PERSON IN PRIESTLEY'S BELL JAR

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Humans take for granted the presence of oxygen in the air they breathe. However, the Earth's atmosphere has not always been as hospitable as it currently is. Over the Earth's four and a half billion year history the combination of gases that form the atmosphere have changed considerably; initially oxygen was only present in minuscule traces. From evidence in ancient rock formations it is likely that four billion years ago, the atmosphere was almost entirely nitrogen. Levels of carbon dioxide and ammonium then rose as a result of lava pouring from volcanoes on the Earth's surface. Early single-celled organisms soon developed the ability to produce energy using carbon dioxide, photosynthesis, releasing oxygen into the atmosphere as a toxic waste product. As the atmosphere evolved and oxygen levels rose due to increasing photosynthesis, life forms dwelling upon the Earth were forced to change and adapt. Other single-celled organisms mastered the ability to use oxygen in order to produce energy, expelling carbon dioxide as their waste. However it was not until around 600 million years ago that the simple single-celled organisms developed into complex multicellular organisms and eventually humans, as we know them today, approximately 200,000 years ago.

Joseph Priestley's part in the discovery of oxygen, and its life-giving properties heralded the beginning of centuries of research into how the human body uses this gas to unlock energy and how we respond when its availability declines at high altitude. In the 1770s, Joseph Priestley conducted a series of experiments that revealed the intimate relationship between plant and animal life. In his principal experiment, Priestley placed a mouse within a sealed jar and observed it to eventually perish. When repeated with sprigs of mint placed within the jar, neither did the animal die 'nor was it at all inconvenient to a mouse.' Priestley had made the remarkable scientific breakthrough that plants produce a substance that is life-giving to animals, oxygen.

Scientists are often fascinated to see if they can reproduce the work of other scientists, in order to verify their findings. We were interested to see whether Priestley's experiment could be repeated but instead of using a mouse, we wanted to use a human volunteer. So as part of a BBC documentary called '*How to Grow a Planet*' we set about constructing the first ever reconstruction of Priestley's Bell jar experiment using a human. The experiment was conducted within one of the biomes at the Eden Project in Cornwall. A transparent airtight container measuring $2.0 \times 2.5 \times 6.0$ meters was constructed and within it were placed 274 separate plants. The plants were specifically selected for their powerful photosynthetic properties and included maize, banana, peace lily, ferns and mint.

The purpose of the experiment, like Priestley's, was to prove that when separated from the atmosphere animal life could be sustained simply by the oxygen released via photosynthesis from plants within the sealed container. However, to really test the theory to its limits, we decided to remove much of the oxygen from the container before the volunteer entered, such that the level of oxygen was reduced from 21% to 12.4%, the equivalent of being up a 4500m mountain. Thus when the willing volunteer entered for the first time, he was instantly rendered 'hypoxaemic' – a lack of oxygen in his blood. Whilst in the container the volunteer was monitored by a doctor throughout, to ensure no harm came to him as a result of the oxygen depletion. The team outside the container then sat back for 48 hours and watched what happened to the air inside the container.

Powerful lights were shone on the container to ensure photosynthesis was maximal for the duration of the study. However, this made the temperature inside the container an uncomfortable 26 degrees centigrade. Gas analyzers monitored the oxygen and carbon dioxide levels within the container and data was recorded on the hour, day and night. Camped outside the container the doctor could speak to the volunteer inside using a radio system. The plants required regular watering to ensure they remained in optimum condition for photosynthesis and this task had to be performed by the volunteer inside.

The experiment was a great success and the volunteer emerged from the container unscathed 48 hours after entering. The concentration of oxygen rose steadily throughout, demonstrating how effective the plants were at replenishing it in the air. Accordingly, the volunteer's blood oxygen levels also rose.

This simple experiment, like Priestley's was a humble reminder of the fundamental relationship between animal and plant life. Without plants in the sealed container, the concentration of oxygen would have fallen and carbon dioxide concentration would have risen to a point at which the volunteer's life could no longer be supported. Without the presence of plants on the Earth, the atmosphere would be unable to sustain animal or human life.

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Sealed container with plants, subject and sunlight and external artificial lighting.