known from any one locality of the continental North American Tertiaries. However, the state of preservation of the specimens is not always satisfactory, and it may not be possible specifically to describe all of them.

The particular interest of this fauna does not lie in its richness, but in its geologic import. The Tertiary coral faunas of the United States below the Chipola horizon were very isolated, no species from the continent, excepting the *Orbicella* mentioned, being found in any other area. This fauna is distinctly Antiguan in types. Besides the *Orbicella* referred to, there is a very large-celled *Orbicella*, very close to *O. crassilamellata* (Duncan), if not identical with that species, found abundantly at Russell Spring. An *Astrocœnia* is extremely close to *A. ornata* of Duncan from Antigua. The same remark will apply to the *Stylophora* and *Alveopora*.

From this field examination it appears that the reef corals of the Antiguan marls and cherts can be correlated with the base of the Chattahoochee limestone, the base of Dall's Upper Oligocene. It is also quite probable that the Oligocene reefs in the vicinity of Lares, Porto Rico, and of Serro Colorado, Curaçao, represent the same horizon. The Bowden, Jamaica, fauna would be slightly higher, to be correlated with the Chipola fauna.

It is evident that this coral fauna from Russell Spring, besides filling a gap in the faunal succession on the continent, furnishes a basis for correlating many of the West Indian fossil reefs with the continental Tertiary section, and we may confidently expect more light upon the correlation of American and European horizons.

One interesting feature of these corals, not already mentioned, is that they apparently bring the fauna of Vicksburg, Mississippi, into closer relation with the succeeding faunas. A great deal is shown regarding the succession and interrelations of the faunas of the continent itself.

A fossil coral reef is always interesting, as it reveals in an accurate manner the physical conditions prevailing in a region during a certain portion of its geologic history.

When the material collected has been carefully studied in the office, a detailed account will be published.

T. WAYLAND VAUGHAN.

BAINBRIDGE, GA., Nov. 3, 1900.

PEACH YELLOWS: A CAUSE SUGGESTED.

SOME scientific problems lie beyond the reach of present knowledge, in the sense that they are inaccessible through combinations of known facts or methods of research; in dealing with such matters speculation is permitted full sweep in the hope that some hypothesis may point the way to experimental effort and demonstration. There are, however, other questions to which it seems that ascertained facts should furnish a sufficient clue, though the solution may long elude us. With regard to these, speculation appears to have less propriety, perhaps because we have learned to expect more from increased skill and improved methods of research than from theoretical considerations. But if one of these apparently ripe fruits of knowledge refuses to fall, the efforts of the investigating scientists take on added interest, and the bystanders may become anxious to tell just how it should be done. Thus far these well-intentioned people have not been permitted much satisfaction in connection with the mystery of the peach-yellows, the vigorous and sustained attack by the first investigator, Dr. Erwin F. Smith,* having left untried no theory or method which had been applied in previous studies of

* Dr. Smith's results were finally summarized in Farmer's Bulletin No. 17, U. S. Department of Agriculture, 1894.

plant pathology. Results of great economic value were reached, but the cause has still eluded proof or well-founded suspicion.

And yet after the lapse of a decade interest in peach-yellows has increased rather than abated in the minds of those who witnessed and properly appreciated the original researches. It is true that the wish to repeat any of Dr. Smith's comprehensive investigations would scarcely occur to any one who realized the thoroughness of his methods, but in my experience, at least, every new fact or suggestion which seemed in any way likely to furnish an analogy or other clue to peach-yellows has been carefully scrutinized. During the past summer it has seemed to me to be possible to meet the peculiar requirements of the facts by means of a hypothetical cause, and as this is of a nature such that observation and demonstration may be expected to prove difficult and time-consuming, it seems justifiable to place on record the circumstantial evidence drawn from more general biological considerations, in order that those specially concerned with investigations in this line may have any advantage possible from a suggestion which there is no present opportunity to put to a practical test.

Briefly stated, the proposition is simply that the 'yellows' of the peach may be the result of the poisoning of the protoplasm of the living cells by the bite of a small arthropod, probably a mite of the family Phytoptidæ. The fact that plant cells may be so poisoned by mites as to become yellow and yet retain their vitality for many months, or even for years, was impressed upon my attention while observing a palm of the genus *Thrinax*, which had been infested with the so-called 'red-spider' (*Tetranychus*). That this animal was the cause of the injury was inferred from the fact that the formation of yellow spots ceased as soon as it was exterminated from the plant. This was graphically shown in a young leaf which while still folded was attacked on the exposed lateral segments, where the yellow spots are still distinct, though all other parts are entirely untouched and have remained uniformly green. Discoloration spreading thus from the puncture of an insect or a mite is, of course, no new thing, and is often accompanied by much more serious injuries; moreover, we have all the wonderful phenomena of galls as evidence of the power of animal secretions in profoundly modifying vegetable tissues and structures. The interest of the spots of the *Thrinax* lies merely in the suggestion of a progressive and permanent injury of the tissues without malformation or other striking symptoms. It is true that there is a wide gap between progressive change in a spot less than a quarter of an inch across and one which covers a whole peach tree, but the difference may be one of degree and not of kind, and from the physiological standpoint the galls go far to connect the two extremes. This analogy is especially pointed with the galls induced by inoculation, such as those of the plant-lice and mites, which remain outside the tissues of the host-plant, and yet cause protective malformations.

As the effects of yellows upon the plant tissues could scarcely be thought to be of any advantage to the animal, it may be supposed that no special secretion is involved other than the normal salivary fluid, which might be expected to contain digestive ferments or enzymes,* some of which are now known to exhibit the phenomenon of indefinite self-propagation when brought into contact with substances on which they are capable of acting.

* I am informed by Mr. A. F. Woods that he has for some time entertained an opinion of the enzymotic nature of peach-yellows, drawn from a study of the symptoms of the disease, and from the presence of abnormal quantities of oxydizing enzymes. Cf. *Centralblatt für Bakteriologie, etc.*, 2 Abt., V, p. 574.

Among the important points demonstrated by Dr. Smith, in addition to the absence of any parasitic organism within the tissues, was the communicability of the disease. This fact the present theory amply accommodates, and at the same time does not require insects or mites in large numbers, since the disorder is known to be progressive throughout any tree which has once given evidence of infection. Inoculation by budding from diseased trees also communicates the yellows, a fact which would exclude insect injuries as commonly understood, but which is not inconsistent with the present theory, although the isolation of the deleterious substance or even direct inoculation by the application of the juices and disorganized tissues has thus far failed.*

The presence of an infected tree has been believed to have a distinct effect in inducing the disease in others, though trees will sometimes remain healthy for a considerable period in close proximity or even in contact with those already victims of the malady, and young trees planted in the places of those killed by the yellows are no more liable than others to take the disease. These facts seem peculiarly perverse in connection with a theory of direct infection by a parasitic organism, but become quite comprehensible if the injury be ascribed to mites carried about by bees or by birds; infection would thus be largely accidental, and while the chances would be greater in the neighborhood of diseased trees, no regularity nor continuity in the spread of the disorder need be expected.*

Finally, it was demonstrated by Dr. Smith that neither the character, condition or relative fertility of the soil, nor the age, vigor or variety of the tree has any appreciable influence in predisposing to attack or in securing immunity. Such facts are evidently ample for the exclusion of any hypothesis based on the predication of a constitutional disorder originating independently in the tissues of the trees. The implications point uniformly in the contrary direction, to a definite cause in the form of a specific noxious substance the application of which is followed by a uniform bio-chemical reaction. This inference is not weakened by the fact that the reaction is slow, and that the results of infection become apparent only in new growth from buds or tissues which have been reached by the disease. Thus the first definite symptom of debility caused by infections which may be supposed to have taken place in the spring appears in the premature ripening of the fruits. It has also been noted by Dr. Smith that the degree of prematureness is extremely variable, a fact which seems ex-

* Dr. Smith tells me that *Phytopti* were frequently found by him on yellowed peach trees, and that while the idea that they might cause the disease in the usual manner of parasitic insects suggested itself early in the course of his studies, he rejected it because entirely inadequate to explain the extensive constitutional symptoms which led him to compare the yellows to hydrophobia and smallpox, other communicable diseases of which the causes have resisted investigation. It is true also that the infection phenomena of these diseases appear to include the necessity of inoculating or poisoning cells which remain alive, and from which the disease may be propagated by protoplasmic continuity. Bacteria, on the contrary, are able to pass from one plant cell to another only by breaking down the cell-walls, though the disorganizing effects of their chemical products may precede them.

* The presence of bird's nests may prove to be connected with the not infrequent occurrence of several apparently simultaneous infections in the same immediate vicinity, though not necessarily on contiguous trees. If brought in by small birds it is easy to see that the chances of forming a colony of the injurious mites are many times greater on a tree where a nest is placed, and where the birds spend a large part of their time during the breeding season. Moreover, the well-known persistence of the migratory birds in returning to the same nesting-place would tend to insure a rapid dissemination of the yellows in the year after a colony of the mites had been established in the orchard.

plainable by possible differences in the dates of infection and in the distances through which the disease must propagate itself before it reaches the growing fruit, the normal development of which is inhibited, although the tissues previously formed remain apparently uninjured. The suggestive phenomena of the palm are also capable of a similar explanation, the susceptibility to spotting being apparently confined to the young leaves; otherwise it is difficult to understand why the entire area of the older leaves had not turned yellow long since. The same is likewise true of the leaf-spot or stigmonose of carnations, investigated by Mr. A. F. Woods.*

It can scarcely be expected that many cases completely parallel to the yellows will be found in nature, since parasites which produce such disastrous effects upon their hosts must be unable to maintain extended existence. It is accordingly not to be supposed that the peach is the natural or exclusive habitat of an insect or mite which is able to produce such a disease as peach-yellows. In the biology of galls the localization of the irritant or pathological effect is essential to the establishment of a successful and permanent symbiotic relation, although the possibilities of extensive change through animal irritants are amply shown in the general debility evident in some plants when parasitized by gall-forming insects. These considerations are of special interest in connection with a fact which is of use at least as an analogy, and which may possibly furnish a direct clue to the mystery, since on other plants both galls and hexenbesens have been connected with species of the same group of mites. In a disease of plum nursery-stock reported by Mr. M. B. Waite, one of the prominent symptoms of peach-yellows, the fasciculate branching or hexenbesen formation, was found to be caused by a minute parasitic mite (*Phytoptus?*). In this instance the terminal bud is killed, while the lateral buds in the neighborhood are pushed into premature growth. That this latter development is not caused simply by the death of the terminal bud, but is stimulated by the presence of a noxious compound, is probable, though the disorder is not progressive in the plum, and the removal of the malformed branches permits the resumption of normal growth. The suspicion that the active cause may be similar, if not the same as that of the yellows, is considerably strengthened by the fact that the yellows, while recorded as occurring in almonds, apricots, nectarines and Japanese plums, is not known to affect other sorts of plums. With the supposition of such identity of cause we arrive at the proposition that the mite elaborates in its salivary or other glands an enzyme or other active compound to which the tissues of the peach and closely related fruits are peculiarly susceptible, and which produces in them a permanent and ultimately fatal debility accompanied by definite constitutional symptoms. And that this susceptibility depends on some delicate relation of structure or composition is shown by the fact that the Japanese plums are affected, while the European and American cultivated species appear to stand on the plane of at least partial immunity, being able to resist and recover from the infection. It would thus be possible to accommodate all the related facts in the construction of a complete analogy with the known limitations of many other diseases to groups of related varieties and species.*

* Bulletin No. 19, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture, 1900. This disease was formerly ascribed to bacteria, but is here shown to be due to the punctures of aphides.

*The force of this analogy is rather strengthened, although its terms may need to be altered, by a fact verbally communicated by Mr. Waite, that a similar dis-

The only novel proposition employed in this hypothetical solution of the problem is that of the indefinite propagation of the pathological effects of a toxic compound of animal origin, introduced in an infinitesimal quantity and of so mild a physiological action as to cause no immediately appreciable damage. And yet the fact of inoculation shows that this requirement must be admitted as far as the internal phenomena are concerned, whatever be the supposed nature of the exciting cause. As already pointed out by Dr. Smith, this phase of the subject has analogy with other abnormal conditions such as variegation of foliage, which in some plants may also be propagated by grafting. But albinism may easily prove to be a composite phenomenon, sometimes constitutional and sometimes induced, and then transmissible. That the albinism theory of peach-yellows is not, however, necessarily inconsistent with that of its origin through mites is indicated by a curious fact for which I am indebted to Mr. H. J. Webber. An albinistic variety of orange, 'Drake's Star,' was found in Florida to be entirely immune to the orange-rust, caused by one of the Phytoptidæ. As albinism, or variegation, is generally admitted to be connected with or accompanied by a lack of vigor, there is the greater warrant for expecting that the present instance of immunity will not prove to be due to any ability to resist the attacks of the mites, but will be found explainable by the absence from the albinistic protoplasm of the compounds affected by the secretions of the *Phytopti*. A definite relation of incompatibility having been established between an albinistic condition and a disease caused by *Phytoptus*, and involving a yellow discoloration of the cells, the physiological analogy between yellows and albinism is strengthened, and the anomalous proposition of an animal poison causing a constitutional plant disease transmissible by budding loses something of its apparent improbability. Further possibilities not unworthy of mention lie in the production of immunity in the peach through inoculation with a less harmful mite, or with a modified enzyme or antitoxine, or with a mild form of albinism, or through the propagation of albinistic varieties. The uniform susceptibility of the sorts now in cultivation in the infested districts renders it extremely improbable that a normal variety able to resist the yellows could be secured by selection or introduction from abroad.

A further biological reason for belief in a definite external cause for peach-yellows is to be found in what may well be considered a second species of the same genus, the so-called 'peach-rosette,' which has appeared in the orchards of Georgia and as far west as Kansas. This disorder is of a much more virulent type than the yellows, and is able to attack and destroy the plum. It has distinctly different, though similar, symptoms and is likewise contagious and communicable by budding. With two such diseases occupying reasonable definite geographic areas and both repeatedly occurring sporadically within wide general limits, the probability is greatly increased that we are dealing with the injuries of two species of *Phytoptus* or related mites which are normally parasitic on native vegetation, probably indigenous species of *Prunus*, whence they are accidentally transferred to the peach and related fruits of foreign origin, supposably by bees or by birds. Such a method would explain the many independent reappearances of the diseases, and their capricious distribution in orchards, where contiguity or even contact

order of peach nursery stock has also been traced to a mite, even though it may be found that the animal is of a species different from that of the yellows. Neither can we as yet exclude the possibility that the peach may be less susceptible when young than after it has reached bearing age.

has sometimes been found to have little or no effect in facilitating transmission. The facts which have been taken to indicate a gradual spread of the diseases, and thus have been used as an argument for an epidemic type of infection, are as well or even better provided for in the above suggestion, if proper allowance be made for the fact that such diseases are brought to the attention of pathologists only when they threaten serious damage to commercial interests in the hands of intelligent horticulturists. This would be by no means the first instance where the extension of our knowledge of a disease has been interpreted as an extension of the disease itself. As with most other plant diseases, neither the yellows nor the rosette was recognized as a definite malady until an organized industry was attacked. Both were at first supposed to be local, and though a wide distribution has been ascertained, there is nothing to indicate that either was introduced from Europe or has spread to California, facts which also militate strongly against theories of the constitutional origin of the diseases, though possibly comparable with the failure of the above-mentioned orange-rust mites to establish themselves in the dry atmosphere of California.

That the yellows has not gone south and that the rosette has not come north are also indications that the diseases are not spread entirely from the peach, if we admit that both disorders had probably existed for many decades before their scientific recognition. In fact, the various considerations of distribution are sufficient to warrant a belief in local origin and external infection, and it is not even necessary to insist that they are transferred in nature from one peach tree to another, since the existence of the injurious species in the neighborhood of an orchard would mean that infection might be indefinitely repeated. It is also to be remembered that under the theory of infection of an entire tree by a single puncture it is to be expected that there will be many trees with yellows where none of the injurious mites can be found, since only when fertilized females or both sexes are transferred will the species be multiplied. Thus might the yellows be 'contagious' from some trees, where colonies are formed, while not contagious from others.

But though the mite should be found to breed upon the peach, insecticides would remain useless, since the infected trees are injured beyond repair and may as well be removed and burned, as Dr. Smith has urged. That this policy has appeared to keep the yellows in check in some parts of Michigan may mean that either our supposititious mite or the agent of its transfer to the peach is locally rare. We have, in fact, all gradations from an apparent epidemic in some parts of the East to a merely sporadic condition in Illinois, where competent investigators are not yet convinced that the disease is contagious.

It is a fact well known to entomologists that the numbers of many species of insects and other short-lived arthropoda vary enormously in different years or periods of years. An unfavorable season, an active enemy, or a disease may reduce a species to practical non-existence for a time, until the return of favorable conditions permits a gradual increase to the former numbers, or even to unrecorded abundance. These fluctuations are also closely comparable with those which appear in connection with parasitic fungi and bacteria, species previously so rare as to have remained quite unknown to the botanist often appearing suddenly as the agents of extensive injury. Seasonal and periodic as well as local differences in the apparent 'virulence' of peach-yellows would thus be readily explainable on the present theory, to which plant pathologists need not object because of reasons drawn from the history of the malady.

A permanent solution of the problem on these lines may be postponed by the fact that, notwithstanding their well-known economic importance, the Phytoptidæ remain a little-known group, even from the systematic standpoint, doubtless owing to their excessively small size. But if the present hypothesis should prove to have any basis in fact, it will probably be possible to control or even to exterminate the yellows by the local destruction of the wild relatives of the peach which may be found to harbor the offending creatures. The extent to which this would be necessary for the protection of peach-orchards will depend upon the agency of transmission. Fortunately the mites are without wings, and whether carried by small birds or by insects, the distances whence they would ordinarily be brought are not great. There is thus opened another possibility, at least, of the relief of this important industry from the ravages of maladies which not only cause thousands of dollars of damage annually, but which are chargeable with a further public injury in limiting the production and popular enjoyment of this finest of temperate fruits.

O. F. COOK.

WASHINGTON, D. C.

SCIENTIFIC BOOKS.

Leçons de chimie physique. Professées a l'Université de Berlin. Par J. H. VAN'T HOFF, membre de l'Académie des Sciences de Berlin. Professeur ordinaire a l'Université, et directeur de l'Institut de Physique de Charlottenbourg. Ouvrage traduit de l'allemand par M. COEVISY, Professeur agrégé au Lycée de Saint-Omer. Paris, Librairie Scientifique, A. Hermann. 1899.

The book in hand is a French translation of Van't Hoff's lectures on 'Selected Chapters in Physical Chemistry' which he now delivers at the University of Berlin. As the title implies, the book is not a systematic treatise on the whole subject of physical chemistry, but the number and importance of the subjects dealt with are so great that the scope of the work is not small.

The order of arrangement is quite different from that usually adopted. It is the general custom to take up first the older work in physical chemistry which has to do with the relations between composition and physical properties, and constitution and physical properties. This is then followed by the newer physical chemistry, dealing with solutions and energy transformations in the broad sense; concluding with chapters on chemical dynamics and chemical statics.

Van't Hoff has, indeed, exactly reversed this order. Part first is on Chemical Dynamics, including chemical equilibrium and reaction velocity. Part second, on Chemical Statics, contains chapters on molecular weights, molecular structure and molecular grouping; and it is not until the third and last part of the book is reached that we find a discussion of the relations between properties and composition; comprising relations between physical properties and composition on the one hand, and chemical properties and composition on the other.

In those who have been accustomed to the older order of things this new order of presentation produces a little discord. This, however, may not argue against the method adopted by Van't Hoff. It should, nevertheless, be noted in this connection that the more generally accepted order of presentation is far more closely in accord with the historical development of the subject, and there are those who believe in the pedagogical value, at least, of the historical method.

The newest work of Van't Hoff, like everything which he has written, is full of original and brilliant suggestions. There is hardly a subject touched, in the whole book, without new light being thrown upon it and new relations pointed out. No one can read the work without feeling that physical chemistry is here treated by a master hand, which not so much compiles as creates.

These lectures are, for the most part, rather advanced, as we should naturally expect them to be. They should, therefore, not be placed