

9. Embryo of *Astacus fluviatilis* just before leaving the egg. The carapace has been cut away from the side turned toward the observer, in order to show the gills. The first and last pairs of abdominal appendages are undeveloped; otherwise the embryo has the essential characters of the adult, and undergoes no marked metamorphosis after leaving the egg. From Rathke, Untersuchungen über die Bildung und Entwicklung des Flusskrebses, Taf. I. fig. 16, Leipzig, 1829.
10. *Astacus fluviatilis*, two lately hatched young attached by their chelipeds to one of the abdominal appendages of the mother. Four times natural size.  $\delta$ , protopodite;  $\epsilon$ , endopodite;  $\zeta$ , exopodite of the abdominal appendage of the mother.  $\eta$ , ruptured egg-cases. From Huxley, *op. cit.*, p. 41.
11. Spermatozoon of *Homarus Americanus*. From a drawing by Faxon.
12. Embryo of *Homarus Americanus*. VIII, third maxilliped. The dotted line rests on the exopod. The longer endopod extends beyond the tip of the exopod. The endopods of the succeeding pairs of appendages are concealed by the exopods.  $h$ , heart. From a drawing by Stimpson, June 6, 1852.
- 13-16. From drawings by Faxon, Newport, R. I., July 18, 1881.
13. First antenna of embryo of *Homarus Americanus* just before hatching. The shaded part indicates the antenna of the larva seen through the cuticle of the embryo.
14. Second antenna of the same.
15. Tail of the same.  $\sigma$ , median spine of the tail of the first larval stage.  $\iota$ , lateral spine of tail of first larval stage. All the spines of the enclosed larval tail are shortened by invagination.
16. Tail of first larval stage of the same. The larva is about to moult, and the tail of the following larval stage is seen through the cuticle.
17. First larval stage of *Homarus Americanus*. Leaves the egg in the Mysis condition. Natural size, about 8mm. long. From a drawing by A. Agassiz, Nahant, Mass., July 1, 1866.
- 18-30. Development of *Paguridæ*.
18. Section of egg of *Eupagurus Prideauxii* before cleavage. The nucleus has divided into eight, four of which are seen in the section. Each nucleus is surrounded by a thin layer of protoplasm which sends out thread-like processes into the surrounding yolk. The segmentation is at first total, but after the fourth phase the cleavage spheres fuse in the deutoplasmic centre of the egg, and the subsequent cleavage is superficial. From Mayer, Zur Entwicklungsgeschichte der Dekapoden. Jenaische Zeitschr., XI, Taf. XIII. fig. 1, 1877.
19. The same after the fourth cleavage.  $nc$ , nuclei surrounded with a layer of protoplasm. From Mayer, *op. cit.*, Taf. XIII. fig. 4.
- 20-23, 25-30. From drawings by Faxon, Newport, R. I., August, 1881.
20. First larval stage of *Pagurus*. Leaves the egg in the zœa form, the first and second maxillipeds serving as locomotive organs, the third maxillipeds (VIII) present but rudimentary. No thoracic or abdominal appendages. The sixth abdominal segment is fused with the telson. The posterior thoracic segments are potential merely.
21. First antenna of the same.
22. Second antenna of the same.  $sp$ , spine.  $ri$ , rudimentary flagellum.  $re$ , squamiform appendage.
23. One half of the hind border of the tail of the same, armed with seven setæ, the sixth of which (counting from inner side) is reduced to a small curved hair. Within the tail, represented by light shading in the figure, are seen the caudal setæ of the next larval stage. It appears that the inner seta of the first stage will be replaced by two ( $1'$ ,  $1$ ) in the second larval stage.
24. Tail of embryo of *Eupagurus Prideauxii*. The seta numbered 6, which becomes a rudiment in the first larval stage, is well developed. All the setæ are feathered except the outer ones, 7. From Mayer, *op. cit.*, Taf. XV. fig. 43.
25. Tail of second larval stage of *Pagurus*, from Newport, R. I. Comparison with Fig. 23 shows that a new seta ( $1'$ ) has been developed on the inner side of the seven primary setæ of the first larval stage.
26. Mouth parts of the same.  $lb$ , labrum.  $mt$ , metastoma. III, mandible. IV', IV'', IV''', first maxilla. V', V'', V''', V''''', second maxilla.
27. Third larval stage of *Pagurus*. The exopods of the third maxillipeds have become functional swimming organs. Rudiments of the chelipeds (IX) and two or three following pairs of thoracic appendages have appeared, and they are simple from the time of their first appearance. There is thus a syncopation of the Mysis stage in *Pagurus* and in *Anomoura* generally. In the suppression of the Mysis stage and in the late functional development of the third pair of maxillipeds, the *Anomoura* resemble the *Brachyura* rather than the typical *Macroura* like *Palæmonetes vulgaris* (see Pl. XI.). In the structure of the second antennæ, spatulate form of the terminal segment of the abdomen, and the appearance of the posterior abdominal appendages (XIX) in advance of the rest, *Pagurus* agrees in its development with *Palæmonetes vulgaris*. XIX, last pair of abdominal limbs. Their inner branch is commencing to grow as a small lobe from the proximal end. The sixth segment of the abdomen is now a free segment.
28. First antenna of the same.
29. Second antenna of the same.
30. Telson and appendage of sixth abdominal somite.  $\kappa\epsilon$ , rudimentary inner branch of appendage. The Arabic numerals indicate the correspondence of the setæ of the telson with those in the earlier larval stages.

PLATE XIII.

*Development of DECAPODA, continued. Figures from ALEXANDER AGASSIZ and WALTER FAXON.*

<i>b r.</i> Gill.	<i>l b.</i> Labrum.	<i>r e.</i> External branch of appendages.
<i>c t.</i> Embryonic cuticle.	<i>m t.</i> Metastoma	<i>r i.</i> Internal " "
<i>h.</i> Heart.	<i>o c.</i> Eye.	<i>s t.</i> Stomach.
<i>i.</i> Intestine.	<i>r.</i> Rostrum.	

The Roman numerals denote the appendages of the body in their consecutive order.

- 1-9. Development of *Paguridae* (continued from Pl. XII.).
1. Larva of *Pagurus*, from Newport, R. I. Later stage than the one represented by fig. 27 on the previous plate. Viewed from the dorsal side. The abdomen now carries five pairs of appendages, on the second to the sixth somites. From a drawing by A. Agassiz, Newport, R. I., August 4, 1875.
- 2-4. From drawings by Faxon, Newport, R. I., August, 1878.
2. Larva of *Pagurus* of about the same age as the one represented by fig. 1. Lateral view.
3. The same, ventral view.
4. One half of the hind border of the telson of the same. Seta 4 has become very short, so that the armature of the telson at first sight appears to be the same as in the first larval stage (Pl. XII. fig. 23).
- 5-9. From drawings by A. Agassiz.
5. Older stage of a *Pagurus* from Naushon Island, Mass., August 23, 1865. 2½ mm. long. This is the genus *Glaucothoë* of Milne-Edwards, *Prophylax* of Latreille. The two sides of the body and the appendages are still symmetrical, except in the greater development of the chela of the right side. The two posterior pairs of thoracic appendages are much shorter than the anterior pairs. All the abdominal somites bear appendages except the first.
6. Abdomen of the same, from the ventral side.
7. One of the abdominal appendages of a little older stage, when the abdomen begins to curl to one side.
8. Young *Pagurus* from Newport, R. I., August 23, 1875, at the age when it takes up its abode in a Molluscan shell.
9. Abdomen of a little younger specimen than fig. 8, showing the atrophy of the curled side. Newport, R. I., July 24, 1876.
10. Zoëa stage of *Porcellana (Polyonyx) macrocheles*. First stage after shedding the embryonic cuticle. VIII, rudimentary third maxilliped. From a drawing by A. Agassiz, Newport, R. I., August 31, 1865.
11. Last zoëa stage of the same. 16 mm. from tip of rostrum to tips of posterior horns of carapace. The first antennæ are now two-branched. The five posterior thoracic appendages (IX-XIII) are present in a rudimentary shape, bent up under the carapace. The telson is not distinct from the sixth abdominal somite. The second, third, fourth, and fifth abdominal somites carry simple unsegmented appendages. From Faxon, On some Young Stages in the Development of *Hippa*, *Porcellana*, and *Pinnixa*, Pl. II. fig. 1. Bull. Mus. Comp. Zoöl., V., 1879.
12. Third maxilliped of the same stage, more highly magnified. *r i.*, inner branch. *r e.*, outer branch. From axon, *op. cit.*, Pl. II. fig. 12.
13. Five posterior pairs of thoracic appendages (chelipeds and ambulatory limbs) of the same stage, removed from the body. *b r.*, gills.
14. Young *Polyonyx* following at a single moult the zoëa represented in fig. 11. Dorsal view. Length of carapace, 2 mm. It has now all the essential characters of the adult. The sixth abdominal segment is now separated from the telson by a movable joint, and bears a pair of appendages (XIX). From a drawing by A. Agassiz, Newport, R. I., August 30, 1865.
15. Adult specimen of the same, from South Carolina, twice the natural size, viewed from above. Observe the width of the carapace compared with that of the young stage represented by fig. 14. From Faxon, *op. cit.*, Pl. III. fig. 11.
- 16-18. *Carcinus maenas*. From Faxon, On some Points in the Structure of the Embryonic Zoëa, Pl. I. Bull. Mus. Comp. Zoöl., VI., 1880.
16. Young just after it leaves the egg (protozoëa stage). ¼ mm. long. Within the transparent embryonic cuticle may be seen the zoëa as it will appear at the next moult. The cuticle of the abdomen is unsegmented, has no rostral or dorsal spines, nor appendages back of the second maxillipeds. The two pairs of antennæ are enormously developed as in nauplii or the protozoëa of *Peneus*, &c. VIII, IX, X, third maxilliped and first two ambulatory appendages of the adult, seen through the cuticle.
17. Caudal fin of the same stage. The tail is forked and bears on each side seven spines (1-7). At this stage the tail of the Brachyuran larva can be compared part for part with the fourteen-spined caudal fork of the larvæ of the lower *Decapoda*, e. g. *Peneus*. (See Pl. IX. figs. 14, 18.) The shaded portion represents the tail of the following stage, seen through the transparent cuticle. 1'-5', spines on the tail of the next (zoëa) stage, much shortened by invagination. 4' becomes the great lateral prong of the tail of the zoëa. (See Pl. XIV. fig. 2.)
18. The same in the process of moulting the protozoëa cuticle. *c t.*, cuticle peeling off from the abdomen. After the cuticle has fallen off from the tail the little hooks which terminate the caudal fork of the zoëa are used to tear the embryonic membrane from the anterior parts of the body. The great dorsal spine of the zoëa which has been bent down forwards upon the back is now unfolding and lifting the cuticle as it rises.

PLATE XIV.

*Development of DECAPODA, continued. Figures from WALTER FAXON and CARL CLAUS.*

a.	Anus.	sp.	Spinous process of second antenna of zoëa.
ab.	Abdomen.	st.	Stomach.
br.	Gill.	α.	Dorsal spine.
h.	Heart.	β.	Ophthalmic artery.
i.	Intestine.	γ.	Spine on the second somite of abdomen.
lb.	Labrum.	δ.	Lateral spine of carapace.
oc.	Eye.	ε.	Mandibular palpus.
r.	Rostrum.	ζ.	Tendon of mandibular muscle.
re.	Exopodite.	η.	Retinaculum.
ri.	Endopodite.		

- 1-4. *Carcinus maenas* (continued from Pl. XIII.). From Faxon, *op. cit.*, Pl. II.
1. First zoëa stage, immediately succeeding the stage figured on the preceding plate. VIII, IX, X, rudimentary third maxillipeds and first and second ambulatory appendages. The abdomen has six segments, the telson being not yet separated from the sixth somite.
  2. Tail of the same stage. The Arabic numerals indicate the homology of the spines with those of the tail of the protozoëa (Pl. XIII. fig. 17).
  3. First antenna of the same stage.
  4. Second antenna of the same stage. *sp.*, spinous process corresponding to the spine on the second antenna of larvæ of prawns (Pl. XI. fig. 11, &c.) and *Paguridae* (Pl. XII. fig. 22). *re*, squamiform process, homologous to the external branch of the antenna of larval *Macrourea*, to the antennal scale of adult *Macrourea*. Both of these parts become aborted in the adult. The flagellum (endopodite) of the second antenna of the adult is wanting in the youngest zoëa stages, or represented only by a small tubercle at the base of the squamiform process.
- 5-11. From Claus, *Untersuchungen zur Erforschung der Genealogischen Grundlage des Crustaceen-Systems*, Taf. X., XI., Wien, 1876.
5. Later zoëa stage of a Portunid from Chili. 4 mm. long. This is probably the last zoëa stage, preceding the megalopa. The first and second maxillipeds still serve as swimming organs. The five ambulatory legs (IX-XIII) are quite largely developed but still functionless. From the time of their first appearance they are simple appendages destitute of external swimming branches. The chela is already prominent on the first pair (IX). The second to the sixth abdominal somites are now provided with appendages. The last pair (XIX) do not anticipate the others, as in *Pagurus* (Pl. XII.) and most *Macrourea* (e. g. *Pencus*, Pl. IX., *Lucifer*, Pl. X.).
  6. First antenna of the same. *re*, outer branch. The inner flagellum, wanting in the earlier zoëa stages, is developing as a sac-like process.
  7. Second antenna of the same. The flagellum (*ri*, wanting in fig. 4) is now quite well developed and segmented.
  8. Mandible of a younger zoëa stage of a Brachyuran (*Fissocaris*) showing the commencement of the growth of the mandibular palp (*ε*) which is wanting in the earliest zoëa stage.
  9. Mandible of the late zoëa stage of the Portunid represented in figs. 5-7. *ε*, palpus.
  10. First maxilla of young zoëa stage of *Thia polita*. 1, 2, basal joints (protopodite of Huxley). *ri*, endopodite in the form of a two-jointed palpus.
  11. Second maxilla of the same. 1, 2, basal joints or protopodite, each joint presenting a bilobed blade. *ri*, endopodite, also bilobed. *re*, exopodite or scaphognathite.
- 12-26. *Cancer* from Newport, R. I. From drawings by Faxon, July, 1879.
12. Megalopa stage. Among the *Brachyura* no schizopod stage is found, but the zoëa passes into the megalopa phase, in which most of the characters of the adult are seen. The abdomen, however, is largely developed, and provided with swimming-feet. The megalopa stage of the Brachyuran corresponds very closely with the adult Anomouran. The maxillipeds are now converted into mouth parts, and the five Decapodal legs have their full development. The caudal fork of the zoëa has become a telson plate similar to that of the adult. The crossed lines on the left of the figure indicate the natural size.
  13. First antenna of the same.

14. Mandible of the same. The palpus has been removed.  $\zeta$ , tendon of the mandibular muscle.
15. Mandibular palpus of the same.
16. Second maxilla of the same.
17. First maxilliped of the same, with endopodite (*ri*), exopodite (*re*), and epipodite.
18. Second maxilliped of the same.
19. Third maxilliped of the same. *br*, gills.
20. Proximal end of left cheliped of the same, furnished with a stout hook. Seen from ventral side.
21. Proximal end of left leg of the second pair, with two hooks, seen from ventral side. From the same stage.
22. One of the three long curved setæ on the terminal segment of the last pair of legs of the same (see fig. 12).  
The other two setæ are destitute of the teeth with which this one is furnished.
23. One of the abdominal limbs of the same. The endopodite is provided with hooked setæ ( $\eta$ ), which serve to lock together the abdominal limbs of the two sides.
24. Posterior abdominal appendage. No endopodite.
25. The megalopa represented by fig. 12 passes by a single moult into the crab stage of the form represented in this figure, dorsal view. The eyes are much larger than in the adult, the antennæ longer, and the length of the carapace much greater in proportion to its breadth, and of very different outline. Breadth of carapace, 4 mm.
26. The same, ventral view. The form of the abdomen would seem to indicate that this specimen is a young male. The third, fourth, and fifth abdominal segments, which, in the adult male, are fused together, are still free.
27. Carapace of adult *Cancer borealis*, half natural size. The megalopa and young crab represented in figs. 12, 25, and 26 belong either to this species or to the closely allied *C. irroratus*. This figure is introduced to show the marked difference in proportions and outline between the young and adult stages. Drawn on stone, from nature, by A. Meisel.
- 28-30. Young stages of *Pinnixa (Sayana?)* from Newport, R. I. From Faxon, On some Young Stages in the Development of *Hippa*, *Porcellana*, and *Pinnixa*, Pl. IV., V. Bull. Mus. Comp. Zool., V., 1879.
28. Last zoëa stage, seen from above and in front. *ab*, penultimate abdominal segment, produced on each side into a rounded lobe. Through the transparent carapace are seen the rudimentary and as yet functionless ambulatory appendages. The cross denotes the natural size.
29. The third maxilliped and five ambulatory limbs removed from the body. VIII, endopodite of third maxilliped. VIII', exopodite of third maxilliped. VIII'', epipodite of third maxilliped.
30. The zoëa (fig. 28) passes directly, at one moult, into the adult form shown in fig. 30. This abbreviation of the developmental history whereby the megalopa stage is eliminated is very unusual among the marine *Brachyura* which leave the egg in the zoëa form. S. I. Smith has shown that another species of *Pinnixa* passes through a megalopa stage. Some land-crabs, as has long been known, leave the egg in the adult form, like *Astacus* among the *Macrourea*.

EMBRYOLOGICAL MEMOIRS.

MEM. M.C. Z. IX. No. 1.

CRUSTACEA PL. I



