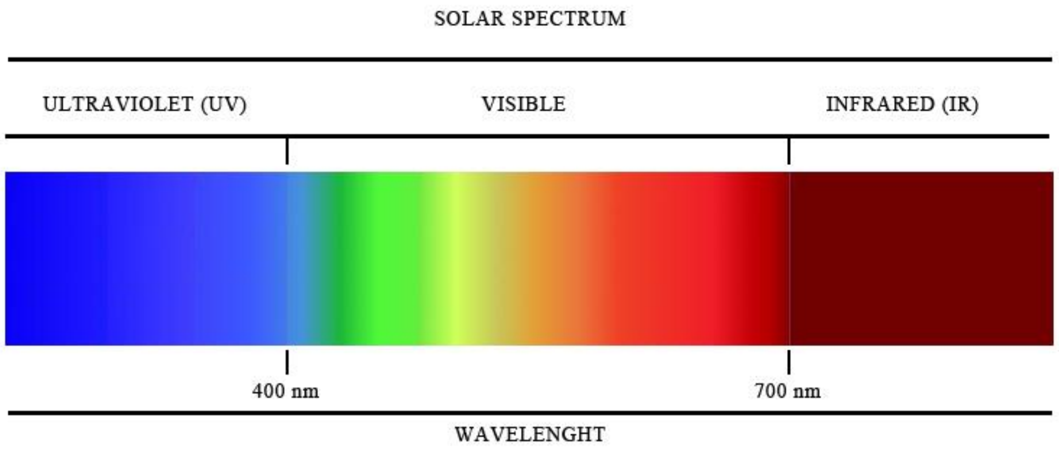
The great biodiversity we can see currently on our planet id the results of million years of evolution of life. This evolution has been based on the adequacy to the environmental conditions that, at each instant, have dominated the planet. So evolution of life has been always directly linked to geological evolution of the planet Earth.

We depend on the sun

The relationship between the planets of our solar system and the main star, the Sun, is extremely important, especially the distance between the planet and the star.

The Sun is an enormous nuclear power station where hydrogen (H) is transformed into helium (HE) by means of nuclear fusion reactions.

The result of this transformation is the liberation of a great amount of radiation, coming to us in the form of Ultraviolet radiation, Visible radiation and Infrared radiation.



The Sun emits radiation with a wavelength among 0,015 μm y 4 μm. The radiation with a wavelength among 0.015 μm and 0.36 μm is called Ultraviolet radiation (UV); the radiation with a wavelength among 0.36 μm and 0.76 μm is called Visible radiation, and the radiation with a wavelength among 0.76 μm y 4 μm is called Infrared radiation (IR).

These three types of radiation represent the 99% of the total radiation we receive from the Sun (7%UV, 43% Visible and 49% IR).

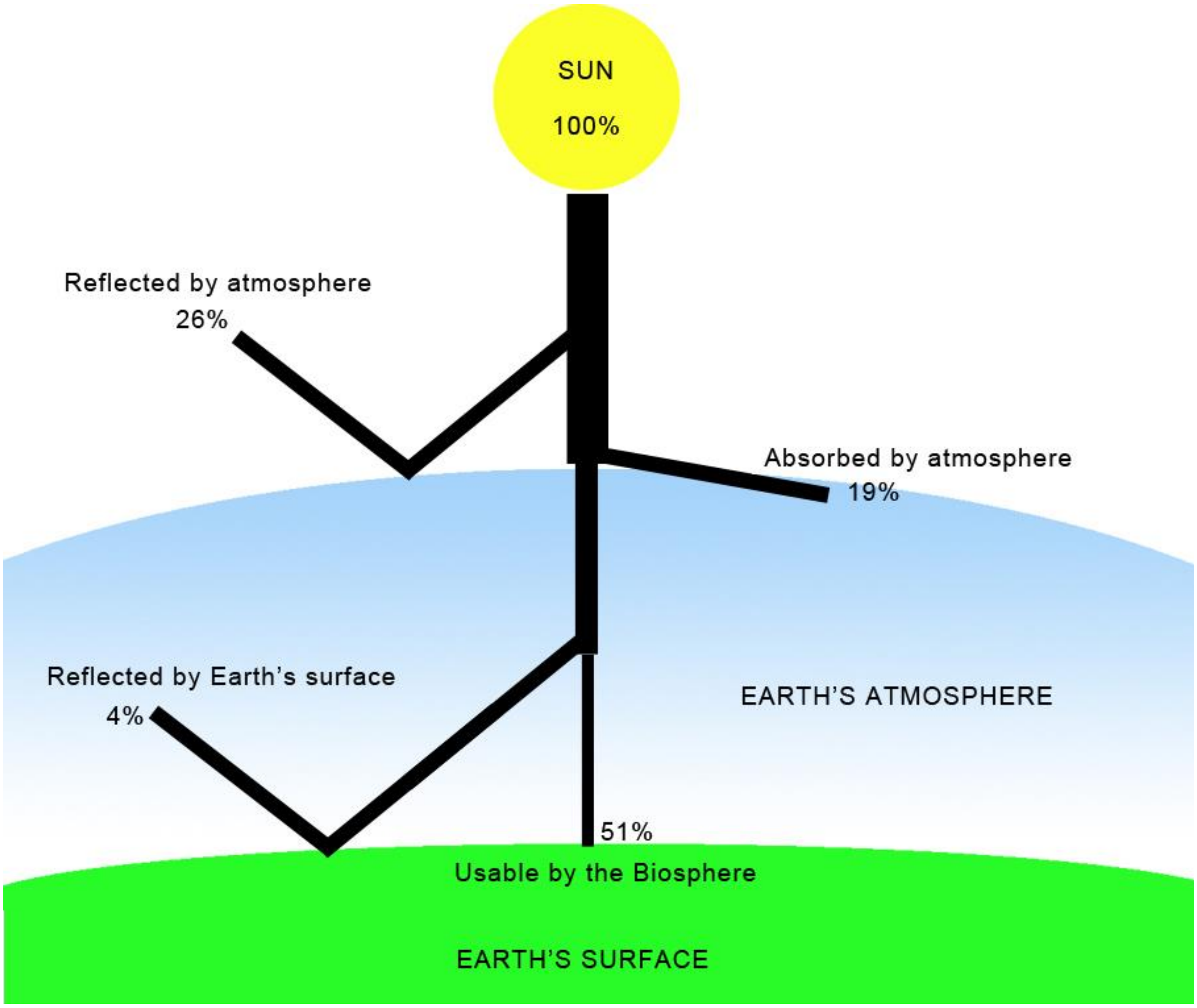
At the upper part of the Earth's atmosphere approximately the 26% of the total radiation is reflected to the outer space and lost.

The gases conforming our atmosphere (78.08% nitrogen, 20.95% oxygen, 0.93% argon, 0.03% carbon dioxide and 0.01% other) act as a filter for the solar radiation, mainly for the UV and IR radiation, and absorb approximately the 19% of that total radiation.

Finally, the Earth's surface (both soil and oceans) reflects approximately another 4% of the total radiation.

The final result is that, approximately only the 51% of all the energy that reaches the external part of the atmosphere ends on the planet surface, on the continents and oceans' surface.

That is the energy, the radiation, the light available for the organisms inhabiting the Earth, the light we all depend on, and the light that has defined the evolution of life in our planet.



The first photosynthesis

We use to relate photosynthesis with green plants, trees and flowers.

These plants use the light to convert the carbon dioxide (CO_2) into sugar as glucose. Nevertheless, plants were not the first photosynthetic organisms

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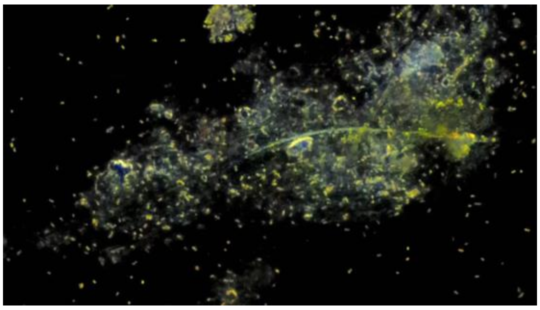
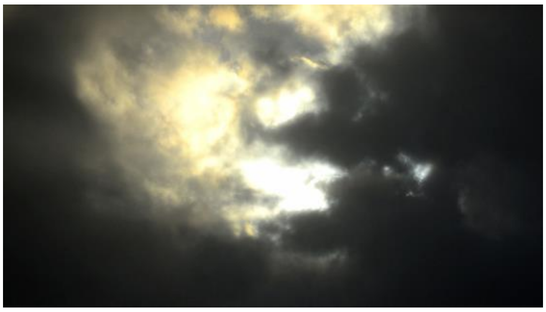
As has been happening many times during the evolutionary history of life on our planet, the truly inventers of most of the metabolic pathways were bacteria.



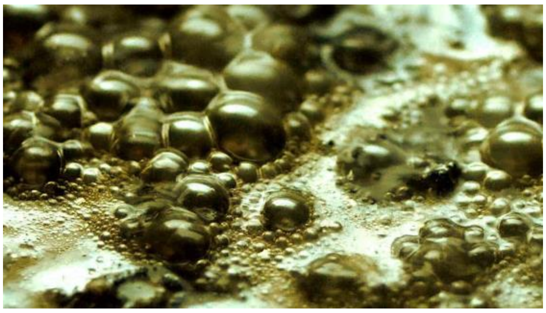
During the early stages of the evolution of life on Earth organisms faced very different environmental conditions from the current ones.



The primitive atmosphere were probably formed mainly by compounds as the carbon dioxide (CO_2), hydrochloric acid (HCl), nitrogen (N_2), sulfur dioxide (SO_2) and water vapor (H_2O). There was not free oxygen in the gas form, so it was a reducing atmosphere.

Volcanic emissions injected (it is also currently happening) a great amount of gases into the atmosphere, mainly H_2O (vapor), SO_2 and CO_2, and in a lesser measure other gases among them hydrogen sulfide (H_2S) and methane (CH_4).

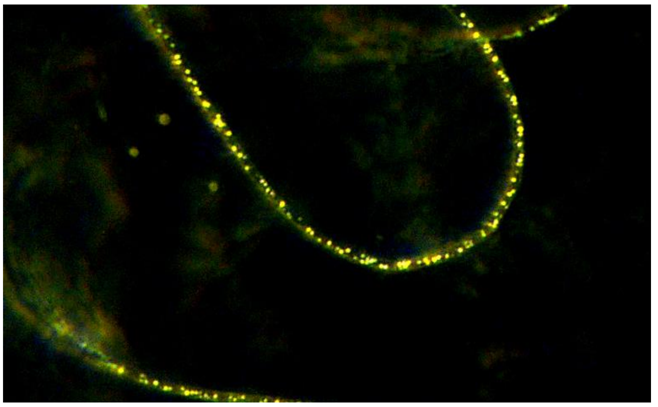
Condensation of that water vapor originated the liquid water forming the oceans. It also dissolved an important quantity of compounds as the CO_2, the HCl, the H_2S and the SO_2, and as a result of this the gas nitrogen (N_2) remained as the principal atmospheric component (as it is also today).



At that moment, with abundant water and dissolved inorganic compounds, the first organisms started their evolution.

They were prokaryotic organisms, mostly bacteria that were able to use different sources of energy to live. Some of them were able to oxidize the H_2S and to extract the needed energy for their metabolism. They do not need anything more, they were chemolithotrophic organisms.

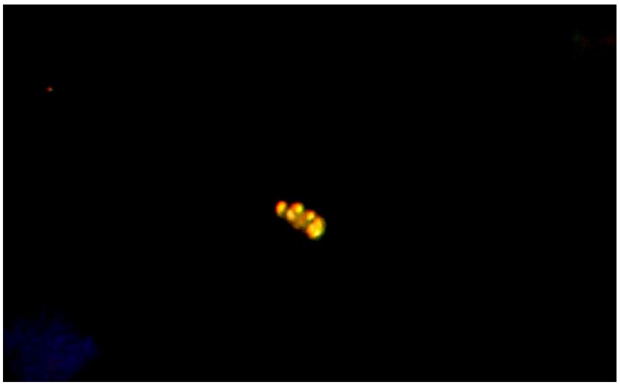
Today we can find several species of these chemolithotrophic organisms inhabiting the ecosystems, among them bacteria of the genus *Beggiatoa*, which accumulate the sulfur resulting from their metabolic reactions inside the cells.



Jointly with that group of bacteria there appeared another one, that of the photolithotrophic organisms, which used the solar energy, the light, to extract the energy from the hydrogen sulfide molecule (H_2S) and used it to convert the inorganic matter (CO_2) into organic matter ($C_6H_{12}O_6$) developing the following chemical reaction:

$$\boxed{6CO_2 + 12H_2S \rightarrow C_6H_{12}O_6 + 6H_2O + 12S}$$

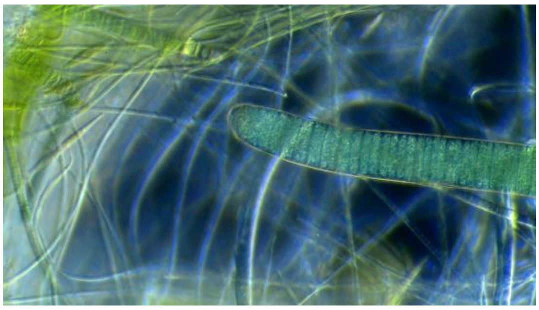
As we can see, as a result of the reaction of 6 molecules of CO_2 and 12 molecules of H_2S it appears 1 molecule of glucose ($C_6H_{12}O_6$) with the liberation of 6 molecules of water (H_2O) and 12 atoms of sulfur (S). This reaction does not liberate oxygen (O) but sulfur (S), which is accumulated as yellow grains both inside and outside the bacterial cells (depending on the type of bacteria). This is the reason this reaction is called ANOXYGENIC PHOTOSYNTHESIS.



That was the first type of photosynthesis in our planet, and even today, some bacteria as *Allochromatium* keep using this method to obtain the energy to develop their metabolic functions.

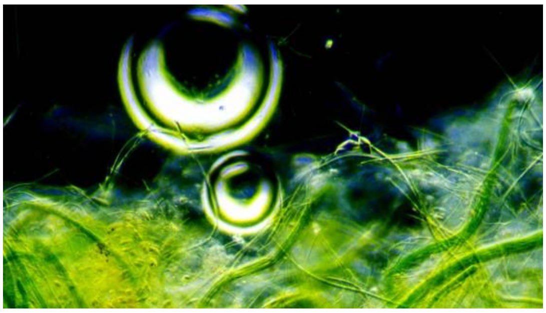
A “subtle” variation

At some point in those initial episodes of the evolution of life on Earth, another group of bacteria, called Cyanobacteria, acquired a new ability.



Instead of using the light to break down the molecule of hydrogen sulfide (H_2S), they used it to break down a much more abundant molecule: water (H_2O).
This change does not seem a lot, but its repercussions both on the planet and the life developing on it have been enormous.
The “new” photosynthesis “invented” by Cyanobacteria is described by the following chemical equation:

$$6CO_2 + 6H_2O \rightarrow 2(C_6H_{12}O_6) + 6O_2$$

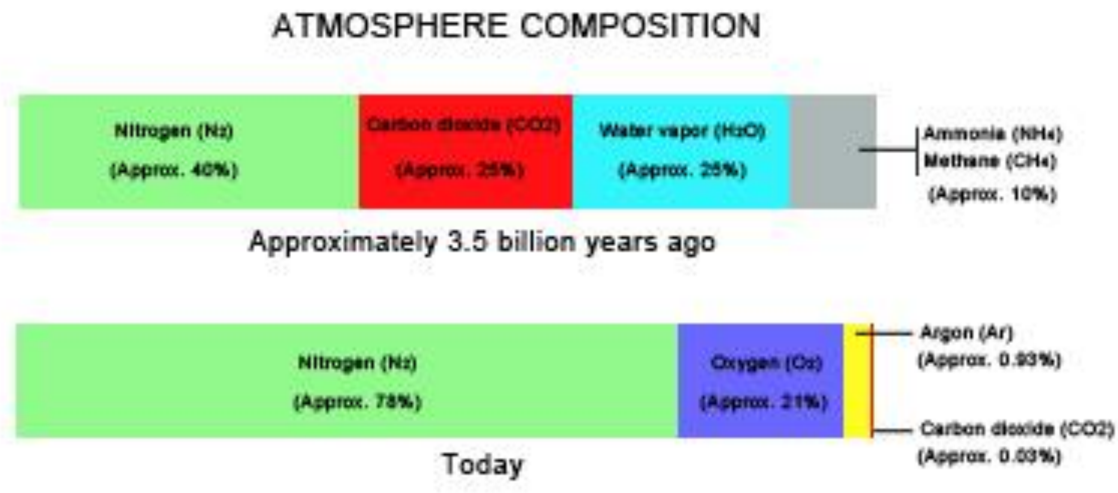


Unlike what happens in the anoxygenic photosynthesis, this new one does not liberate sulfur (S) but oxygen (O).

For a long time that oxygen liberated into the water reacted with other chemical compounds and elements, mainly iron (Fe) to form oxides which were deposited at the sea bottom. Now we can see that process by looking at the banded iron formations from Minnesota and many other places in the world. However, there came the moment when there was not iron enough to react with all the oxygen liberated by the organisms using this new photosynthetic pathway, and oxygen began to escape into the atmosphere as molecular oxygen (O_2).

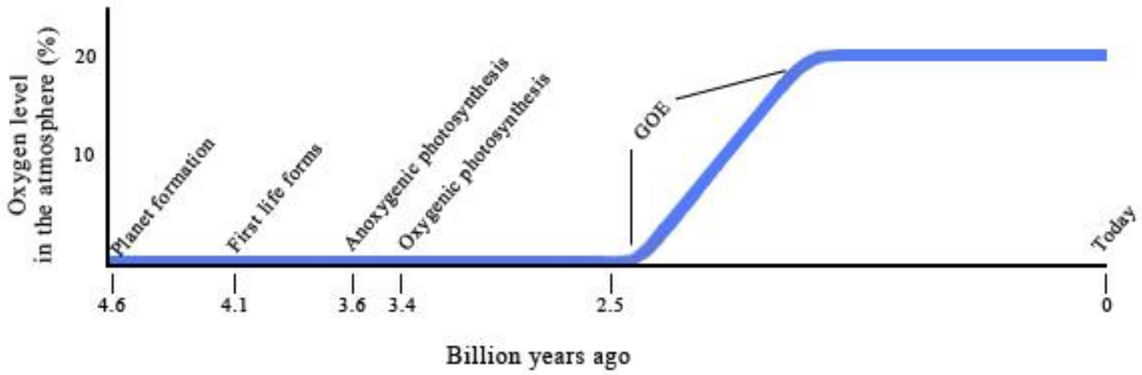
The Great Oxidation Event (GOE)

A direct consequence of this quick liberation of oxygen into the atmosphere was the radical change of the atmospheric conditions, which changed from reductive to oxidative.



That drastic change is what scientists call the Great Oxidation Event (GOE).

It is estimated that the GOE took place around 2.5 billion years ago, and it had an enormous repercussion over the life on Earth.



Oxygen is an enormously reactive and toxic gas, so its accumulation in the atmosphere was the responsible for one of the biggest extinction crisis in the history of our planet.

Organisms had to adapt to the new environmental conditions and to find new mechanisms to protect themselves from the oxygen. That originated a new period of biological diversification, a new era of evolution, of emergence of new living forms resulting in the biodiversity we can see today in our planet Earth.

Species appearing in the program


Roe deer (*Capreolus capreolus*)


Wild boar (*Sus scrofa*)

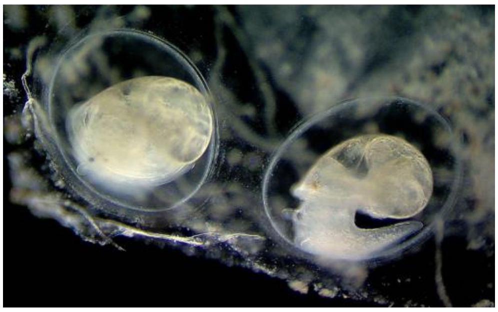

Black-headed warbler
(*Sylvia melanocephala*)


Viper (*Vipera berus*)


Common frog (*Rana perezi*)

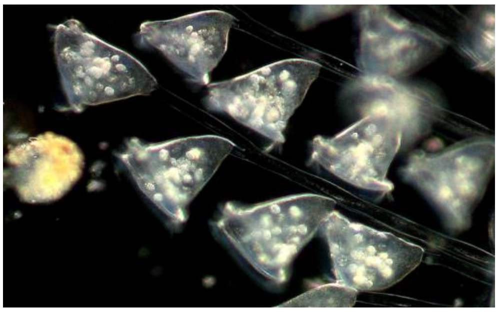

Mullet (*Mugil cephalus*)

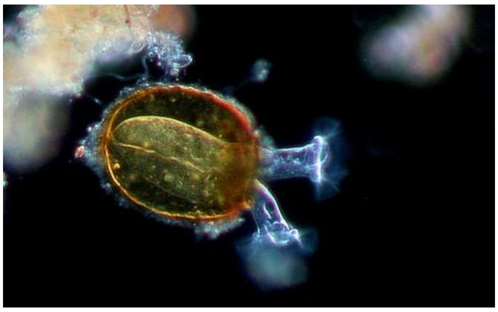

Mosquito (*Culex pippiens*)

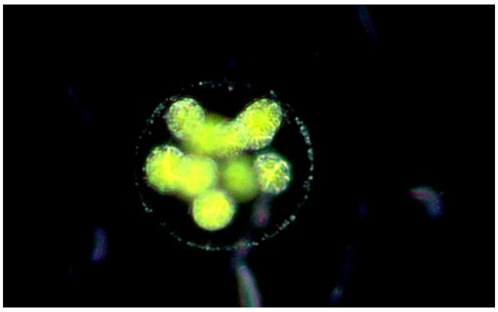

Freshwater snail (*Physa* sp.)

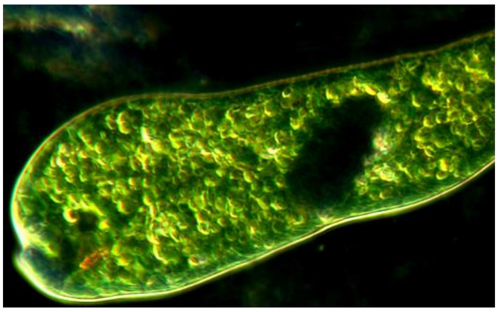

Brine shrimp larva (*Artemia salina*)

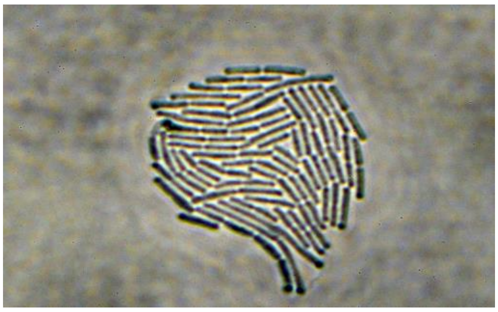

Jellyfish ephyra (*Aurelia aurita*)

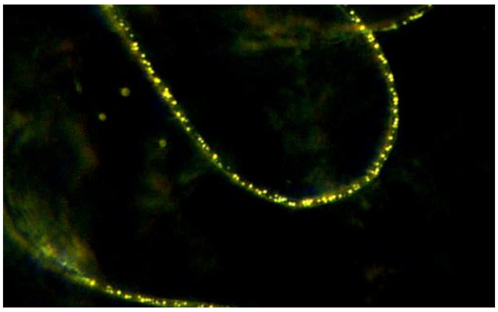

Ciliate (*Carchesium* sp.)

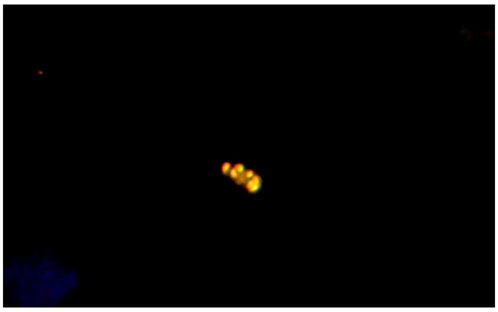

Ciliate (*Platycola* sp.)

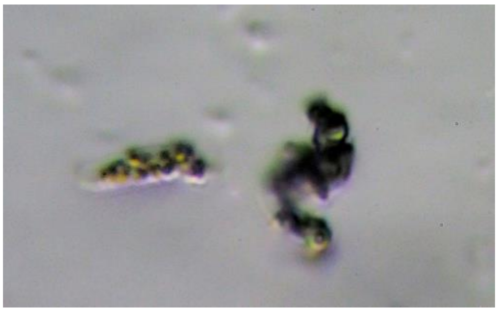

Microalgae (*Pandorina* sp.)


Microalgae (*Euglena* sp.)


Colony of bacteria (*Bacillus* sp)

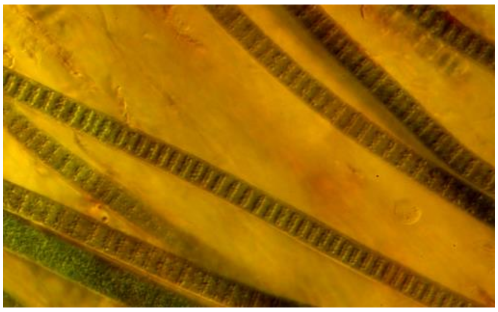

Bacteria (*Beggiatoa* sp.)


Bacteria (*Allochromatium* sp.)

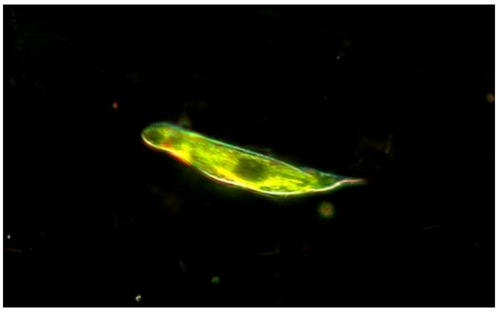

Bacteria (*Titanospirillum* sp.)

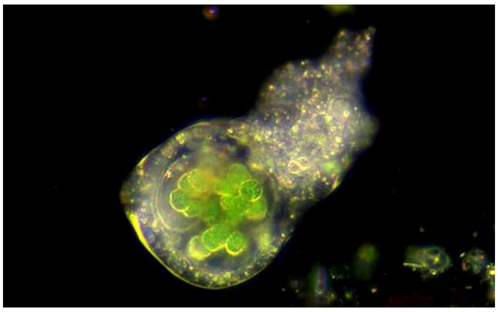

Cyanobacteria (*Chroococcus* sp.)


Cyanobacteria (*Phormidium* sp.)


Cyanobacteria (*Lyngbya* sp.)


Cyanobacteria (*Microcoleus* sp.)


Microalgae (*Euglena* sp.)


Protozoa (*Amoeba* sp.)

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