tion must be larger than those of either of the two substances when separate, the solution consisting of compounds or hydrates of the two. I showed, moreover, in the paper above referred to that the hydrate theory of solutions was quite capable of accounting for and explaining the fact that the dissolved substance may for many purposes be regarded as being in a quasi-gaseous condition in weak solutions, and that calculations based on the idea of its being truly gaseous would yield very nearly correct results.

The hydrate theory will also, as I showed, give an explanation of the fact that electrolytes will give abnormally high osmotic pressures, and that the magnitude of these pressures can be calculated from their electric conductivity: and the explanation based on this theory also obviates many of the objections to which the idea of dissociation into ions is open. Moreover, the only critical experiment which, as far as I know, has ever been made to test the validity of the dissociation hypothesis, gives an unequivocal answer against it, and in favour of the hydrate theory. When, for instance, sulphuric acid is dissolved in excess of water, it is represented by the dissociationists as splitting up into its ions, so that the solution will contain more acting units (ions and molecules) than the acid and water together contained before they were mixed: whereas, on the hydrate theory, combination will have occurred, and there will be fewer acting units present. The number of acting units may be ascertained by observing the depression produced by the solution on some other solvent, such as acetic acid (that is, by using the very method which the dissociationists use to prove the supposed dissociation of substances), and when this is done it is found that the sulphuric acid solution contains *fewer*, instead of *more*, units than the acid and water separately.

Even if the above were the only arguments to be urged, it is evident that although the idea of the dissolved substance being gaseous and often dissociated may be a good working hypothesis for the directing of investigation, it can scarcely be accepted as a true theory of the nature of solutions.

SPENCER PICKERING.

On a Supposed Law of Metazoan Development.

IT is difficult not to feel disappointed that Dr. Beard has given only "a preliminary sketch by way of clearing the ground" (NATURE, vol. xlvii. p. 79), in place of "producing the full argument" for a law in the existence of which he has by "observation and reflection" been led to believe. For it is not easy to gather from his sketch how he is able to apply a universal law to so varied a series of events and phenomena such as he mentions, and at the same time to point out "the analogy which obtains between the suggested mode of Metazoan development, and the accepted fact of an alternation of generations in the life histories of all plants above the lowest Thallophytes." For in the higher plants the alternation of generations referred to occurs with constancy as regards period of life history, and varies only slightly within the limits of the same group.

Dr. Beard alludes, I presume, to one form of alternation of generations—that of sexual with asexual generation only, or Metagenesis. This he asserts constitutes a general law in the development of Metazoa.

In a sense this may be true enough. If, for instance, we regard the division of each cell as a new asexual generation, then Metagenesis is a very constant phenomenon amongst Metazoa. In this case the life history of a Metazoon consists of a sequence of thousands of asexually produced generations alternating with one sexually produced generation, which gives apparently a stimulus for another run of asexual generations in which polymorphism and division of labour are exhibited in extraordinary complexity and beautiful harmony.

But this is not at all what Dr. Beard means. The series of instances which Dr. Beard gives, or system of "nursing" as Steenstrup termed it, is at most a series of disconnected phenomena of frequent occurrence, and not a law.

Because most Metazoa possess eyes, it is not therefore a law of Metazoan development that eyes should be developed. Diversity in form, number, and time of appearance of eyes, is sufficient to show that the law cannot exist; so also is it in the cases of nursing to which Dr. Beard alludes, and on which he bases his argument.

It seems to me that no "law" of alternation of generations in Metazoa can be "enunciated" unless there is evidence forthcoming of its constant action at corresponding periods in the life histories of all animals of different groups, and in a closely similar manner in individuals of one and the same group. Also a law of such a nature, if it is to be found to act universally amongst Metazoa, must surely have come into action at a very early period in the evolution of Metazoa.

Metagenesis is of constant if not universal occurrence in the cycle of life of Protozoa. A long series of generations produced asexually is followed by a generation produced sexually, that is, a generation produced by the conjugation of two individuals; this is followed again by another long series of asexually produced generations, and so on. If this is so constant among unicellular organisms of the present day, it is not very unreasonable to suppose it was common among the protozoan ancestors of the Metazoa and of the Plants. If we are to find any form of Metagenesis as a *universal phenomenon* in the Metazoa, it must be to the most protozoon-like stages of development of the Metazoon that we should look.

There is but one strict meaning to the phrase sexual generation, and that is a fusion of two cells. If Metagenesis means anything it means the alternation of a generation resulting from the fusion of two cells, with one or more generations resulting from the division of cells.

This we can perhaps find in the protozoon-like stages of Metazoan development, and in a way analogous to the alternation of generations among plants.

Spermatozoon and ovum fuse and form the fertilized ovum which is the true sexually produced generation. This produces by division a vast number of cells, and if we regard these as a number of generations then Metagenesis is obvious enough. But it is no more metazoic—if I may use such a word—to call the whole animal resulting from the segmentation of the fertilized ovum, the sexually produced generation.

This generation buds off the immature ovum. This is really the "Primitive ovum" of the embryo. I see no reason why this may not be regarded as a distinct asexually produced generation—like the formation of the spore of the plant.

The immature ovum divides into two cells—first Polar body, and more mature ovum. The more mature ovum divides into two cells, namely, second Polar body and mature ovum. It does not materially affect the argument whether we should regard these two processes as two separate consecutive asexually produced generations, or as one asexually produced multicellular generation. If we take the latter view, then the maturation of the ovum is more analogous to the prothallus stage of the life history of plants.

In either case the result is the formation of the mature ovum, comparable to the oosphere of plants.

The mature ovum fuses with the mature spermatozoon, and the sexually produced generation recurs, and the cycle of development is completed.

I cannot help thinking that if Dr. Beard wishes to discover a law of Alternation of Generations applicable to the whole of the Metazoa, he will find a more favourable hunting ground amongst those stages of development at which the several groups of Metazoa approximate, than amongst those stages where they are farthest apart; and also Dr. Beard will find the analogy between the supposed Metazoan law and the accepted law of the vegetable kingdom closer than he could ever hope to find it if he continues his present line of search.

If the above theory of the cycle of Metazoan life can be considered tenable, we see that both in the Higher Plants and in the Metazoa there are constantly alternating "sporophyte" and "gamophyte" generations, and further, we can find evidence, as we should expect to do, of the origin of such a universal phenomenon in the single celled or protozoan life, where the continuance of the species may be secured in both these ways, namely, by the formation of asexually produced spores, and as a consequence of cell fusion, *i.e.* conjugation.

RIC. ASSHETON.

Oxygen for Limelight.

THE employment of oxygen for limelight and other purposes has increased enormously since the commercial introduction of the Brin method, by which the gas is separated from atmospheric air by a now well-known chemical process. The gas so obtained is practically pure, analysis showing that as now supplied by the Brin companies it contains on an average 95 per cent. of oxygen, the remaining five per cent. consisting of inert nitrogen.

The success of this comparatively new industry has been so marked, that, as a natural result, competitors with rival processes have come forward. Some of these met with failure at an early stage of their career, but others are supplying oxygen to the public. This is by no means a state of things to be deplored from the consumer's point of view, if the product from the one source is as good as the other, for benefit generally arises from healthy competition. But when the rival product turns out to be not oxygen, but a half and half mixture of oxygen and air, with a slight excess of the latter, the competition is of a decidedly unhealthy character, and is correspondingly bad for the consumer. I recently obtained a sample of gas from a dealer, which on testing (with a Hempel absorption pipette, charged with metallic copper and ammonia) I found to be a mixture containing only 60·6 of oxygen. I next tested the illuminating value of this highly-diluted oxygen with a limelight jet, and for sake of comparison, placed by its side a precisely similar jet supplied with Brin's oxygen, and, as might have been expected, the light given by the former was little more than one-half as intense as that afforded by the latter. With the good oxygen the lime cylinder was quickly pitted, whilst the other showed no symptom of destruction. It is also to be remarked that the consumption of the diluted gas was, for a given period, about one-third more—striving with both jets to get the best possible light—than that of good oxygen. On the same principle a mountaineer at a high altitude will pass more (rarefied) air through his lungs than he will when he is in the valley breathing that which contains the normal quantity of oxygen.

As this matter is of great importance to many workers, I trust that you may be able to find room in your valued publication for these words of necessary caution.

T. C. HEPWORTH.

45, St. Augustine's Road, Camden Square, N.W.,
December 6.

THE STAR OF BETHLEHEM.

IN the *Astronomical Journal* of November 26 we find the second of two very interesting articles written by Mr. J. H. Stockwell, bearing on the chronology of certain ancient events. In the introduction the author discusses and sums up some of the more important and historical dates which he has determined by calculations of ancient eclipses. He next refers to the help which may be obtained in the same direction by means of calculations of conjunctions of the planets, and quite appropriately to the present season points out that the appearance of the star of Bethlehem may have been due to the conjunction of the planets Venus and Jupiter, instead of Saturn and Jupiter, as was suggested on incomplete data by Kepler nearly three hundred years ago. We cannot do better than lay this part of Mr. Stockwell's communication before our readers.

"Although the heliocentric conjunctions of the planets occur with a considerable degree of regularity, and are also very easily calculated, the geocentric conjunctions are subject to many inequalities in the periods of their successive occurrences; so that it requires somewhat elaborate computations to determine accurately the character of any geocentric conjunction of two planets which occurred in ancient times. On account of the frequency of planetary conjunctions, and the indefinite manner in which they are usually described, it becomes a matter of very great difficulty to identify any particular conjunction unless it is associated with some other event whose data can be independently determined. A remarkable case of this character is given in the Bible, for Matthew informs us in the days of Herod the King 'there came wise men from the East to Jerusalem saying, "Where is he that is born King of the Jews? for we have seen his star in the East, and are come to worship him."' From the subsequent inquiries and mandates of Herod the King concerning the time when the star appeared, we are led to infer that its appearance took place within two years preceding the death of Herod, and it has been sought to explain the appearance of the star by means of a conjunction of the planets—the Creator employing celestial phenomena to proclaim 'the good tidings of great joy, which shall be to all people.'

"The illustrious Kepler was the first to suggest that the star of the wise men might be explained by means of a conjunction of the planets Jupiter and Saturn, and he even undertook to calculate the times when such conjunctions took place. Much has been said and written on the subject of the 'star of the wise men' during the past few years; but no important contribution to the natural history of the star has been made since the days of Kepler, nearly three hundred years ago. But the supernatural history and functions of such a star have been discussed in a very able and interesting manner by many writers in theological, literary, and semi-scientific periodicals during the past twenty years, and perhaps nothing of interest and importance can now be added to what has already been published on that subject.

"I find, however, that Kepler overlooked one important element of the problem in his calculations, and consequently left the natural history of the problem in an incomplete and unsatisfactory condition. I shall therefore here attempt to complete more fully what Kepler began, and show that the Biblical narrative concerning the 'star in the east' is better satisfied by a conjunction of Venus and Jupiter than by any of the conjunctions computed by Kepler.

"We have already seen that the death of Herod took place early in the year B.C. 4, and if we can now show that there was a very conspicuous conjunction of two bright planets, visible only in the east, within two years preceding that date, the hypothesis that such conjunction was the event referred to in the Biblical narrative will at least be rendered plausible, if not entirely legitimate; and for this purpose I have here undertaken the calculation of all the conjunctions of the planets which took place near that epoch. I shall first enquire whether there was a conjunction of the planets Jupiter and Saturn about that period of time which would satisfy the required conditions. The mean interval between two heliocentric conjunctions of Jupiter and Saturn is 7253·4638 days; and they were in mean conjunction B.C. 6, January 30. Now the time of true heliocentric conjunction may differ from the time of mean heliocentric conjunction by 241 days, on account of the inequalities in their elliptic motions, and by 23 days more by reason of the great inequalities of long period in their mean motions. But the time of geocentric conjunction of Jupiter and Saturn may differ from the time of heliocentric conjunction by 102 days; so that a geocentric conjunction may occur one whole year before or after the time of mean heliocentric conjunction. In the present instance I find that the true heliocentric conjunction took place B.C. 7, September 23, which is 129 days before the mean heliocentric conjunction; and that there were three geocentric conjunctions during the year B.C. 7, which took place as follows:—

"The first conjunction took place June 7, in which Saturn passed 1° 4′ to the south of Jupiter; the second conjunction took place September 18, in which Saturn passed 1° 2′ to the south of Jupiter; and the third conjunction occurred on December 15, in which Saturn passed 1° 8′ to the south of Jupiter.

"In the first conjunction the planets would have an elongation of about 73° to the westward of the sun, and would be seen during four or five hours in the east in the morning. The second conjunction took place near the time of opposition with the sun, and would be visible during the whole night, so that it could not properly be designated as a star in the east any more than a star in the west. In the third conjunction the planets would have an elongation of about 84° to the eastward of the sun, and could therefore appear only as evening stars