oxygen

Editorial

Oxygen: Highlights from the Papers Published in the Journal up to February 2024

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Oxygen (O_2) was discovered approximately 250 years ago (Contribution 1), a breakthrough accredited to at least three people: Antoine-Laurent de Lavoisier in France (Antoine Lavoisier), Carl Wilhelm Scheele in Sweden, and Joseph Priestley in England. It is probable that the first person to isolate oxygen was Scheele, but he was not the first to publish his work. Much work was then carried out at the end of the 18th century on the biological significance of oxygen, and such research has continued ever since. It was soon recognized that higher plants produce O_2 and that O_2 is used in respiration. Later, the role of O_2 in other physiological events also became evident, such as in the respiratory burst invoked during pathogen challenge.

Of course, O_2 is not only relevant to biological systems, and is involved in industrial processes (e.g., [1]), atmospheric science (e.g., [2,3]), and other geological studies (e.g., [4]). The journal *Oxygen* strives to encompass work across all such fields, with the focus on the instrumental roles of atomic or molecular oxygen, as well as compounds based on oxygen, such as the reactive oxygen species (ROS) in biological systems.

Since its inception in June 2021, the journal *Oxygen* has published a range of papers, encompassing primary articles, reviews (including systematic reviews), communications, perspectives, and brief reports, with a focus on the place that oxygen has in the research reported.

To understand the research published in *Oxygen*, it is probably best to consider it as falling under a number of different themes. The lack of oxygen (anoxia being the total absence of oxygen (e.g., [5])), low oxygen levels (hypoxia (e.g., [6])), or elevated oxygen (hyperoxia [7]) are common themes in biological research. Several papers have appeared in *Oxygen* covering these issues. For example, den Ouden et al. (Contribution 2) found that parameters such as the diffusing capacity of carbon monoxide (TL_{CO}) were altered by diving, an activity which often leads to hyperoxic conditions. At the other extreme, Breedon and Storey (Contribution 3) looked at RNA metabolism—including microRNA and mRNA—in anoxia-tolerant turtles. They studied Red-eared slider turtles (*Trachemys scripta elegans*) which during the winter endure short-term hypoxia and long-term anoxia. Looking at the liver and skeletal muscle of these animals via immunoblotting, for example, they reported that hepatic miRNA biogenesis was downregulated in the early stages of processing, but that later stages were upregulated. Clearly, tissue levels of available oxygen are important to understand, not least during tumour formation, where hypoxic conditions are often seen [8].

In biological systems one of the major uses of oxygen is the formation of ROS. These reduced forms of oxygen include the superoxide anion ($O_2\cdot^-$), hydrogen peroxide (H_2O_2), and the hydroxyl radical ($\cdot$OH). Although ROS are used as signalling molecules in plants [9] and animals [10], a build-up of these compounds can lead to a cellular state known as oxidative stress, a condition which has been implicated in the onset and maintenance of a range of diseases, including cancer [11], diabetes [12], and neurodegenerative diseases such as Parkinson's [13]. To combat excessive oxidative conditions, cells contain antioxidants such as the enzyme superoxide dismutase (SOD) and catalase (CAT) [14], as well as an intake of antioxidants from the diet [15]. Several papers in *Oxygen* have discussed the themes of ROS, oxidative stress, and antioxidants. For example, Edge and Truscott (Contribution 4) reviewed the roles of ROS, saying they will focus on "especially pro- and anti-oxidative processes". In another review, Blackstone (Contribution 5) looked at ROS in signalling and how this may have had an impact on evolutionary processes.

Of course, ROS does not work in insolation. Reactive nitrogen species (RNS), such as nitric oxide (NO), are instrumental in signalling processes [16], as are reactive sulfur species (RSS), such as H_2S [17], and the action of all these redox-active compounds work in an orchestrated way [18]. In another review by Blackstone (Contribution 6), the interaction of ROS and RSS is further explored, and he suggests that "Many of the signaling pathways involving ROS may have first evolved using RSS". It has been known for a long time that ROS and RNS are involved in the reproduction of plants [19,20] and of animals [21], but the details in different species are still being elucidated. An article in *Oxygen* on olive trees concentrated on the role of ROS in reproduction (Contribution 7), whilst a paper by Cilio et al. (Contribution 8) looks at the effects of antioxidants in male infertility, with Benko et al. (Contribution 9) contributing a related article on the capacitation of spermatozoa, a process which has implications for in vitro fertilization [22].

Work on ROS and RNS, such as nitric oxide (NO) and peroxynitrite ($ONOO^-$), is often centred on disease. Again, such a focus is not new. It has been known for a long time that excessive ROS and NO may be involved, for example, in viral diseases [23], neurodegenerative disease [24], and diabetes [25]. Tan et al. presented a review of ROS in diabetes with a focus on some therapeutic use of plants (Contribution 10), whilst Atlante et al. (Contribution 11) looked at ROS in Alzheimer's disease and the Tau protein. Miranda et al. (Contribution 12) had a focus on gastrointestinal diseases and ion channels, and they suggested that association between ion channels and oxidative stress could be used for diagnostics and the development of new therapies.

Oxygen evolution by plants and its relationship to animal respiration has been studied for over two centuries, going as far back as the late 18th century work of people such as Priestley [26]. However, the production of molecular oxygen is still written about today. Björn (Contribution 13) reviewed the photosynthetic production of molecular oxygen, whilst Nosaka (Contribution 14) looked at the process of artificial photosynthesis. A range of oxygen evolution reactions (OER) are discussed and critiqued, with some suggestions of where the future focus for research should be. Photosynthesis is not the only oxygen-focused research on the environment that the journal has covered. Hocke (Contribution 15) looked at atmospheric oxygen, ending his article by saying that "The global evolution, distribution, and trends of atmospheric oxygen are discussed". Kourtidis and Vorenhout (Contribution 16) concentrated on soils, whilst Polutchko et al. took the journal into the realms of space, looking at suitable crops which could be used to conquer space, saying that "Lemnaceae (duckweeds) has enormous potential as a space crop", (Contribution 17). Of course, finding oxygen naturally in space has been a focus of many astronomers, with research such as that by Cunningham et al. [27] reporting oxygen-containing atmospheres beyond Earth on other astronomical bodies, in particular the second largest moon of Jupiter, Callisto.

Food products and the extraction of compounds has been a regular theme in *Oxygen*. Studies covering these topics have focused on antioxidants and the reduction of ROS. Dietary antioxidants have been shown to have a range of effects on animals, for example, impacting the gut microbiome [28] and being involved in disease states such as Parkinson's disease [29]. In *Oxygen*, these themes were picked up by Navarre et al. (Contribution 18) and an article by Raymond et al. (Contribution 19), who looked at the use of spinach extract by athletes, for whom respiration rates etcetera are paramount to good performance. Interestingly, they concluded that the extract increased lactate removal from muscles, so may help combat fatigue.

The work on food also overlaps with papers *Oxygen* has received on the chemistry of oxygen, and processes and techniques which involve oxygen. In August 2023, a paper in *Nature* reported the "First observation of ^{28}O" [30], a paper already cited several times (e.g., work by Li et al. [31]), showing that there is still much to learn about the chemistry and physics of oxygen. Along these lines, physical properties were examined by Nomura et al. (Contribution 20), who concluded that oxygen-related chemical processes may be controlled by external magnetic fields. Others looked at the isotropic chemical shift using nuclear magnetic resonance (NMR) spectroscopy, as a measure of electron density of oxygen (Contribution 21).

Several other techniques and methodologies have been explored by papers in *Oxygen*. The optimisation of an extraction based on pulsed electric-field technology (Contribution 22) showed a significant increase in the yield of polyphenols. Interest in the use of nanoparticles has increased recently, both for biomedical [32] and agricultural purposes [33], in the latter case for use as delivery of herbicides, pesticides, fungicides, fertiliser, and as sensors. Samrot et al. (Contribution 23) focused on the oxidant and antioxidant properties of nanoparticles, concluding their review by saying that understanding such properties of these particles is important, as is understanding the mechanisms in which they are involved.

Other technologies have also been examined or proposed by studies in *Oxygen*. Samokhin et al. (Contribution 24) suggested an inexpensive method for culturing mammalian cell cultures, where levels of O_2, amongst other things, were regulated. This may help research in places where finances are not easy to come by. In a similar vein, the use of home oxygen therapy was reviewed by Melani et al. (Contribution 25). They suggested that: "Indications on titration of oxygen flow and the best oxygen delivery device for optimal management of AOT [Ambulatory Oxygen Therapy] in COPD and ILD subjects are often vague or lacking". Work such as this will improve patient care in the future.

Finally, this editorial started by pointing out the 250th anniversary of the discovery of oxygen, which was covered in the journal (Contribution 1), although it is likely that the exact details of what happened in the 18th century will never be known for sure. However, *Oxygen* has seen several other papers on the history of research, such as one on O_2-sensitive K^+ channels (Contribution 26). *Oxygen* has also published articles on the wider aspects of oxygen science, such as the overview of oxygen in biological systems (Contribution 27).

So far, the journal *Oxygen* has had a range of papers, and will continue to welcome submissions where oxygen or oxygen-based compounds and processes are the focus of the research. *Oxygen* also welcomes suggestions for Special Issues where areas of oxygen-based research can be highlighted. The journal has seen a healthy start from its inception and will hopefully continue to champion work in which oxygen is a key component.

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