the grayish pulverulent appearance of the extremities that the wear was greater on the ends than on the sides, though it should be remarked that this pebble was probably thrown sideways quite as frequently, if not more frequently, than endwise against its neighbors.

THE GENERIC EVOLUTION OF THE PALÆOZOIC BRACHIOPODA.

BY AGNES CRANE, BRIGHTON, ENGLAND.

IT is a time-honored saying that "a prophet is not without honor save in his own country," but the name and fame of Professor James Hall, LL.D., director of the State Museum of Natural History of New York, and its veteran State geologist, are well known in Canada and the United States and have long been recognized and appreciated among the geologists and invertebrate palæontologists of Europe. The highest recognition in geological circles was accorded him nearly a quarter of a century ago, when he was awarded the Wollaston Medal of the Geological Society of London, the year after Barrande, and a year before Charles Darwin received it. His arduous life-long researches have resulted in the production of the fine series of monographs of "The Palæontology of New York," of which Vol. VIII., Part I., Brachiopoda,[1] by James Hall, assisted by John M. Clarke, has recently made its appearance, with an unusually interesting text and the well-executed plates for which the series has been remarkable. As a fossil brachiopodist Professor Hall ranks with his eminent contemporaries, the late Dr. Thomas Davidson, F.R.S., and Joachim Barrande of Prague. In one respect he may be said to take higher position as a philosophical investigator, inasmuch that he kept free from prejudice with regard to the theory of evolution as applied to the class Brachiopoda at a time when, owing to the condition of our knowledge of the group, it was not possible to adduce actual proofs of the logical postulate in that direction.

Times and methods have changed indeed since the celebrated Bohemian palæontologist definitely proclaimed that the evidence of the Cephalopoda[2] and of the Brachiopoda[3] was opposed to the truth of the theory of evolution, and Dr. Davidson, in answer to a personal appeal from Darwin, replied that he was unable to detect direct evidence of the passage of one genus into another.[4]

There has been a marked advance in the philosophical treatment of this important group of ancient and persistent organisms during the last decade, and to this progress American scientists have contributed largely. Mr. W. H. Dall has differentiated and described some new genera and species of the recent forms of interest and value. Professors Morse, Brooks, and Beyer, and of late Dr. Beecher and Mr. Clarke, have revealed suggestive phases in the developmental history of typical genera and well-known species. Now Professor James Hall and Mr. J. M. Clarke have sifted and compared the vast accumulations of data recorded by earlier writers by the older methods of descriptive palæontology, and, combining the results thus gained with the best features of the new school of investigators, have effected a revolution in the general treatment of the entire class of Brachiopoda. They trace important stages in the phylogeny of the fossil forms and various links connecting them through their immediate successors with the surviving members of the group.

Much of this work could not possibly have been accomplished had it not been for the mass of descriptions and figures of the vast number of species recorded in the works of Barrande, Davidson, De Koninck, D'Orbigny, Defrance, Deslongchamps, Suess, Lindstrom, Pander, Quenstedt, Geinitz, Littell, Oppel, Oehlert, Waagen, and Neumayr, in Europe, and Billings, Hall, Clarke, Meek, Shumard, Worthen, Walcott, White, Whitfield, and others on the continent of America.

[1] Natural History of New York. Palæontology, vol. viii. (Geological Survey of the State of New York), "An Introduction to the Study of the Genera of Palæozoic Brachiopoda." Part. I. By James Hall, State Geologist and Palæontologist, assisted by John M. Clarke. Albany, 1892.

[2] Cephalopodes, Etudes Générales par Joachim Barrande, Prague, 1877, p. 224.

[3] Brachiopodes, Etudes Locales, *Ibid*, 1879, p. 206.

[4] "What is a Brachiopod?" by Thomas Davidson, F.R.S., Geological Magazine, Decade II., vol. iv., 1877.

The warm and discriminating recognition of the valued labors of his European fellow-workers is one of the most agreeable features of Professor Hall's new volume. It is pleasant to read "of the greatest of all works on the Brachiopoda by Thomas Davidson," of the just appreciation of Barrande's herculean efforts in the Silurian field, of the excellence of William King's anatomical investigations, to find Pander's early work valued and his names restored. These are just and generous tributes to the memory of comrades who have gone before most welcome in these latter days of that strident "individualism" which is often mere egotism in disguise.

The New York palæontologist's recent work is not only a critical *résumé* with descriptions and figures of the Brachiopoda of New York, but a careful analysis of the results of the labors of his predecessors and contemporaries in the same extended palæozoic field of research in the United States, Canada, Russia, Sweden, and Great Britain. This gives it a cosmopolitan value, and affords opportunity, by means of critical comparisons of genera, species, and varieties from the geological horizons of both hemispheres, to recognize the identity of species, to define synonyms, to collate genera and sub-genera, to indicate their inter-relationships, and to illustrate the passage-forms linking one group, or assemblage of allied genera, to another. To this branch of the subject we must now restrict our observations.

With singular modesty the authors refrain, for the present, from proposing any new scheme of classification. The primary division of the class into two orders comprising the non-articulated and articulated genera is adopted. We fail to see why Owen's names of *Lyopomata*, or "loose valves," and *Arthropomata*, or "jointed valves," should have been discarded, for they define the same limits and distinctions as Huxley's simpler, but later, names, *Articulata* and *Inarticulata*, the first of which was employed by Deshayes to designate certain forms of Brachiopoda before the publicatian of Huxley's "Introduction to the Classification of Animals." In England it is generally conceded that the priority and scope of Owen's orders were clearly established by the American systematist, Dr. Theodore Gill. The matter, however, is of less moment now that a general tendency to admit greater ordinal sub-division has arisen. Waagen has proposed six orders, Neumayr eight, and Beecher four, based on the peduncular opening and associated characters.

The names *Inarticulata* and *Articulata* express certain general distinctions. Nevertheless, it is a matter of fact that forms have often appeared which cannot be separated thus, for tendencies to transgress these artificial limits become apparent in various directions. For instance, the species of the Silurian genus *Trimerella* was shown by Davidson and King to be but feebly articulated, and now *Neobolus*, *Spondylobolus*, and Hall's new linguloid genus, *Barroisella*, are shown to exhibit the same propensity. We are glad to note that, although fifteen years have elapsed since the publication of the Memoir on the *Trimerellidæ*, by Thomas Davidson and William King,[5] it is frankly admitted that later observations have hitherto added comparatively little to the results achieved by those eminent investigators and have taken away nothing from their value.

In the present publication the semi-artificial, but convenient, family designations are not adopted, but the genera discussed fall into groups of associated genera, often exhibiting intermediate characters, which link one genus naturally with another. More has been accomplished in this direction than could possibly have been anticipated, and the eighth volume of the Geological Survey of the State of New York (Palæontology) would have made glad the heart of Darwin, for its dominant note is the evolution of genera.

Hitherto *Lingula* has always been regarded as taxonomically at the base of the Brachiopoda in spite of the acknowledged complexity of its muscular system and the date of its appearance in the geological series. It is now shown conclusively to be developed from an obolelloid type which culminated in a faunal epoch anterior to the appearance of *Lingula*, and Brook's history of the development of the living species is cited as confirmatory proof

[5] Quarterly Journal of the Geological Society of London, vol. xxx., p. 124, 1874.

of the direct obolelloid derivation of the palæozoic *Lingulæ* from *Obolella*. *Lingulella* and *Lingulepis*, forerunners of *Lingula*, may be found to be important connecting links, having the outward form of linguloids with the muscular arrangements and narrow pedicle slit of the obolelloids. "The development on the linguloid line has continued, as we believe, from early Silurian to the present time with frequent modifications. From *Lingula* we may depart in many directions. In *Lingulops* and *Lingulasma* we get indications of physiological influences on the origin of genera."

It appears that "augmented muscular energy and concomitant increased secretion of muscular fulcra" with the large size and consequent displacement of the liver induced the thickening of the entire area of muscular implantation. Gradual excavation of this solid plate ensued, and the formation of a more or less vaulted platform, extremely developed, in the feebly articulated Trimerellids of those Silurian seas, which favored the rapid development of the platform-bearing Brachiopoda, a race which was abruptly exterminated at the close of the Niagara and Wenlock period. Hall's new genus, *Barroisella*, is a divergent so marked by the development of deltidial callosities as to indicate their approximating specialization for articulating and interlocking purposes. Thus we get most striking evidence of a tendency to span the interval between the so-called edentulous *Inarticulata* and the articulated genera in the Linguloid and Trimerelloid groups.

The genus *Obolus* is shown to be more specialized than *Obolella*, less so than *Lingula*. *Neobolus* being an intermediate form with cardinal processes, also indicative of progress in this direction towards the *Articulata*. In *Obolus*, however, the muscular scars are excavated as in *Lingula*, not elevated as in the forms tending to *Trimerella*. Thus we get indications in the history of the ancestral Trimerellids of the attainment of a like remarkable resultant along distinct lines of development, of which another instance has been furnished by Messrs. Fischer and Oehlert's recent studies of the development of the living *Magellanæ* of the boreal and austral oceans, to which we had elsewhere occasion to refer.[1] As Hall and Clarke's generalizations are formulated with a due regard to geological sequence, they possess more validity than the phylogenetic deductions enunciated by a Teutonic palæontologist, in which that important factor was somewhat neglected.[2] "We have yet to seek," the American brachiopodists conclude, "the source whence these numerous closely allied primoidial groups are derived, in some earlier comprehensive stock of which we have yet no knowledge. The ages preceding the Silurian afforded abundant time for a tendency to variability to express itself" (p 168).

From this satisfactory discussion of the origin and development of the palæozoic unarticulated genera and species, Hall and Clarke proceed to consider the structure and relations of the far more numerous and more complicated order of the articulated species, and commence with the Orthoids, the lowest forms of the Articulata, as, by common consent, they are now regarded. The allied Strophomenoid, Streptorhynchoid, and Leptaenoids, as defined by Dalman, are then treated of and the first part terminates with a discussion of some carboniferous Productoids. The spire-bearers, Rhynchonelloids and Terebratuloids, of the Palæozoic seas are thus left for the concluding volume, when we may look for a valuable general summary of results and for that systematic classification, based on their completed investigations, which the authors are bound to propose in the interest of students for the root, stem, branches, and twigs of the genealogical tree of the Brachiopoda, as they have definitely abandoned the family names hitherto in vogue. It must certainly be admitted that brachiopodists have often found it difficult, and sometimes impossible, to determine to which of two well characterized families certain annectent forms should be definitely referred.

In Europe, however, the retention of family designations is not always considered incompatible with the modern philosophical and evolutional methods of class treatment. They have been preserved with advantage; for instance, in Mr. A. Smith Woodward's[3] masterly systematic classification of the fossil fishes in the British Museum, and also in Professor W. A. Herdman's[4] exhaustive report on the Tunicata dredged by the "Challenger" expedition, associated in this case with evolutional data and the presentation of numerous phylums showing the inter-relations of genera, somewhat after the same plan as that adopted in the "Introduction to the Study of the Palæozoic Genera of Brachiopoda." With all due respect to the veteran of the old school and the disciple of the new, we venture to submit the impossibility of impressing on the mental retina a permanent photograph of the innumerable and fascinating phylums which they have provided with such industrious research. But we are not all endowed with so much insight, knowledge, and experience.

The most revolutionary feature in the present instalment of their researches on the *Articulata* is the extreme sub-division to which the great group of Orthoids has been subjected. The genus *Orthis* is absolutely restricted to eight species (instead of two hundred), with *O. callactis* of Dalman as the type, and his early figures and original descriptions are judiciously reproduced for the benefit of American students. The remainder of the large number of species are placed under various new genera and sub-genera, or restored to their former appellations. For instance, Pander's name, *Clitambonites*, is once more applied to species unjustly usurped by D'Orbigny's *Orthisina*, and *Plectambonites* of the same Russian palæontologist is restored for the Palæozoic species grouped by the French conchologists and those who followed them under the genus *Leptaena* of authors not of Dalman. The *Leptaena rugosa* of this author is taken as the type of his genus, the scope of which is thus much restricted, and new generic names are proposed for several of the species indifferently described as *Strophomenas* or *Leptaenas* by various authors. Linné's sub-genus *Bilobites* is revived for those abnormal bilobed species of *Orthis*, which, according to Dr. Beecher's investigations, originated from a normal form at the adolescent and mature stages of growth in both direct and indirect lines of development. In view of the extensive breaking-up of the Orthoids, here proposed, into several genera and sub-genera, we are willing to confess that to object to the revival of *Bilobites* would be but straining at a gnat and swallowing the camel. We, however, admit a preference for those among the proposed new or restored designations which give some indications of the former position of the species among genera. Such are *Protorthis*, *Plectorthis*, *Heterorthis*, *Orthostrophia*, *Platystrophia*, and so on. *Orthidium* for the generic divergent nearest allied to *Strophomena* seems a less happy selection. Tabular views, both instructive and suggestive, are given to show the approximate range in the geological horizons from the calciferous shales of the Lower Silurian to the Upper Coal Measures which indicate the appearance, persistence, and extinction of the various genera into which, under new, old, or restored appellations, the Orthoids, Strophomenoids, and Leptaenoids are sub-divided — a sub-division which, with its associated shifting of types will not escape criticism.

There will always be differences of opinion respecting generic values. Here, as Heckel long ago pointed out, the personal equation becomes prominent. We believe Professor Cope was the first to advance the then heterodox view that species could be transferred from one genus to another without affecting their specific characters. Many so termed genera represent what have now become abbreviated transitional phases in the development of the race which, of old time, became stereotyped for periods of longer or shorter geological duration. The researches of Friele and Oehlert on the recent Magellanæ (*Waldhumia*) the ultimate phase of development of the long-looped branch of the Terebratuloids, illustrate this point most clearly. If the inter-relationships and passages of these generic phases are carefully noted, they become so many illustrations of one method of the evolution of genera, which, sometimes, it is evident, originated from causes incidental to individual development, accelerated growth, and the circumstances of the environment.

[1] On the Distribution and Generic Evolution of Some Recent Brachiopoda, By Agnes Crane, Natural Science, January, 1893.

[2] Neumayr, "Die Stämme des Thierreichs Brachiopoda," 1890.

[3] A Catalogue of the Fossil Fishes in the British Museum, Part I., 1889; Part II., 1890.

[4] Reports of the "Challenger" Expedition: Tunicata, vols. vi., xiv., and xxvi.

Professor Hall evidently considers it better to deal with a small number of well-characterized species instead of a large number of ill-defined forms, and that such minor structural internal modifications as can be shown to be constant in a recognized geological horizon should be raised to generic or sub-generic rank. The description and portrayal of such generic divergencies afford the best means for general comparison and thus tend to promote a clearer comprehension of the manifold phases of the evolution of genera. The fact that specific characters sometimes make their appearance in individual development before generic features is most suggestive. For the laws of "science and growth,"[1] first made known by Heckel, and since extended by Hyatt to the *Cephalopoda*, Jackson to the *Pelycypoda*, and Beecher and Clarke to the Brachiopoda, the term auxology[2] has been lately proposed by English systematists, with some elucidative and etymological modifications in Hyatt's terminology. These principles govern individual and specific development of genera. For genera are stages in the life history of the race as distinguished from the genealogical records of the individual. It would seem, however, that just as the co-existence of a large number of individuals tends to perpetuate specific variation, so the simultaneous occurrence of abundance of species in one horizon and area is productive of the divergence of genera.

We cannot enter further into details; enough has been written to show beyond contradiction the value and interest of his "Introduction to the Study of the Genera of Palæozoic Brachiopoda," with its concise descriptions of genera and passage-forms, their inter-relations, and affiliated species. It is rendered complete by excellent specific bibliographies, well considered genealogical trees, showing the common ancestry, diverging lines of descent, and affinities of genera with their geological range, a register of genera and of species, authors' and general index. The work is most creditable to Professor James Hall and his assistant, Mr. J. M. Clarke, and reflects honor on America in general and the State of New York in particular. It deserves to be carefully studied by invertebrate biologists in both hemispheres. We trust the publication of the second part will be proceeded with, and that by its rapid completion, on similar lines of thought, science may be enriched by a general view of the evolution of the Brachiopoda. It is much to be desired that the relations of the secondary and tertiary species should be discussed in a like thorough, philosophical, and generally satisfactory manner.

We have become so convinced of the advantages of this method of treatment, that we have begun to form the nucleus of a collection in the Brighton Museum, destined to illustrate the evolution of genera among the Brachiopoda.

ON THE SO-CALLED INCAS EYES.

BY W. S. MILLER, UNIVERSITY OF WISCONSIN, MADISON, WIS.

AT the time of the earthquake and accompanying tidal-wave which swept over Arica, Peru, August 13, 1868, causing so much destruction of life, property, and shipping, the U. S. man-of-war "Kearsarge" was lying some two hundred miles down the coast. The shock there was comparatively slight to what it was at Arica. Word was received the following morning of the disaster up the coast, and the vessel left immediately to render such assistance as lay in its power. The history of that earthquake is well known. I will refer any who may wish to read an account of the occurrence to an article in *Harper's Monthly* for April, 1869. The late Lieutenant Gardner, U. S. N., was at that time stationed on the "Kearsarge," and it is to him that I am indebted for the material which forms the subject of this article.

After the officers of the "Kearsarge" had rendered what assistance they could towards alleviating the distress caused by the earthquake, they turned their attention to the havoc wrought by the shock and tidal-wave. Prominent amidst the debris, and about a quarter of a mile from the shore, they found a number of so-called "mummies," which had been exposed by the receding tidal-wave. These Peruvian mummies are not mummies in the same sense that we speak of those of Egypt. The Egyptian mummies were preserved artificially from putrefaction by being embalmed, an art peculiar to the people of that country; but the Peruvian bodies are simply desiccated, the conditions of the atmosphere and soil being conducive to their preservation.

The mummies are usually found in vaults or chambers of adobe, roofed with sticks or canes and a layer of rushes; these usually contain several bodies, which are placed in a sitting posture, the chin resting on the knees, the hands being clasped around the knees. Sometimes the face rested on the hands, with the elbows crowded down between the thighs and abdomen. The bodies are wrapped in native cloths and bound with cords. A small thin piece of copper was usually placed in the mouth; this corresponded to the *óbolos* which the ancient Greeks put into the mouths of their dead as a fee for Charon. They were accustomed to bury with them such utensils as they were supposed to need in the country to which they journeyed. The farmer had seeds of various kinds and agricultural implements placed about him; the fisherman had his net wrapped about him, and nearby fish-hooks were placed with barbs wonderfully like those in use at the present time. The wealthy had costly articles in pottery and precious metals buried with them, and it is on account of this custom that many graves have been opened with the expectation of finding valuables. The women had their spindles for spinning, and in some instances the last thing they did before leaving their work forever, as shown by the unfinished web of cloth placed about them. Flowers were found by Lieutenant Gardner as fresh to the eye as if plucked only a short time previous, but of course in a dried state.

Articles of the toilet were also found, such as mirrors, combs made of fish bones set in wood, and hollow bones of birds carefully plugged with cotton and filled with pigments of various colors, while close at hand was the swab used in applying them to the face. Rings were in some instances of the precious metals, but all those seen by Lieutenant Gardner were made of copper; he also found implements for sewing. The children were surrounded by toys of native make.

On account of their nearness to the shore and their surroundings, it is highly probable that the mummies seen by Lieutenant Gardner were those of fishermen and their families.

The most interesting thing about these mummies is the finding of the so-called "Incas eyes." These were of various sizes, corresponding to the age of the individual.

These eyes are of an oval outline, flattened at one end and made up of concentric layers deposited about a central point. They are brittle and quite iridescent. They were found in the orbit, being held in place by the cloth which was bound about the head. Lieutenant Gardner was not certain whether they were placed under the eyelid — the eye being removed — or were outside the lid. His impression was, that they were outside, as they fell out as soon as the cloths which bound the head were removed. I cannot find any reason why they were used.

At first, I thought the eyes were composed of some resinous substance, but as soon as I began to examine them critically, I found that my first impression was erroneous. After examining sections and fragments, softened by long immersion in glycerine, I came to the conclusion they were the crystalline lens of some animal.

The next point to decide was from what animal they were taken. A clue was given by the fact that fragments left in distilled water for a day or two under a dust-shade, developed an odor which I could compare to nothing but that of old bilge water. Although this was a very questionable clue, yet it led to the successful solution of the question.

If the eye of a cephalopod be removed and carefully opened, it will be found that the "anterior of the retinal chamber is occupied by a bi-convex lens divisible into a smaller outer and a larger semi-globular internal part, the two being separated by a membrane." The principle of the well-known Coddington lens is the same as that which enters into the formation of this eye. The posterior portion of this eye is the one made use of by the

[1] αὔξη, growth, and λόγος, science.

[2] See a paper entitled "The Terms of Auxology," by S. S. Buckman, F.G.S., and F. A. Bather, M.A., F.G.S., London, in the Zoölogischer Anzeiger, No. 405 and 406, p. 42 1, Nov. 14 and 28, 1892.