wireless equipment, or one of the several wireless telegraph companies will take the matter up; for although it may not lead to a better understanding of aurora, it might help to the understanding of 'freak distances' over the wire. C. J. STUART.

MONTREAL, October 29, 1906.

THE GLACIAL EPOCH.

TO THE EDITOR OF SCIENCE: While I much regret having overlooked the references to which Professor Chamberlin calls attention in the first few lines of his communication to SCIENCE (October 26, page 531), his further remarks (tending to demonstrate that Dr. Manson's theory is untenable), when considered in connection with the equally modern and equally reliable views of Professor E. W. Hilgard (as expressed in the last paragraph of his paper quoted on page 440 of this journal) afford an instructive illustration of how difficult it is, even for an able and conscientious investigator, to avoid dogmatism in science. J. M. SCHAEBERLE.

ANN ARBOR,
October 29, 1906.

SPECIAL ARTICLES.

VARIATION IN PARTHENOGENETIC INSECTS.

IF, as the Neo-Darwinians claim, amphimixis is the principal cause of variation (of the continuous or fluctuating sort taken by Darwin and Weismann to be the material used by natural selection for species-building), it would seem to follow that much less variation, of this type, should occur among parthenogenetically produced individuals than occurs among individuals of bi-sexual parentage. The Neo-Darwinians explain variation as a product of sex and sex as a product of the necessity for variation.

The variation of bisexually produced individuals is proved by limitless miscellaneous observation and the more recent better compiled and expressed work of biometricians. But data and facts concerning the variation in parthenogenetically produced individuals are not so readily accessible. In the following paragraphs will be found a summary statement of the results of certain observations made by several assistants[1] and myself, on the variation exhibited in certain series of parthenogenetically produced insect individuals.

It is obvious that a comparison of the variation in agamically produced individuals with that of those of bi-sexual parentage *in the same species* would be particularly pertinent. And this we have been able to make in the case of the honey-bee. The variation[2] of various wing characters (dimensions of wings and vein-parts, modification of venation, number of costal hooks of hind-wing, etc.) has been studied in series of drones (parthenogenetically produced individuals) from queen-laid eggs (and also in series from worker-laid (!) eggs) and in series of workers, which are of bi-sexual parentage. Among these series are some (both of drones and of workers) in which the individuals were taken directly from the brood-cells (just as they were ready to issue) and hence before their exposure to any intra-specific (individual) selection on a basis of their adult characters (among which are all wing characters), and other series made up of actively flying, *i. e.*, exposed individuals. There are also series of drones hatched from worker-laid eggs and reared in worker cells (instead of in the usual larger drone cells), the variation in these series having a special interest because of the possibility of its modification by the extrinsic factor, size of cell. In addition to the bee series the variation in wing characters in a series of parthenogenetically produced female plant-lice (Aphididæ) has been studied. The studies are all statistical and quantitative and have been compiled, tabulated and summarized according to the now fairly familiar methods of biometric variation study. In this note only the baldest statement of results can be made, and their presumable significance suggested.

Variation in drone (parthenogenetically produced) and worker honey-bees (of bi-

[1] R. G. Bell, B. E. Wiltz, A. Wellman and F. Yantis.

[2] Some of these data of variation in the honey-bee have already been published by Kellogg and Bell, 'Studies of Variation in Insects,' *Proc. Wash. Acad. Sci.*, Vol. 6, pp. 203–332, 1904.

sexual parentage).—The honey-bee, *Apis mellifica*, is an insect with complete metamorphosis. The larvæ are footless, soft-bodied, white grubs which are born from eggs laid in cells, and which live for their whole life protected and cared for in the cells, those of any one community living under identical conditions of light and temperature and presumably of food and care. Even those of different communities have practically an identical environment. The larvæ pupate in the cells and the imaginal bees issue with wings, legs and numerous other structures wholly formed and in definitive character, and not corresponding to any functional larval parts. The variations, therefore, in the wings —to select structures particularly available for quantitative comparison, and wholly foreign to the larval body as functional parts, *i. e.*, parts capable of use or subject to disuse —must be looked on as variations as strictly congenital and independent of modifying extrinsic influences (*i. e.*, without trace of modifications acquired during development due to varying environment) as it is possible to find among animals. The wings, also, are structures possessed by all the three kinds of individuals composing the honey-bee species, and in all three kinds function identically, so that any variations the wings may exhibit can not be attributed to differences in the special function of the wings in the different kinds of individuals, but may be safely associated with the other general features in the make-up of each kind of individual, and be referred to as fair indicators of the kind and extent of variation characteristics of the different kinds of individuals.

The right and left fore and hind wings (removed and mounted on glass slides) of various lots of drones and workers were examined and measured for variations in (*a*) modifications of the normal (= modal) venation, consisting of the addition of vein spurs in 'slight,' 'fair' or 'marked' condition, and interpolated new incomplete or complete cells; (*b*) dimensions, as length and breadth of the whole wing, and length of vein-parts, these parts determined by the giving off of branches in the insertion of cross-veins; and (*c*) the number of grasping hooks along the costal margin of the hind wings.

The lots studied were: (1) a lot of 300 Italian drones taken from a laboratory hive, (2) a lot of 300 workers taken from same hive, (3) a lot of 48 Italian drones from a field hive, (4) a lot of 300 workers from this hive, (5) a lot of 100 German workers from another field hive, (6) a lot of 200 Italian drones from a field hive which were taken from their brood cells when just ready to issue, (7) a lot of 54 Italian workers from the laboratory hive taken from brood cells, (8) a lot of 25 Italian workers taken from cells and 50 workers acting as nurses (not yet having ventured from the hive) from a field hive, (9) a lot of 26 Italian drones from a field hive, taken from worker cells, (10) a lot of 200 drones from a queenless field hive (these drones hatched from worker-laid eggs and reared in worker cells), and (11) a lot of 60 Italian drones from worker eggs in worker cells taken from the cells at time of emergence. The lots of individuals taken from the brood cells just when ready to emerge (in fully formed imaginal condition with all wing-parts fully developed and in fixed definitive condition) were obtained for the purpose of ascertaining what difference, if any, exists in the amount of variation (in venation of wings) between bees exposed to the struggle for existence and bees not yet so exposed. If selection is really rigorous and intra-specific, that is, if varying individuals are preserved or extinguished on a basis of rigorous selecting among these variations, then one would expect that a series of individuals of any one species examined after exposure to this rigorous individual selection would show less variation than a series of individuals of the same species not yet exposed to this personal selection. The unexposed series should reveal the total amount of the variation characteristic of the species; the exposed series should reveal the amount of variation tolerated by a rigorous intra-specific selection. Also, as the workers in their constant going and coming outside the hive, carrying heavy loads of pollen, and exposed to any danger which slow or imperfect flight might induce, as capture by birds and robber flies, may be fairly said to run much more risk in their life than the drones which make but a single brief daily flight (and that not every day), it might be thought or assumed that this strenuous life of the workers would tend to weed out by life-and-death selection every slight disadvantageous variation in the supporting skeleton (the venation) of the wings, all-important organs in this outside life. The series of drones reared in worker cells were obtained for the purpose of testing the assumption of Casteel and Phillipps (*Biol. Bull.*, V., 6, pp. 18–37, 1903) that extrinsic factors, depending on the shape and size of the brood cells, are of large importance in producing the drone variation. The series of drones hatched from worker eggs were obtained for the purpose of ascertaining the differences, if any, in the amount of variation exhibited by individuals normally parthenogenetically produced (from queen-laid eggs) and those abnormally parthenogenetically produced (from worker-laid eggs).

Now, the results of all this examination, mensuration and compilation (and this work, extending over several years, has been not inconsiderable) might be presented in a detailed way by curves and mathematical expressions, with, I hope, some special interest and profit to students of bionomics (which is evolution), but for the purposes of this note the baldest and most summary statements of them must suffice. These statements are the following: (*a*) In all but one of the characteristics studied, the amount of variation, both quantitative and qualitative, is markedly larger among the drone bees than among the workers, and in the one exceptional characteristic it is no less; (*b*) no more variation in wing characters is apparent among drones or workers that have not been exposed in imaginal condition to the rigors of personal selection than exists among bees, drones or workers, that have been so exposed; (*c*) the variation in wing characters in drone bees reared in worker cells is no greater than that among individuals reared in drone cells; (*d*) the variation among drones hatched from worker-laid eggs is markedly larger than that among drones hatched from queen-laid eggs (the drones of worker parentage are considerably smaller than those of queen parentage).

The significance of these results may be suggested to be: of result *a,* that the blastogenic variation among bees does not depend on amphimixis but is a result of some other factor; of result *b,* that the assumed rigorous intra-specific selection among slight continuous variations, which is a basic assumption in the natural-selection theory of species-forming, does not appear to exist in the case of honey-bees; of result *c,* that the larger variation of drone (parthenogenetically produced) bees compared with worker bees (of bi-sexual parentage) is not an ontogenetic phenomenon due to special extrinsic factors (size of cell) operative during development; and of result *d,* that the farther we get from amphimixis the greater we find the blastogenic variation to be!

I do not mean to insist too strongly on this last conclusion! There are two possible facts which may tend to invalidate it. One is that of the abnormality of parentage; the lack of practise, as it were, of the worker parents in the complex business of reproduction; the other is that our series of drones of queen parentage reared in worker cells is unfortunately too short to safeguard properly the conclusions derived from the study of the variation in it. While, as already stated as result *c,* the variation in this series showed no signs, except perhaps in one characteristic, of being proportionally larger than among drones reared in drone cells, a larger series might have revealed this possible larger variation. But the data of this short worker-cell series are typical of short-series data generally, and the marked lessening of the range in variation shown is quite in consonance with what should be found in a normal fractional part of a large series. However, it is well to accept result *c* with some reservation and hence to carry that reservation over to result *d,* inasmuch as the drones of worker parentage were all reared in worker cells. The actual fact, however, stated in result *c* is wholly true, namely, that the drones of worker parentage show a much larger variation than those of queen parentage. Their coefficient of variation is from 50 per cent. to 75 per cent. greater. Also if results *d* and *c* are to be accepted with reservations, then so are the interpretations of their significance.

It may be said by some that the larger variation in the drones as compared with the variation in the workers may be due to the fact (?) that 'males vary more than females.' This generalization, which is one of Darwin's variation canons, has long been disproved as a general law. It is true in certain cases or classes of cases, these being mostly those in which the males possess certain secondary sexual characters of ornament and bizarrie, such as tufts, plumes, horns, processes, etc. The variation in such characters seems to be larger than in other body parts or at least this is generally believed to be true, although I do not now recall the detailed variation studies on which this belief is based, or should be based. But the characters chosen for study in the bees are precisely such as are not secondary sexual ones or special adaptations but are characters common in structure and use to both drones and workers. In other variation studies of exactly these characters, namely, characters of wing venation, in other kinds of insects, for example, the mosquito, we have not found the males to show a larger variation than the females. In these other cases both sexes are of bi-sexual parentage.

Variation in female aphids (parthenogenetically produced).—In the following paragraphs is presented a brief statement of the variation conditions found to exist in the venation of a series of parthenogenetically produced *female* insects. Unfortunately, the variation of these parthenogenetically produced females can not be compared with that in series of bi-sexual parentage of either sex in the same species, but, thanks to the methods of the biometricians, the mathematical expression of this variation (the coefficient of variation according to Pearson's formula) allows us to compare its extent with the variation of venation characteristics in other kinds of insects, male or female, of bi-sexual parentage.

In a series of 200 winged females of the mustard plant louse (species unknown), produced viviparously by agamic stem-mothers, and collected on the university campus, the variation in wing size, in dimensions of vein-parts, in modification of the venation (addition or loss of branches and cells, etc.) in fore and hind wings, and the number of grasping hooks on the hind wings were studied. In all these characters a notable variation is apparent. In modification of venation (addition or loss of branches, change of forking, interpolated cells and the like), 76 wings out of the 800 show notable variation. No biometric expression can, of course, be given for this substantive variation. For the meristic variation, however, in number of costal hooks, in length and breadth of wings, in length of various vein-parts (varying independently of the varying size of the wings) the coefficients of variation have been determined, and are notably large. For example, they are as large as the coefficients of the variation in similar wing-parts in mosquitoes,[3] ants and worker bees, in all of which amphimixis is the rule. We have not been able to compare the variation in parthenogenetically produced aphids with that in the early spring generation of stem-mothers that comes from eggs of bi-sexual parentage. Perhaps we shall be able to do this in another year. But what we have already before our eyes is sufficient to show us that variation actually exists among these parthenogenetic individuals in extent and character sufficient to serve natural selection as a species-building basis, if the familiar fluctuating, continuous or Darwinian variation ever is sufficient for this purpose. Amphimixis is not only not necessary in order to insure Darwinian variation, but there is no evidence (that I am aware of) to show that it increases this variation. There is, on the other hand, a little evidence, some of it pre-

[3] For determinations of variation conditions in these other insects see Kellogg and Bell, 'Studies of Variation in Insects,' *Proc. Wash. Acad. Sci.*, Vol. 6, pp. 203–332, 1904.

sented herewith, to show that such variation occurs, whether the offspring be of uniparental or bi-parental ancestry, and to show that this variation is no greater in amphimixis than among parthenogenetically produced individuals. Yet Weismann's plausible assumption will probably long continue to hold its unproved own.

VERNON L. KELLOGG.
STANFORD UNIVERSITY, CALIF.

A STATISTICAL STUDY OF AMERICAN MEN OF SCIENCE. II.

THE MEASUREMENT OF SCIENTIFIC MERIT.

MANY of the problems that the writer had in view in the present research might be solved by the study of any group of a thousand American men of science, so long as they had been objectively selected. The objective selection of a group sufficiently large for statistical treatment is, however, essential. As cases can be quoted to illustrate the cure of nearly every disease by almost any medicine, so examples can be given in support of any psychological or sociological theory. The method of anecdote, as used by Lombroso, may be readable literature, but it is not science. A thousand names might have been selected by lot from all the scientific men of the country, assuming a list to have been available, but a group of the thousand leading men of science arranged in the order of merit has certain advantages. Information in regard to them can be better obtained than in the case of those who are more obscure. Correlations can be determined between degrees of scientific merit and various conditions. The comparison with a similar group selected ten or twenty years hence, or with a similar group of British, French or German men of science, would give interesting results. The list itself, if printed after an interval of twenty years, would be a historical document of value. Lastly, the data can be so used as to carry quantitative methods a little way into a region that has hitherto been outside the range of exact science. It is the last problem that I wish to take up in this paper.

It will be remembered that we have in each science the workers in that science arranged in the supposed order of merit by ten competent judges, who made their arrangements independently. If the ten arrangements agreed exactly, we should have complete confidence in the result, except in so far as it was affected by systematic or constant errors. If there were no agreement at all, the futility of any attempt to estimate scientific merit would be made clear. The conditions are naturally intermediate. There is a certain amount of agreement and a certain amount of difference of opinion. Thus taking, for example, the ten astronomers—I., II., III., etc.—whose average positions were the highest, the order given to them by each of the ten observers, *A*, *B*, *C*, etc., is as shown in the table:

TABLE I. THE ORDER ASSIGNED TO TEN ASTRONOMERS BY TEN OBSERVERS.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
A	1	2	4	3	10	6	9	5	11	8
B	1	4	2	5	6	?	9	3	8	7
C	1	4	?	5	2	*16	6	17	7	*21
D	?	2	4	3	1	5	7	13	8	6
E	1	*9	2	5	6	3	8	4	7	11
F	1	4	10	2	5	6	3	7	8	11
G	1	3	5	*16	2	6	7	13	4	8
H	1	3	5	7	6	4	9	?	8	2
I	1	2	8	4	10	6	7	3	11	5
J	1	2	4	5	12	8	3	6	13	7
AV.	1.0	3.5	4.8	5.5	6.0	6.6	6.8	7.8	8.5	8.6
av.	1.0	2.9	4.8	4.3	6.0	5.5	6.8	7.8	8.5	7.2
m.v.	0.0	1.4	1.9	2.4	2.8	2.3	1.7	4.3	1.9	3.4
P.E.	0.0	.45	.59	.84	.84	.85	.48	1.15	.54	1.09
p.e.	0.0	.39	.57	.68	.79	.69	.48	1.28	.54	.96