**Oxygen (O2)**

The response of an organism to O2 in its environment depends upon the occurrence and distribution of various enzymes which react with O2 and various oxygen radicals that are invariably generated by cells in the presence of O2. All cells contain enzymes capable of reacting with O2.

* In aerobic organisms in oxidative phosphorylation, oxygen serves as the terminal electron acceptor. Some of the oxidation–reduction enzymes interact with molecular oxygen to give rise to superoxide (O•2 −), hydroxyl radicals (OH•), and hydrogen peroxide (H2O2), all of which are extremely toxic:

**O2 + e − oxidative enzyme O2•**

**O2  + H2O2 non enzymatic O2 + OH• + OH−**

* Superoxide dismutase is present in aerobic organisms and those that are aerotolerant, but not in strict anaerobes. The enzyme **superoxide dismutase** dissipates superoxide:

**Superoxide dismutase**

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**2O•2 + 2H H2O2 + O2**

* Many, but not all, aerobes also produce catalase, which can eliminate the hydrogen peroxide formed:

**Catalase**

**2H2O2  2H2O + O2**

* Aerotolerant organisms generally do not produce catalase. Hence, growth of these organisms is frequently enhanced by culture on media containing blood or other natural materials that contain catalase or peroxidase activity.
* All photosynthetic (and some non-photosynthetic) organisms are protected from lethal oxidations of singlet oxygen by their possession of carotenoid pigments which physically react with the singlet oxygen radical and lower it to its nontoxic (triplet) state.

Organisms can be grouped into six classes according to their tolerance of O2:

1. **Obligate aerobic:**

Microorganisms that require O2 for growth; they use O2 as a final electron acceptor in aerobic respiration. Many fungi are obligate aerobes.

1. **Facultative anaerobic (or facultative aerobes):**

Are organisms that can switch between aerobic and anaerobic types of metabolism. Under anaerobic conditions (no O2) they grow by fermentation or anaerobic respiration, but in the presence of O2 they switch to aerobic respiration (e. g. *E coli*, Yeast: *Saccharomyces*).

1. **Microaerophiles**

Gaseous air contains approximately 20% O2. Microaerophiles need reduced concentrations of oxygen, *Campylobacter* spp. will grow in 5–10 % oxygen.

1. **Obligate anaerobes (aerophobes)**

Obligate or strict anaerobes will not grow in the presence of very low concentrations of oxygen, in fact, O2 is a toxic substance, which either kills or inhibits their growth. Obligate anaerobic microorganisms may live by fermentation, anaerobic respiration (e.g. *Clostridium*, *Methanococcus* and the fungus *Neocallimastix*)

1. **Aerotolerant anaerobic:**

Are microorganisms with an exclusively anaerobic (fermentative) type of metabolism but they are insensitive to the presence of O2. They live by fermentation alone whether or not O2 is present in their environment. *Enterococcus faecalis.*

**Water H2O:**

A measurement of the availability of water is aw or water activity, that supports most bacteria must below values of 0.98. aw is defined as the ratio of the vapour pressure of the substance over that of pure water. The aw of pure water is 1.0 while that of a saturated salt solution is 0.75.  Most spoilage bacteria require a minimum aw of 0.90.  Some bacteria can tolerate an aw above 0.75 as can some yeasts and most molds.  Most yeasts require 0.87 water activity.  An aw of 0.85 or less suppresses the growth of organisms of public health significance.

**Nutrition:**

All living organisms have certain basic nutritional requirements: sources of carbon, nitrogen, energy, and essential growth factors (minerals and vitamins) are needed to support growth. Microorganisms vary widely in their nutritional requirements.

Essential Nutrients are any molecular or elemental form of nutrient that is required by an organism. Two categories of essential nutrients; macro-nutrients and micro-nutrients.

**Macro-nutrients**

are needed in larger amounts (carbon, oxygen, hydrogen, phosphorus, potassium, nitrogen, sulfur, calcium, iron, sodium, chlorine, magnesium) Used to help with cell structure and the cell's metabolism.

**Micro-nutrients**

or trace elements are needed in a lot smaller amount. They help enzyme function and help to maintain protein structure. They include elements such as zinc, manganese, and nickel.

Organisms can be classified based on their sources of carbon, energy and electrons:

1. **Carbon Source**
2. Autotroph: synthesize organic materials from inorganic materials CO2.

**CO2 + H2O** **sun light** **(CH2O)n + O2**

1. Heterotroph: use chemical energy, organic molecules from other organisms
2. **Energy Source**
3. Phototrophs: these organisms derive their energy from sunlight.
4. Chemotrophs: organisms derive their energy from oxidation of organic or inorganic compounds
5. **Electron Source**
6. Lithotrophs: reduced inorganic chemicals
7. Organotrophs: Organic molecules

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Nutrition types | Carbon Source | Energy Source | Electron Source | Examples |
| Photolithoautotrophy  Photoautotrophs | CO2 | Light | Inorganic  e- donor | *Thiospirillum*  *Chromatium* |
| Photoorganoheterotrophy  Photoheterotrophs | Organic carbon but CO2 may be used | Light | Organic  e- donor | *Rhodospirillium* sp. |
| Chemolithoautotrophy Chemoautotrophs | CO2 | Inorganic chemicals | Inorganic  e- donor | *Nitrosomonas* sp. |
| Chemolithoheterotrophy  Chemoheterotrophs | Organic carbon but CO2  may be used | Inorganic  chemicals | Inorganic  e- donor | *Thiobacillus* |