would be expected if the fading were due to Faraday rotation. An example of fading curves in which the spin of the satellite produced a negligible effect is shown in Fig. 9.

From computations of the geometry of transits for which such curves have been obtained it has been possible to determine $\int N dh$ up to the height of the satellite.

For example, observations at 0330 on October 20 when the satellite was at a mean height of 475 km. indicated a total electron content up to this height of $1 \cdot 8 \times 10^{13}$ cm.$^{-2}$.

Other Investigations

(*a*) *Density of the Atmosphere.* The observed decrease in the period of the orbit allows an estimate to be made of the air drag. We have used the published mass of 84 kgm. and diameter of 58 cm. and have neglected the cross-section of the aerials; on the assumption that the gas particles adhere temporarily to the surface of the satellite and leave with thermal velocities, we have estimated that the mass of air encountered in each orbit is 1·8 gm.

Because the orbit is elliptical, this result can only be used to derive the air density if the scale height is known. Assuming a temperature of 1,000° K., the density at a height of 200 km. was found to be about 4×10^{-13} gm. cm.$^{-3}$.

Continued observations of the changes in the orbit should allow the determination of both density and temperature as functions of height.

(*b*) *Precession of the Orbit.* The observed retrograde motion of the ascending node over the period October 8–18 was found to be 2° 33′ ± 5′ per day. For comparison we have computed the expected precession for the observed orbit and the accepted figure of the Earth using the relationship given by Davis, Whipple and Zirker[2], and find a value of 3° 45′.

It does not seem possible to account for this discrepancy in terms of secondary effects of the air drag, or by electromagnetic forces. It is possible that a more detailed analysis of the expected precession may resolve the difficulty, and it is clear that an improved measurement of the precession by continuing the present observations is of great interest.

The work described here has involved practically the whole staff of the Mullard Radio Astronomy Observatory, as well as several of the members of the Ionosphere Section of the Cavendish Laboratory.

Besides our own observations we have been able to make use of a large number of valuable recordings provided by the Post Office receiving stations at Banbury, Baldock and Brentwood, by the Marconi Research Laboratories at Great Baddow and by Mr. F. W. Hyde of the Radio Section of the British Astronomical Association. We are most grateful for their co-operation, and would like to thank all those whose advice we have sought, in particular the Superintendent and the staff of the Nautical Almanac Office.

[1] *Nature*, **180**, 784 (1957).

[2] Davis, R. J., Whipple, F. L., and Zirker, J. B., "Scientific Uses of Earth Satellites" (1956).

UNDERWATER SWIMMING AND DIVING

A SESSION of Section I (Physiology) of the British Association, held on September 11, was devoted to the problems of underwater swimming and diving. The meeting was opened by Dr. H. J. Taylor (Royal Naval Physiological Laboratory, Alverstoke), who discussed the physiological aspects, and he was followed by Capt. W. O. Shelford, R.N. (retd.) (Siebe Gorman and Co. Ltd.), who gave an account of apparatus development. M. Frederic Dumas of the Groupe d'Etudes et de Recherches Sous-marines, Toulon, then presented three films illustrating some of the activities of underwater swimmers.

Dr. Taylor opened with a warning against the indiscriminate use of underwater apparatus by the uninitiated. He urged those interested to join recognized clubs, to become well acquainted with the apparatus, to acquire as much information as possible about the hazards of underwater swimming and never to dive alone but always with a companion. In particular he emphasized the serious dangers in the use of oxygen sets by amateurs.

Dr. Taylor said that the problems raised by diving and underwater swimming, quite apart from the technical and engineering aspects, are those of the effect upon the body of exposure to increased pressure.

It is a remarkable fact that in the recent British world record deep dive a man tolerated an exposure to a pressure of 17 tons per square foot. This is because the body, except for some sealed air spaces, is made up of solids and fluids which are, for all intents and purposes, incompressible. Pressure is transmitted to all parts and equalized. This of course implies that air must be breathed at the pressure to which the diver is subjected. A swimmer who makes a dive to 100 ft. (that is, to a pressure of 4 atm. absolute) merely by holding his breath will have his lung volume compressed to about one quarter of its original volume. This is approximately the volume of the residual air, that is, the air left in the lungs after the greatest possible expiration. Any further increase of pressure will produce a condition known as a 'squeeze', and fluid and blood may be forced into the lungs; this damage may be severe. Further increase of pressure may cause the chest wall to collapse. This 'squeeze' may also occur if the pressure of air within the helmet of a diver falls below the external pressure. The shoulders and body will be pushed with great force into the rigid helmet with, usually, fatal results. The ear is very susceptible to damage by pressure, which, when applied to the ear-drums, must be equalized otherwise rupture will occur. This equalization is accomplished by allowing air to pass up the Eustachian tube to the middle ear. This is a procedure which the diver himself must carry out and is known as 'clearing the ears'. Difficulties are sometimes encountered in equalizing the pressure in the accessory sinuses and severe pain may result.

Problems can also arise when the pressure on a diver or swimmer is reduced, particularly when he comes to the surface. Normally, on rising towards the surface the pressure of the air in the lungs is maintained almost equal to the external water-pressure by means of a relief valve on the helmet or breathing apparatus. If the relief valve fails to function or if the ascending man holds his breath a positive pressure may be built up inside the lungs. The lungs would become over-expanded and some air sacs and blood vessels become torn. Air could be forced into the ruptured tissues or blood vessels producing spontaneous pneumothorax in one case or air embolism in the other. The results of this may be serious in the extreme, and recompression to the original depth or deeper is essential in order to prevent fatal consequences. Death has occurred after an ascent from only fifteen feet. These dangers can be overcome only by experience and careful training, and this fact cannot be over emphasized.

There are, however, more hazards due to physiological processes concerned with the respiration of gases under pressure. Almost all gases, even the so-called inert ones—nitrogen and the rare gases—exert their own special effects, when breathed at higher partial pressure than normal.

Oxygen is probably more important from the military aspect than it is from the purely recreational. If it is essential that an underwater swimmer must not give his position away with bubbles, then pure oxygen must be breathed in association with an absorbent for carbon dioxide. The hazards of breathing this gas are, therefore, almost entirely confined to operational duties.

Oxygen produces two effects—the Lorrain-Smith or chronic effect and the Paul Bert or acute effect. The former, in the main, is produced by the irritant effect of oxygen, when breathed at between 0·6 and 2 atmospheres, on the delicate membranes of the lung. Much research on this problem has been carried out, but since the effect only occurs after breathing oxygen for many hours it is not looked upon as being a hazard of diving or other underwater operation.

The Paul Bert or acute effect is much more important. This appears when oxygen is breathed at a partial pressure in excess of 2 atmospheres. The greater the pressure the shorter the time of onset of signs and symptoms of the toxicity of oxygen. In man and other mammals this is characterized by a convulsion, epileptiform in character, and the onset of such an effect in an underwater swimmer can be most dangerous. The depth and duration of underwater operations involving oxygen breathing is therefore severely limited.

Much research has been carried out on the cause of this phenomenon, without, it must be admitted, a great deal of success. This is not surprising since comparatively little is known about epilepsy itself. One of the main theories postulates interference in oxygen breathing with the dual function of hæmoglobin. If oxygen at partial pressures greater than two atmospheres is breathed, then there is sufficient oxygen dissolved in simple solution in the plasma to satisfy the needs of the body under conditions of comparative rest. No reduced hæmoglobin is available, therefore, for transport of carbon dioxide and one might expect an accumulation of this gas in the body tissues. It is suggested, therefore, that the effect is really due to excess carbon dioxide in the tissues. Experimental evidence is available which appears to confirm this idea, since the tension of carbon dioxide in the tissues during oxygen breathing shows a marked rise. In addition, it is known that the respiration of a low proportion of carbon dioxide with the oxygen greatly enhances the effect. However, more recent experiments by some workers in the United States show that there is reduced hæmoglobin available in the brain and the normal removal of carbon dioxide can take place. If it is assumed, as is generally the case, that the brain is the source of the manifestation of oxygen poisoning, then a blow has been dealt at the Gesell hypothesis. The American work is, however, open to some criticism. Other theories are (*a*) that oxygen interferes with brain metabolism, for example, that it affects enzyme systems; (*b*) that neuro-muscular transmission is impaired.

The Royal Navy has been seeking a suitable drug which can be given to an underwater swimmer to increase his resistance to oxygen poisoning, and some success has been obtained.

There is another effect characterized by sudden lack of consciousness at comparatively shallow depths which has been ascribed to breathing oxygen. This is sometimes called 'shallow-water black-out' or 'oxygen syncope'. The cause is obscure, but experimental work is proceeding. It may be due to a cerebral vasco-constriction by oxygen.

Nitrogen, when breathed under pressure, exerts a narcotic action. There is a slowing up of mental processes, and fixation of ideas is a characteristic response. Frequent errors are made in simple arithmetic and in the recording of information. These responses may be similar to those associated with anoxia or with alcoholic stimulation. If nitrogen in the oxygen–nitrogen mixture is replaced by helium then the effect is much reduced. It may be that the fact that the oil/water solubility ratio for helium is much less than that for nitrogen has some bearing on the problem (cf. the Meyer–Overton law). It has also been suggested that decreased elimination of carbon dioxide due to decreased pulmonary ventilation produced by the heavy gases might be a factor, but measurements of alveolar carbon dioxide under conditions of high pressure have shown this to be normal and have disproved this hypothesis.

Recent work, involving electro-encephalograph records, has been rewarding. Normally the occipital alpha-rhythm shows an abrupt fall in amplitude (blocking) when a subject concentrates on a problem. After exposure to a pressure of four atmospheres in air the time to give an answer to a simple calculation is increased and further exposure leads to abolition of the blocking. On returning to atmospheric pressure, this process is reversed. Using different pressures it is found that the time to abolition of the blocking is inversely proportional to the square of the pressure, suggesting a diffusion process. On replacing nitrogen by helium, blocking is not abolished. It seems, therefore, that nitrogen is responsible for these effects. Consequently, for deep dives a helium–oxygen mixture replaces air.

Nitrogen and all the inert gases produce an effect, only observed when the pressure drops, due to the quantity of gas dissolved in the body. Exposure to these gases under pressure produces an increased tension in tissue, dependent on the depth and duration of the dive and on circulatory efficiency. When a certain quantity of inert gas in the tissues is exceeded, direct decompression to atmospheric pressure will lead to the formation of bubbles and the so-called 'bends'. This has led to the introduction of diving tables; so that a man is not brought directly to the surface but has a series of stops at different depths and times depending on the nature of the original dive.

Several of these diving tables have been produced, but all have some unsatisfactory features. This is because of a lack of fundamental information regarding inert gas exchange in tissue. Research is therefore proceeding at the Royal Naval Physiological Laboratory on this subject and some success has been achieved. It would appear that only one type of tissue is involved, and that saturation and desaturation are not reversible, as has previously been assumed. The removal of dissolved gas on decompression is retarded by the presence of bubbles which may not be of sufficient size to produce signs of bends. The fact that exposure to pressure appears to produce these silent bubbles must be taken into account in the calculation of safe decompression tables.

As regards carbon dioxide, if the absorbent canister is working efficiently in a closed-breathing set there should be no danger from this gas. Nor should it be a hazard in deep diving if the flow of gas is sufficient to wash out the carbon dioxide.

Naturally, there was not sufficient time to enlarge on all the problems arising from diving and underwater swimming. Such a one as protection from the cold was not mentioned, but it has its importance. There is, however, one phenomenon which is becoming more and more important as dives become deeper and deeper, and that is the voice-change produced by increased pressure and also by breathing helium. Communication thus becomes more and more difficult, and the audience was asked to listen to a tape recording of a man speaking under pressure. The explanation of this effect is not yet clear, but in the recent world deep dive to 600 ft. it was found almost impossible to understand what the diver said.

This recording was of an Irishman repeating the well-known verse, "In Dublin's fair city . . . singing cockles and mussels alive, alive O!" at a pressure of 132 lb./sq. in. (about 264 ft. of sea water). The euphoria and speech distortion produced by nitrogen under pressure were well illustrated.

Capt. W. O. Shelford spoke next; he classified diving apparatus into four types: (1) self-contained closed circuit; (2) self-contained open circuit; (3) surface-supplied open circuit; (4) surface-supplied closed circuit.

The best known set of the first group is that designed by Sir Robert Davis for submarine escape. This involves the use of pure oxygen, carbon dioxide being absorbed by 'Protosorb'. Other forms of oxygen diving apparatus were greatly used during the Second World War for all types of offensive operations. The great advantage of oxygen is the compact nature of the set and the absence of tell-tale exhaust bubbles. It also gives great endurance, for example, that used by human torpedo-men had a tested endurance of six hours in 25 ft. of water with a considerable margin of reserve. One of the greatest problems in this sort of set is the absorption of carbon dioxide. Much valuable research work was carried out at the Chemical Defence Experimental Establishment, Porton, both on canister design and in the control of the absorbent chemicals.

A great advance was made during the Second World War in the use of mixtures of oxygen and nitrogen for breathing in a semi-closed circuit apparatus. The theory of mixture breathing was developed by Prof. J. B. S. Haldane and Dr. K. W. Donald and the idea is to give as much oxygen as possible in the mixture (and so provide maximum endurance) consistent with the least danger of oxygen poisoning. The optimum concentration of oxygen depends upon the depth of the dive. The set is a semi-closed circuit one giving partial rebreathing with a flow fixed according to the depth by a regulator which is compensated automatically for change in sea pressure. The regulator delivers a constant mass of gas at any diving depth. Mixtures have been used in Britain for many years with success, and Norway and the United States are now beginning to experiment with their use. The French have recently developed a mixture breathing set which supplies gas on demand without the use of a regulator.

Possibly the greatest interest since the War is in the compressed-air open-circuit apparatus. This is commonly known as the aqualung and its use has been popularized by Capt. Cousteau, M. Frederic Dumas and their associates. Air is stored in bottles at high pressure and delivered to the diver at the pressure of the surrounding water to be compensated instantly as the diver descends or ascends. This has to be done by a demand valve capable of supplying sufficient air to a diver even when he is making the maximum possible inspiratory effort. Being an open-circuit apparatus, the endurance varies with the depth. As regards surface-supplied open-circuit apparatus, there is the standard rigid-helmet type which has been in use for more than a hundred years. No change in principle—which is to compress air on the surface and supply it to the diver by a hose at a pressure equivalent to his depth—has been made, but naturally, suits, compressors and all ancillary equipment have improved. A recent variation is to supply air to the diver at about 100–50 lb./sq. in. and he regulates his own supply by breathing from a demand valve.

This last class of diving is that using the partial self-contained closed-circuit system, almost exclusively in very deep diving. On open circuit it was found that carbon dioxide tended to accumulate in the helmet due to pocketing. This led to the adoption of the Siebe–Gorman injector re-circulating system which was applied to the standard diving dress. In this system, air is supplied at a pressure higher than the ambient sea pressure, sufficient to maintain a constant flow through an injector. This injector feeds into a Venturi tube, creating a partial vacuum in a carbon dioxide absorption canister worn on the back of the diver. The air containing carbon dioxide is therefore drawn through the canister and back into the helmet. Very much less air from the surface is therefore required. As diving depths become greater so the problem of nitrogen narcosis becomes more important. Nitrogen is therefore replaced by helium. At first considerable difficulties were encountered and the construction of the helmet had to be improved still further and, since helium is so much less dense than nitrogen, new injectors and venturis had to be designed.

World record dives to 540 ft. in 1948 from H.M.S. *Reclaim* under Capt. Shelford's command and to 600 ft. from the same ship in 1956 testify to the success of these developments.

Another field in which considerable advance has been made is that of divers' clothing. Two-way stretch nylon, proofed with neoprene, is being used to give a supple suit with maximum protection properties. Despite much research, it is still thought that the standard diving woollen undergarments are the best for protection against cold.

Capt. Shelford went on to predict further developments. He foresaw a time when all suits would be of rubber- or neoprene-proofed 'Terylene' fabrics fitted with light-weight ball-race shoulder and waist joints. The special copper helmet inside which the diver rotates his head may be replaced by a comparatively tight-fitting helmet rotating and elevating at the neck joints so that its volume and buoyancy can be greatly reduced. There could be considerable development in the open-circuit aqualung set if new materials, allowing for greater charging pressures, were allowed by the authorities for the construction of cylinders. Capt. Shelford ended by saying that he had no doubt that industry would supply any equipment which the scientist needed to provide for deeper and deeper depths.

The last part of the meeting was devoted to the showing by M. Frederic Dumas of three films. The first, in black and white, was of some of the experiences of cave diving. The film started by giving an insight into the organization required before such a project could be undertaken, how the interest of the local population was aroused and how the morale of the divers was maintained in the local cafés. In the caves themselves the pictures were most fascinating. particularly when attempts were made to find the sources and direction of flow of the water.

The second film, in colour, was an account of an exploration for oil in the Persian Gulf carried out for the Kuwait Oil Company. Fine seascapes and pictures of fish and animal life were shown. A cage for protection against sharks was a reminder of one of the special hazards in this sort of work.

The third film, again in colour, showed the discovery and investigations of some Roman galleons sunk in the Mediterranean. Marble pillars and other portions of buildings which were being transported in the galleon when it sank were in a remarkable state of preservation. Later, the film showed how an underwater swimmer can help in tunny fishing. This looked particularly hazardous, but M. Dumas assured his audience that this was not so.

During the subsequent short discussion members of the audience gave accounts of the work of their own sub-aqua clubs, endorsing the warnings that Dr. Taylor gave earlier on. Questions were asked about the reported failure of some men to carry out quite simple tasks at shallow depths, when nitrogen narcosis could be ruled out. It was suggested that this was probably due to apprehension and anxiety.

H. J. TAYLOR

THE ORIGINS OF LIFE

MOSCOW SYMPOSIUM

THE Academy of Sciences of the U.S.S.R. acted as generous host to the first of the specialist symposia that the International Union of Biochemistry has decided to arrange in years when there is no international congress. The symposium was organized by Prof. A. I. Oparin ; it was on "The Origin of Life on the Earth", and this is also the title of the new edition of a book by him that Dr. Ann Synge has recently translated into English.

About sixty papers were circulated, read in summary, and then discussed during three and a half well-filled days. This was certainly the most ambitious attack on the problem that has as yet been made, but, contrary to the claim that was often made at the symposium, it was by no means the first serious scientific attack on it. At the end of last century and the beginning of this one the British Association dealt with the subject regularly. Huxley, Tyndall, Schafer and others had a clearer grip on the nature of the problem than most contemporary writers. They also often have priority. If participants in future symposia on biopoesis would read the old literature we might be spared the embarrassment of hearing eminent scientists portentously making suggestions that were familiar 50–80 years ago.

There is now general agreement that life can arise from non-living matter but there is disagreement about how often it does so. The possible points of view are set out in Table 1. Possibilities 1 and 2 are not now often advocated, but 1 will soon become amenable to experimental test when astronauts set out to look for what Haldane calls "astroplankton". Possibility 5 was effectively disproved during last century, not so much by the work of Pasteur as by the existence of the food-canning industry. That leaves 3 and 4. Many people advocate 3 because they claim that the biochemical uniformity of present-day life, and the preponderant use in proteins of amino-acids of only one of the two antipodal series, suggests a common origin. This point of view was maintained at the symposium by R. L. M. Synge ; but it does not seem to me to pay sufficient attention to the operation of food chains in Nature. If any group of organisms started to use one antipodal series it would be advantageous for any other group, even slightly dependent on the first, to come into line. And there are obvious advantages in using one series only. Though biopoesis is probably a rare event it is probably not a unique

Table 1. BIOPOETIC THEORIES

	No. of biopoeses	General character
1	None	Life has always pervaded space and an apparent origin is simply a transfer from place to place
2	One	Creation by divine intervention
3	One	Evolution on Earth by the action of inevitable, normal processes
4	Several	Repeated co-ordination of eobionts or sub-vital units
5	Innumerable	Classical and medieval idea that life appeared whenever there was a suitable environment