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Greenhouse gases and bioenergy: Theologians and radicals have a laugh whilst Martians eat metals

By Professor David Richardson

We humans obtain the energy we need for life by respiring oxygen. This process involves using electrons extracted from the food we eat to convert oxygen to water in a process known as oxygen reduction. Free energy is released in this process and we use this to make ATP, which is the universal energy currency of life. Our dependency on oxygen makes us 'obligate aerobes', take away the oxygen and we die. Thus we are confined to living on the surface of planet Earth where oxygen is freely available. However, the vast proportion of Earth's habitable environments are not exploited by humans, but by micro-organisms, including bacteria, that can live in the absence of oxygen in 'anoxic' environments where they catalyse a process called anaerobic respiration. These bacteria impact on the balance of several biogeochemical cycles, such as the nitrogen, sulphur and carbon cycles and can in turn influence the release of potent greenhouse gases, such as nitrous oxide. Many pathogenic bacteria use anaerobic respiration of substrates such as nitrate to survive and proliferate in parts of our gut where oxygen is absent. Incredibly, some bacteria can also live deep in the earth's subsurface and survive by 'respiring rocks'. This is because some of the most abundant respiratory substrates in the earth's subsurface environments are insoluble minerals of iron. Such bacteria can have potentially important biotechnological impacts in bioremediation of environments contaminated with toxic organic pollutants or radioactive metals, or in microbial fuel cells where the bacteria are used to generate electric currents (bioenergy). This lecture will explore a number of bacterial respiratory processes, particularly those associated with the nitrogen and iron cycles, and their potential environmental, biomedical and biotechnological impact.