Colorado R. R. in 1852 near Harrisburg. It is now known as the Galveston, Harrisburg and San Antonio Railway. Construction on the Houston and Texas Central R. R. began in 1853; on the Galveston, Houston and Henderson in 1854; and on the Texas and Pacific in 1856. By 1860, 284 miles of railway were in operation in Texas; by 1870, 583 miles; by 1880, 2581 miles; by 1890, 8486 miles; and by 1900, 9869 miles. Texas has donated to the railways of the State 34,179,055 acres of public land, or 53,405 square miles, or one-fifth of its total area. This territory would form a State as large as Arkansas.

Of the States of the Union Texas is third in railway mileage. Were it as well developed in proportion to area as Illinois it would have 50,759 miles; if as well as Pennsylvania, it would have 57,900 miles of railway.

The effect upon the mileage of the State resulting from the donation of land to the railways was also shown.

Professor Nagle's paper dealt with a few of the more important questions which present themselves to the sanitary engineer and their relation to public health. Statistics regarding the death rate from preventable diseases were given, special attention being devoted to typhoid epidemics as affected by impure water supplies. Methods of water purification were described and their relative values discussed and the necessity of preventing water waste emphasized. Methods of sewage treatment and garbage disposal were similarly treated, and figures given to show the degree of purification attainable.

It was pointed out that during the past fifty years the medium age of man has been increased about 25 per cent. and this was attributed to the marvelous discoveries in bacteriology. That the sanitary engineer has provided means to greatly diminish the death rate due to bacteriological diseases there can be no question. The remarkable vitality of certain forms of bacterial life under what appear to be unfavorable conditions was illustrated by reference to actual examples as were also the effects attained by changes in water supplies and the treatment of sewage.

The speaker took the position that the engineer should not only execute such works as may be entrusted to him but should endeaver in every legitimate way to mould public opinion in such matters, and furthermore, that when the fact is recognized that the assistance of the engineer is often-times as necessary as that of the physician, then will a more sanitary condition exist, especially in the cities and towns of the south and west.

The following officers were elected for the ensuing year: President of the Academy, Henry Winston Harper, M.D., F.C.S., Professor of Chemistry in the University of Texas; Vice-President, O. C. Charlton, Professor of Science in Baylor University, Waco; Secretary, Frederic W. Simonds, Ph.D., Professor of Geology in the University of Texas; Treasurer, R. A. Thompson, M.A., C.E., Engineer to the Texas Railroad Commission, Austin; Librarian, Wm. L. Bray, Ph.D., Professor of Botany in the University of Texas; other Members of the Council: H. L. Hilgartner, M.D., Austin; J. C. Nagle, M.A., M.C.E., Professor of Engineering in the Agricultural and Mechanical College of Texas, and T. U. Taylor, M.C.E., Professor of Applied Mathematics in the University of Texas.

F. W. S.

## *DISCUSSION AND CORRESPONDENCE.*

### EPITROPISM, APOTROPISM AND THE TROPAXIS.

IN an article published in SCIENCE for July 13, 1900, entitled 'The Structure and Signification of Certain Botanical Terms,' I mentioned epitropism, apotropism and tropaxis as among terms of that kind which I had long personally used but never before published. The following notes illustrate the manner in which I originally used them in my college lectures and, in rewriting them, I have found it convenient to retain in part their original didactic style. It is not my present purpose to compare my method of treating this subject with the methods of other writers, and I shall therefore not refer to them.

The archetype, or elemental form, of every highly organized plant, especially every phenogam, is a simple erect shaft, which becomes the main shaft of the mature plant. As the main shaft increases in growth from the plantlet secondary shafts spring from it, those from the upper portion becoming branches and those from the lower portion becoming roots. The primary or main shaft has two axes, a longitudinal and a transverse. In endogenous plants the longitudinal axis, although always existent, is seldom visually well defined. In the woody exogens, however, its position is clearly marked by the central pith. The transverse axis is visually inconspicuous in all plants but no structural or functional portion has a more real existence than has this axis. Its location is in a discoid portion of the main shaft, and from it the upward and downward growth-forces diverge, or turn in opposite directions. I have therefore called it the tropaxis. The condition, or manifestation of growth-force, which is normally exhibited by the part of the plant above the tropaxis I have called apotropism, and that exhibited by the part below the tropaxis, epitropism, as explained in the former article. Therefore while growth of the respective parts is, in a general way, toward and from the earth it may more distinctively be said to proceed in opposite directions from the tropaxis.

Epitropism and apotropism reside potentially in the individual cells of the growing parts of the plant. Each condition is normal in its own division and in the ordinary growth of the plant each is stable as a physiological balance to the other. Both epitropism and apotropism are, however, less stable in some plants than in others, in which cases the normal condition is, at certain points, exchanged for the opposite condition. That is, under circumstances presently to be mentioned, cells that are normally apotropic change to an epitropic condition, when secondary roots or aërial rootlets result; and under other circumstances epitropic cells undergo the reverse change, when suckers or new plants result. Again, there is a kind of both epitropism and apotropism due to special physiological causes. Therefore there are not less than three kinds or grades of epitropism and apotropism.

The normal apotropic condition of that part of the plant which is above the tropaxis may be called primary apotropism. It is that manifestation of growth-force which is concerned in giving form and character to all that part of the plant above ground. Secondary apotropism is that condition which results in the change of small clusters of cambium cells at certain points upon the roots of a plant from their normal epitropic to a complete apotropic condition. It is this change which results in the production of suckers or new plants. Secondary apotropism is sometimes spontaneous and sometimes due to exciting causes, among which is the infliction of wounds. Spontaneous results are seen in the abundant suckers which rise from the roots of the Silver-leaf poplar, and those caused by wounds are seen in the suckers which freely rise from the spade-wounded roots of the garden cherry tree. Another interesting example of secondary apotropism, which is accompanied by secondary epitropism, is seen in the method of propagating willows and cottonwood trees which is sometimes practiced on our prairie soils. Poles are cut down, trimmed, notched at intervals with the ax, and buried in furrows of moist earth. Clusters of primary apotropic cambium cells adjacent to those wounded by the ax take on secondary apotropic action and suckers result, which are well nourished in their early stage from the poles. Special apotropism will be presently mentioned.

The three grades or kinds of epitropism proper, are primary, secondary and special, all of which are distinct from the ordinary epitropism of gravitation. The latter is plainly mechanical and is conspicuously observable in the drooping of branches and in the downward curving of the stems of heavy fruits. Primary epitropism is confined to that part of the plant below the tropaxis where it is a balancing, but in some sense an opposing force to primary apotropism. It is secondary epitropism which is manifested in the production of secondary roots and aërial rootlets. It may be spontaneous, when it constitutes one of the acquired habits of the plant in which it occurs, or it may be due to accidental circumstances. In each case clusters of apotropic cambium cells take on epitropic action and form, not adventitious buds, as is the normal habit of such cells, but aërial rootlets or true roots. The aërial rootlets of the ivy and the frequent rooting of creeping plants are familiar examples of spontaneous secondary epitropism, and the ready rooting of cuttings of the grape and the common currant are equally familiar examples of secondary epitropism resulting from wounds and contact with moist earth. The Banyan tree presents a remarkable case of spontaneous secondary epitropism. Pseudo-branches of this strange tree, or branches which seem to have become epitropically surcharged, begin a rapid growth toward the earth, perhaps aided by gravitation. When the distal end has reached the earth true roots spring from it and penetrate the soil, and a new tropaxis is formed immediately above them. Above the tropaxis the shaft assumes a fully apotropic condition and sends forth branches some of which repeat the process described until the added shafts form a vitally united grove.

The tropic balance is so stable in some plants, the oaks and walnuts for example, that it is difficult if not impossible to produce in them either secondary epitropism or secondary apotropism. Therefore, the forester propagates these trees only from the seed. In other plants, however, the tropic balance is so unstable that propagation is readily accomplished by cuttings and layers, success in these cases being due to secondary epitropism. In the case of cuttings the fragments of apotropic branches which are used for the purpose become the main stems of the new plants, a new tropaxis forming in each just above the end which is inserted into the moist earth, and whence the new roots spring. It is an interesting fact, as illustrated by the grapevine and the common currant bush that those plants which most fully and readily manifest secondary epitropism as a consequence of wounds seldom manifest it spontaneously. So persistent are cuttings of the currant bush, for example, in producing roots when inserted into moderately warm, moist earth, that they do so even when otherwise subjected to wanton violence. As a result of one of my experiments when the distal or upper end of the cutting, instead of its proximal or lower end was inserted into the soil, roots and a new tropaxis were produced there as they were at the proximal end of those which were not reversed; and branches sprang from the axillary buds, as they did in the other cases.

Examples of special epitropism and apotropism are seen in the epitropic curve of the peduncle of nodding flowers and the subsequent erection of some of them with the seed-laden ovary against gravitation, under the influence of fertilization of the ovules. The Western Primrose, *Dodecatheon medea* is a good example of this kind. Special epitropism alone, under the same influence, is seen in the laying of its fertilized ovary upon the ground by *Cyclamen Europæum*, and in the thrusting of its fertilized ovary beneath the soil by the common peanut plant.

As a rule, the growing parts of every plant, except its tropaxis, is under the influence of either epitropism or apotropism, but other parts of some plants are also neutral or atropic. This condition exists in the slender organs called runners such, for example, as those of the strawberry above ground and the so-called stems of the potato under ground. The strawberry runner begins its growth just above the tropaxis, assumes a horizontal position, increases only at the terminal point and shows no tendency to differentiate in form or either to rise or enter the soil until it has reached considerable length. Then suddenly both epitropic and apotropic action takes place in the terminal cells which results in a new and perfect plant, rooted in the soil and becoming wholly independent by the withering of the runner from which it sprang. The function of the runner was that of a temporary vehicle for the dispersion of the species and purveyor of primary subsistence for the new plant. Among the ordinary roots of the potato plant atropic underground runners are produced at the distal end of each of which the potato, a tuberous branch having embryonic buds, is formed. In these buds apotropism is potentially developed but temporarily suspended. The function of these runners is that of one method of propagating the species and the storing of subsistence for the future plants.

It need not be mentioned that the foregoing condensed notes contain the statement of no new fact or principle, but I am confident from my former use of this method of presenting the subject that they possess some educational value. I also claim that the special terms I use are more expressive and convenient than are some others which are used with reference to the same subject.

CHARLES A. WHITE.

SMITHSONIAN INSTITUTION,
July 12, 1900.

### INITIATION OF NEW ELEMENTS IN FOSSIL FAUNAS.

THE constantly growing refinement in investigative method that is demanded by every branch of geological science has caused even the most familiar phenomena to be examined from new view-points. In no department of geology has this change of position been more marked than in paleontology. In problems of geological correlation and comparative chronology the individual species of fossils have come to be considered more from the standpoint of dependent components of complex faunas than as mere isolated accidental factors.

With this closer study of organic remains and in their consideration broadly as distinctive assemblages or faunas, there has arisen a tendency on the part of paleontologists to give new meanings to old conceptions. Conspicuous among examples of this sort is a decided proneness to push backward the geological time divisions.

As an illustration, the appearance of an Ordovician type among fossils occurring in recognized Cambrian is pointed out as profoundly significant. The occurrence of several such younger factors among older ones has given grounds for proposing to lower the basal line of the newer terrane notwithstanding the great preponderance of the older forms of life.

The initial appearance of younger or newer faunal elements is no doubt highly significant, but it can hardly have the transcendent importance often ascribed to it. The importance of all such events is fully recognized. When, however, it comes to making one or a few factors of this kind overbalance predominating older elements some caution is necessary.

We can hardly consider a new faunal age to begin with every initial introduction of a new faunal element. Faunas have their beginnings far down in depths of older faunas. They expand, displace the older elements and culminate. They decline and fade away far up among still newer faunas. We have analogous examples in the progress of nations. The initiation of a new element does not indicate a new dynasty. A new political movement has its birth amid a multitude of conflicting elements. It may grow in importance and finally displace the existing government. Only when it has overcome the older, ruling powers is a new régime inaugurated. Not until then does the nation acquire a new name. There are long steps between the initiation of a new element and the initiation of a new régime.

So, also, the relative geological ages of rock sections more or less remote from one another is now capable of being determined with great accuracy by methods other than the use of fossils. Modern stratigraphy rests upon grounds wholly different from what it did even a few years ago. The exact position of a terrane in the general geological column is now not so important as the relative local position with reference to known associated formations. Faunal age has ceased to be any longer a vital consideration to the geologist. When he has found out what are the geological units, or terranes, and their relations to one another, he cares little or nothing about what biotic age is assigned. He has in his possession the skeleton frame work which he can, at his leisure, clothe with flesh and blood. No subsequent finding of 'Devonian' fossils in one part, 'Carboniferous' forms in another, or even 'Tertiary' species underneath all will change the ascertained relative position of his units. The disputes of 'exact geological age' according to a standard that he no longer recognizes as infallible or essential, concern him little. If the question of 'geological age' or rather 'biotic age' can be settled even approximately satisfactory to all so much the better. If not, his stratigraphic work can go on without interruption. Questions as to age according to this criterion or that, are left for those who have more time than he to answer them.

CHARLES R. KEYES.

### RAPID CHANGES IN THE STRUCTURE OF THE CORONA.

TO THE EDITOR OF SCIENCE: The question as to whether rapid changes take place in the structure of the corona is an interesting one.