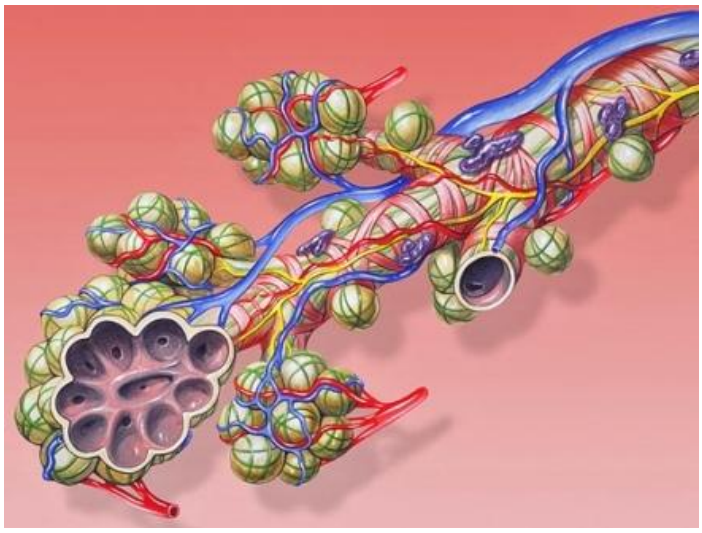
Respiration



Bronchial anatomy detail of alveoli and lung circulation. Source: Patrick J.Lynch

Respiration is the gas exchange effected by living organisms for the purpose of sustaining vital metabolic processes. In the case of most animals, oxygen is taken into the organism, and carbon dioxide is expelled. In the case of plants, the inverse process occurs of consuming carbon dioxide and expelling oxygen as a waste gas.

Respiration may also be viewed at a cellular level, examining gas exchange at the cell wall; for very simple organisms, such as unicellular lifeforms, the process of gas exchange with the environment is simplified, so that cellular wall gas exchange is the totality of respiration for such an organism.

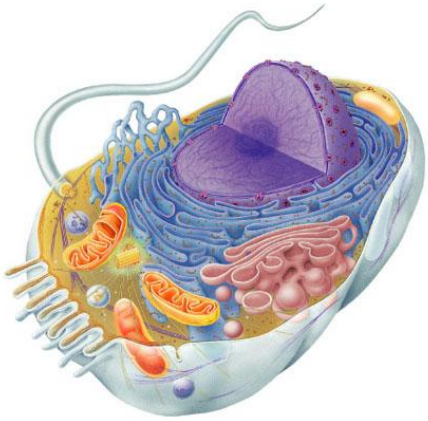
In the case of some bacteria and archaea, respiration sometimes occurs without any oxygen, and alternativemolecular gases such as hydrogen sulfide or methane may participate in respiration and subsequent cellular metabolic reactions. Often such organisms are classified as extremophiles, or lifeforms which can survive inabiotic environments with unusual characteristics (e.g. low oxygen environments) .

Physiologic respiration in higher animals

Most higher animals have complex physiologic respiratory systems for delivering atmospheric oxygen to the various body tissues. Although fish, and other organisms who spend most of their time submerged, have specialized organs for extracting dissolved oxygen from water, most terrestrial higher animals simply extract air from the atmosphere by some type of muscular diaphragm action bringing air from an exterior aperture (typically mouth or nose) into a structure such as the trachea and subsequently into bronchial apparatus. In the smallest cavities of the lungs, alveoli then exchange waste carbon dioxide for fresh oxygen, with the oxygen then entering the bloodstream aboard haemoglobin.

Dependent respiration is physiological level breathing which varies with the partial pressure of oxygen in ambient air. When the partial pressure of oxygen is low, respiration rate manifests correspondingly slow. With higher oxygen partial pressure, the respiration rate increases. **Independent respiration** is the opposite breathing phenomenon, where respiration rate does not vary with the partial oxygen pressure.

Cellular respiration in animals



Cell diagram showing cell wall, across which cellular respiration occurs. Source: U.S. NIH

Biochemical respiration takes place at the cellular level for all animal life, from the smallest zooplankter to mammoth creatures such as the Blue whale. In all these cases oxygen is transported across the cell wall in order to participate in a metabolic process by which an organism obtains energy by reacting oxygen with glucose to give water, carbon dioxide and adenosine triphosphate (ATP). The only real difference is that higher animals have delivered oxygen through a complex pathway (e.g. mouth-trachea-lung-alveoli-pulmonary capillaries-vascular system), while simpler organisms have their cell walls exposed to atmospheric or aqueous oxygen; for such lower animals, the simple process of gas diffusion across the cell wall is the entirety of respiration.

Plant respiration

The most important respiration of plants takes place at leaf surfaces through stomatal openings, although some species have stomates on other tissue such as stems. Molecular carbon dioxide enters the stomatal openings which are controlled by guard cells that regulate the optimum time for such opening; correspondingly molecular oxygen gas exits the stomates as a plant waste. There are three different metabolic processes, one of which is typically adopted by a given plant species:

- **C3 carbon fixation**
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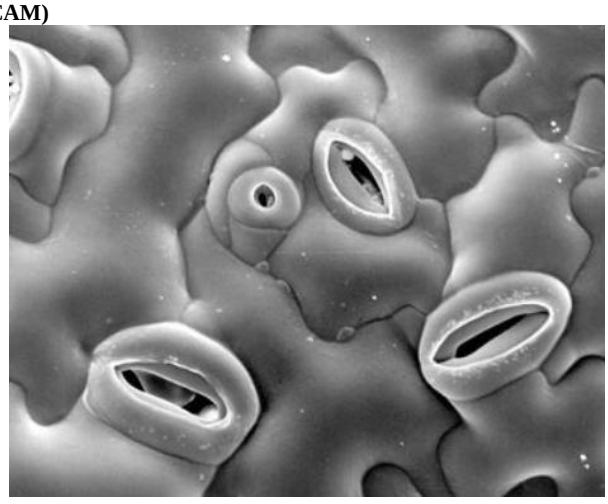
- **Crassulacean acid metabolism (CAM)**



Stomatal cells for plant respiration, Arabidopsis thaliana leaf. Source: Fred Sack

Each of these processes involves gas exchange in stomates, but is differentiated from the others in the time of day or meteorological conditions under which stomatal opening is maximized, and is also distinguished in the metabolic reactions subsequent to gas exchange. Plant species that utilize only C3 fixation prefermeteorological conditions in which there is moderate sunlight intensity and intermediate ambient temperature; C3 plants thrive where carbon dioxide concentrations are at least 200 parts per million, and where root zone water is abundant. The C3 plants, originating during Mesozoic and Paleozoic eras, predate the C4 carbon fixation species, and comprise about 95 percent of Earth's plant biomass. C3 plants lose 97% of the water taken up through their roots to transpiration.

CAM is a carbon fixation which certain plant species have developed as an adaptation to very dry atmospheric conditions. Stomates stay shut in daytime to minimize water loss, but open at night to let carbon dioxide into the plant. The carbon dioxide is then stored as the four-carbon acid malate, and then utilized in photosynthesis when sunlight re-appears. Carbon dioxide collected by night is concentrated around the enzyme RuBisCo, enhancing photosynthetic efficiency.

Respiratory diseases

A number of respiratory diseases can afflict animals and plants. In the case of animals, the most common respiratory serious problems are asthma, pneumonia, lung cancer and emphysema; while asthma can be a congenital condition, virtually all respiratory illnesses can be generated or exacerbated by air pollution. Pneumonia is an inflammatory infection most often caused by bacteria, virus, fungus or parasite, that can be treated, but is also aggravated by air pollution. The most common air pollutants are from man-made sources and include sulfur dioxide, hydrocarbons, black carbon (a form of particulate matter), oxides ofnitrogen and carbon monoxide. Respiratory diseases are often progressive and lead to diminished fitness and ultimately are the cause of death for many faunal organisms. Disease syndromes may also occur at the cellular level, but these are normally classified as metabolic malfunctions.

In the case of plants, air pollutants can also cause damage to stomatal structures, reducing photosynthetic efficiency. In addition, some air pollutants can trigger stomatal closing at times that are important for photosynthesis, thus impairing the plant metabolic functions.

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