granting of honorary degrees by our colleges to men outside of academic life has any reason to be, and surely it has, it is because such academic recognition is an expression of appreciation on the part of the personnel of the college of the things in which alone the results of their labors take on the garb of reality. As an expression of this kind of appreciation the function of the college in the granting of honorary degrees contributes vastly more to the credit of the college when wisely performed than to the sum of honor that rests upon those who do the world's work and carry its heavy dignities.

Quite the most absurd notion respecting this conferring of honorary degrees is the more or less confused idea of many a circumscribed academician that it is the making rather than the marking of a distinction; and growing out of this pitifully foolish idea is the exaggerated dread of the prostitution of this really vital function of our academic institutions.

Let one read the words of President Van Hise (SCIENCE, July 15, p. 92) and consider whether anything could be more stimulating to a group of young graduates at a time when everything conspires to awake in them the most serious emotions. If the granting of honorary degrees is not a vital function it may easily be made such, and as such its greatest, perhaps its only benefit would accrue to the institution performing it.

It is a general impression, and perhaps it is true, that the number of engineers is disproportionately small among those who at each commencement season receive honorary degrees. If it is true, it is to be hoped that some of our larger schools of engineering may consider it. In any case it would be appropriate for our Society for the Promotion of Engineering Education to look into the matter.

W.

'PTERIDOSPERMAPHYTA.'

TO THE EDITOR OF SCIENCE: In proposing the name 'Pteridospermaphyta' (SCIENCE for July 1, 1904, p. 25), Professor Lester F. Ward does not seem to have noticed that Oliver and Scott have published 'Pteridospermæ' as the name of the group, in a paper presented to the Royal Society, January 21, 1904, entitled 'On the Structure of the Paleozoic Seed *Lagenostoma Lomaxi*, with a Statement of the Evidence upon which it is Referred to *Lyginodendron*.' Abstract preprints of this paper were distributed early in the year, were published prominently in *Nature*, 69: 334, February 4, 1904, and reviewed in the *Botanical Gazette*, 37: 237, March, 1904. The name was further established by Oliver in a paper entitled 'A New Pteridosperm,' published in the *New Phytologist*, 4: 32, January, 1904, and also reviewed in the *Botanical Gazette* (*l. c.*).

It was proposed by Oliver and Scott to establish 'a distinct class,' under the name Pteridospermæ, to 'embrace those paleozoic plants with the habit and much of the internal organization of ferns, which were reproduced by means of seeds.'

JOHN M. COULTER.

SPECIAL ARTICLES.

AUTOTOMY, REGENERATION AND NATURAL SELECTION.

HISTORY warns us that it is the customary fate of new truths to begin as heresies and to end as superstitions; and as matters now stand it is hardly rash to anticipate that in another twenty years the new generation, educated under the influences of the present day, will be in danger of accepting the main doctrines of the 'Origin of Species' with as little reflection and it may be with as little justification as so many of our contemporaries twenty years ago rejected them. —Huxley, 1880.

Huxley's prophecy has not been quite fulfilled, for the fate of natural selection as a scientific account of organic adaptations still depends on the testimony of witnesses. Nevertheless, the warning of 1880 is a wholesome stimulant to take before considering some recent objections that selection accounts neither for the process of self-mutilation, so common among the crustacea, nor for the ability of living things in general to repair injuries by the restoration of lost parts.

These two processes, autotomy and regeneration, have been studied by those who consider them evidence in favor of selection, as well as by those to whom Darwinian explanations seem absurd. In this latter group is Professor T. H. Morgan, whose books, 'Regeneration' and 'Evolution and Adaptation,'* assert the inadequacy of selection. As the work summarized in the first volume has inspired the point of view from which the second one was written, a careful criticism of the former is a test of the soundness of the latter. Such criticism is difficult, not only from the nature of the subject, but especially because of a paradoxical frame of mind due to my agreement with Professor Morgan's main contention without being able to accept his own reasons for it.

Autotomy.—Professor Morgan regards the process of autotomy as a fatal stumbling block for the theory of natural selection. Thus on page 155 of 'Regeneration' we read:

Even if it were granted that the theory of natural selection is correct, it does not follow that all useful processes have arisen under its guidance. We may, therefore, leave the general question aside, and inquire whether the process of autotomy could have arisen through natural selection (admitting that there is such a process for the sake of the present argument), or whether autotomy must be due to something else.

If we assume that the leg of some individual cray fishes or crabs, for example, broke off, when injured, more easily at one place than at another, and that regeneration took place as well, or even better, from this region than from any other, and if we further assume that those animals in which this happened would have had a better chance of survival than their fellows, then it might seem to follow that in time there would be more of this kind of animal that survived. But even these assumptions are not enough, for we must also assume that this particular variation was more likely to occur in the descendants of those that had it best developed, and that amongst those forms that survived, some had the same mechanism developed in a still higher degree, and, the process of selection again taking place, a further advance would be made in the direction of autotomy. This, I think, is a fair, although brief, statement of the conventional argument as to how the process of natural selection takes place. But let us look further and see if the results could be really carried out in the way imagined, shutting our eyes for the moment to the number of suppositions that it is necessary to make in order that the change may occur. It will not be difficult, I believe, to show that even on these assumptions the result could not be reached. In the first place, the crabs that are not injured in each generation are left out of account, and amongst these there will be some, it is true, that have the particular variation as well developed as the best amongst those that were injured, and others that have the average condition, but there will be still others that have the possibilities less highly developed, and the two latter classes will be, on the hypothesis, more numerous than those in the first class. The uninjured crabs will also have an advantage, so far as breeding and resisting the attacks of their enemies are concerned, as compared with those that have been injured, and in consequence they, rather than the injured one, will be more likely to leave descendants. Even if some of those that have been injured, and have thrown off the leg at the most advantageous place, should interbreed with the uninjured crabs, still nothing, or very little, can be gained, because, on Darwinian principles, intercrossing of this sort will soon bring back the extreme variations to the average.

The process of natural selection could at best only bring about the result provided all crabs in each generation lose one or more of their legs, and amongst these only the ones survive that break off the leg at the most advantageous place; but no such wholesale injury takes place, as direct observation has shown. At any one time only a small percentage, about ten per cent., have regenerating legs, and as the time required completely to regenerate a leg, even in the summer, is quite long, this percentage must give an approximate idea of the extent of exposure to injury. It is strange that those who assert offhand that, because autotomy is a useful process, therefore it must have been acquired by natural selection, have not taken the pains to work out how this could have come about. Had they done so, I can not but believe they would have seen how great the difficulties are that stand in the way.

A further difficulty is met when we find that each leg of the crab has the same mechanism. If we reject as preposterous the idea that natural selection has developed in each leg the same structure, then we must suppose that a crab varies in the same direction in all its legs at the same time; and if this is true it is obvious that the prin-

* 'Regeneration,' by Thomas Hunt Morgan, The Macmillan Company, New York, 1901. 'Evolution and Adaptation,' by Thomas Hunt Morgan, The Macmillan Company, New York, 1903.

ciple of variation must be a far more important factor in the result than the picking out of the most extreme variations. The same laws that determine that one individual varies in a useful direction farther than do other individuals may, after all, account for the entire series of changes. If it be replied that natural selection does not take into account the causes of the differences of individual variation, this is to admit that it avowedly leaves out of account the very principles that may in themselves, and without the aid of any such supposed process as natural selection, bring about the result. The Lamarckian principle of use and disuse does not give an explanation of autotomy, since the region of the breaking-joint is not the weakest region of the leg, or the place at which the leg would be most likely to be injured.

We can not assume autotomy to be a fundamental character of living things, since it occurs only under special conditions, and in special regions of the body. While it might be possible to trace the autotomy of the legs of the crustacea, myriapods and insects, to a common ancestral form, yet this is extremely improbable, because the process takes place in only a relatively few forms in each group. The autotomy of the wings of white ants that takes place along a preexisting breaking line must certainly have been independently acquired in this group. The breaking off of the end of the foot in the snail helicarion is also a special acquirement within the group of mollusca.

Bordage has suggested that the development of the breaking joint at the base of the leg of phasmids has been acquired in connection with the process of moulting. He has observed that during this period the leg can not, in some cases, be successfully withdrawn through the small basal region; and hence, if it could not break off, the animal would remain anchored to the old exoskeleton. It escapes at the expense of losing its leg. The animal, having acquired the means of breaking off its leg under these conditions, might also make use of the same mechanism when the leg is held or injured, and thereby escape its enemy. The fact that the crayfish has a breaking joint only for the large first pair of legs would seem to be in favor of this interpretation, but the crab has the same mechanism for the slender walking legs that one would suppose could be easily withdrawn from the old covering. It should also be remembered that we do not know whether the breaking joint at the base of the leg of the crab and of the crayfish would act at the time when the leg is being withdrawn from the old exoskeleton, unless the leg were first injured outside of the joint.

Our analysis leads to the conclusion that we can neither account for the phenomenon of autotomy as due to internal causes alone in the sense of its being a general property of protoplasm, nor to an external cause, in the sense of a reaction to injury or loss from accident. There would seem then only one possibility left, namely, that it is a result of both together, or in other words, a process that the animal has acquired in connection with the conditions under which it lives, or in other words, an adaptive response of the organism to its conditions of life.

We are not, however, able at present to push these questions farther, for, however probable it may seem that animals and plants may acquire characteristics useful to them in their special conditions of life, and yet not of sufficient importance to be decisive in a life-and-death struggle, still we can not, at present, state how this could have taken place in the course of evolution. For, however plausible it may appear that the useful structure has been built up through an interaction between the organism and its environment, we can not afford to leave out of sight another possibility, viz., that the structure or action may have appeared independently of the environment, but after it appeared the organism adopted a new environment to which its new characters made it better suited. If the latter alternative is true, we should look in vain if we tried to find out how the interaction of the environment brought about the adaptation. The relation would not be a causal one, in a physical sense, but the outcome of a different sort of a relation, viz., the restriction of the organism to the environment in which it can remain in existence and leave descendants.

For one whose life consists of a struggle for existence, it is difficult to appreciate the delicate humor with which Professor Morgan 'admits' natural selection for the sake of argument; it is more difficult for him to understand the objection that variations are not fit until they have been fitted into some part of the external world; but it is harder yet for him to see that 'the restriction of the organism to the environment in which it can remain in existence and leave descendants' differs from 'natural selection' except in the number of words used to express the same idea. These minor points, however, have little bearing on the evidence from autotomy. To appreciate the value of this evidence it is necessary first of all to disentangle the fact that the crab has a mechanism to facilitate self-mutilation, from the fact that the mutilated parts are restored. This distinction is not only easy to make, since the legs regenerate at other levels, but it is also very important. One who recognizes the independence of these two facts does not hold the foolish opinions attributed to him any more than he accounts for his ability to mend a broken clavicle by referring to gifted ancestors whose success in life depended on the frequency and completeness with which they broke their collar bones.

The separation between the fact that there is a mechanism for throwing off legs, and the fact that the legs are regenerated from the point at which they are thrown off, leaves for consideration only the basis of the belief that the breaking joint is not of use to the species. The evidence for this belief is as follows: 'At any one time only a small percentage, about ten per cent., have regenerating legs, and as the time required completely to regenerate a leg even in the summer is quite long, this percentage must give an approximate idea of the extent of exposure to injury.' Thus the extent to which the mechanism is used is held to be too slight to account for its existence in the other ninety per cent. of the crabs. However, as this determination is only for 'any one time,' it falls into a class of statistical evidence which shows, according to Professor Brooks, that 'our subject matter lies midway between those exact sciences in which we are told that figures can not lie * * * and those social and political sciences which show us continually how easily one may lie with figures.'*

Granted that at any given time ten per cent. of crabs show that they have made use of the mechanism for throwing off their legs, this percentage gives no idea of the extent to which each crab uses the breaking joints during its entire life. How long a crab lives is not definitely known, but from analogy and indirect evidence five years is within the limit of life for some species. 'As the time required completely to regenerate a leg even in the summer is quite long,' it follows that in six months an appendage may regenerate completely.

Five years represent ten periods of six months. If in each period we were to count the ten injured individuals of a given hundred, then at the end of the full term we should have counted one hundred injuries, which, according to the doctrine of chance, would have been distributed among sixty-five individuals. Thus in five years, two out of three crabs would have been injured one or more times.

Regeneration.—Professor Morgan's book is one continuous protest that natural selection does not account for the ability of organisms to regenerate lost parts. Thus on the last page of 'Regeneration' he summarizes his convictions in the following words: "It seems highly probable that the regenerative process is one of the fundamental attributes of living things, and that we can find no explanation of it as the outcome of the selective agency of the environment. The phenomena of regeneration appear to belong to the general category of growth phenomena and as such are characteristic of organisms."

This demonstration, 'that the regenerative process is one of the fundamental attributes of living things,' seems valid; but to those who believe that natural selection is a law of nature, proof that the regenerative process is fundamental is likewise proof that natural selection has no bearing on this process. Natural selection is not an explanation of things ultimate any more than the law of falling bodies is an explanation of the fundamental characteristics of matter. No one holds that Newton's laws are invalidated because they do not explain the ultimate attributes of materials that fall, or of the space in which they fall, or why they fall in the order that we observe, because every one knows, or has known, that Newton's laws are merely records of events. Natural selection is the series of events which occurs in nature as the outcome of individual differences, the high rate of increase and the environment of living things. The charge, therefore, that this

* W. K. Brooks, 'The Intellectual Conditions for Embryological Science,' SCIENCE, XV., p. 488.

series of events does not explain one of the fundamental attributes of living matter is irrelevant.

An explanation of this curious misapprehension, as well as a remedy for it, may be found in the definition of regeneration as either the homomorphic or the heteromorphic replacement of lost parts, or the development of whole as well as imperfect organisms from pieces of adults, embryos or eggs. This definition leaves out of account a large class of true regenerative phenomena. Unless the term 'regeneration' has become a technical one, intended to convey only half of its legitimate sense, every restorative process should be included under it. It seems to me that if all anabolic processes were included in our common acceptance of the term, we should neither forget that the ability to regenerate is a fundamental attribute of living things, nor try to account for it by natural selection.

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CURRENT NOTES ON METEOROLOGY.

JAMES GLAISHER.

IN the *Quarterly Journal of the Royal Meteorological Society,* Vol. XXX., 1904, pp. 1–27, Mr. William Marriott, assistant secretary of the society, has a paper on the meteorological work of the late James Glaisher, F.R.S., whose death, in February, 1903, was duly noted in these columns. Glaisher was the founder of the Royal Meteorological Society in 1850. He had, in 1840, been appointed superintendent of the magnetic and meteorological department of the Royal Observatory, Greenwich. He soon became interested in and conversant with all kinds of meteorological investigations, and through his instrumentality numerous meteorological stations were equipped in various parts of the country. From 1847 to March, 1902, he supplied quarterly the results from those stations to the registrar general. He prepared various tables of corrections for the use of the observers, the principal of which were his 'Hygrometrical Tables,' which have passed through nine editions. He was a juror of the Great Exhibition of 1851, and as such he caused a great stimulus to be given to the manufacture of reliable meteorological instruments. Glaisher was best known to the public by the twenty-eight balloon ascents which he made for scientific purposes in the years 1862–1866, on behalf of a committee of the British Association. A bibliography of the writings of Glaisher is appended, and the statement is made that the instruments which he used during his balloon ascents have been given to the Royal Meteorological Society by his son. The last paper by James Glaisher appeared in the *Quarterly Statement of the Palestine Exploration Fund,* 1902, and is entitled 'Rainfall at Jerusalem in the Forty-one Years 1861–1901.'

THE DUST-FALL OF FEBRUARY, 1903.

'THE Great Dust-Fall of February, 1903, and its Origin' is discussed by H. R. Mill, R. G. K. Lempfert and J. S. Flett in the *Quarterly Journal of the Royal Meteorological Society,* Vol. XXX., 1904, pp. 57–88. The dust fell over nearly all parts of England and Wales to the south of a line drawn from Anglesey through Wrexham and Northampton to Ipswich, except in parts of northern Cornwall, Somerset, Wilts and Mid-Wales. At many stations to the north of this line the dust-fall did not attract the attention of observers, but is believed to have taken place on account of the distinct marks of yellow dust detected on the sunshine cards sent in to the Meteorological Office. The dust usually attracted attention either in the form of a dense yellow haze, like a London fog, or as a reddish-yellow powder, lying thickly on trees or roofs, or adhering to windows. There is reason to believe that the air which reached the southern half of England on February 22 started from the northwest coast of Africa on the nineteenth. Dr. Flett, who examined the dust microscopically, reports that the bulk of each specimen of dust presented to him for examination consisted of comparatively coarse particles of mineral and organic origin derived from the locality where it was collected. In addition to the coarser particles, all the samples contained a very fine-grained reddish clay, the particles of which were too minute