

Introduction:

Oxygen and Life

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HOW IMPORTANT is oxygen to the development and maintenance of life? This article will present some of the background information necessary to begin to answer this question. Much of it will be highly speculative; the reader will have to discriminate between fact and fancy. Specifically, this article will give information on the abundance of oxygen, the role of oxygen in the atmosphere, oxygen toxicity, and oxygen therapy.

Abundance of Oxygen

The most abundant atoms in the universe are, in decreasing order; hydrogen, helium, oxygen, carbon, and nitrogen.¹ Although oxygen is the third most abundant element, it comprises only 0.09 per cent of the total. The earth's crust is composed mainly of oxygen atoms, 54 per cent of the total atoms; hydrogen atoms are only 18 per cent. Oxygen supplies a fourth of all the atoms in the biosphere. Oxygen is the third most abundant atom in the universe, the second most abundant atom in the biosphere, and the most abundant atom in the earth's crust.¹

Oxygen is practically all in the nuclear form of ^{16}O , with very small quantities of ^{18}O and ^{17}O .¹ The isotope ^{16}O is extremely stable. An explanation for this stability has been given by the nuclear shell theory. According to this theory, nuclei which contain certain "magic numbers" of protons or neutrons are extremely stable.² The number eight is one of these "magic numbers"; hence, since ^{16}O contains eight protons and eight neutrons, it possesses a double "magic number," which gives ^{16}O its unusual stability.

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Oxygen's competitor in abundance is hydrogen. Hydrogen is the most prevalent atom in the cosmos and biosphere, and the second most plentiful element in the earth's crust.¹

Helium is the second most abundant atom in the universe, but since it is chemically inert, it does not play a quantitative role in the production of chemicals.

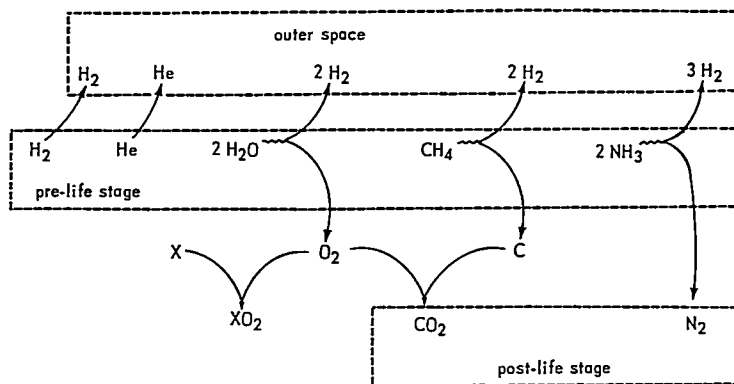
History of Oxygen in the Atmosphere

Let us examine a statement made by Priestley, the codiscoverer of oxygen, in 1775,³ "Whether the air of the atmosphere was, in remote times, or will be in future time, better or worse than it is at present, is a curious speculation. . . ." We will now attempt to consider this curious speculation.

Because of the predominance of hydrogen in the universe, the first atmosphere of a planet should logically be a reducing one. However, hydrogen is light, and thus constitutes the element most likely to escape the planet's gravitational field, leading to a dehydrogenation of the planet. This dehydrogenation would produce a more oxidizing atmosphere. Eventually, the entire atmosphere would be lost.

Figure 1 illustrates the chemical sequences by which this process might occur. The initial reducing atmosphere, composed of hydrogen, helium, water, methane, and ammonia, would be transformed to one finally composed of carbon dioxide and nitrogen. If this transition continued long enough, then metastable compounds characteristic of living cells could possibly be developed; subsequently, a biosphere could be evolved using these compounds.^{1, 4-6}

Thus, we have a model for the evolution of



X represents other substances oxidized by oxygen

FIG. 1. Evolution of atmosphere. Taken from reference 1.

planetary atmospheres: they go from a pre-life stage to a possible-life stage, and finally to a post-life stage. We know that some very small amounts of water exist on Mars; perhaps it might be ending its life stage or beginning its post-life stage.^{7,8} Venus has in its atmosphere a high quantity of carbon dioxide, and might be in the post-life stage.⁸

Figure 2 illustrates three possible phases of biospheric evolution in the initial reducing atmosphere on earth.⁷ According to this model, when the bulk of the hydrogen escaped, then the photochemical production of hydrogen from water would be possible. This phase we will designate "Phase 1." Nonbiological syntheses would form metastable compounds, such as $C_nH_{2n}O_n$, as byproducts. A biosphere composed of these metastable compounds could then be developed.

The primitive biosphere could obtain biological energy by hydrogen respiration, as depicted in Phase 2. In order to maintain this reductive respiration at a reasonable rate, mechanisms for the photosynthetic production of hydrogen would have to be developed (Phase 3). In essence, the biosphere would be catalyzing the reaction in Phase 1. The

hydrogen in the atmosphere would tend to destroy the biosphere by reducing the metabolic compounds back to methane and water; hence the biosphere would have to cope with the problem of hydrogen toxicity. The present biosphere still contains biochemical remnants of these proposed Phases 2 and 3, as well as systems sensitive to hydrogen toxicity.⁹

As the hydrogen continued to escape, hydrogen would be released from its bound sources, the most prevalent one being water. As this process continued, the next phases of biospheric evolution in a more oxidizing atmosphere would occur as shown in figure 3.⁷ Photodissociation of water, releasing hydrogen and oxygen, would occur during Phase 4. Hydrogen would escape, leaving oxygen behind. However, oxygen is very reactive and would combine with many compounds and elements in the earth's crust. The primitive biosphere would now have an opportunity to utilize the oxygen as an energy source by oxidative respiration (Phase 5). Now, in order to maintain this energy-producing biological reaction, mechanisms for the photosynthetic production of oxygen would have to develop (Phase 6).

Let us now compare the parallel development of hydrogen and oxygen as sources of biological energy. The two gases involved in reductive respiration and photosynthesis are methane and hydrogen, whereas carbon dioxide and oxygen constitute the two gases involved in oxidative respiration and photosynthesis. Per mole of carbon involved, oxidative respiration can supply three and a half times the energy of reductive respiration. Thus, although hydrogen can be considered a storage form of energy, it would not perform as well as oxygen.

In general, here are the necessary qualities of a storage form of biological energy: it should be abundant, be easily accessible, possess a high potential, and act in a relatively sluggish manner. If we consider the possibilities, oxygen seems to provide the best biological storage form of energy.⁴ It is very abundant, being the third most abundant element in the universe. Under ordinary circumstances, it occurs as a gas and is easily accessible. It possesses a high potential and thus can release much energy. It acts in a relatively sluggish manner, since it must overcome energy barriers.⁹ If it were not sluggish, it would dissipate itself too rapidly and destroy the constituents of the biosphere. Nevertheless, some biospheric destruction will occur. Thus, during the reducing phases, hydrogen toxicity occurred, and now during the oxidizing phases, oxygen toxicity occurs.

Oxygen is not only an energy source for the biosphere, it is also a constituent in biosynthesis.¹⁰

We must note here a basic point: virtually the entire primitive atmosphere has been lost, and so our present atmosphere is secondary in origin.^{4, 11, 12} Nonetheless, the primitive atmosphere has left its imprint on the evolving biosphere.^{4, 8} During this period, the biospheric constituents could have become trapped in the liquid and solid portions of the earth's crust. The depths of the hydrosphere could shield pockets of the biosphere from the deleterious effects of solar and cosmic radiations. Degassing of the earth in volcanic eruptions could account for a secondary atmosphere. Since volcanoes today release water vapor and other gases,¹³ we can picture the released water being photodissociated into oxygen and hydro-

gen. Hence, perhaps this period should logically occur during Phase 4 (see fig. 3).

We do not know just when these transitions from a reducing atmosphere to an oxidizing atmosphere on earth occurred. However, it appears that oxygen was probably within an order of magnitude of our present concentration in the atmosphere 600 million years ago, during the transition between the Precambrian period and the beginning of the Paleozoic period.¹⁴⁻¹⁶ One consequence of the presence of oxygen in the atmosphere is the formation of ozone, which can act as a shield against the harmful effects of ultraviolet radiation on the biosphere.¹⁷

During the transition from a reducing atmosphere to an oxidizing atmosphere, mechanisms against the toxic effects of oxygen developed.^{4, 9, 18-23} Although there might have been some damped fluctuations in the oxygen content of the atmosphere, it does not seem likely that oxygen was ever substantially higher than at the present time. Since photosynthesis is inhibited by oxygen toxicity,²⁴ oxygen toxicity probably acts as a braking action against the development of too much oxygen.

Even though at the present time our atmosphere is an oxidizing one, there still are pockets of reducing environments; for example, in the depths of Lake Tanganyika, the Black Sea, and the Dead Sea.²⁵

Present Oxygen Sources

The different storage forms and turnover routes of oxygen are illustrated in figure 4. One Emole represents $1 \cdot 10^{18}$ moles.¹ Of the 37.7 Emoles of oxygen in the atmosphere, 37 Emoles occur as molecular oxygen, and almost all the rest is in the form of water vapor.¹

The atmosphere contains many reactive species of oxygen besides molecular oxygen, particularly at high altitude and in smog. Some of these species are: ozone,²⁶ excited molecular oxygen in the singlet state,^{26, 27, 27a} atomic oxygen,²⁶ the OH free radical²⁶ and the RO_2 free radical.²⁶

The ozone concentration reaches a maximum at an altitude of about 30 km.¹ The mol per cent of the total dry atmosphere is 20.95

FIG. 2. Phases of evolution occurring in reducing atmosphere. Taken from reference 7.

PHASE	ΔF_0 (KCAL)
Phase One – Non-Biological Synthesis of Metabolic Compounds $6 \text{ H}_2\text{O} + 6 \text{ CH}_4 \rightleftharpoons \text{C}_6\text{H}_{12}\text{O}_6 + 12 \text{ H}_2$	195
Phase Two – Biological Release of Energy By Reduction $\text{C}_6\text{H}_{12}\text{O}_6 + 12 \text{ H}_2 \longrightarrow 6 \text{ H}_2\text{O} + 6 \text{ CH}_4$	-195
Phase Three – Photosynthetic Production of Hydrogen $6 \text{ H}_2\text{O} + 6 \text{ CH}_4 \longrightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 12 \text{ H}_2$	195

FIG. 3. Phases of evolution occurring in oxidizing atmosphere. Taken from reference 7.

PHASE	ΔF_0 (KCAL)
Phase Four – Non-Biological Synthesis of Oxygen $12 \text{ H}_2\text{O} \rightleftharpoons 6 \text{ O}_2 + 12 \text{ H}_2$	680
Phase Five – Biological Release of Energy by Oxidation $\text{C}_6 \text{ H}_{12}\text{O}_6 + 6 \text{ O}_2 \longrightarrow 6 \text{ H}_2\text{O} + 6 \text{ CO}_2$	-688
Phase Six – Photosynthetic Production of Oxygen $6 \text{ H}_2\text{O} + 6 \text{ CO}_2 \longrightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2$	688

for molecular oxygen and only $40 \cdot 10^{-6}$ for ozone.⁸ The ozone concentration in the lower atmosphere is variable,²⁸ being about $2 \cdot 10^{-6}$ to $10 \cdot 10^{-6}$ mol per cent.²⁹ In smog, it can be $50 \cdot 10^{-6}$ mol per cent.²⁶

Singlet molecular oxygen is characterized by oxygen possessing no spin unpaired electrons. Because a single electron possesses a spin, resulting in a magnetic moment, there is generally a strong tendency for electrons with op-

posite spins to pair together in a molecular or atomic orbital and eliminate a net electron spin. If a chemical species contains a single orbitally-unpaired electron, then it is a free radical. In ordinary molecular oxygen, each of the two highest orbitals contains a single electron possessing the same spin.⁹ Therefore, these two electrons are spin unpaired and orbitally unpaired. However, there is interaction between these unpaired electrons, and the

electronic state of such a configuration is known as a triplet state.³⁰

In singlet oxygen occurring as $O_2(^1\Delta_g)$, one of these orbitals is not filled at all and the other orbital contains two spin paired electrons. In singlet oxygen occurring as $O_2(^1\Sigma_g^+)$, each of the two orbitals contains a single electron, with their electron spins being opposite to each other. Thus, these electrons in $O_2(^1\Delta_g)$ are spin paired and orbitally paired, whereas the electrons in $O_2(^1\Sigma_g^+)$ are spin paired and orbitally unpaired. Ordinary molecular oxygen in the ground state, *i.e.*, $O_2(^3\Sigma_g^-)$, is more stable than $O_2(^1\Delta_g)$, which in turn is more stable than $O_2(^1\Sigma_g^+)$.^{27, 31} It is not known whether the biological behavior of singlet oxygen is different from that of molecular oxygen in the ground state.³²

The biosphere gives off oxygen mainly in the process of photosynthesis and takes up oxygen mainly in the process of respiration. Terrestrial photosynthesis produces about 0.0073 Emoles per year of oxygen; ocean photosynthesis produces only about half that amount, or 0.0037 Emoles per year.³³ The highest production per unit of ocean surface area of respiratory and photosynthetic processes is close to land.^{33, 34} Oxygen production for the earth totals 0.011 Emoles per year. The net production of atmospheric oxygen due to the

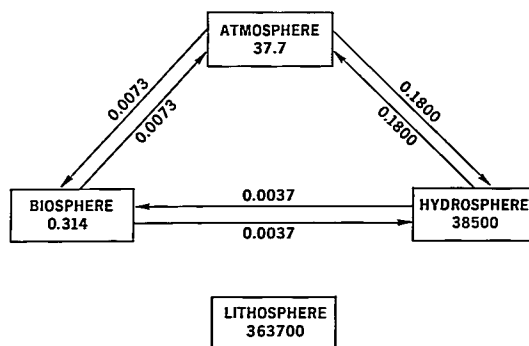
photosynthetic and respiratory processes is practically zero.¹ The oxygen in the atmosphere, therefore, is replaced by photosynthesis every 3,400 years, *i.e.*, 37 Emoles divided by 0.011 Emoles/year.

Since oxygen possesses such a large potential energy, it will react with many elements, given sufficient time. Thus, the presence of a substantial amount of oxygen in a planetary atmosphere is indicative that there is a photosynthetic and respiratory exchange between the atmosphere and a biosphere.

Oxygen is absorbed into the hydrosphere at the high rate of 0.18 Emoles per year. This amount is released from the hydrosphere at the same rate.¹

The exchange rates of other oxygen processes, such as photodissociation of water, oxidation of the lithosphere, and natural combustion, are much smaller in magnitude.¹

Figure 4 shows that 90 per cent of the oxygen in the earth's crust lies in the solid part, or lithosphere. More than half of this amount is found in the form of silicon dioxide. Oxygen combines with the following other elements in the lithosphere, in decreasing order: aluminum, hydrogen, calcium, iron, magnesium, sodium, and titanium. The hydrosphere contains almost 10 per cent of the oxygen, practically all in the form of water.¹



RESERVES ARE IN EMOLES O₂.
RATES ARE IN EMOLES O₂/YEAR.

FIG. 4. Major oxygen turnover routes. The exchange rates of 0.0073 Emoles O₂/yr between the biosphere and atmosphere and of 0.0037 Emoles O₂/yr between the biosphere and hydrosphere were calculated from the net world production figures given by Whittaker³³ of 109·10⁹ and 55·10⁹ dry tons organic matter/year for land and ocean, respectively. In this calculation, it was assumed that 40 per cent of the dry organic matter by weight consists of carbon.³³ It was also assumed that these values should be doubled to obtain the gross production of photosynthesis. Other values were obtained from reference 1.

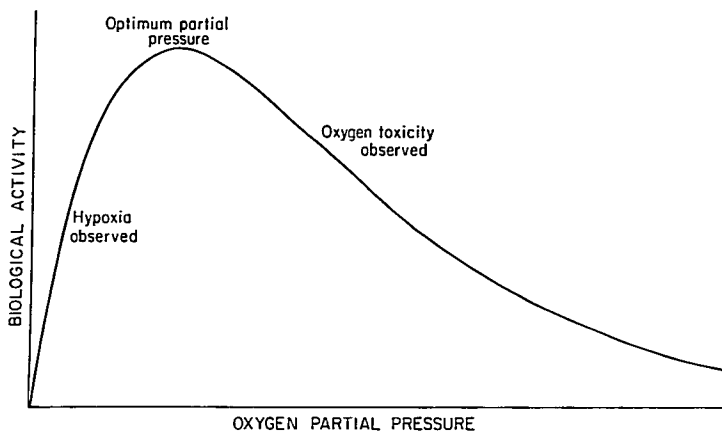


FIG. 5. Effect of oxygen on biological activity.

Future of Atmospheric Oxygen

The regulation of atmospheric oxygen is controlled in part by photosynthesis. Photosynthesis can be regulated by both carbon dioxide and oxygen. The rate of photosynthesis is decreased either by a decrease in carbon dioxide¹ or by an increase in oxygen.²⁴

There is far more oxygen in the atmosphere than the amount needed to react with the 0.9 Emoles of the coal and oil reserves. Burning this amount of these reserves would decrease the partial pressure of oxygen in the atmosphere only from 158 torr to 154 torr.¹ Hence, it appears that oxygen continues to be relatively stable in our present atmosphere.^{1, 25, 26}

Eventually, however, as the hydrogen escapes from the earth, oxygen will tend to burn up everything and convert all the exposed carbon to carbon dioxide. The atmosphere at this stage would then be composed of carbon dioxide and nitrogen; all life would cease. Finally, these two gases would also escape the gravitational field of the earth, and the atmosphere would be completely lost.

Oxygen Toxicity

As we have already seen, the development of oxygen on earth forced the development of

biological antioxidant defenses against the toxic effects of oxygen. These toxic effects were first noticed by Scheele, when he discovered oxygen.²⁷ Priestley, the co-discoverer of oxygen, also thought that perhaps oxygen was toxic.² The role of oxygen toxicity has been extensively reviewed.^{15-20, 23-25, 42a, 43, 44, 44a, 45-48}

Oxygen is a double-edged sword; it not only promotes life, but it also destroys life. Lavoisier⁴⁹ noted these two opposing functions when he wrote (translated from the French), "... when there is an excess of vital air [oxygen], the animal only undergoes a severe illness; when it is lacking, death is almost instantaneous." Increasing the oxygen tension will increase the available energy for the biological process to a maximum. But as the oxygen tension increases, more of the cellular constituents will be destroyed. These two effects occur at all concentrations of oxygen until there is finally no biological activity. What is the result? There will be an optimum oxygen pressure, *i.e.*, the oxygen pressure when the observed biological activity is at a maximum.

Figure 5 illustrates a dose-response curve for oxygen. Hypoxia is observed at low pressures of oxygen. Even at these low pressures,

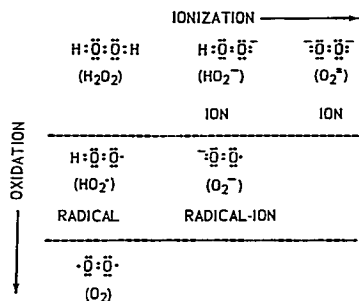


FIG. 6. Radicals and ions of oxygen.
Taken from reference 6.

the toxic effects of oxygen are present.¹⁸⁻²⁰ At high pressures of oxygen, the predominant factor is oxygen toxicity. The form of the curve was fitted by the following equation:

$$Y = A[1 - \exp(-B \cdot P)] \exp(-C \cdot P)$$

The factor $\exp(-C \cdot P)$ represents the oxygen toxicity factor. When the oxygen pressure is zero, this factor is one, and there is no oxygen toxicity. At high pressures of oxygen, there is no biological activity because the oxygen toxicity factor equals zero. Biological activity is represented by Y and the oxygen pressure is represented by P. This equation, *per se*, should not be taken too seriously. It is meant to give a very general formulation only. However, the data obtained for *Azotobacter*, where the per cent of maximum rate of respiration is the biological activity,²⁰ fit this equation as a rough approximation, where $A = 110$ per cent, $B = 50 \text{ ATA}^{-1}$, and $C = 1 \text{ ATA}^{-1}$.

The various biological activities need not have the same optimum partial pressure of oxygen. Also, there might be a large range of partial pressures at which the biological activity is maintained relatively constant at its maximum. This possible plateau and the width of the plateau will depend quantitatively upon the two opposing influences of oxygen. Here, then, is the dual nature of oxygen with its two diametrically opposing factors.

According to the Gerschman theory of oxygen toxicity, free radicals act as intermediates

in the reaction of oxygen and the cellular constituents.²¹ Because free radicals contain an unpaired electron, they are highly reactive. Radicals of oxygen are illustrated in figure 6. When oxygen is reduced by hydrogen to water, four electrons are added to the oxygen molecule. It is believed that the four electrons are added one at a time.²¹ The first electron addition results in the free radical, HO_2^\cdot ; the second electron addition results in the formation of hydrogen peroxide; the third electron addition results in the splitting of the oxygen bond and the formation of water plus the hydroxyl radical, OH^\cdot ; the fourth electron addition to the OH^\cdot radical results in another molecule of water.

Oxygen is sluggish because it must be activated to free radical states before it can react.^{9, 15} However, if free radicals are present, then molecular oxygen is not sluggish and oxidations can occur via chain reactions. Figure 7 illustrates a chain reaction in which a chemical, RH, is oxidized to RO_2H by molecular oxygen. The chemical, RH, could be an important cellular constituent, and its oxidation could be harmful to the cell.

There is no doubt that free radicals do exist in the body. For example, it is thought that xanthine oxidase generates the free radical-ion O_2^- and H_2O_2 ,²² and, secondarily, the OH^\cdot radical. The superoxide radical, O_2^- , is removed by the enzyme, superoxide dismutase.²³

Increased oxygen tensions should result in an increase in the turnover of the free radicals. The demonstration of this increase is difficult because of two problems. One difficulty is that measuring free radicals using the electron paramagnetic resonance spectroscopy technique requires a large free radical concentration in a biological sample, the detection limit being about 6.10^{-8} M .²⁴ The other difficulty is that this technique detects free radical concentration instead of actual free radical turnover.

One might expect that the onset of a disorder caused by oxygen toxicity would be dependent upon the free radical concentration. If there are chain branching reactions producing an increase of free radicals, then the time necessary for the disorder to begin would decrease. This effect would be more likely to occur at high pressures of oxygen. The em-

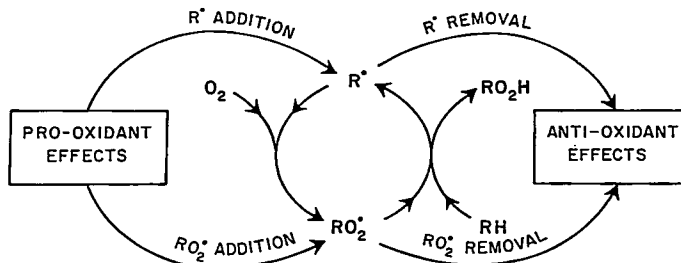


FIG. 7. Chain reaction. Taken from reference 9.

pirical relationship between the time at which the deleterious effect is measured and the oxygen pressure has been described mathematically as follows⁵⁵:

$$\log T = \log C - D(\log P)$$

where T is the time at which the deleterious effect is noted, P is the oxygen pressure, C is a constant, and D is a constant. This relationship has been shown to be a fairly good approximation for various biological systems.⁵⁶⁻⁶⁰

We might suppose that the reactivity of ozone would also be mediated through free radical mechanisms.⁴⁵ In fact, Schönbein, the discoverer of ozone, in 1857, thought that molecular oxygen had to be converted into ozone before it could be used in biological oxidations.⁶¹

The deleterious effect of x-irradiation on living cells is mediated in good part by free radicals.^{45, 51} Since the amount of energy required by x-irradiation to destroy living tissues is so small, we can suppose that x-irradiation acts merely as a catalyst; it supplies free radicals for the potentially-dangerous oxygen (see fig. 7).

The toxic effects of oxygen can affect membrane function,⁶²⁻⁶⁴ perhaps by oxidizing sulfhydryl groups⁶⁵ and by reacting with lipid double bonds, resulting in lipid peroxidation.⁶⁵⁻⁶⁷ The absence of oxygen is vital in preparing some artificial membranes.⁶⁸ Oxidizing agents have some influence on the electrical properties of the nerve membrane,^{69, 70} and sulfhydryl-combining agents impair the nerve impulse.^{69, 71} Increased oxygen pres-

ures impair the nerve impulse^{66, 72-74} and decrease the chronaxie.⁷³ Part of these effects can be explained by a breakdown of the membrane active transport processes,⁷⁵ which would result in a change in the ionic concentrations across the cell membrane.

In spite of oxygen toxicity, let us note that oxygen can be concentrated to 100 ATA in the swimbladder of the fish.⁷⁶

Oxygen toxicity also plays a role in the ecological balance of nature. Oxygen pollution of the atmosphere by photosynthesis actually inhibits mosquito breeding.⁷⁷

Antioxidant Defenses

Antioxidant defenses occur in many and varied forms. One type of defense results from the various barriers confronted by oxygen in its path from the external environment to the intracellular environment. An inspired oxygen tension of about 60 torr results in an intracellular oxygen pressure in the rat cortex of only about 0.6 torr⁷⁸; the oxygen tension is thereby reduced a hundredfold. Although this inspired oxygen tension is hypoxic, practically all the pyridine nucleotide in the rat cortex is found in the oxidized form at this 1-micromolar intracellular oxygen concentration.⁷⁸ Hence, the cellular constituents are supplied with a large amount of oxygen, but at a low oxygen tension. This phenomenon is due in great part to hemoglobin's acting as a protective device against oxygen toxicity. It provides a large quantity of oxygen at a low oxygen tension.^{9, 23}

There are many enzymes and chemicals which can help to decrease free radical concentrations (see fig. 7) and other oxidizing intermediates of oxygen; hence they act as antioxidants.⁹ Glutathione peroxidase⁷⁹ and superoxide dismutase⁸² are examples of antioxidant enzymes. Vitamin E, which inhibits lipid peroxidation,⁸⁰⁻⁸³ is a good example of an antioxidant chemical.

Oxygen is normally present in an atmosphere composed mainly of nitrogen. The role of nitrogen and other inert gases suppresses oxidation, as evidenced by the fact that in a pure-oxygen environment maintained at the same oxygen tension, the fire hazard is increased.⁸⁴ There is some indication that atelectasis is more prevalent in pure-oxygen environments.^{82, 86} Oxygen effects in the absence of inert gases are still being studied.^{87, 88} On the other hand, high pressures of inert gases have been shown to be synergistic with the toxic effects of oxygen.^{89, 90}

Intermittent exposure to increased oxygen pressure increases resistance to the toxic effects of oxygen.^{91, 92} Part of the increased resistance might be caused by a thickening of the alveolar walls,⁹³ resulting in an increased barrier to the oxygen entering the blood. Perhaps, in addition, compensatory increases in other types of antioxidant defenses might develop.

Gerschman has suggested that aging might be considered a result of the toxic effects of oxygen at an oxygen pressure of 0.2 ATA.¹⁸ Since free radicals are considered intermediates of oxygen toxicity,⁵¹ aging might in great part be due to the deleterious effects of free radicals.^{18-20, 94, 95} Antioxidant defenses can resist the toxic effects of oxygen, but cannot completely prevent them: the result is the aging process. It is interesting to note that plants can survive for very long times; indeed, the bristlecone pine, *Pinus aristata*, can survive 4,600 years.⁹⁶ Perhaps the longevity of some plants can be explained in part by possession of antioxidants. Plants do contain phenols,⁹⁷ which possess antioxidant activity.⁹⁸

Oxygen Therapy

In spite of the dangers of oxygen toxicity, oxygen therapy does have a place in medi-

cine.⁹⁹ It might possibly be used as therapy in decreasing cholesterol and other lipids in atheromatous arteries,¹⁰⁰ for example. Nevertheless, because of its dangers, it should not be used unless there is good reason to do so.⁹⁹ The deleterious effects of oxygen toxicity in man have been experienced by Haldane,¹⁰¹ and these effects should always be considered before any oxygen therapy is used. Oxygen therapy is indicated when the advantages of using excess oxygen are greater than the disadvantages. Even under these circumstances, it should be used with caution. Only the minimum oxygen pressure and the shortest time of exposure necessary to alleviate a condition should be used; increasing the oxygen tension beyond this amount should not be tolerated.

Summary

Oxygen is one of the most abundant elements in our universe. The presence of it in the atmosphere is indicative of a biosphere. The amount of oxygen in the atmosphere is relatively stable at the present time. However, it is speculated that the atmospheric oxygen eventually will disappear, and all life will cease.

Oxygen serves as an excellent source of biological energy. However, it has a Dr. Jekyll-Mr. Hyde personality. It also destroys life. Fortunately, our bodies contain several defenses against oxygen toxicity, but even these defenses are overrun, resulting in the aging process. When oxygen therapy is indicated, it should be used only with caution.

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