photography by Lippmann (1891, 1892), showing that the electric and not the magnetic vector is photographically active.

The theory of interferences from a broader point of view, and including the occurrence of multiple reflections, was successively perfected by Poisson (1823), Fresnel (1823), Airy (1831). It has recently been further advanced by Feussner (1880, et seq.), Sohncke and Wangerin (1881, 1883), Rayleigh (1889) and others. The interferences along a caustic were treated by Airy (1836), but the endeavor to reconstruct geometric optics on a diffraction basis has as yet only succeeded in certain important instances, as already mentioned.

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(To be continued.)

SCIENTIFIC BOOKS.

Species and Varieties, their Origin by Mutation. By HUGO DE VRIES; edited by DANIEL TREMBLY MACDOUGAL. Chicago, The Open Court Publishing Co.

De Vries's great work 'Die Mutationstheorie' marks an epoch in biology as truly as did Darwin's 'Origin of Species.' The revolution that it is working is less complete, perhaps, because there has remained no such important doctrine as that of continuity to be established. But there was need of a revolution in our method of attacking the problems of evolution. Ever since Darwin's time most biologists have been content to *discuss* and argue on the *modus operandi* of evolution. The data collected by Darwin have been quoted like scriptural texts to prove the truth of the most opposed doctrines. We have seen biologists divided into opposing camps in defense of various isms, but of the collection of new data and, above all, of experimentation we have had little. The great service of de Vries's work is that, being founded on experimentation, it challenges to experimentation as the only judge of its merits. It will attain its highest usefulness only if it creates a widespread stimulus to the experimental investigation of evolution.

To be read, nowadays, a book must be brief. Much of the success of the 'Origin of Species' was due to the mass of material which was left out. The very bulkiness of de Vries's original work must prevent its being read as widely as it deserves. There was needed a briefer presentation of de Vries's views and one in English, and this need has fortunately been filled by de Vries himself in the work now under review. This book should be read with care by every biologist; the brief synopsis of its contents which alone is possible here can in no wise make such a reading unnecessary.

After an introductory chapter, the fundamental distinction between elementary species and varieties is discussed. Elementary species are forms that are distinct in several characters from their close allies and breed true. They are thought to have arisen from their parent form in a progressive way, *i. e.*, by the addition of a new characteristic. In this they are distinguished from retrograde varieties on the one hand and mere fluctuations of characters on the other.

The subject of retrograde varieties (constituting the third section of the book) assumes great importance in de Vries's system. They are varieties in the new (restricted) sense. They differ from the parent species usually in the absence of some single character; for example, the white flower variety of a plant or the hairless form of an ordinarily hirsute species. The eliminated characters are of a few, definite, constantly recurring kinds. In this respect varieties differ from elementary species whose differential characters are most varied. Moreover, varieties are subordinate to some elementary species, whereas elementary species are coordinate.

In self-fertilization varieties behave in a characteristic way. They are frequently constant. Even varieties that are intermediate between the parent species and other varieties may be as stable as the latter. Indeed, we know that certain garden varieties have been bred in their present form for two or three centuries. Such varieties may, however,

sometimes even, though rarely, revert to the ancestral form. When varieties are crossed with the ancestral species the characters of the species are dominant in the hybrids, so that the hybrid appears like the species. De Vries finds, accordingly, that many cases of apparent reversion, or atavism, in the offspring of a variety of plant are due to the accidental cross pollination with the ancestral species; the 'reverted' forms are really hybrids. This phenomenon is called by de Vries 'vicinism'—the false atavism being due to the presence of the species in the vicinity. In addition to this false atavism there can be distinguished a true one. For, although in retrograde varieties the quality that has dropped out *may* become wholly lost, it may, on the other hand, be merely latent and may reappear, usually suddenly, in some individual. At this point de Vries introduces the idea of positive varieties as opposed to negative ones. These are characterized by the addition of a quality which had been latent. (The addition of a *new* quality is, it will be recalled, in de Vries's scheme, the origin of an elementary species. But will it not be often impossible to say whether a new appearing quality is truly new or old?)

In cross-breeding the contrast between varieties and species still holds. When a new species, which is characterized by a new quality, is bred to the parent form, its germ cell bears a unit-character of which the parent species offers no representative with which it may be mated in the conjugation of the sex cells. This sort of cross is called a 'unisexual' cross (unbalanced or unsymmetrical cross would have been less ambiguous). Varieties, on the other hand, have the same characters as the parent species, only one of them is latent. This latency of the characteristic does not prevent its union with the corresponding patent characteristic of the parent species. The offspring of a unisexual cross are apt to have the various characters of one or the other parent intact, fully developed, side by side. These first generation hybrids are all of the same type; in general aspect they are intermediate between the two species and this intermediacy persists when the hybrids are inbred. In the so-called bisexual crosses, on the other hand, the first hybrid generation is said to resemble the parent species. When such hybrids are inbred a segregation of the various characters in different individuals appears. This segregation occurs in accordance with Mendel's law, and that law is applicable only to bisexual (balanced) crosses.

The fourth section treats of 'ever-sporting' varieties and is the most novel and suggestive in the book. It is essentially experimental, yet one feels that the results gained are tentative. Ever-sporting varieties are defined as 'forms that are regularly propagated by seed, are of pure and not hybrid origin, but which sport in nearly every generation.' Of such varieties two types are recognized: 'poor' races or 'half' races, and 'rich' races or 'middle' races. In the former a sport transmits its peculiarity to only a small percentage—one per cent. to three per cent.—of its progeny. In the latter a transmission to twenty-five per cent. to fifty per cent. of the offspring may occur. However, the two sorts of races are not so sharply differentiated as these figures would indicate, but naming the extremes will accentuate the fact of variability in the transmissibility of sports, in plants. The same thing is found in man. Polydactylism is in some families strongly transmitted, in others less strongly, in others almost not at all. De Vries was unable to establish a race of five-leaved crimson clover, whereas he quickly got a race of five-leaved red clover. Monstrosities behave like other variations, showing both poor and rich races. In the further development of the subject de Vries is led to explain cases of functional adaptation in plants on the ground that two types are always present in species showing these adaptations, and that 'during their juvenile stage a decision is taken in one direction or the other.' He even goes so far as to ascribe the difference in height of some plants, according as they occur in rich or poor soil to a dimorphic tendency toward, one or the other stature. This conclusion requires statistical proof before it will be generally accepted.

The fifth section is headed 'Mutations' and is, we think, the most powerful in the book. The author tells in two chapters of his early attempts to produce races having certain abnormalities—a toad-flax with peloric flowers (*i. e.*, having radial instead of bilateral symmetry) and a double daisy out of a single one. He tells the story of his discovery of the mutating evening primrose and the way it produced new varieties and species in his garden. These new forms, *when self-fertilized,* reproduced themselves in a high percentage of cases. His experience with these mutating plants led him to formulate seven laws as follows: (1) New elementary species appear suddenly, without intermediate steps; (2) they spring laterally from the main stem (not replacing it); (3) they attain their full constancy at once; (4) some of the new strains are elementary species, others are to be regarded as varieties; (5) the same new species are produced in a large number of individuals; (6) mutations undergo fluctuating variation, but the latter is not evolution and (7) mutations take place in nearly all directions.

An apparent difficulty to accepting mutations as the sole source of new species is their rarity. An investigation of the literature, however, convinces de Vries that there is a number of records of species and varieties arising by mutation and in horticulture mutating strains play an important part. In the lecture on systematic atavism the author shows that many mutations are repetitions of an ancestral condition that has lain latent (by the author's previous definition the coming into activity of latent characters is the production of positive varieties); and in the illuminating lecture on taxonomic anomalies he cites numerous wild species that are distinguished by characteristics that appear to be sports and have probably arisen *per saltum.*

In his lecture on periodic mutation de Vries sets forth the theory that in species periods of rest or stability alternate with periods of mutation. If ever we can produce the mutating period at will then we can hasten the course of evolution. De Vries concludes that, despite the long periods elapsing between successive mutation periods in any species the theory demands less time than that of selection of infinitesimal variations and so fits in better with the newer conclusions of physicists who are tending to shorten the probable age of the earth.

The final section of the book is devoted to 'Fluctuations.' It contains a keen argument against the importance for evolution of the selection of minute variations. After discussing the general laws of fluctuation as enunciated by Quetelet and Galton (and warning biologists against the use of ultra-biometric methods whose biological significance is uncertain) de Vries states that fluctuations take place in two directions only; they are either plus or minus. Mutations, on the other hand, are going on in 'all directions.' The cause of fluctuating variability is variation in nourishment. (This can hardly be true of the rays of *Pecten,* whose number is independent of size and is fixed a few hours after hatching.)

Although new species may not be produced by the selection of fluctuating characters, it is recognized that such selection may be of great importance in improving the quality of any characteristic; particularly when the improvement can be propagated by asexual methods as (in plants) by cuttings. The true method for the breeder of perennials is indeed to combine the preservation of sports, the selection of the best variants, and hybridizing. In the case of annuals it will be found that improvement by selection is impossible beyond a certain point and constant attention is needed to maintain any advance made. Indeed, it is just this difficulty of maintaining an advantage that rules out selection inside the species as of importance in nature.

The foregoing is a summary of de Vries's argument. Its force is sufficiently proved by the widespread acceptation it has gained and by the stimulus it has already given to experimental work.

As to the correctness of de Vries's conclusions the future alone can give the final decision—doubtless in some points of detail they will have to be modified. The main truth of the vast importance of mutations in the origin of species can no longer be ques-

tioned. The reviewer is convinced that as good an argument might be made from the zoological side as de Vries has made from the botanical. Undoubtedly many, if not most, of the characteristics of the races of domesticated animals and probably of feral species have arisen by mutation. Take, for example, poultry. The qualities that differentiate them are of the order of mutations—feathered feet, rose comb, elongated tail, taillessness, silky feathers, frizzled feathers, cerebral hernia, polydactyl feet, albinism and many others. All the evidence we have goes to show that these have arisen suddenly, and none of them is halved in cross-breeding. Various wild birds show these same qualities and we must conclude that in wild species also these characteristics have arisen suddenly. Thus we have various wild birds with crests like the Polish fowl (*i. e.*, the umbrella bird, *Cephalopterus*); there are 'cross bills,' showing an abnormality not uncommon among poultry; there is a syndactyl species of monkey; and there are hairless species of mammals. The long tailed condition of certain Japanese fowl is exactly duplicated in the widow-bird (*Chera*). There is hardly a sport not actually prejudicial to the well being of animals which is not realized in some species.

On the other hand, it is certainly true for zoology that many species are based chiefly on 'more' or 'less' of a certain character than an allied species. Further, since animals have a more definite form than plants, and one less modified by variations in environment the fact of geographic variation is a striking one. Now in geographic variation the forms of adjacent localities are distinguished by differences of the order of fluctuating variants; the mode being different in each place; yet the differences between remote localities are of the order of mutations. Geographic variation has been repeatedly observed among birds, fishes, insects and mollusca. It is, of course, possible that the absence of discontinuity in the species may be due to hybridization with blending of characteristics, but blending of characteristics is not so common among hybrids as to justify, offhand, such an explanation. That there is evidence of evolution without mutation can not be denied.

The distinction between species and varieties is clearly expressed by de Vries, but it is doubtful if it will be of wide service because of the difficulty of distinguishing between a 'new' character and an 'atavism.' De Vries admits (p. 564) 'It is often difficult to decide whether a given form belongs to one or another of these two groups.' We look with interest to the experimental testing of de Vries's distinction in animals.

As to the literary qualities of the book, one has first to praise the general method of exposition. It is quite a model. Apart from an occasional non-idiomatic phrase or inapt word the diction is good; but much of this success is of course due to Dr. MacDougal's careful editing. It is unfortunate that the proof reading has been rather carelessly done and that commas are so atrociously misplaced as often to obscure the sense. Otherwise the publishers have done their part well. The broad margins leave plenty of room for the reader's remarks and memoranda which so suggestive a book tends to call forth in great number.

De Vries's book is one to read and reread and then to act upon. We would not wish it less clear cut in its presentation, for then it might merely amuse. As it is it gives a stimulus to the experimental testing of his broad generalizations and iconoclastic conclusions. C. B. Davenport.

Theoretical Chemistry from the Standpoint of Avogadra's Rule and Thermodynamics. By Professor Walter Nernst, Ph.D., of the University of Göttingen. Revised in accordance with the Fourth German edition. Translated into English by Robert A. Lehfeldt. London and New York, Macmillan and Company, Limited. 1904. Pp. 771.

The appearance of the fourth edition of this valuable treatise will be welcomed by all advanced workers in the field of physical chemistry. The general character of this work is too well known to call for special comment. It is distinctively an advanced work, and adapted only to those who have already a good