the Darwin celebration in Baltimore last Christmas, there is need of modifying the statement (p. 414) that "it is altogether likely that Lamarck was wholly unacquainted with" [Erasmus] "Darwin's work, which had been published in England." Charles Darwin lived at Downe not Downs.

Is it true (final chapter, p. 441) that experiments with "artificial fertilization by changes in osmotic pressure . . . have greatly altered opinions regarding the nature of fertilization, and of certain other phenomena of development," or (p. 442) that "recent advances in physiological chemistry have greatly widened the horizon of our view regarding the nature of vital activities"? Would not both statements be stronger if more modest in their claims for the results of recent research in these most important fields? It is doubtful if even in a popular book of this sort it is justifiable to attempt to state the duration of geologic periods in years (cf. p. 344–5).

One finds in the book some phrases and sentences whose form is not beyond criticism —(p. 443) "studies of a pathological character"; (p. 294) "sheep and other cattle"; (p. 383) "pigeons and other fowls"; (p. 429) Wallace is said to be "notable for the publication of important books, as the 'Malay Archipelago,'" etc.; the phrase "fossil life," is frequently used, once it appears as "fossil vertebrate life"; it seems strange (p. 337) to refer to Leidy, Cope and Marsh as "these gentlemen" instead of these men. They were big enough to deserve the bigger word. Why does it seem strange (p. 335) to speak of Huxley shedding light "*in* the province of paleontology," for the phrase is good and is exactly what is meant; or why does one smile when the author refers (p. 190) to Johannes Müller as "one of the lights of the world."

A few errors which escaped the proof reader will doubtless be corrected in another edition. The index is so incomplete as to lessen the usefulness of the book. Many important subjects and men treated in the text are not mentioned in the index. Such a historical account does not soon become out of date. It will surely have a number of editions and its minor defects can readily be removed.

Professor Locy has done good service in bringing together into one volume information as to the development of all the broader phases of biology and in presenting a general view which is, on the whole, so sound and well balanced.

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The Young of the Crayfishes Astacus and Cambarus. By E. A. ANDREWS. Smithsonian Contributions to Knowledge. Vol. XXXV. Pp. 1–80, pls. I.–X. Washington. 1907.

The European crayfish has been upon the whole exceptionally fortunate in its biographers, for with it are associated the names of such excellent observers as Réaumur, Roesel von Rosenhof, Rathke, Huxley and Reichenbach, whose combined work, and more especially that of Huxley, have made it a classical type in the teaching of modern zoology. It is accordingly a little surprising that the American species, especially of *Cambarus,* which everywhere abound, should have escaped that careful analysis of their habits and development which their importance would seem to demand, until a series of papers extending to the monograph under review was begun by Professor Andrews five years ago.

The distribution and description of the many species, as well as the embryology and physiology of the common *Astacus fluviatilis* of Europe form the subject of a rather extensive literature, while the behavior and development of the young after leaving the egg, and the interesting family life first described by Roesel more than a hundred and fifty years ago, have hitherto received but scant attention. As the author suggests, this neglect may be attributed in some measure to the lack of a complete metamorphosis for which the crayfishes have been distinguished from the time of Rathke. Since their young are invariably hatched in a form which closely resembles the adult, greater interest has been taken in the life histories of marine crabs and shrimp, which, as a rule, hatch from

small eggs and must pass through a long and fascinating series of changes before the adult form and habit are attained. It should be added, however, that in the modern zoologist the lure of the sea is strong, even when crayfish abound in his back-yard and burrow all over his lawn. Roesel indeed complained of the neglect which obscured the life of common things in his day, and recalled the old Latin proverb to the effect that what is daily seen is little heeded.

In the present monograph, as well as in his earlier papers, Professor Andrews has thrown a light on many obscure questions, and has probably added more to our knowledge of the crayfish family life and general natural history than all previous observers combined.

For the first time the habits and development of an American species of *Astacus*, from the Pacific coast, are described, while its young have been reared to a length of two inches and an age of five months, when they have molted twelve times, and reached essentially the adult state. The behavior of these young is subjected to a careful analysis, and the text is illustrated by a series of excellent pen drawings showing in detail the slight but important changes which ensue in the body proper and its nineteen pairs of appendages during the first three stages, or until the young have become independent of their mother. Careful drawings to a uniform scale have seldom or never been made to represent the complete metamorphosis of any crustacean, and students of this important class will appreciate their value in the present case.

The habits and development of *Cambarus affinis* are treated in a similar descriptive and pictorial way, and the author devotes a chapter at the end to the weighing of the differences and agreements found in the two genera, and to certain speculations upon the possible origin of their diverse dependent stages and family life.

Astacus leniusculus lays its eggs, to the number of five hundred in the cases observed, in autumn, probably in October, and carries them attached to its pleopods all winter; these eggs are dark in color, and very large for a crustacean, having a diameter of two and one half millimeters, which accords with the precocious character of the young at birth. Hatching took place in late April and early May, and extended over several days. The young leave the egg in a relatively advanced but quite helpless condition, and if expelled from the mother, as in the case of the marine lobster, they would perish from lack of parental care, for they present a curious compound of embryonic, larval and adult characters. It is at this juncture that the peculiar family life of the crayfish has been developed to tide the young over a helpless period of infancy to complete independence, and the account of this interrelation of parent and child, and the correlated structures and instincts upon which it is based constitute the most interesting part of Professor Andrews's work.

The family relation in this *Astacus* endures for over a fortnight or until the little crayfish has molted for the second time, and is dependent upon a complicated chain of events, which suggests the story of the old woman who went to market to buy a pig. If the egg-stalk does not adhere to a "hair" of the parental swimmeret or to another egg; if the two egg-shells are not themselves adherent; if a certain delicate thread, which is spun as it were from an embryonic molt shed at hatching time, does not itself stick on the one hand to the telson of the young, and on the other to the inside of the inner egg-shell and thus tether the little one to its mother; if, again, a little later, when its leading string has broken, this young one has not been enterprising enough to seize and "hook on" to some part of the egg-glue with its great forceps, the tips of which have been bent into fish-hook form—it comes to certain grief. The result is fatal, at whatever point the chain weakens and snaps.

A few hours after hatching the helpless little crayfishes, still dangling from the "telson-threads," which secure each to the parent, begin to flap their abdomens, and to open and close their big hooked claws. In this way they manage to seize the old stalk of

the egg, and with hooks embedded in its tough chitinous "glue" they hold on literally "for dear life," often grasping the same stalk with both chelæ. So strong was this seizing and holding instinct that the young when forcibly separated from the mother would sometimes lay hold of a suspended string, and were thus successfully reared until the period of dependence was over. Once fixation with the claws is successful, the telson-thread breaks and the young remain thus attached by the claws alone for a period of from four to thirteen days, according to condition, when they molt to the second stage.

At the second molt this crayfish is for the first time free, and soon begins to descend the parental pleopod, climbs over its mother's body, and makes short excursions in the neighborhood, returning again and again to the alma mater and the family brood. Hitherto it has been sustained solely by the generous supply of yolk inherited from its egg-state, but since the egg-stalks and cases, as well as the cast skins which remain attached to the mother, disappear at this time, it is thought that they are eaten by the young and constitute the first direct food that they receive before beginning to forage for themselves.

The second stage *Astacus* develops a strong climbing instinct; it is brilliantly arrayed in red and blue pigments as well as the colors which the transparent skin transmits from liver and yolk. The swimmerets are functional, and the appendages generally are garnished with numerous sensory setæ; but the powerful "propeller" or tail-fan is not completed by the liberation of the sixth and largest pair of pleopods until the third stage is reached. Then the little crayfish becomes very active, voracious and pugnacious, frequently losing its limbs at the "breaking joints" and as freely regenerating them. At the fourth stage the rudimentary first pair of pleopods make their appearance, and probably in the males only.

The *Cambarus affinis*, which Professor Andrews has studied with marked success, lays its eggs in March or April, and carries them about seven weeks. Its eggs are smaller and rather more numerous than in the *Astacus*, and the young are correspondingly less advanced at the time of hatching. They do not leave their mother until the third stage, but are associated with her for about two weeks only, or for nearly the same length of time as in *Astacus*. In this case also at hatching the young are tethered, and prevented from escaping from the mother, but by an "anal thread" of a peculiar character. When this young escapes from the egg it leaves behind it a larval cuticle or molt, which sticks at two points only, on the side of the mother to the egg-membranes which are adherent to her, and on that of the child to a portion of the intestine where its cuticular lining is not at first set free. As a result of the tension this embryonic molt is stretched and crumpled with a tendency to turn the abdominal part inside out. This telescoping and partial inversion of the discarded cuticle is checked by the flat molted plate of the telson with the resultant production of a narrow creased ribbon, the "anal thread," which is firmly fastened to the intestinal wall.

The young of this crayfish attain a length of two inches during the first summer, when they may be fertilized by a male of corresponding age and lay fertile eggs in the following spring. In one case a female which was reared from the egg laid eggs herself in two successive seasons, when about one and two years old, and when somewhat more than two and three inches long respectively. Andrews remarks that since the young of this *Cambarus* reared in captivity not only laid fertile eggs, but since this was repeated in the next or third generation there would seem to be no obstacle to the domestication of this crustacean and rearing of it upon an extensive scale.

The first two stages of the young are thus not only peculiarly modified for association with the parent, but in some way unknown, correlated structures of a most delicate kind, not to speak of instincts, have arisen in both to bring this about. These may be compared to the first three stages of the lobster, in

which the young is not only a true larva, but pelagic. The lobster also makes good use, but in a different way, of a "lost larval molt," which is shed at the time of hatching. In this case also the molt sticks to the mother, that is, to the inside of the inner egg-membrane or chorion, and by being slightly adherent to the setæ or swimming hairs of the larva, helps to pull them out or evaginate them, and thus bring them into position for immediate use. To escape merely from its egg-shells, without losing in the proper manner this inner cuticular molt, is as fatal to the lobster as the premature breaking of the telson or anal threads would be to the crayfish.

The third stage in the crayfish corresponds approximately to the fourth stage in the lobster, in which the animal passes as if by a sudden leap into the adult-like form, but the transition is less abrupt in crayfishes since their most striking larval characters have been lost.

In giving up the free-swimming habits of their marine lobster-like ancestors, the crayfishes have apparently acquired their peculiar family life, and a "crawling instinct" would seem more in accord with the needs of many of the species which inhabit fresh watercourses liable to go dry, or which even burrow deep in the ground to find the necessary moisture.

The larval history of *Astacus* is thought to be "more primitive in having a more complete representation of a lost larval stage still evident in a complete cast cuticle within the egg." But this cuticle is apparently not homologous with that cast by the lobster at birth, the pre-pelagic stage of this form being represented by an egg-stage in *Astacus*. Again, since the family life is more completely developed in *Cambarus*, and the genus is more specialized than in *Astacus*, "we may therefore suppose," says Andrews, "that as *Cambarus* has migrated over the middle and eastern United States it has become split up into the sixty odd species now found and in some, as in *Cambarus affinis*, has made more perfect the association of young and parent already present in the *Astacus* ancestor."

It is further suggested that the apparent relation between acquisition of family life and migration from the sea to fresh water may be illusory, since metamorphosis has already been reduced in the marine lobsters, and since in bays and estuaries which must have been first encountered this dependent relation would seem to be especially valuable.

While it is easy to speculate on the origin of the specific characters of crayfishes, and we might add of any animals whatsoever, he concludes that "the nature and the amount of differences of the hard parts and in the larval history that distinguish one kind of crayfish from another are such as to raise the question whether utility and natural selection have played any part in their formation or in their perfection. All the specific and generic characters of crayfish may be as useless as color differences, and they may have arisen suddenly perfected as we see them, or they may have progressed in certain lines for long periods of time independent of external agencies." Much more evidence is needed before we can conclude that the various parts and functions displayed "have ever in any manner been connected with utility to the species or with the survival or extinction of individuals. Until the contrary is proven we may therefore regard them as the unmeaning by-products of unknown activities in the living protoplasm."

Such criticisms as are suggested in the reading of this careful paper are of a minor character. It does not seem proper to describe the invaginate matrix cells of the epidermis which secrete the cuticular sheaths of spines or setæ as "glands," since all the superficial cells of the epidermis are chitinogenous. Further, it would appear to be less confusing to limit the use of the troublesome term "larva" to the first two stages of the young, and to designate as "adolescent" or "adult-like" those stages in which the adult characters appear most pronounced, unless we resort to some such cumbersome terminology as that proposed by Hyatt.[1] It is certainly objectionable to designate as "larvæ"

[1] Science, N. S., Vol. V., p. 167.

(p. 39) the older young, which have attained a length of over an inch and may be several weeks, or even months, old.

It might appear hypercritical to raise the question whether the walking legs of a higher crustacean like the crayfish have claws (p. 23). Huxley got around this difficulty by using the terms "double" and "single claws" for the forceps of the first three and the "nails" of the last two pairs of legs, respectively, which describe the conditions met with in the crayfish exactly. This, however, does not correct the inappropriate though technical use of the Latin word *chela* for the pincers alone.

It is certain that metamorphosis in the higher crustacea has been reduced or eliminated under very different conditions in the rather numerous cases in which a reduction has occurred, as seen not only in the common lobsters (*Homarus*), but in many deep sea shrimps, shallow water *Alphei* and terrestrial crabs (*Gegarcinus*). As regards the possible influence which conditions of life in fresh water may entail, it is interesting to note that metamorphosis has been practically eliminated, not only in the fluviatile crayfish, but also in *Palæmonetes varians* of Europe and in *P. exilipes,* of parts of the eastern United States, one of the few fresh-water genera of prawns known, and that in this case their immediate marine ancestor, the common little *Palæmonetes vulgaris,* has a metamorphosis both long and complete.

FRANCIS H. HERRICK

Astronomy of To-day. By CECIL G. DOLMAGE, F.R.A.S. Pp. xvi + 363, with 45 illustrations and diagrams. Philadelphia, J. B. Lippincott. 1909.

The fascination of astronomy seems as strong to-day as in the distant past, when some knowledge of the heavens was essential to the every-day life of the traveler and the householder. To-day the compass, not the pole-star, guides the voyager across the seas and deserts; the watch and the calendar have replaced as timepieces the sun and the constellations, yet the interest in matters astronomical never wanes. To a large extent this interest is due to the ever-widening fields of astronomical research. Fifty years ago astronomy was practically confined to a mathematical explanation of planetary motion, with a few dry statistical facts concerning the size, shape and mass of the various bodies. To-day astronomy deals with the bodies themselves, with their physical conditions, their life histories, and the probable stages of their evolution. Physics and chemistry are the tools with which an astronomer of to-day works, photography and the photographic plate have replaced the eye and the hand in picturing the wonders of the heavens. Now this new astronomy appeals more directly to the popular reader than did the mathematical astronomy of the past century: one is more interested in knowing what a body is and how it came into being, than in learning the minute details of the path it is describing. That such is the case and that the interest in things astronomical is general, is evidenced by the increasing number of popular and non-technical books on various astronomical subjects.

The field of astronomy to-day, however, is so broad, it covers so much ground, that it can hardly be adequately treated of in a single small volume. The space in even a large book hardly suffices to give proper account of a single minor division of the great science. A single volume, which attempts to cover the entire field, can be but little more than a general index, pointing out to the reader the divisions of the subject, the relative importance of each, sketching in a broad way the principal facts and the underlying theories of celestial development, and indicating who the real workers are and where special details and facts can be obtained.

Now in some of these particulars the well got up and attractive book of Mr. Dolmage falls short of what such a book might be. If we regard the amount of space devoted to a subject as indicating to a certain extent the importance of the subject, then this volume shows some rather remarkable conceptions. For us the sun is undoubtedly the most important body in the heavens, it is the center