tinuity of the phenomena for so long a time seems to confirm the idea of a variety of periods for the particles, and indicate also the repeated omission of the meteors from the body of the comet. If the forces of disruption were only those which have ordinarily been considered, the meteors would be dispersed in a long thin stream along the length of the orbit, as in the case of the November meteors; but since the orbits of the meteors are variously inclined to that of the comet, another force, acting transversely to the plane of the orbit, must be admitted as an important factor. The anomalous phenomena of the tails of some comets—a subject with which Dr. Bredichin is already closely associated—and the energetic emissions which have been noted in several comets, including that which is connected with the Perseids, serve to demonstrate the possibility of such an action as that which he supposes to have taken place in the case of this swarm.

COMET 1894 I (DENNING) AND BRORSEN'S COMET.—Dr. Hind contributes to the current number of the *Astronomische Nachrichten* (No. 3271) a very interesting note as to the identity of Denning's comet with that discovered by Brorsen. To investigate the question, he has found, with M. Schulhof's elements for Denning's comet and Dr. Lamp's elements for Brorsen's comet, that the distance of the orbits would be 0·0367 in Longitude 285° (1894·0), and that in April 1881 the comets approached one another within a distance of 0.138. On this account, he says, during the comet's recession from perihelion, might not Brorsen's comet have met with a catastrophe, causing disintegration and the return of a portion of it to perihelion, in a somewhat different orbit, in Denning's comet of last year?

Dr. E. Lamp has also considered this question of identity, and, in referring to Dr. Hind's note, writes that the similarity of the two orbits is very striking, and that, in the beginning of 1881, the two bodies must have been very close to one another near the point of intersection of the two orbits. With the same elements as used by Dr. Hind, he finds the point of intersection of the orbits in Longitude 284° 47′ and South Latitude 1° 57′. The places of the two bodies are then as follows:—

	Denning.	Brorsen.
	° ′	° ′
True anomaly	154 22	169 7
Ecc. anomaly	123 22	147 25
Radius vector	5·240	5·218

The point of nearest approach in the orbit of Denning's comet occurs in a position 5′ behind, and in the Brorsen's orbit 4′ before, the actual place, the distance between these points being 0·022 radii of the earth's orbit. Dr. Lamp suggests that, by decreasing Schulhof's value of the mean daily motion by about 28″, the comets would thus be brought together. The question, however, is in a very undecided state, but astronomers will await with interest the results of Dr. Lamp's investigation as to whether the comets furnish an instance of a mere approach or of a real physical connection.

STARS HAVING PECULIAR SPECTRA.—Prof. E. C. Pickering states in the *Astronomische Nachrichten*, No. 3269, that an examination of photographs of stellar spectra, taken at the Arequipa Station of the Harvard College Observatory, has led to the discovery of four new variable stars in Centaurus, Lupus, Pavo, and Microscopium, and ten other objects with spectroscopic peculiarities. Of these, the spectra of five are classified as Type IV.; two appear to belong to Type V.; one (R.A. 18h. 38·4m. Decl. −27° 55′) is a nebula; one has H_β bright; and the photographic spectrum of the remaining object contains no blue light. To show how difficult it is to draw any sharp distinction between nebulæ and bright line stars, we quote the concluding paragraph of Prof. Pickering's communication. "The photographic spectra of faint gaseous nebulæ and stars of the fifth type closely resemble each other, and can only be distinguished by the wave-length of the principal bright line. In gaseous nebulæ this line (5007) is of greater wave-length than H_β, while in stars of the fifth type, the line 4688 is of shorter wave-length. A superposition of a chart and spectrum plate of the star whose approximate position for 1900 is R.A. = 15h. 10m. Decl. −45° 17′, which has been announced as a star of the fifth type (*Astronomische Nachrichten*, vol. 135, p. 195), shows that this object is in reality a gaseous nebula."

NITROGEN FIXATION IN ALGÆ.

IN NATURE of March 29, 1894, Prof. Marshall Ward gave a clear and excellent *résumé* of certain aspects of the question of nitrogen fixation in plants. Since the publication of that article, fresh and most important additions have been made to the subject.

Last May, P. Kossowitsch published an account of his experiments on Algæ in respect to their nitrogen-fixing powers (*Bot. Zeitung*, May 16, 1894), and a short account of this contribution should form an appropriate supplement to Prof. Ward's paper.

In 1888, Prof. Frank, of Berlin, had stated his opinion that Algæ possessed the power of free nitrogen fixation.

In 1892, Messrs. Schloesing and Laurent published an account of their classical researches dealing with many plants, among which Algæ also found a place. Their experiments with these forms range in two series. In the first they found that if they kept soil, covered with Algæ and containing bacteria of certain kinds, under observation for some time, an increase in nitrogen was perceptible. On the other hand, if they prevented the formation of Algæ, although the same bacteria remained, there was no noticeable addition to the nitrogen of the system. In the second set of experiments, in which different Algæ were employed, no nitrogen fixation could be perceived. It was evident from this that either particular kinds of Algæ only have "fixing" powers, or that suitable bacteria were not simultaneously present in the second case, and that Algæ can only fix with the additional aid of these micro-organisms.

In the following year, Koch and Kossowitsch devoted their attention to the subject, and went over much the same ground as Laurent and Schloesing, confirming their results, and adding new facts, the value of which, however, was somewhat enhanced by the algal cultures never consisting of any single species alone, but of several intermingled. Accordingly when, in 1894, Kossowitsch set himself the task of determining whether Algæ in themselves possess the power of assimilating free atmospheric nitrogen or not, the first obstacle he had to overcome was the difficulty of finding a method by which he could obtain a single algal species in absolute purity. This was ultimately effected by growing the Algæ on gelatinous silicic acid permeated with a nutritive solution, and subsequently on sterilised sand also containing food solution. The steps by which the isolation was effected were slow and beset with difficulties, which sprang up in the most unexpected manner, and the pages of Kossowitsch's memoir which deal with this subject possess a separate and great interest of their own; space, however, will not permit that the matter be detailed here. Having obtained the Algæ in a state of purity, the next step was to transfer them to the apparatus in which their nitrogen-fixing powers were to be tested.

This consisted of a central air-tight vessel connected with a series of U-tubes, which were blown into bulbs at certain intervals. These bulbs contained strong sulphuric acid. The whole apparatus was sterilised, and the Algæ under consideration sown upon a sterilised nutritive substratum in the central vessel. Air freed from all traces of nitrogen compounds was blown into the vessel through the U-tubes, the sulphuric acid in which killed any organisms which might be contained in this air.

The Alga which was first experimented on was Cystococcus (or an extremely similar form). Every precaution was taken in introducing this into the apparatus.

Using a nutritive solution perfectly free from all nitrates, it was seen that the Algæ refused to show any signs of growth; it was clear, therefore, that at least to start development a trace of nitrate must be added to the sand. The addition of other nitrogen compounds was found to be useless, and accordingly a small and accurately measured quantity of a nitrate was mixed with the food solution in the central vessel. The whole apparatus thus fixed up was placed in the light, and left for some weeks. At first rapid increase in the Algæ was noticeable, but after the lapse of about three weeks things evidently came to a standstill.

The addition of more nitrate-free nutritive solution gave no result; but if only the merest trace of a nitrate were added, there was an immediate resumption of activity.

These facts in themselves are very good proof of the inability of Cystococcus to fix atmospheric nitrogen; but to make matters doubly sure, a careful chemical analysis was made. This showed that there was no increase in nitrogen during all the weeks the Algæ had been flourishing, and that accordingly no iota of the stream of free nitrogen which had been constantly passing through the apparatus had been "fixed." So far, then, the first Alga which had been put to the test of experiment showed itself incapable of utilising atmospheric nitrogen.

Kossowitch now turned to fresh experiments, choosing algal cultures of sometimes one, sometimes several species taken together; to all of these he added simultaneously soil-bacteria of mixed sorts. The apparatus employed was very nearly the same as that above described. In these experiments he desired to test the supposition of Berthelot and Winogradsky, who considered the presence of certain organic substances to be favourable to the fixation of nitrogen; he accordingly arranged his experiments in five pairs, both members of each couple having identical conditions, except that in the one a small quantity of sugar (dextrose) was added to the nutritive solution, whilst in the other no organic compound was present. One set was arranged with Cystococcus and soil-bacteria, and the results obtained showed that in the absence of organic materials a small but yet noticeable increase in the nitrogen of the system had taken place (from 2·6 mg. to 3·1 mg.) Where sugar had been previously added, however, there were three times as much nitrogen after the experiment as before. In a second pair of cultures the Alga Stichococcus and certain bacteria were used, but here in no case, either with or without sugar, was there any increase in nitrogen. This shows that Stichococcus has in itself no power of nitrogen fixation.

Another couple contained a mixture of several Algæ, Nostoc, Cylindrospermum, &c., and certain soil-bacteria. In this instance a very large fixation of nitrogen took place, both where sugar was present and where not; in fact, in the former case the nitrogen was increased more than nine-fold.

All these observations shed much light upon the question of the relations existing between Algæ, micro-organisms, and atmospheric nitrogen. They show:—

(1) That at least two Algæ—Cystococcus and Stichococcus—possess no "fixing" powers in themselves.

(2) That many Algæ, taken together with certain micro-organisms of the soil, do possess the power of assimilating atmospheric nitrogen.

(3) That this power is much increased by the addition of such organic substances as sugar.

It should be noticed that among the ten cultures used in the second set of experiments, only two contained definitely isolated algal species, viz. the cases of the two cultures of Cystococcus and soil-bacteria.

It was just in this instance, moreover, that it had been shown that the Alga itself had no capacity for fixing atmospheric nitrogen. Accordingly, there could be little doubt that it was through the agency of the micro-organisms that the "fixation" had taken place in these latter cultures.

The experiments of Laurent and Schloesing had shown that if in a culture of Algæ and bacteria endowed with "fixing" powers, the Algæ were destroyed, the bacteria lost partly, if not entirely, this capacity, which the mixture had possessed. This pointed clearly to the fact that there was some close relationship existing between the Algæ and micro-organisms.

There are many facts which seem to indicate the nature of this relationship.

Berthelot found that the nitrification of the soil only took place as long as organic compounds were present; if these were exhausted, the nitrifying process ceased. Gautier and Drouin also showed the importance which organic compounds have with respect to nitrification. Kossowitsch's own experiments, in which the advantage of adding sugar to the culture was shown, also point in the same direction.

From such observations as these, Kossowitsch concludes that the relationship which the Algæ bear to the micro-organisms is one connected with the organic food supply of these latter; he thinks that the Algæ, furnished with nitrogen by the bacteria, assimilate carbohydrate material, part of which goes to their own maintenance, but part also to that of the micro-organisms. It is, therefore, in his belief, an instance of symbiosis in which each supplies the wants of the other. There are many facts, partly the result of his own observations, partly the result of those of others, which uphold this view. If the mixed culture be placed in the light, there is a far more noticeable nitrogen increase than when in darkness. Again, if a rich supply of carbon dioxide gas be provided, this is marked by a decided rise in nitrogen-fixing powers. Both these conditions are such as are known to influence carbohydrate assimilation in chlorophyll-containing organisms; but all experience is antagonistic to the view that light should be beneficial to the vital activity of the bacteria, and there are only one or two exceptional instances (Nitromonas, &c.) in which carbon dioxide can be directly assimilated by these micro-organisms.

Moreover, in the cases where the bacteria are brought into immediate contact with the Alga, as in those species of Algæ which are enveloped in a gelatinous covering wherein the micro-organisms become embedded, nitrogen fixation appears to be greatly aided, and the addition of sugar to the culture has no such marked effect as in the instances where non-gelatinous Algæ are employed. The explanation of this seems to be that the bacteria embedded in the gelatinous sheath are amply provided with carbohydrate food without the addition of sugar, which, therefore, comes more or less as a superfluity.

All this seems to justify Kossowitsch's view of the part played by the Algæ in the fixation of nitrogen; it appears to show that they have an indirect, but none the less important, influence upon the process.

This is roughly the extent of Kossowitsch's article; it has been impossible to give here its details, the bare outlines of his researches could alone be mentioned, but it is hoped that sufficient has been said to show the importance of his work, perhaps even to indicate the interest which every page of his memoir possesses, dealing as it does with one of the most fascinating branches of vegetable physiology.

RUDOLF BEER.

THE COMMERCIAL SYNTHESIS OF ILLUMINATING HYDROCARBONS.[1]

THE direct combination of carbon and hydrogen in the electric arc is a true case of synthesis, and if we could form acetylene in this way in sufficiently large quantities, it would be perfectly easy to build up from the acetylene the whole of the other hydrocarbons which can be used for illuminating purposes. For instance, if acetylene be passed through a tube heated to just visible redness, it is rapidly and readily converted into benzol; at a higher temperature naphthalene is produced, whilst by the action of nascent hydrogen on acetylene, ethylene and ethane can be built up. From the benzol we readily derive aniline, and the whole of that magnificent series of colouring matters which have gladdened the heart of the fair portion of the community during the past five-and-twenty years, whilst the ethylene produced from acetylene can be readily converted into ethyl alcohol, by consecutively treating it with sulphuric acid and water, and from the alcohol, again, an enormous number of other organic substances can be produced, so that acetylene can, without exaggeration, be looked upon as one of the great keystones of the organic edifice, and, given a cheap and easy method of preparing it, it is hardly possible to foresee the results which will be ultimately produced.

In 1836, it was found that when making potassium, by distillation from potassic carbonate and carbon, small quantities of a bye-product, consisting of a compound of potassium and carbon, was produced, and that this was decomposed by water with liberation of acetylene; whilst Wöhler, by fusing an alloy of zinc and calcium with carbon, made calcic carbide, and used it as a source from which to obtain acetylene by the action of water.

Nothing more was done until 1892, when Macquenne prepared barium carbide by heating at a high temperature a mixture of barium carbonate, powdered magnesium, and charcoal, the resulting mass evolving acetylene, when treated with water; whilst, still later, Travers made calcic carbide by heating together calcic chloride, carbon, and sodium. None of these processes, however, gave any commercial promise, as the costly nature of the potassium, sodium, magnesium, or calcium-zinc alloy which had to be used, made the acetylene produced from the carbide too expensive.

Whilst working with an electric furnace, and endeavouring by its aid to form an alloy of calcium from some of its compounds, Mr. T. L. Willson noticed that a mixture containing lime and powdered anthracite, under the influence of the tem-

[1] Abstract of a paper by Prof. Vivian B. Lewes, read before the Society of Arts, Wednesday, January 16.