associated with two of these in metabolic insects. The pupa of the Holometabola is regarded as being to a certain extent a phylogenetic stage, analogous to the subimago of the Ephemeridea, but as having developed its peculiarities (quiescence, unchanged external form and profound internal changes) in correlation with the structural differences that separate the larva from the imago. These differences are described as follows:

In the Hemimetabola the whole development appears as at first progressively imaginipetal (total habitus), later as temporarily and progressively imaginifugal (provisional organs), with ontogenetic adaptations, and finally as regressively imaginipetal (involution of the provisional organs). In the Holometabola, on the contrary, development is at first regressively imaginifugal (total habitus and imaginal organs), then progressively imaginifugal (development of provisional organs of first and second order) and finally (in the pupa) progressively (total habitus and imaginal discs) and regressively imaginipetal (involution of provisional organs). Hence the Holometabola are characterized in the metembryonic portion of their life cycle by a regressively imaginifugal type of development, which changes to the progressively imaginipetal type in the pupa. In other words: Whereas the continuously progressive development of the Hemimetabola is not interrupted and is only slightly affected by the formation of provisional organs, the progressive development of the Holometabola up to the imaginal stage suffers a long interruption (during the larval stage) and is not resumed till the transition to the first imaginal stage (the pupa), in order to attain, by passing through this, the definitive imaginal form.

Deegener, like many other students of insect metamorphosis, regards the pupa as a teleological development which enables the organism greatly to lengthen its larval life, and through the magnitude and intensity of the changes which it undergoes, to drop out or fail to recapitulate, a great number of phylogenetic stages and thus to pass directly into the adult condition. The development of such a pupal stage, he believes, has been facilitated by the ability, so frequently observed in insects, to fast for long periods of time. In this connection he might also have called attention to the adaptation of the pupal stage to tiding over unfavorable seasons (cold winters in temperate and boreal, dry seasons in tropical regions), as has been pointed out by Lubbock, Haacke, Handlirsch and others.

WILLIAM MORTON WHEELER

The Systematic Relationships of the Coccaceæ, with a Discussion of the Principles of Bacterial Classification. By CHARLES-EDWARD AMORY WINSLOW and ANNE ROGERS WINSLOW. New York, John Wiley & Sons. 1908.

The book before us is the completed results of work by these authors of which we have had preliminary information through articles in SCIENCE[1] and the *Journal of Infectious Diseases*.[2]

This work is by far the most important contribution to the purely scientific side of bacteriology which has appeared in a long time. It marks the beginning of a new era in bacteriological classification and nomenclature.

The systematic classification of the bacteria has always been extremely artificial and arbitrary. Outside of the three large morphological groups, the cocci, bacilli and spirilla, classification has probably never expressed natural relationships. However useful for purposes of identifying species artificial classification may be, it never reaches its highest function until it tells us more than whether a species has been previously described in the literature. It can never be really useful until it expresses for us the real position of the species in question in relation to other forms, and to some extent, at least, tells us the probable line of descent which the species has followed in its development from other forms. This is the ultimate goal which the classification of all living forms should seek.

A few attempts have been made to recognize certain "groups" among the bacteria, and undoubtedly some of these groups repre-

[1] "A Revision of the Coccaceæ," SCIENCE, N. S., XXI., 1905, 669.

[2] "A Statistical Study of Generic Characters in the Coccaceæ," Biological Studies by the Pupils of William Thompson Sedgwick, Boston, 1906; also *Journal of Infectious Diseases*, III., 1906, 485.

sent natural families or genera. Some of these groups are based on morphological distinctions while others are simply held together by certain physiological resemblances. And in practically all cases as soon as the firm ground of morphological characters is left, and attempts are made to make use of physiological differences, we find systematic bacteriology becoming simply determinative bacteriology, and all semblance of natural relationships is lost in a confusion most bewildering.

It has remained for the work of the Winslows to bring order out of chaos, to show us how it is possible to delimit the different groups of bacteria and to determine their natural relationships, with just as sure a footing, whether we make use of morphological or physiological characters.

Their method of defining bacterial groups is by a study of the numerical frequency of various characters in a large series of cultures. It matters not whether the characters are morphological or physiological as long as they are measurable. It is true this method of defining species is not original with these authors; anthropologists and students of variation and heredity have developed it for the study of their particular facts. Even among bacteriologists it was being used at the same time that the work of the Winslows was going on by Andrewes and Horder in England for the classification of the streptococci. But it was our present authors who pointed out the importance of this method for work with the bacteria, and it is to them that all credit should be given for working out the method and applying it on a large scale to the problem of bacterial classification.

It is not necessary here to refer to the method of biometry. It depends on the fact that fluctuating variations, when measured in a considerable number of individuals, group themselves in a curve which follows the simple mathematical law of chance. If two large arrays of individuals are measured the curves obtained are practically identical. But if arrays from different origins are measured the shape of the curves will differ, as well as the position and height of the modes. Such curves measure the peculiarities of a group as a whole, and serve to discriminate the different types, even though particular members of the groups are indistinguishable. By extending the observations to include the correlation of characters in the different racial types, the statistical method will indicate the systematic relationship of the different types.

As the authors themselves say:

> The biometric methods, which have proved so useful in the study of the races of man, promise to be of even greater value in the systematic analysis of types among the bacteria, where so many factors combine to preserve varietal differences on so wide a scale. If individual strains only are considered, an infinite series of differences appear. If the same strains are considered statistically, that is, if the frequency of a given character be taken into account, it is apparent that certain combinations of characters are much more common than others. Measurement of almost any character by quantitative methods shows that the bacteria examined group themselves on a simple or complex curve of frequency. The modes of this curve indicate centers of variation about which the individuals fluctuate; and these centers of variation are the real systematic units of the group. The recognition of such centers, as specific types, offers the natural and satisfactory compromise between systematic multiplicity and vague generalization. The grouping of specific types is an even more important problem than the definition of the types themselves; and here the correlation data obtained by biometric study are of assistance. A true natural classification is tree-like and includes branches and twigs of varying grades of importance. Genera of bacteria should be aggregates of those specific types which are most nearly related; and the basis of the relationship will differ in each individual case. . . . Finally, the results may be analyzed with two ends in view. First, each center of numerical frequency, marking a group of organisms varying about a distinct type in regard to a single definite property, may be recognized as a species. Second, those species which are bound together by the possession of a number of similar properties may be constituted as genera, and larger groups of genera, still characterized by some characters in common, may receive the rank of families or subfamilies.

The recognition of these principles will throw a flood of light upon all our future at-

tempts to classify the bacteria. It will give us a sound foundation upon which to build our systematic groups. It will give us a simple and natural nomenclature in place of the unwieldy generic names in use at present, and will do away with the tendency so noticeable now to use trinomial or even quadrinomial names.

Besides pointing out the proper way to work out the classification of the bacteria the authors have set us an example of just how to go about the work by their careful study of the Coccaceæ. They collected 500 different strains of cocci from different sources and submitted each one to a series of eleven definite, and in most cases, quantitative tests. The frequency curve for each character was plotted, the modes determined, and these modes were taken as the bases for the establishment of the various groups. The eleven characters were chosen after due deliberation and while there may be a difference of opinion as to the relative value of these characters and others which might have been selected, yet we must agree with the authors when they say that the eleven tests chosen furnished sufficient information to warrant the recognition of the most important natural groups. A further study of the correlation of these characters seems to point to the fact that these systematic units are marked by the general association of a number of independent characteristics. Such an association can be explained, our authors say, only on the ground of relationship, therefore the classification which they have arrived at is a natural one, and one which meets the requirements of expressing the natural relationships of the different groups.

The authors find eight genera among the Coccaceæ, each of which they define and discuss. To the bacteriologist familiar with the earlier classifications some very striking and totally unexpected results appear. First of these is the importance of pigment production as brought out by this method. Hitherto it has been taken for granted that such an easily modifiable character as the production of pigment was scarcely even of varietal rank. But a study of chromogenesis by the biometrical method shows that the production of the various pigments is the property of certain well-defined types, and when we take into consideration the singularly perfect correlation between this property and the fermentation of the sugars, and with other characters, we must agree with the authors that it is really of genetic significance. Second, we find that the authors lay little stress on such characters as the shape and markings of colonies on gelatin or agar, the shape of the liquefaction in the gelatin stab, the luster or surface appearance of agar streaks, characters which we have been in the habit of considering important. They show that for the most part these characters are but the result of differences in general vigor of growth and in the rate of liquefaction of the gelatin. They summon sufficient evidence to support their position so that we are forced to agree with them. But they are careful to state that their conclusions apply only to the Coccaceæ and that some of these characters may be found important when other groups are studied.

The book closes with a summary of the genera and species of the Coccaceæ, an admirable key to these genera and species, and finally a complete bibliography and author and subject indexes.

While the work on the Coccaceæ is most admirably done and gives us a working basis for all future study of these forms, yet its real worth is not in its own intrinsic value, but in its immense suggestiveness for all future work in the classification of other groups of bacteria. We hope that this will be but the first of a long series of monographs dealing with other groups of the bacteria, all worked out along the lines which these authors have so well marked out for us.

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A Treatise on Gold and Silver. By WALTER R. CRANE, Ph.D. New York, John Wiley & Sons. 1908.

The preface states that "The object of this work with others of a series is to give a complete and accurate record of the development