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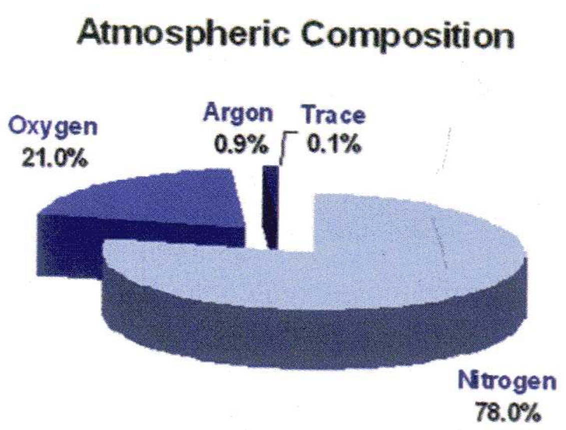
Contribution of Oceans to The Air Resources

Atmosphere and composition of the atmospheric gases

The atmosphere contains many gases, most in small amounts, including some pollutants and greenhouse gases. It is concentrated at the earth's surface and rapidly thins as you move upward, blending with space at roughly 100 miles above sea level. The atmosphere is very thin compared to the size of the earth. However, it is responsible for keeping our earth habitable and for producing weather.

The atmosphere is composed of a mix of several different gases in differing amounts. The permanent gases whose percentages do not change from day to day are nitrogen, oxygen and argon. Nitrogen accounts for 78% of the atmosphere, oxygen 21% and argon 0.9%. Gases like carbon dioxide, nitrous oxides, methane, and ozone are trace gases that account for about a tenth of one percent of the atmosphere.

Water vapours is unique in that its concentration varies from 0-4% of the atmosphere. In the cold, dry artic regions water vapours usually accounts for less than 1% of the atmosphere, while in humid, tropical regions water vapours can account for almost 4% of the atmosphere.



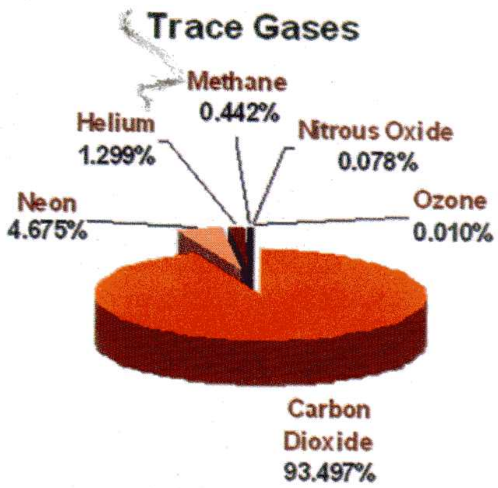


Fig.1 : Graphs of the overall atmospheric concentration and the relative percentages of trace gases.

Oxygen production of Ocean

Rainforests are responsible for roughly one-third (28%) of the Earth's oxygen but most (70%) of the oxygen in the atmosphere is produced by marine plants. The remaining 2% of Earth's oxygen comes from other sources. The ocean produces oxygen through the plants (phytoplankton, kelp and algal plankton) that live in it. These plants produce oxygen as a by-product of photosynthesis, a process which converts carbon dioxide and sunlight into sugars the organism can use for energy.

The phytoplankton, Prochlorococcus, releases countless tons of oxygen into the atmosphere. It is so small that millions can fit in a drop of water. Prochlorococcus has achieved fame as perhaps the most abundant photosynthetic organism on the planet.

Prochlorococcus is a genus of very small (0.6 μm) marine cyanobacteria with an unusual pigmentation (chlorophyll a2 and b2). These bacteria belong to the photosynthetic picoplankton and are probably the most abundant photosynthetic organism on Earth. Prochlorococcus microbes are among the major primary producers in the ocean, responsible for a large percentage of the photosynthetic production of oxygen.

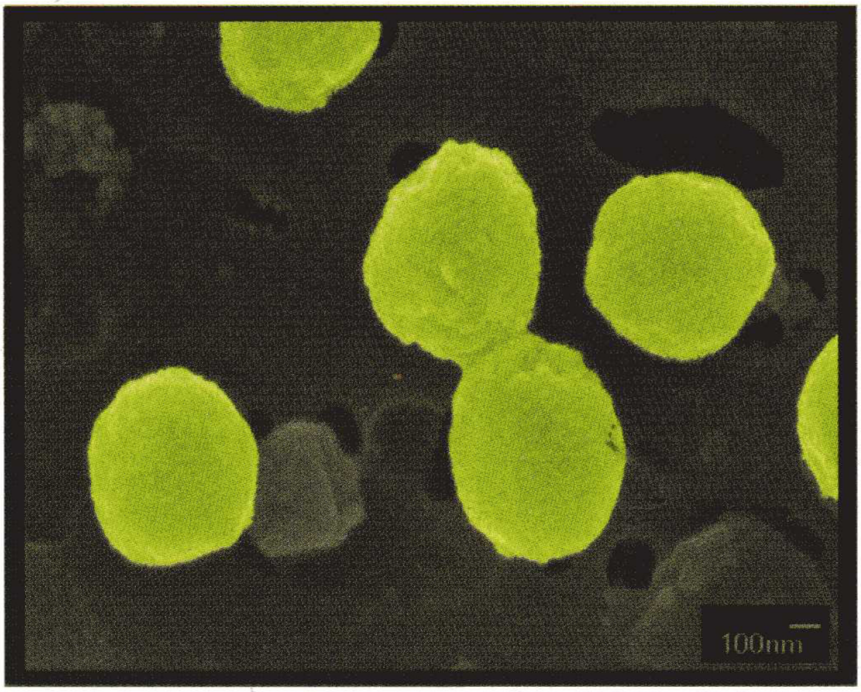


Fig. 2 : Image of Prochlorococcus

Phytoplankton, also known as microalgae, are similar to terrestrial plants in that they contain chlorophyll and require sunlight in order to live and grow. They get their own energy through photosynthesis and are responsible for producing an estimated 80% of the world's oxygen. As such, climate scientists are interested in learning more about phytoplankton because of the role they play in oxygen production, as well as in carbon sequestration. Through photosynthesis, phytoplankton consume carbon dioxide on a scale equivalent to forests and other land plants. Some of this carbon is carried to the deep ocean when phytoplankton die, and some is transferred to different layers of the ocean as phytoplankton are eaten by other creatures, which themselves reproduce, generate waste, and die.

They are responsible for most of the transfer of carbon dioxide from the atmosphere to the ocean. Carbon dioxide is consumed during photosynthesis, and the carbon is incorporated in the phytoplankton, just as carbon is stored in the wood and leaves of a tree. Most of the carbon is returned to near-surface waters when phytoplankton are eaten or decompose, but some falls into the ocean depths. A recent study conducted by Bosse et al. demonstrated how powerful winter storms create oceanic structures that can affect the distribution of nutrients to phytoplankton communities, as well as the organisms' ability to produce and store carbon.

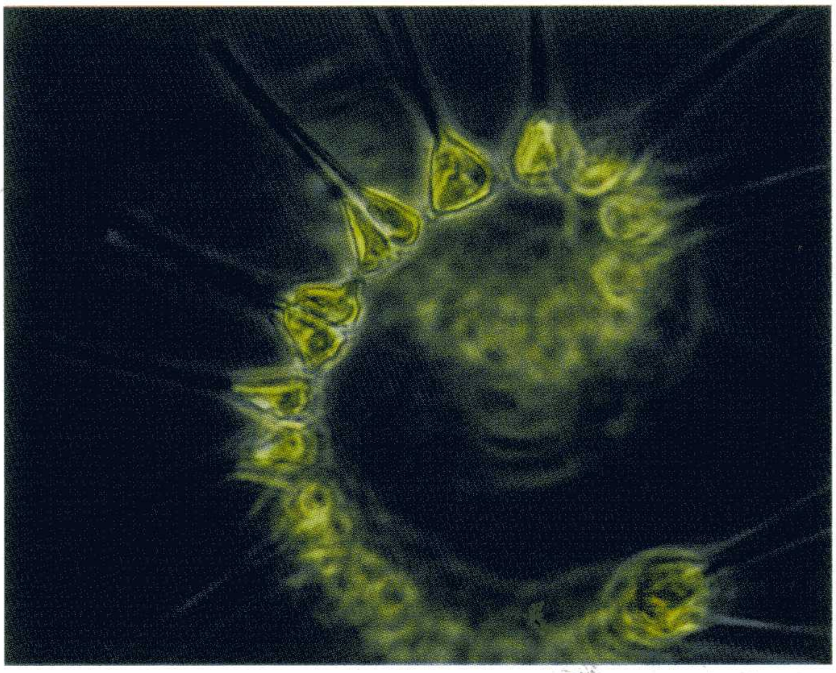


Fig. 3 : Image of Phytoplankton

Scientists agree that there's oxygen from ocean plants in every breath we take and also that phytoplankton contribute between 50 to 85 percent of the oxygen in Earth's atmosphere. By the way, by about 400 million years ago, scientists say, enough oxygen had accumulated in Earth's atmosphere for the evolution of air-breathing land animals. But free oxygen by itself wasn't enough. Another form of oxygen was also essential: the build-up of a special kind of oxygen at the top of Earth's atmosphere. There, where three atoms of oxygen bonded together, ozone formed. This layer of ozone at the top of Earth's atmosphere shields land organisms from harmful ultraviolet radiation from the sun.

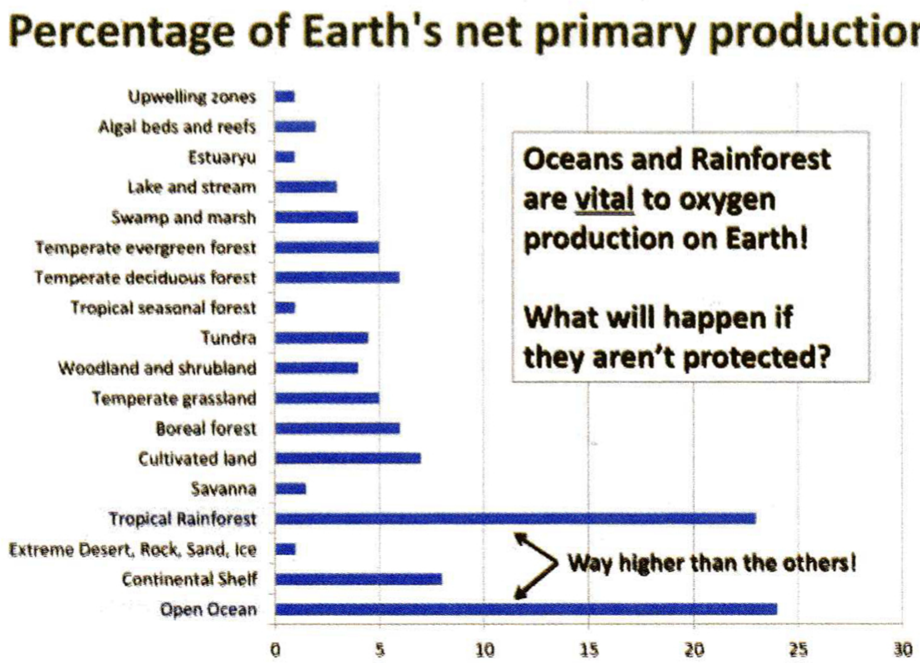


Fig.4 : Oxygen production of various ecosystems

Contribution of Ocean to the Carbon Dioxide balance

Carbon dioxide (CO_2) is a soluble gas which dissolves in the oceans and is taken up by marine plants (phytoplankton). A natural cycle results in which CO_2 is absorbed from the atmosphere in some (generally cooler and more biologically active) parts of the ocean and released back to the atmosphere in other (generally warmer and less biologically active) parts.

CO_2 enters to the atmosphere as human's burn fossil fuels and release greenhouse gases, those gases are directly contribute to increases in global temperatures and climate consequences such as more frequent and severe heat waves, droughts, changes to rainfall patterns, and rising seas. But for many years scientists have known that not all of the carbon dioxide we emit ends up in the atmosphere. About 40% actually gets absorbed in the ocean waters.

The biological pump plays a negligible role, because of the limitation to pump by ambient light and nutrients required by the phytoplankton that ultimately drive it. Total inorganic carbon is not believed to limit primary production in the oceans, so its increasing availability in the ocean does not directly affect production (the situation on land is different, since enhanced atmospheric levels of CO_2 essentially "fertilize" land plant growth to some threshold). However, ocean acidification by invading anthropogenic CO_2 may affect the biological pump by negatively impacting calcifying organisms such as coccolithophores, foraminiferans and pteropods. Climate change may also affect the biological pump in the future by warming and stratifying the surface ocean, thus reducing the supply of limiting nutrients to surface waters.

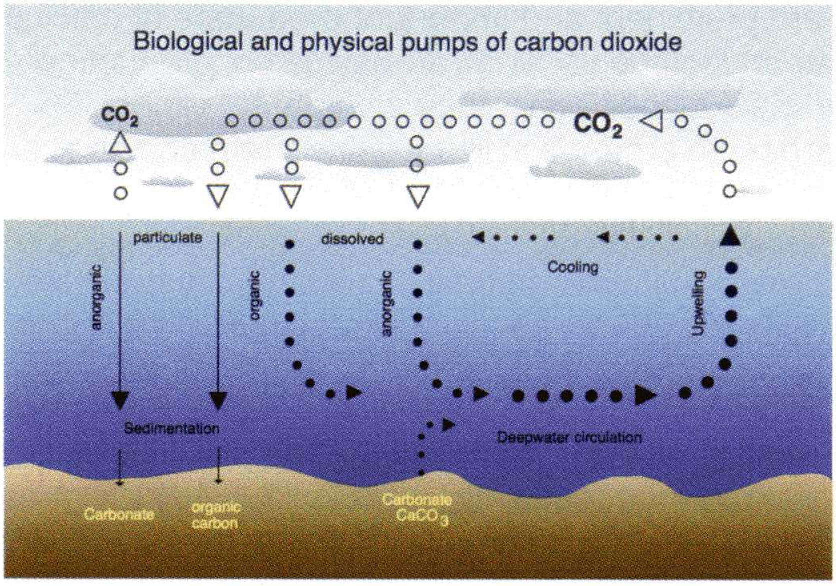


Fig. 5 : Carbon Dioxide cycle in the Ocean

Coccolithophores are one-celled plant-like organisms that live in large numbers throughout the upper layers of the ocean. Coccolithophores surround themselves with a microscopic plating made of limestone (calcite). The construction of $CaCO_3$ coccoliths (calcification) leads to additional impacts.

The first and perhaps the most important of these is that $CaCO_3$ contains carbon and the vertical downward flux of coccoliths thereby removes carbon from the surface oceans. It might be expected that this would lead to additional removal of CO_2 from the atmosphere to the oceans, to replace that taken up into coccoliths, but in fact, because of the complex effect of calcification ($CaCO_3$ synthesis) on seawater chemistry, the production of coccoliths actually increases the partial pressure of CO_2 in surface seawater and promotes outgassing rather than ingassing.

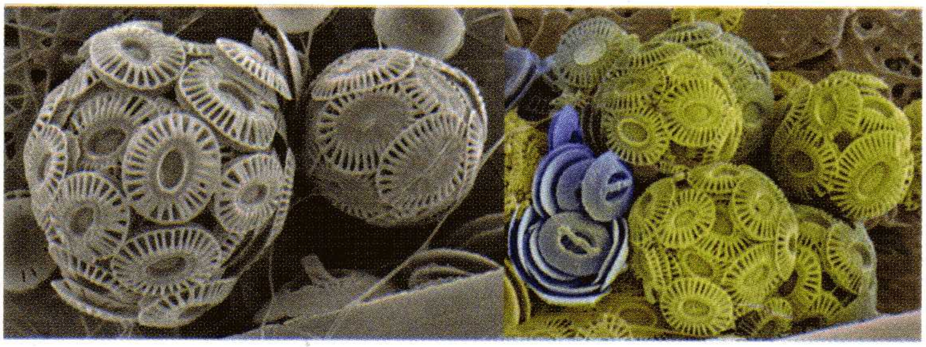


Fig. 6 : Microscopic images of Coccoliths

Foraminifera are single-celled organisms (protists) with shells or tests. They are abundant as fossils for the last 540 million years. The shells are commonly divided into chambers that are added during growth, though the simplest forms are open tubes or hollow spheres. Depending on the species, the shell may be made of organic compounds, sand grains or other particles cemented together, or crystalline $CaCO_3$ (calcite or aragonite).

Foraminifera's are prominent and important producers of calcium carbonate in modern tropical environments. With an estimated production of at least 130 million tons of $CaCO_3$ per year, they contribute almost 5% of the annual present-day carbonate production in the world's reef and shelf areas (0–200 m) and approximately 2.5% of the CaCO3 of all oceans.

Together with non-symbiont-bearing smaller foraminifera, all benthic foraminifera are estimated to annually produce 200 million tons of calcium carbonate worldwide. The majority of foraminiferal calcite in modern oceans is produced by planktic foraminifera. With an estimated annual production of at least 1.2 billion tons, planktic foraminifera contribute more than 21% of the annual global ocean carbonate production. Total CaCO3 of benthic and planktic foraminifera together amounts to 1.4 billion tons of calcium carbonate per year. This accounts to almost 25% of the present-day carbonate production of the oceans, and highlights the importance of foraminifera within the $CaCO_3$ budget of the world's oceans.

Fig. 7 : Image of Foraminiferans

The amount of carbon dioxide that the ocean can hold depends on the ocean temperatures. Colder waters can absorb more carbon; warmer waters can absorb less. So, a prevailing scientific view is that as the oceans warm, they will become less and less capable of taking up carbon dioxide. As a result, more of our carbon pollution will stay in the atmosphere, exacerbating global warming. But it's clear that at least for now, the oceans are doing us a tremendous favour by absorbing large amounts of carbon pollution.

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