protected the State against any dangerous accumulation of electricity. But Prof. Milne showed that the laying down of rails in Japan had no such effect. He thought the electric phenomena which sometimes attended earthquakes were their consequences, not their causes. He had himself experimented with dynamite placed in a hole; an earth-plate was fixed about thirty yards away from the dynamite, and from it a wire was carried some distance to another earth-plate. When the dynamite charge was exploded there was certainly a current produced, as was indicated by a strong deflection of a galvanometer-needle at the end of the wire. He attributed this to chemical action. When the ground was shaken there was always a greater or less action by increase or decrease of pressure in connection with the earth-plate. Earth currents unquestionably accompany earthquakes, but, as has been said, they appear to be the consequences, not the causes, of the latter. Next came the chemical theories, which were very strong in Europe up to the beginning of the present century. It was imagined that underground there were various substances, such as sulphur, nitre, vitriol, which, by their action on each other, resulted in violent changes, giving rise to vapour, the sudden production of which, in certain cases, would shake the ground. It was only in 1760 that Dr. Mitchell, who wrote a good deal on the subject, first threw out the theory that earthquakes were connected in some way with volcanoes, because they were most frequent in volcanic countries. He observed that large quantities of steam were given off from volcanoes, and came to the conclusion that an earthquake was produced at the time that an attempt was made to form a volcano, that steam got in between certain strata, and, as it ran between them, caused pulsations. Prof. Rogers, about the same time, in North America, endeavoured to show that it was not steam, but really lava, that ran along underneath the ground, causing it to rise and fall, thus producing an earthquake. Prof. Milne having thus dealt with unscientific and *quasi*-scientific theories, passed on to those of modern science. It is unnecessary here to follow him into this portion of his subject, although it occupied the main part of the lecture.

ON THE EFFECT OF CERTAIN STIMULI ON VEGETABLE TISSUES[1]

THE object of our paper is to describe the behaviour of turgescent pith when placed in water and treated with certain reagents. If from a growing shoot the external tissues be removed, a well-known result is seen: the pith suddenly lengthens, becoming longer than the specimen was at first. This experiment shows that turgescent pith is normally in a compressed condition—it is always trying to get longer—and when it is freed from the coercion of the unyielding external tissues, it at once does become longer. This tendency to become longer is further manifested by allowing turgescent pith to remain in damp air, or in water, for some time, when a great increase in length takes place. In such a piece of pith we have the essential, active factor in growth, freed from interference, and at liberty to perform its function rapidly and freely. The tendency in turgescent pith to get longer is the very power which calls forth that increase in length which we call growth; so that in studying turgescent pith we are studying the active agent in the production of growth. We do not suppose that our results are necessarily directly applicable to normal growth,[2] but we think that they have a bearing on normal growth sufficiently close to give interest to our experiments.

The pith,[3] after being cut into pieces about 6 inches in length and $\frac{1}{3}$ inch in thickness, was ready for use. The lower end of the pith was fixed to a hook at the bottom of a narrow jar, the upper end was attached by a silk thread to the short arm of an auxanometer lever. The jar was then filled with water, and as the pith elongates the short arm of the lever ascends and the long arm rapidly descends. Its movement, read off on a millimetre scale, gives an index of the rate of "growth" of the pith. The lengthening of the pith is, in fact, observed like the normal growth of a plant, the only difference being that the "growth" of the pith is so rapid that the descent of the long arm is clearly visible to the naked eye and is correspondingly easy to measure. It is most striking to see the index travelling down thus quickly and traversing (it may be) 10 mm. ($\frac{2}{5}$ inch) in a minute. We used a stop-watch to determine the time in which the point of the long arm of the lever travelled over a certain distance, and we could thus estimate the changes in the rate of growth from minute to minute.

The first thing needful to know is the ordinary course of growth of the pith in water. It was found that an interesting phenomenon—an apparent *grand period*—takes place. That is to say, the growth is at first slow, then more rapid, and ultimately becomes slow again, the whole period taking perhaps twenty minutes to complete. This is precisely the series of changes which a growing organ exhibits in the course of days instead of minutes. We do not suppose that our grand period is necessarily of a kindred nature to the grand period of normal growth. For we are aware that purely mechanical processes, such as the moistening of a hygroscopic awn, exhibit the same thing—the awn at first untwists slowly, then more quickly, and then again slowly. But the knowledge of the fact is of great importance to us, since unless we know the normal course of growth we cannot study the effect of reagents.

Warmth.—Before going on to consider the action of reagents, we will say a few words as to the stimulation caused by an increase in the surrounding temperature. If the water in the jar is gradually warmed, the growth of the pith increases in speed in the most striking manner. The increase is fairly steady from, say, 17° C. to about 35°, the rate at this latter temperature being perhaps four times as high as it was at first. It then usually becomes irregular, with some diminution; and, just before a temperature is reached which kills the tissues, a sudden and rapid fall in the rate of growth sets in. This we found usually to occur at about 55° C. This is, no doubt, an unusually high temperature, but not higher than plants are known to be able to survive.

The chief interest in these temperature experiments is this: they show that the phenomena we are considering is a truly vital one. We have always been on our guard in this matter, and have wished to make certain that the observed phenomena are not in some mysterious way mechanical, instead of, as we believe, the response of living tissues *as* living tissues. Therefore, when we find that heat has a normal effect on our material, we are encouraged to believe that our other results—to which we now pass on—are also vital phenomena.

Alcohol.—The pith was attached to the auxanometer, and the jar filled with water. As soon as the rate of growth was found to be steadily diminishing, a small quantity of alcohol was added. The result was an immediate and striking increase in the rate of growth. For instance, when 2 per cent. of spirit was added, the growth was accelerated within two minutes by 50 per cent.

The result is temporary, so that in the course of another two minutes the rate of growth sinks to what it was before stimulation. Similar results were obtained with ether, and here the pith was allowed to grow in damp air, and was subjected to ether in the form of vapour. When the vapour was present in the proportion of 0·27 per cent., the acceleration was 56 per cent.; with 0·4 per cent., the acceleration was 100 per cent. Here, as in the case of alcohol, the result was temporary, the rate falling in a few minutes to what it was before stimulation.

When the ether amounts to 3 per cent. of the atmosphere, the pith is killed, and shows no increase, but, on the contrary, a decrease[1] in length. Elfving has shown that ether has a stimulating effect on respiration, and on the sensitiveness of swarm-spores to light. He also tested its effect on the growth of phycomyces. His results differ from ours, inasmuch as he found no stimulating effect: the ether produced either no effect whatever, or else it retarded, or even stopped, growth.

Ammonia.—We employed the *Liquor Ammoniæ fortior* of the "British Pharmacopœia" for the preparation of our solutions, and we found that various strengths ranging between 0·5 and 2·4 per cent. produced acceleration of growth. Here again, as with ether and alcohol, the acceleration was very temporary.

Acids.—As a rule, acids produced no acceleration, but caused either retardation, or flaccidity and death. Thus, for instance, acetic acid (0·5 and 1 per cent.) produced retardation; 5·4 per cent. produced death.

Hydrocyanic Acid did not cause flaccidity such as we have described in the case of acetic acid. The action of this reagent is comparable rather to that of alcohol, but is not

[1] Abstract of a Paper by Anna Bateson (Newnham College) and Francis Darwin (Cambridge), read before the Linnean Society, January 20, 1887.
[2] For the sake of convenience we shall nevertheless use the word "growth" to mean the elongation of the pith under observation.
[3] Sunflower and Jerusalem Artichoke.

[1] This contraction is simply a symptom of flaccidity, and usually of death.

identically the same. It produces either a temporary acceleration, such as is due to alcohol, or else a remarkably steady and high rate of growth. On the action of this reagent we hope to make further observations.

Quinine Chloride.—Extremely dilute solutions acted poisonously, and produced a shortening of the tissues. When contraction took place it was manifested within a remarkably short time. In one case contraction seemed to begin simultaneously with the exposure to the poison, and was certainly well marked in less than one minute.

Conclusion.—The most interesting fact which we have established is the possibility of stimulating turgescent tissues to increased elongation by such reagents as alcohol, ether, and hydrocyanic acid. And we incline to think that our results may help to direct attention to a factor in the problem of cell-mechanism—namely, the protoplasmic element, rather than the purely osmotic side of the question.

SOCIETIES AND ACADEMIES

London

Royal Society, February 24.—"On the Relation between Tropical and Extra-Tropical Cyclones." By the Hon. Ralph Abercromby. Communicated by Mr. R. H. Scott, F.R.S.

All cyclones have a tendency to assume an oval form; the longer diameter may lie in any direction, but has a decided tendency to range itself nearly in a line with the direction of propagation. Tropical cyclones have less tendency to split into two, or to develop secondaries than those in higher latitudes. A typhoon which has come from the tropics can combine with a cyclone that has been formed outside the tropics, and form a single new, and perhaps more intense, depression. There is much less difference in the temperature and humidity before and after a tropical cyclone than in higher latitudes. The quality of the heat in front is always distressing in every part of the world.

The wind rotates counter-clockwise round every cyclone in the northern hemisphere, and everywhere as an ingoing spiral. The amount of incurvature for the same quadrant may vary during the course of the same cyclone; but in most tropical hurricanes the incurvature is least in front, and greatest in rear; whereas in England the greatest incurvature is usually found in the right front. Some observers think that broadly speaking the incurvature of the wind decreases as we recede from the equator. The velocity of the wind always increases as we approach the centre in a tropical cyclone; whereas in higher latitudes the strongest winds and steepest gradients are often some way from the centre. In this peculiarity tropical cyclones approximate more to the type of a tornado; but the author does not think that a cyclone is only a highly developed whirlwind, as there are no transitional forms of rotating air.

The general circulation of a cyclone, as shown by the motion of the clouds, appears to be the same everywhere. All over the world, unusual coloration of the sky at sunrise and sunset is observed, not only before the barometer has begun to fall at any place, but before the existence of any depression can be traced in the neighbourhood. Cirrus appears all round the cloud area of a tropical cyclone, instead of only round the front semicircle, as in higher latitudes. The alignments of the stripes of cirrus appear to be more radial from the centre in the tropics, than tangential, as indicated by the researches of Ley and Hildebrandsson in England and Sweden respectively. Everywhere the rain of a cyclone extends farther in front than in rear. Cyclone rain has a specific character, quite different from that of showers or thunderstorms; and this character is more pronounced in tropical than in extra-tropical cyclones.

Squalls are one of the most characteristic features of a tropical cyclone, where they surround the centre on all sides; whereas in Great Britain, squalls are almost exclusively formed along that portion of the line of the trough which is south of the centre, and in the right rear of the depression. As, however, we find that the front of a British cyclone tends to form squalls when the intensity is very great, the inference seems justifiable that this feature of tropical hurricanes is simply due to their exceptional intensity.

A patch of blue sky, commonly known as the "bull's-eye," is almost universal in the tropics, and apparently unknown in higher latitudes. The author's researches show that in middle latitudes the formation of a "bull's-eye" does not take place when the motion of translation is rapid; but as this blue space is not observed in British cyclones when they are moving slowly, it would appear that a certain intensity of rotation is necessary to develop this phenomenon.

The trough phenomena,—such as a squall, a sudden shift of wind, and change of cloud character and temperature, just as the barometer turns to rise, even far from the centre—which are such a prominent feature in British cyclones,—have not been even noticed by many meteorologists in the tropics. The author, however, shows that there are slight indications of these phenomena everywhere; and he has collated their existence and intensity with the velocity of propagation of the whole mass of the cyclone.

Every cyclone has a double symmetry. One set of phenomena, such as the oval shape, the general rotation of the wind, the cloud ring, rain area, and central blue space, are more or less related to a central point. Another set, such as temperature, humidity, the general character of the clouds, certain shifts of wind, and a particular line of squalls, are more or less related to the front and rear of the line of the trough of a cyclone. The author's researches show that the first set are strongly marked in the tropics, where the circulating energy of the air is great, and the velocity of propagation small; while the second set are most prominent in extra-tropical cyclones, where the rotational energy is moderate, and the translational velocity great. The first set of characteristics may conveniently be classed together as the rotational, the second set as the translational, phenomena of a cyclone.

Tropical and extra-tropical cyclones are identical in general character, but differ in certain details, due to latitude, surrounding pressure, and to the relative intensity of rotation or translation.

Linnean Society, February 17.—Mr. W. Carruthers, F.R.S., President, in the chair.—The Rev. A. Johnson exhibited drawings of an abnormal *Begonia Veitchii* grown by him the preceding autumn. The peculiarity consisted in the flower having a single, large, flask-shaped, ovarian-like organ (?) placed centrally, and surmounted by a single, simple, straight style; thus, though doubtless a male, indicating an hermaphrodite condition, while presenting resemblances to the normal female organs of *Laurus nobilis*.—Mr. E. M. Holmes exhibited some irregularly-developed lemons, in which the carpels were more or less separated at the apex; the arrest of the normal union of the carpel being attributed to the bite of an insect in the early stage of the growth of the fruit.—There were exhibited, for Mr. J. G. Otto Tepper, a new *Stylidium* (*S. Tepperiana*, F. Muell.), collected in November 1886 on Mount Taylor, Kangaroo Island, Victoria, Australia. It was found in the interstices of a Tertiary limestone. Other trees which grew in the neighbourhood were stunted Eucalypts, Hawkeas, and an Acacia somewhat resembling *A. pycnantha*.—Sir J. Lubbock drew attention to examples of *Peziza coccinea* from Ilfracombe.—A dried specimen of *Primula imperialis*, Jungh., collected by Dr. Sydney Hickson in Java, was exhibited from the Royal Gardens, Kew. This species is a giant form of *Primula*, being over 3 feet in height. Plants of this Himalayan and Malayan species are now under cultivation at Kew, and form an interesting addition to this popular group of garden plants.—Mr. G. Maw showed two rare Narcissi, both known under the name of *N. cernuus*. The daffodil discovered by Mr. Buxton in the Pyrenees at 7000 feet altitude is interesting as the only white form known in a wild habitat. A diminutive, orange-coloured species, flowered by the Rev. C. Wolley Dod from bulbs collected by Dr. Henriques, of Coimbra, appears to be allied to *N. triandrus*.—Sir J. Lubbock read the second part of his paper on phytobiological observations, and on the leaf of *Liriodendron*. In *Œnothera bistorta* the seed-leaves are linear, terminating in a large round expansion. There is nothing to account for it in the seed, nor does it appear to be of any advantage to the young plant. On watching the growth, however, and comparing it with that of other allied species, the explanation appears to be as follows: the cotyledons are at first round, but a growth takes place at the base of the cotyledon, which closely resembles that of the subsequent leaves, hence their peculiar figure in this species. In allied species the seed-leaves consist of two parts, a terminal portion—the true or original cotyledon—and a subsequent growth resembling in each species their true leaves. With reference to seed-leaves in which the stalks are connate, *e.g.* *Smyrnium*, the union seems clearly advantageous as giving additional strength. Other characters in various species, *Plantago*, *Tilia*, *Heliophila*, *Cardamine*, &c., were instanced. As to the tulip-tree (*Lirio-*