erence. Guenée, however, says his species is very near to *rumicis*, with the same design and nearly the same colors, and this is strikingly true of the witch-hazel species (*subochrea* Grote), whereas *inclara* Smith certainly differs somewhat in design. Guenée's so-called types in the British Museum should not weigh against his descriptions. The descriptions were published fifty years ago and are the ultimate standard, whereas the "types," after transportation and arrangements, are only now invoked. Therefore, I conclude that *Acronycta hamamelis* Guenée should be applied to the Hamamelis Acronycta, and the disagreeable misapplication of the name may be hereafter avoided.

—The last paper was by Prof. Cook, and entitled:

EVOLUTIONARY INFERENCES FROM THE DIPLOPODA.*

By O. F. Cook.

A large proportion of evolutionary arguments and theories have been based upon studies of the characters and habits of such groups as the mammals, birds, insects, and flowering plants. Among these higher organisms there are many acute struggles for existence, and many striking specializations and adjustments to environment have been discovered. As primary evidence of extensive adaptation we have the fact of great diversity in habits and habitats among the members of each of these classes of organisms, and it has naturally been supposed that in some manner still unexplained the varied conditions and the selective influences of the ever present competition have induced the changes responsible for the existing variety of form and structure.

As a test or "control" of such inferences no better experiment could have been devised than the Diplopoda or "thousand-legged worms," a class of animals of great antiquity, some Carboniferous types not differing greatly from those of the present day. Since the Coal Period the insects have sought openings in all parts of creation, and have accomplished the most complex and wonderful adaptations to other animals and plants and to each other. They have distributed themselves over the whole earth, not excepting the air and water. The conservative diplopod, on the contrary, has shown no such enterprising tendencies. His ancestors chewed for a livelihood on Sigillarian stumps of Nova Scotia, and though the Sigillarias have been extinct for ages his predilection for rotten

* The inferences here presented were afterward summarized and formulated as "A Kinetic Theory of Evolution." (*Science*, N. S., XIII, 969-978, June 21, 1901.)

stumps is in no way abated. He has not accustomed himself to any other diet than decaying vegetable matter, and he has developed no very acute preferences regarding the origin or quality of this simple provender. Back in the Carboniferous or before, he made a single invention of sufficient effectiveness to secure immunity from molestation until the advent of the nineteenth century naturalist. He anticipated, in fact, the warfare of the future, and is prepared to deliver broadsides of prussic acid and other noxious substances,* which render him an unpleasant companion and an unpalatable morsel. But notwithstanding this effective equipment he has remained an anti-expansionist. Others have striven for possession of the earth, air, and water, while he continues to live because he can subsist on what is not useful to his more enterprising relatives.

Food being plentiful and unvaried, he has had no need to follow the insects in specialized mouth parts. Having no enemies, and living in concealment, he cannot be accused of mimicry or other ruses for self-preservation. He has not invited destruction by injuring others, nor overreached himself by attempting to increase too fast, and thus destroyed his own means of subsistence. His eyes, when not altogether wanting, are only useful in his efforts to keep from exposure to light, which is soon fatal; perhaps it poisons him by disintegrating his defensive ammunition. He cannot be seen by his mate, so that sexual selection cannot be invoked to explain his bright colors,† nor can these be looked upon as warnings to enemies, since he leaves concealment only at night.

The diplopod has, in short, been exceedingly careful to keep outside the undignified struggle for existence. If he has become differentiated, it is on his own motion and not as a concession to enemies or adverse circumstances. The Diplopoda offer, perhaps, the finest of opportunities for the study of variation accumulated without interposition of the principles of selection. Without the introduction of diversity into the life-history of the organism, there have come into existence numerous groups showing great and constant structural differences, but each apparently filling with equal success the same place in the economy of nature.

In the insects we find numerous adaptations of obvious utility occurring within ordinal and even within family limits, but in the diplopods similar reasoning finds but the slightest application. Drawings illustrating the peculiar characters of some members of the African family Oxydesmidæ are submitted herewith.‡ While

* *Science*, N. S., XII, 516–520, October 5, 1900.

† Eyes are entirely wanting in the large order Merocheta, to which belong nearly all the bright-colored species.

‡ To be published elsewhere with a revision of the Oxydesmidæ.

in some respects unique, they are not more wonderful nor more difficult of explanation than numerous other differences to be found among the members of this class. Such extreme cases are, however, of special interest, since they illustrate more strikingly the evolutionary status of the group. Among the highly adaptive insects it would be extremely rash to deny that any or all structural characters would find an explanation based on natural selection,* and in the Diplopoda we have also many peculiarities of apparent utility which obviously may have been brought to their present perfection in this way. It is, nevertheless, worthy of note that in the Diplopoda such adaptations are almost exclusively sexual, in accordance with the extremely simple ecologic relationships noted above.

The Diplopoda have probably not been threatened with extinction by natural enemies, nor are their numbers kept down by inadequate food supplies. With them the struggle for existence centers rather about the problem of reproduction, their methods being at once primitive and complicated. In the different orders and families the extremely varied copulatory legs have been supplemented by other contrivances frequently similar in function and yet different in structure and origin. Specially thickened, or in other cases unusually elongated, claws, pads of hairs, fleshy soles or cushions, rows of tubercles and other contrivances, have, for example, been variously and independently provided to render the last joint of the legs of males more effective in assisting copulation. The mechanical ingenuity of the group, so to speak, seems to have exhausted itself in this direction, and yet structure and color, although neglected by selection, have by no means remained uniform.

Even in dealing with groups more adaptive than the Diplopoda, writers on natural and other forms of selection have been

* Professor Romanes held that a majority of minor specific differences have no assignable utility, a view which he supported by reference to the color differences of birds and mammals. Had his observations extended to the Diplopoda there would have been no need of such limitations either to shades of color or to specific characters, since in this group structural characters of genera and families are as obviously useless from the standpoint of relation to environment It is true, as pointed out by Professor Romanes, that the birds and mammals "represent the highest products of evolution in respect of organization," that is, they have been subjected to an extended experience of acute natural selection throughout which there would have been a strong tendency against the accentuation of certain classes of structural characters, though, as in the Diplopoda, divergences might continue to accumulate in internal or reproductive structures which do not affect external appearance or efficiency in the struggle for existence.

constrained to admit that their favorite principles must have raw materials to work upon. In other words, the advantageous structure or habit must reach the point of being advantageous without the assistance of the principle which then stands ready to encourage its development. Notwithstanding this defect, the theory of selection as variously analyzed and sub-divided has been and is still advanced as an adequate explanation of the *modus operandi*, if not as the actual cause, of evolution.

In groups where complex adaptations to external environment have taken place, the issues are so mixed that contributions of natural, sexual, germinal, or other forms of selection and their resulting coordinations can scarcely be estimated, even in the most general way. The nicety of many adaptations has so encouraged the imaginative mind that extended flights of fancy have not unfrequently passed as sober theory, if not demonstrated fact. Of a bird or an insect blown to a new region, where it changes its climate, food, habits, and even its enemies, much may be predicated with comparative safety, and with sufficiently numerous factors of undetermined importance supplied by conveniently fortuitous circumstances, selection may be made to appear as the main-spring as well as the balance-wheel of creation. But among the diplopods, at least, the simplicity and uniformity of external adaptation, considered in connection with the quantity and constancy of the internal diversity of the group, seems to warrant a view for which analogy indicates a wider application. Diversity is seen to be essentially independent of selection. Selection accelerates, retards, or even reverses evolution, but by interference in a succession of changes which it does not cause. Segregation, of whatever kind, permits the accumulation of variations which it does not initiate nor direct. The biology of the Diplopoda indicates that facilities in the way of segregation have long been ample for the differentiation, not alone of species and genera, but of families and orders. To prove with reference to any individual case the negative proposition that no selection has intervened would be impossible, but the honest student will find the Diplopoda and other groups of similar ecologic status replete with instances of which the unique dorsal processes of the Oxydesmidæ are a minor example. As a single more general illustration may be mentioned that of the repugnatorial pores, constantly present in some orders and constantly absent in others, but in the Merocheta having the peculiarity of occurring in interrupted series. The presence, or rather the absence, of these organs may well be correlated with habits or environment, but that the omission of the pores of a single segment or two segments from an otherwise continuous series is a matter of selective advantage or disadvantage is very difficult to believe.

Pore Formulæ of Merocheta.

Strongylodesmus	5	...	7	8	9	10	11	12	13	14	15	16	17	18	19
Helodesmus	5	...	7	8	9	10	11	12	13	14	15	16	17	...	...
Gomphodesmidæ (numerous genera), Eurydesmus	5	...	7	...	9	10	11	12	13	14	15	16	17	18	19
Polydesmus and nearly all genera not noted here	5	...	7	...	9	10	...	12	13	...	15	16	17	18	19
Napodesmus, Hynidesmus, Cylindrodesmus, Brachydesmus, Scytonotus	5	...	7	...	9	10	...	12	13	...	15	16	17	18	...
Cynedesmus	5	...	7	...	9	10	...	12	13	..	15	16	...	...	...
Comodesmus	5	...	7	...	9	...	...	12	...	...	15	..	17	18	
Heptadesmus*	5	...	.	...	9	...	...	12	...	...	15	...	17	18	19
Batodesmus	5	...	.	...	9	...	...	12?	...	...	15?	...	17?	...	...
Psochodesmus	5	...	7	...	9	...	...	12	13	...	15	...	...	...	...
Stenodesmus, Biporodesmus, Duoporus	5	...	.	...	...	...	...	...	...	...	...	...	...	...	...
Pterodesmus, Xanthodesmus	.	...	7	...	9	10	...	12	13	...	15	16	17	18	19

Since in all other orders of Diplopoda the repugnatorial pores occur in uninterrupted series, that condition may be considered to have been ancestral in the Merocheta as well. The unrelated monotypic genera, Strongylodesmus from Mexico, and Helodesmus from Java, approximate a continuous series, the sixth segment being the only break. The South American genus Eurydesmus, and numerous East African genera of Gomphodesmidæ, have but two interruptions, segments 6 and 8. The formula of Polydesmus is, however, that which on account of its very general prevalence, is looked upon as normal for members of this order, occurring as it does in families the most diverse in other characters. With the exception of those of the genera mentioned above, all other formulæ may be considered as reductions of that of Polydesmus, the absence of pores from segments 6, 8, 11 and 14 being invariable.

Not only is there diversity in the number and distribution of the repugnatorial pores of the Merocheta, their position on the segments and the attendant structural modifications are equally varied and as little likely to have been brought about by any advantage pertaining to the different conditions. Some are close to the margin, some remote; some elevated on tubercles or stalks, others sunk in depressions. But these details are merely illustrations, not arguments, since on no one character or set of characters could a negative proposition be established. The case must rest on the phylogenetic, biologic and ecologic unity of the

* A new genus of Oxydesmidæ from West Africa. The type is *H. connivens* (Cook), described as *Scytodesmus connivens*, Brandtia, p. 10, 1896.

group, viewed in contrast with its structural and evolutionary diversity.

And since such facts are numerous in other fields of biology, there appears to be justification for the view that evolution is a kinetic phenomenon, or an active process of change, from the standpoint of the organism, instead of the result of a passive subjection to external interference in otherwise stable conditions.

The static character of many evolutionary theories is obvious, and even those which depend upon physical or chemical lability as the moving force in vital phenomena, predicate, in effect, a tendency to stable equilibrium. The contrary view is that evolution is one of the normal properties of protoplasmic organisms ; change is the law, the various forms of selection and isolation are the incidents. Underneath the minor fluctuations which have been denominated "fortuitous variations," is a continuous motion, though not in a fixed direction. The minor variations may be looked upon as "feelers" for lines of least resistance, but motion there must be. Selection or isolation may accelerate or retard the evolution of the species, but permanent fixity of type the breeders of plants and animals have long since found impossible.

A kinetic theory of organic succession is not without bearing upon other evolutionary questions. For example, the acquisition of new characters, as in the case of the dorsal processes of the Oxydesmidæ, becomes, in a sense, an axiomatic proposition requiring no special explanation apart from the facts of normal reproduction. Heredity to the extent of absolute duplication does not appear as a part of the programme of nature, and impartially fortuitous variation in any character or characters could result only in a stable, non-progressive average—a state of specific equilibrium. To disturb this and make evolution possible, it has been believed necessary that selection or other external stimuli must be universally predicated. Under the kinetic view, variations may be supposed to arise and to be preserved as a part of the normal and necessary process of change, or because they are variations. The nature of the causes of change is not revealed, but it can be understood that the progressive modifications of successive individuals may not be different in kind, or in any way more mysterious than those of the single individual, except from the standpoint of biologists who have invented complicated mechanical theories to account for what have appeared to them as temporary disturbances of otherwise stable conditions.

The utility of a variation is not determined by the organism, but depends upon the conditions encountered, and the testimony of such groups as the Diplopoda indicates the impartial preservation of useful and useless characters. Selection works by elimination and affects the descendants of the survivors only as an active form of isolation—by limiting descent to those in which the character or power of immediate advantage is already sufficiently pronounced to be of use. But after progressive modification without selection has carried a new feature to the point of utility, it seems gratuitous to predicate another agency as necessary for its further accentuation.

Instead of nicely balanced opposing principles, heredity and variation may prove to be merely two aspects of the same process of gradual change. Organisms react, within limits, to external conditions, some being more adaptive or more plastic than others; they also acquire new characters with greater or less rapidity, but it is not necessary to insist upon any causal connection between these two facts. In some senses acquired characters are hereditary, but it is not necessary, on the one hand, to believe that they originate from external causes, or, on the other hand, that they are predetermined by an inflexible principle of development. Of course, there are other senses in which it is true that no characters are inherited, only tendencies and potentialities, but this does not alter the case when a series of individuals is viewed as a segment of the evolutionary progress of a species.

The history of the individual, like that of the race, variety, or species, shows a process of continuous change or progressive evolution which proceeds in spite of uniformity of environment. Isolation, whether geographical or due to selection or domestication, may influence the direction and rate, but is in no proper sense a cause of the motion.

May 9, 1901.

The 161st regular meeting was held at the residence of Mr. John D. Patten, 3033 P street N.W., the chair being occupied, in the absence of the President and both Vice-Presidents, by Dr. Gill. The others present were Messrs Ashmead, Chapin, Barber, Busck, Howard, Morris, Kotinsky, Patten, Currie, and Sanderson.

Mr. Morris called the attention of the Society to the public exhibition, soon to be held, of the botanical and zoological work of the Washington high schools.

Under Short Notes, Dr. Howard spoke of the many inventions for trapping insects at light recorded at the U. S. Patent Office, mentioning in particular one such device being manufactured in large quantities by a man at Hazeltine, Missouri, for destroying the Codling Moth. He regarded the statistics concerning insects