combination invariably renders it again moist before explosion occurs.

It has been currently supposed that the presence of sharp solid fragments, such as those of glass, exerts a lowering effect upon the temperature of explosion of hydrogen and oxygen. This supposition has been practically tested and found wanting in accuracy. Neither glass fragments nor sea-sand were found to reduce the temperature below the limits above stated. A remarkable result, however, was obtained when pieces of platinum foil and wire were introduced into the explosion bulb. It was found impossible in their presence to bring about an explosion, even when the temperature of the bath was raised to 715°. Quiet combination invariably ensued.

The size of the explosion vessel appears to be immaterial, except when reduced to very small dimensions, such as 4·5 mm. diameter, as in the case of the smallest bulb tested, when the range of molecular forces is approached. In six experiments with this small bulb no explosion occurred; in others the explosion did not occur in the vessel, but the quiet combustion there initiated was transmitted along the leading tube, through the tube containing the brass gauze discs, and eventually occasioned an explosion in the wash-bottle, disastrous to the latter.

In the cases of other explosive mixtures the admixture was effected, in the proper proportion, in a three litre flask, from which the gases were driven first through a wash-bottle, and subsequently through a test-tube, arranged likewise as a small safety wash-bottle, to prevent the explosion reaching the larger one.

Carbon monoxide and oxygen, in the proportion to form carbon dioxide, were found to suffer, for the most part, silent combination in the apparatus, and the wide limits of the observed temperatures of explosion, 636° to 814°, in those cases when explosion did ensue, were found to be due to more or less of such silent combination.

Gaseous mixtures of hydrocarbons and oxygen were found, however, with the exception perhaps of marsh gas and oxygen, to exhibit practically no quiet combination; and these mixtures have afforded most trustworthy and constant temperatures of explosion.

Marsh gas was found to explode, as a rule, with oxygen at temperatures varying from 656° to 678°, but occasionally quiet and complete combustion occurred. Other hydrocarbons never failed to yield an explosion.

Ethane detonated with oxygen in three experiments at 622°, 605°, and 622° respectively. A mixture of ethylene and oxygen exploded at 577°, 590°, and 577° in three consecutive experiments. Acetylene prepared by Gattermann's method, which in Prof. Meyer's experience yields it in a purer state than the more recent convenient method discovered by Maquenne, explodes with oxygen with exceptional violence, the wash-bottle being destroyed in every experiment. The temperature of this explosion was very constant, 510°, 515°, and 509° being successively observed. Propane mixed with five times its volume of oxygen likewise exhibits a very constant temperature of ignition, 548°, 545°, and 548° being indicated in three determinations. Propylene exploded with four and a half times its volume of oxygen at 497°, 511°, and 499°. Isobutane mixed with six and a half times its volume of oxygen detonated at 549°, 550°, and 545°; and isobutylene at 546°, 548°, and 537°. Finally, coal gas mixed with thrice its volume of oxygen was found to explode in three experiments at the remarkably constant temperatures of 649°, 647°, and 647°. It was found impossible, however, to induce a mixture of coal gas and air to explode under these experimental conditions.

It will be clearly seen from the above experiments with gaseous mixtures of hydrocarbon and oxygen, that the temperature of explosion falls as the content of carbon increases. Thus the mean temperatures for methane, ethane and propane are 667°, 616°, and 547° respectively. Further, the temperature also falls with the degree of saturation, or in other words, the less saturated the hydrocarbons become the more readily do they ignite in contact with oxygen. Thus ethane, ethylene and acetylene explode with oxygen at 616°, 580° and 511°; propane and propylene at 547° and 504°; and isobutane and isobutylene at 548° and 543°. It will also be observed, however, as would be expected, that these differences due to difference of saturation diminish as the series are ascended.

A. E. TUTTON.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Mr. Austen Leigh, Provost of King's, the Vice-Chancellor, has been appointed a member of the Geographical Committee, in the place of Dr. Ferrers, resigned. The award of the Geographical Studentship of £100 will be made towards the end of the Lent Term.

The first award of the Walsingham Medal, founded by the Lord High Steward for the encouragement of biological research, has been made to Mr. E. W. MacBride, Fellow of St. John's, for his monographs in zoology.

MR. ARTHUR WILLEY, at present giving a course of lectures in Columbia College, New York, has been elected to the vacant Balfour Studentship by the Special Board of Biological and Geological Studies of the University of Cambridge. It is understood that the investigation prescribed for him will be that of the embryology of *Nautilus pompilius*, for which purpose he will proceed to the South Seas.

SCIENTIFIC SERIALS.

The Quarterly Journal of Microscopical Science for September, 1893, contains studies on the comparative anatomy of sponges: V. Observations on the structure and classification of the *Calcarea Heterocœla*, by Dr. Arthur Dendy (plates 10–14). In this paper the author gives a general account of the anatomy, histology, and classification of the *Calcarea Heterocœla*, from the point of view of one who has for a long time past been engaged in an independent study of the group, and he brings together all that is known on the subject. While on the classification of the group he departs somewhat widely from the lines laid down by previous writers, yet the necessity of doing so was forced upon him by a study of nearly fifty Australian species. The author finds neither the canal system nor the skeleton affords a reliable guide for classification, and a compromise is the only satisfactory way out of the difficulty. The families adopted are: (1) Leucasidæ, (2) Sycettidæ, (3) Grantidæ, (4) Heteropidæ, (5) Amphoriscidæ.—On some points in the origin of the reproductive elements in Apus and Branchipus, by J. E. S. Moore (plates 15 and 16). Calls attention to some important details in the spermatogenesis of Branchipus and in the ovigenesis in Apus. In the former, the observations bear out the general law as to the similarity of the male and female cells, their specific peculiarities being physiological in origin, without morphological import. The divisional phenomena of these cells are intimately related to a protoplasmic structure, which might be fitly described as "Schaumplasma," and one of the initial impulses towards metamorphosis is a fusion of some of the intra-nuclear globules; while a considerable portion of the complicated karyokinetic figures, with their centrosomes, pseudosomes, and dictyosomes, appear to be the logical as well as the actual consequence of the continuance of this process. Some time before and always during the course of the chromatic changes bodies answering to the centrosomes in all details except in their numbers, which is much greater, make their appearance; these the author provisionally names "pseudosomes." The term "dictyosomes" is given to bodies which make their appearance connected one to another and to the inner group of chromosomes by fine strands, and which remain uncoloured by reagents, and are more or less related to the cell periphery. (In connection with these, Farmer's notes and figures of like bodies in the Pollen mother-cells is of interest. (See *Ann. of Bot.* September, 1893).—Notes on the Peripatus of Dominica, by E. C. Pollard (plate 17). Miss Pollard's species is apparently very nearly related to *P. edwardsii*, but differs in the number of ambulatory appendages, there being 29 to 34 pairs in *P. edwardsii*, while in *P. dominicæ*, sp. nov., there are from 25 to 30.—Studies on the Protochordata, by Arthur Wiley, B.Sc. (plates 18–20). II. The development of the neuro-hypophysial system in *Ciona intestinalis* and *Clavelina lepadiformis*, with an account of the origin of the sense-organs in *Ascidia mentula*. III. On the position of the mouth in the larvæ of the Ascidians and Amphioxus, and its relations to the Neuroporus.

Symons's Monthly Meteorological Magazine, November. Mr. Symons gives a summary of all the rainfall observations known to have been taken in Persia; the only places at which such appear to have been made are Ooromiah, in the northwest; Bushire, on the eastern shore of the Persian Gulf, and at Teheran. At Bushire the annual mean for 1878–90 is 12·96 inches. Recent observations at Teheran give a mean of about 10 inches, and the older observations, taken at the Russian Embassy, give a mean of about 11 inches, of which nearly the whole falls in the winter half of the year. To the north of the great mountain range, between Teheran and the Caspian, the fall is nearly four times as great as in Persia. The same number of the magazine contains a summary of the few meteorological papers read at the British Association at Nottingham.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 16.—"Experiments in Heliotropism." By G. J. Romanes, F.R.S.

I cannot find in the literature of heliotropism that any experiments have hitherto been made on the effects of interrupted illumination, when the periods of illumination are rendered as brief as possible—*i.e.*, instantaneous flashes of light. Accordingly I have conducted an extensive research on heliotropism, where the flashes have been caused either by means of electric sparks in a dark room, or by the opening of a photographic shutter placed before the plants in a camera obscura with an arc light or Swan burner, at a distance of several feet on the other side of the shutter. The electric sparks were made either with a Wimshurst machine, induction sparks, or by means of the following contrivance. From the binding screws of the condenser of a large induction coil copper wires were led to a cup of mercury, where, by means of an electro-magnet suitably actuated by clockwork, a current was closed and opened at any desired intervals: each break was therefore accompanied by a brilliant spark. A thick plate of glass was interposed between the seedlings and the electrical apparatus. In all the experiments here described the plants employed were mustard seedlings (*Sinapis nigra*), previously grown in the dark until they had reached a height of between one and two inches. Save when the contrary is stated, in all the experiments comparative estimates were formed by using the same pot of seedlings: during the first half of a comparative experiment half of the seedlings were protected from the light by a cap of cardboard covering half the pot; during the second half of the experiment this cap was removed, and the pot turned round so as to expose the previously protected seedlings to the influence of the light. The principal results thus obtained, and frequently corroborated, were as follows:—

I. Even having regard to the fact that for equal strengths of a stimulus excitable tissues are more responsive in proportion to the suddenness of the stimulus (or in a kind of inverse proportion to the duration of the stimulus), the heliotropic effects of such flashing stimulation as is above described proved to be much greater than might have been antecedently expected. This was shown to be the case whether the effects were estimated by the rapidity with which the seedlings began to bend after the flashing stimulation was begun, or by that with which they continued to bend until attaining a horizontal line of growth, *i.e.* bending to a right angle. Thus, at a temperature of 70° Fahr., and in a moist camera, vigorously growing seedlings begin to bend towards the electric sparks ten minutes after the latter begin to pass, and will bend through 45° in as many minutes; frequently they bend through another 45° in as many minutes more. This is a more rapid rate of bending than can be produced in the same pot of seedlings when the previously protected side is uncovered and exposed for similar durations of time, either to constant sunlight or to constant diffused daylight. This is the case even if the sparks (or flashes) succeed one another at intervals of only two seconds.

II. It would thus appear that the heliotropic influence of electric sparks (or flashes) is greater than can be produced by any other source of illumination. But in order to test this point more conclusively, I tried the experiment of exposing one half-pot of seedlings in one camera to the constant light of a Swan burner, and another half-pot of similar seedlings in another camera, placed at the same distance from the same source of light, but provided with a flash shutter working at the rate of two seconds intervals. The amount of bending in similar times having been noted, the pots were then exchanged and their previously protected halves exposed to the constant and the flashing light respectively. In both cases, the rapidity with which the bending commenced and the extent to which it proceeded in a given time after commencement, were considerably greater in the seedlings exposed to the flashing than to the constant source stimulation. The same is true if, instead of a Swan burner, the source of light is the sun.

III. Many experiments were tried in order to ascertain the smallest number of sparks in a given time which would produce any perceptible bending. Of course the results of such experiments varied to some extent with the condition of the seedlings. But in most cases, with vigorous young mustard seedlings and careful observation, bending could be proved to occur within fifteen to thirty minutes, if bright sparks were supplied at the rate of only one per minute. The most extreme sensitiveness that I have observed in these experiments was that of perceptible bending after half-an-hour's exposure to electrical sparks following one another at the rate of fifty in an hour. This result would appear to indicate that in heliotropism under flashing light there need be no summation or "staircase effect"; but that each flash or spark may produce its own effect independently of its predecessors or successors.

IV. It is noteworthy that, while the heliotropic effects of flashing light are thus so remarkable, they are unattended with the formation of any particle of chlorophyll. In the many hundred pots, and therefore many thousands of plants, which have passed under my observation in this research I have never seen the slightest shade of green tingeing the etiolated seedlings which had bent towards flashing light. On one occasion I kept a stream of 100 sparks per second illuminating some mustard seedlings continuously for forty-eight hours; and although this experiment was made for the express purpose of ascertaining whether any chlorophyll would be formed under the most suitable conditions by means of flashing light, no change of colour in any of the seedlings was produced.

With the exception of those mentioned in the last paragraph, all these results were obtained by using sparks from the coil condenser, as above explained. These sparks were very brilliant, and yielded the maximal results, which alone are here recorded.

"Experiments in Germination." By G. J. Romanes, F.R.S.

The primary object of these experiments was to ascertain whether the power of germination continues in dry seeds after the greatest possible precautions have been taken to prevent any ordinary processes of respiration for practically any length of time.

The method adopted was to seal various kinds of seeds in vacuum tubes of high exhaustion, and after they had been exposed to the vacuum for a period of fifteen months to remove them from the tubes and sow them in flower-pots buried in moist soil. In other cases, after the seeds had been *in vacuo* for a period of three months, they were transferred to sundry other tubes respectively charged with atmospheres of sundry pure gases or vapours (at the pressure of the air at time of sealing); after a further period of twelve months these sundry tubes were broken, and their contents sown as in previous case. In all cases, excepting that of clover, the seeds sown were weighed individually in chemical balances, and seeds of similar weights taken from the same original packets were similarly sown as controls.

The exhaustion of the tubes was kindly undertaken by Mr. Crookes, F.R.S., to whom I must express my best thanks for the assistance he has given. The kinds of seeds used were mustard, red beet, clover, peas, beans, spinach, cress, barley, and radish. In addition to vacuum tubes and control tubes containing air, others were charged with oxygen, hydrogen, nitrogen, carbon monoxide, sulphuretted hydrogen, aqueous vapour, ether, and chloroform.

With the exception of the beans, where only two were sown, ten weighed seeds were sown out of each of the tubes, and also out of each of the control packets which had been kept in ordinary air from the first. These results amply prove that neither a vacuum of one-millionth of an atmosphere, nor the atmospheres of any of the gases and vapours named, exercised much, if any, effect on the germinating power of any of these seeds. I may add that the same remark applies to an atmosphere of carbon dioxide, although in the particular series of experiments quoted this gas was accidentally omitted.

A subsidiary object of these experiments was to ascertain whether any appreciable variations would be caused in plants grown from seeds which, before germination, had been submitted to the conditions above explained. Hundreds of plants