

LARVAL STAGES OF SCHLOENBACHIA.

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INTRODUCTION.

Law of acceleration of development.—A few years ago naturalists were very much given to speculating about the theory of evolution, reasoning abstractly for or against it, and construct-

ing imaginary family trees. To-day a serious naturalist would just as soon think of taking up cudgels in favor of the theory of gravitation as of evolution. Speculation is no longer popular, and now we wish to know, not whether certain organisms developed out of others, but *how*. This change has largely been brought about by the application of the law of acceleration of development to the study of biology. From the studies of Louis Agassiz and his followers we know that, theoretically, each organism in its ontogeny ought to go through stages of growth corresponding to all its ancestors, and that these stages ought to appear in the order of its ancestral forms. A part of this may be verified in biological laboratories, by studying embryonic and larval stages in animals. Even this is difficult, because the habits of larvae are so different at successive periods of growth that, in confinement, it is often impossible to trace them with certainty through the various stages, and we usually have to take different individuals to show the successive development. And when we attempt to correlate growth stages with ancestral genera the task becomes still more difficult, for then we must leave the living organisms, and are thrown back on paleontology. We often find in a growth stage an association of characters that never occurred in any ancestral form, thus obscuring the parallelism. Then, too, the geologic record is notoriously incomplete, and from the nature of things must always remain so; thus the paleontologic record is often lacking just where we most need it.

PALEONTOGENY.

In order to make a satisfactory comparison of ontogeny and phylogeny, the naturalist must select some group in which living and fossil forms are classified on the same basis; such groups are the brachiopods and the molluscs. But brachiopods are scarce, hard to obtain by dredging, hard to rear in marine laboratories, and most of the families are long since extinct, so that ontogenic studies of living species have not thrown much light on the history of the race. Beecher, Schuchert, and J. M. Clarke have, however, succeeded in working out the ontogeny

of a number of fossil species, and have compared the growth stages of these with the history of the group. Here, again, comes in the difficulty that ontogenic series can be obtained only by putting together in a row a number of distinct individuals of various sizes, with the chance of making mistakes in identification increasing as the specimens grow smaller and have fewer characteristic marks. Very naturally, closely related species become more alike as we go down to the younger stages, until it is impossible to tell which species the very young larvae belong to. Of course some species have specific characters thrown back by acceleration until even the earliest larval stages are recognizable, but usually specific characters do not appear until the adolescent period is well advanced. This is true of all marine invertebrates that go through a larval period.

Of living molluscs the gastropods and the pelecypods offer the same difficulties as the brachiopods, and have been much less studied; even of the common oyster not all the larval stages are known, and no other mollusc has been so closely studied as that has.

Life history of cephalopods.—The chambered cephalopods offer the best means of comparing ontogeny with phylogeny, although the one available living form, *Nautilus*, belongs to the old unspecialized group of nautiloids that has changed little since its origin. Here, again, we are thrown back on paleontology, but this time the difficulties are not so great, for there is a great group of cephalopods, the ammonoids, that has left in the stratified rocks abundant materials for study.

The ammonoids branched off from the nautiloids in the Upper Silurian or the Lower Devonian, at first small, simple, and rare, but they developed rapidly, until by the end of the Devonian all the groups of goniatites were already present. These increased steadily in numbers, size, and complexity, and during the Carboniferous gave rise to the first simple ammonites; these latter are a distinctly, although not exclusively, Mesozoic race, which developed with wonderful rapidity from the first rare members into numerous families, hundreds of genera, and thousands of species, reaching their acme in the Jurassic. In the Cretaceous they gradually declined, dropping

off one at a time, until all were gone before the end of that age. Only the simple radicles or stocks persisted, but from time to time certain genera branched off from the main line, became highly specialized, and often gave rise to so-called abnormal forms, such as *Hamites*, *Baculites*, *Crioceras*, *Scaphites*, phylogerontic or degenerate genera (retrogressive), which did not perpetuate their race, but soon died out without descendants.

Of course there were many other phylogerontic genera that were not abnormal in form; thus *Clymenia* branched off in the Upper Devonian into a variety of species, and disappeared as suddenly; *Medlicottia* reached its culmination in the Permian, barely managed to live on into the Trias, and disappeared without posterity; while the main stock of unspecialized *Prolecanitidae* endured as long as the race.

In the beginning the number of phylogerontic forms was small, for most of the goniatites left descendants among the ammonites; but their number increased during the Mesozoic, showing a constantly growing tendency to become abnormal, until before the end of the Cretaceous the entire stock of ammonites had become phylogerontic, and died out finally from sheer lack of plasticity to modify itself further with changing conditions.

The life history of the ammonites is a finished chapter in biology, and we have in museums and monographs a nearly complete record of their development. It only remains to study genetic series of ammonites. One way (that usually adopted) is to compare a series of adults from successive geologic periods, and by tracing resemblances to construct theoretical family trees. Results of this work may be seen in text-books of paleontology, and its unreliability may be realized if one ever tries to use these tentative genealogies. This would undoubtedly be the safer way if we had a complete geologic record and if the faunas of the various geographic provinces had been preserved. But since this is not the case, we have to meet conditions as they are, not as they might be.

Palingenesis. — The other way is to study the ontogeny of representative species under each genus, and by comparing each stage of growth with antecedent forms to find out the

probable relationship of these genera and the meaning of the growth stages. From the researches of Hyatt, Branco, and Karpinsky we have learned that the ammonoids preserve in each individual a complete record of their larval and adolescent history, the protoconch and early chambers being enveloped and protected by the later coils of the shell. Thus by breaking off the outer chambers successively the naturalist can, in effect, cause the shell to repeat its life history in inverse order, for the ontogeny of the individual is an epitome of the history of the race, and each stage of growth represents, if not always an ancestral genus, at least some of the salient characters of that genus, although unequal acceleration often crowds together in an ontogenic stage characters that occurred in genera widely separated in time. But where the parallelism is at all exact these genera appeared (although not necessarily disappeared) in the order of their minute imitations in the larval history of their descendants; thus by comparing larval stages with antecedent adult forms the naturalist finds the key to relationships and is enabled to arrange genera in genetic series.

The ammonoids were all marine, never parasitic, never fixed in station, and with them no resorption of the shell has ever been noted; thus with them, while there often is some slight obscuring of the record, due to unequal acceleration of certain characters, there is no "falsification of the record." Ancestral characters may not be repeated in the same association in the history of the descendants, but they occur in the same order in which they occurred in the history of the race. So far as the writer's experience goes, these characters shown in the larval stages of ammonites are mainly palingenetic; it is a mistake to give the name of *coenogenesis* to crowding together by unequal acceleration in the descendant of characters that occurred in separate generations of ancestors.

Omission of stages. — The only cases known to the writer where stages of growth are actually omitted entirely are: (1) by pushing back remote ancestral stages or characters beyond the protoconch, where they are either lost entirely out of the ontogeny, or at least leave no record in the shell; (2) between the protoconch and the first larval stage. The protoconch is remark-

ably constant in all ammonites, but even in nearly related species of the same genus the first larval stages may be quite different, although the later larval stages may be very similar. It is a well-known fact that free larvae have a much better chance of repeating their ancestral history in unabbreviated form than embryos that go through their development in the egg.¹ It is quite probable that different species of ammonites, just as is the case with living molluscs, were hatched at different stages of growth, and that the omitted stages may correspond to a longer period spent in the egg by one species than that spent by a species that did not omit these stages. Thus certain species of *Schloenbachia* reach the glyphioceran stage immediately after the protoconch, while others go through several generic stages between the protoconch and the glyphioceran stage; this happens in species in the same geologic horizon, so it cannot be due to difference in removal from the parent radicle. Such cases as these make it hard to interpret ontogeny, but they are not "falsifications of the record." Holzapfel² has described the young stages of *Anarcestes karpinskyi* Holzapfel, showing that it goes through a typical mimoceran stage, in which the nepionic shell does not touch the protoconch for half a revolution. But in the ontogeny of a nearly related species, *Anarcestes plebeiformis* Hall, as described by J. M. Clarke,³ this mimoceran stage is omitted, for the shell is close coiled from the very beginning. We might say, however, that the mimoceran character of the open coil is pushed back by unequal acceleration and lost, while other mimoceran characters are retained, though so merged with those of *Anarcestes* that it is impossible to recognize them.

Each ammonite went through a larval history that is long and varied in direct proportion to the length of time from its period back to the Lower Devonian, when the first of the race are known. Thus in the *Nautilinidae*, the first group of ammonoids, the ontogeny is comparatively simple, there being few

¹ Balfour, Treatise on Comparative Embryology, vol. ii, p. 362.

² "Die Fauna mit *Maeneceras terebratum* Sandberger," *Abhandl. k. Preussischen Geol. Landesanstalt*, N.F., Heft 16, p. 77, Pl. III, Figs. 15-20, 1895.

³ "Notes on the Early Stages of Certain Goniatices," *16th Ann. Rep. State Geologist of New York*, pp. 165-168, 1898.

changes from the larval period up to maturity. But the higher Devonian and Carboniferous forms go through several generic changes before they reach maturity, while Mesozoic genera have still longer larval and adolescent periods,—that is, longer in the sense of going through more stages. In Paleozoic species, however, one rarely finds ammonoids preserved so that the inner coils may be separated. In Mesozoic species, while the preservation is often good, the acceleration is usually so great that any certain interpretation of the meaning of larval stages is difficult, not to say impossible.

Method of phylogenic research.—Since ammonites preserve in each individual a complete record of their ontogeny, one might work out the life history of each species from a single specimen by making drawings of each stage before pulling off the coils representing this stage. In some few cases the writer has succeeded in taking off the outer coils so as to show almost the complete ontogeny in a single specimen without destroying the specimen. But this method usually necessitates the destruction of those parts that are taken off, and so the original is lost, and the naturalist has to show for his work only his notes and drawings, which may or may not be sufficiently accurate; his results cannot be verified.

The more satisfactory way is to select a number of well-preserved adults, so as to be sure of the identification of the species and to break off the outer coils until the desired stages are reached. To do this, finger nails and steel dental chisels are all the tools needed. After the specimen is reduced to a small size the coils are pulled off under water to prevent loss. The material used must be selected with great care, preferably limestone, not so soft as to crumble nor so hard as to shatter.¹ The young ammonite may be studied under the microscope in three different mountings: dry on white cardboard to see the surface markings; on white cardboard in a drop of water to see the septa and shape; under water in a watch-glass over a strong

¹ The results given in this paper are based on the study of about 150 specimens, illustrating all the life history of *Schloenbachia oregonensis*, but of course these could not all be figured, nor even included in the tables. Only the distinct stages and not the transitions were selected for illustration.

condensing lens to see the siphon and other internal characters when the specimen is translucent. This latter mounting is well suited to work in direct sunlight with a polarizing microscope, for the whole field is dark except where the doubly refracting calcite of the young ammonite allows the light to pass through.

NOMENCLATURE OF STAGES OF GROWTH.

In order to correlate ontogenic stages with generic changes seen in the development of the race it is necessary to have an exact scientific nomenclature. The most satisfactory, and one now being generally adopted, is that given by Professor Hyatt in "Phylogeny of an Acquired Characteristic."¹

TABLE OF ONTOGENIC STAGES.

Stages.	Stages.	Substages.	Comparison with Phylogeny.	
Embryonic	(1) Embryonic	Protembryo	Phylembryonic	Epacme
		Mesembryo		
		Metembryo		
		Neoembryo		
		Typembryo		
		Phylembryo		
Larval	(2) Nepionic	Ananepionic	Phylonepionic	
		Metanepionic		
		Paranepionic		
Adolescent	(3) Neanic	Ananeanic	Phyloneanic	
		Metaneanic		
		Paraneanic		
Adult	(4) Ephebic	Anephebic	Phylephebic	Acme
		Metephebic		
		Parephebic		
Senile	(5) Gerontic	Anagerontic	Phylogerontic	Paracme
		Metagerontic		
		Paragerontic		

With the embryonic stage the paleontologist can do nothing, except the very last substage, or phylembryo, when the *Mollusca*, *Brachiopoda*, and other groups begin to secrete their shells; but all the later stages are easily accessible in well-preserved material.

¹ *Proc. Amer. Phil. Soc.*, vol. xxxii, No. 143, pp. 391 and 397.

The best example of correlation of ontogenetic stages with phylogeny is the genealogy of *Medlicottia*, worked out by Karpinsky, who has shown that the Carboniferous genus *Pronorites* goes through the following stages: latisellate protoconch, phyl-embryonic; with the second suture it reaches the *Anarcestes* stage, nepionic; about the end of the first revolution the *Ibergiceras* stage begins, paranepionic; second revolution shows the *Paraprolecanites* stage, neanic; on the third whorl begins the *Pronorites* stage, adult. Thus with regard to *Pronorites* the genus *Anarcestes* is phylonepionic, *Ibergiceras* is phyloparanepionic, *Paraprolecanites* is phyloneanic. In the same work Karpinsky has shown that *Medlicottia* is a direct descendant of *Pronorites* and in its development goes through all the stages of the ancestral genus and adds several more. The first revolution of *Medlicottia* could not be studied, but on the second revolution was seen the *Ibergiceras* stage, metanepionic; on the third whorl the *Paraprolecanites* stage, paranepionic; at end of the third whorl the *Pronorites* stage, beginning of the neanic; on the fourth whorl the *Sicanites* stage, end of the neanic; on the fifth whorl the *Promedlicottia* stage, anephebic; and lastly, at end of the fifth whorl, *Medlicottia*, adult in characteristics, though not yet in size.

Genus SCHLOENBACHIA Neumayr, *Sitzungsberichte k. Akad. Wiss. Wien* (Math. Nat. Kl.), Bd. lxxi, 1. Abth., p. 658, 1875.

As originally defined by Neumayr, *Schloenbachia* was to include forms with narrow, compressed whorl, strong curved lateral ribs, a sharp, often notched, keel; septa comparatively little branched, two lateral, and one distinct auxiliary lobe. The genus was supposed to be descended from *Amaltheus*, although Neumayr¹ says that we can only assign *Schloenbachia* with probability to this group, since it appears suddenly in the Cretaceous as an immigrant, without local ancestors; it has later been broken up into a number of genera and subgenera of questionable value, some of which cannot be sharply differentiated from each other.²

¹ *Loc. cit.*, pp. 654 and 658.

² F. B. Meek, "Report on Invert. Cretac. Foss. Upper Missouri," 1876. Gros-souvre, "Les Ammonites de la craie supér. de la France," 1893.

K. A. von Zittel¹ has separated *Schloenbachia* from the *Amaltheidae*, and placed it in a family of its own, the *Prionotropidae*; which change is quite proper, for *Schloenbachia* does not go through in its adolescent period any stages corresponding either to *Amaltheus* or *Oxynoticeras*. Zittel regards the *Prionotropidae* as an offshoot of the *Amaltheidae*, and these in turn from the *Prolecanitidae*; but neither *Schloenbachia* nor the *Amaltheidae* go through larval stages corresponding to this Paleozoic group, but rather to the *Glyphioceratidae*.

SCHLOENBACHIA OREGONENSIS Anderson ms., Pls. A-E.

Schloenbachia sp. indet., aff. *S. chicoensis* Trask; J. P. Smith, *Journ. Geol.*, Pl. A, Figs. 1-7, vol. v, No. 5, p. 521, 1897.

Schloenbachia sp. indet., J. P. Smith, Chapter IX in Jordan's "Footnotes to Evolution," Pl. C, Figs. 1-11.

The adult is narrow, discoidal, high-whorled, with wide, shallow umbilicus, and almost parallel sides. The whorls embrace about two-fifths of the preceding. The surface is ornamented with strong ribs that branch in groups of two from strong knots on the umbilical^{*} shoulders, bend forward and form smaller knots on the angular abdominal shoulders, and then turn forward in a sharp angle to the keel. These ribs are exceedingly variable, sometimes fine, and sometimes coarse, with transitions from one to the other. Between these bundles of ribs there are from one to two single ribs that do not reach the umbilical shoulders. The keel is rather low, sharp, and slightly notched by the ribs; the sloping space between the keel and the abdominal shoulders has no furrow, although the row of abdominal knots may give that impression. A cross-section of the adult is shown on Pl. C, Fig. 7, diameter 22.25 mm., six whorls, on which the increasing relative height and flattening sides of the whorls may be seen. The septa are comparatively simple, and not very digitate; they show a wide external lobe divided by a short and broad siphonal saddle; a deep, broad, first lateral lobe; second lateral lobe about one-half as deep as the first; and a shallow auxiliary lobe. The first lateral saddle is notched rather deeply near the middle, a character that begins

¹ *Grundzüge d. Palaeontologie*, p. 430, 1895.

in the early youth of the shell and continues to increase until the adult stage is reached. The septa of a specimen at diameter 18.50 mm. are shown on Pl. E, Fig. 5.

S. oregonensis grows to a diameter of at least 30 mm., although no perfect specimens of that size were obtained. The measurements of an adult at end of the sixth whorl are as follows :

	MM.
Diameter	22.25 = 1.00
Height of the last whorl	9.00 = 0.40
Height of last whorl from the top of the preceding	7.28 = 0.32
Width of last whorl	5.00 = 0.22
Involution	1.72 = 0.07
Width of umbilicus	7.64 = 0.34

This species is nearest to *Schloenbachia chicoensis* Trask, *Proc. Calif. Acad. Sci.*, vol. i, p. 92, Pl. II, Fig. 1, 1856; and *Palaeontol. Calif.*, vol. i, p. 68, Pl. XIII, Fig. 17, and Pl. XIV, Fig. 17, to which it was doubtfully referred by Mr. F. M. Anderson.¹

S. chicoensis, as figured by Gabb, has narrower and more involute whorls than *S. oregonensis*, flatter sides, and stronger nodes on the shoulder keels, and also has the shoulder keels nearly as high as that on the abdomen. Through the kindness of Dr. J. C. Merriam, of the University of California, the writer was able to examine a series of *Schloenbachia chicoensis*, as figured and described by Gabb; the following are the dimensions of a typical specimen :

	MM.
Diameter	24.0
Height of last whorl	12.0
Width of umbilicus	5.0

The dimensions of a specimen nearing the end of the adolescent stage are as follows :

S. chicoensis (as identified by Gabb),

	MM.
Diameter	13.00 = 1.00
Height of the last whorl	5.3 = 0.40
Height of last whorl from the preceding	4.3 = 0.33
Width of last whorl	3.5 = 0.26
Involution	1.0 = 0.07
Width of umbilicus	4.0 = 0.30

¹ *Journ. Geol.*, vol. iii, No. 4, p. 467.

The adolescent *S. chicoensis* resembles in appearance and in relative measurements the adults of *S. oregonensis*, and very probably is a descendant of the latter species.

Occurrence and locality.—The material on which this paper is based was collected by Mr. Frank M. Anderson, at the Forty-Nine mine, one and one-half miles southwest of Phoenix, Oregon, in beds supposed to belong to the Upper Horsetown formation, top of the Lower Cretaceous, and described by him in "Some Cretaceous Beds of the Rogue River Valley, Oregon."¹ The writer's thanks are especially due Mr. Anderson for the generosity with which he furnished the specimens to illustrate this work. In a forthcoming paper, in the *Proceedings of the California Academy of Science*, Series 3, Mr. Anderson will figure and describe *Schloenbachia oregonensis* and the rest of this interesting fauna.

ONTOGENIC STAGES.

Nepionic or Larval.

Phylembryonic.—The early embryonic stages are shell-less, and necessarily cannot be represented in fossils, so the paleontologist begins his investigations with the phylembryonic, when the shell gland becomes functional, and the class or phylum can be made out. This is represented in the ammonites by the protoconch, which in this species is a smooth, oval, bobbin-shaped body, a little wider than high, to which the chambered coil is attached. With this stage begins the siphon, as a pear-shaped sac, or *caecum*, taking up a large part of the entrance from the protoconch to the chambered shell. The dimensions of the protoconch are remarkably constant in a large number of specimens; those of the protoconch figured on Pl. A, Figs. 1–3, are as follows:

	MM.		MM.
Diameter	0.42	Width	0.48

This stage is analogous to the *protegulum* of the brachiopods, *protaspis* of the trilobites, and *prodissoconch* of the pelecypods, and corresponds to the primitive cephalopod. The embryonic

¹ *Journ. of Geol.*, vol. iii, No. 4.

shell probably included part of the spiral chamber, but for want of a natural indication of the end of the stage, the phylembryonic is arbitrarily limited to the protoconch.

Ananepionic. — With the formation of the first septum the animal is considered to cease to be an embryo and to begin its larval history. This, of course, is purely arbitrary, since the ammonites are all extinct and we have no way of knowing at what stage they left the egg. At this period the siphon, which is in the center, takes up nearly half of the height of the whorl. The first septum consists of a broad, long, abdominal saddle, a pair of rather narrow lateral lobes, and a pair of short, narrow saddles on the umbilical shoulders. This is shown on Pl. A, Fig. 3, and Pl. C, Fig. 1. It is distinctly nautilian and corresponds to some Silurian nautiloid genus, although it is not possible to say which one, because the characters are not distinctive enough. The internal part of the septum is nearly straight, showing no lobes nor saddles.

Metanepionic. — The second larval substage begins at the second septum, when the whorl is low, broad, and deeply embracing. Pl. C, Fig. 1, shows that at the second septum the broad, abdominal saddle is divided by a deep and broad ventral lobe; at this stage the shell resembles the Lower Devonian *Anarcestes*, one of the first of the typical ammonoids. At the third and fourth septa little change takes place, but these probably correspond to *Parodoceras* and *Prionoceras* of the Devonian. At the fifth septum the ventral lobe broadens, showing a transition from *Prionoceras* to *Glyphioceras* (or *Goniatites* s. str.). The ananepionic and metanepionic substages take up the first quarter of a coil. The siphon, during this substage, is still median, and remains so up to three-quarters of a whorl, when the paranepionic stage is well along, but always decreasing in relative diameter as compared with the height of the successive chambers. The form of the shell at the metanepionic stage is shown in the first quarter of a coil from the protoconch, on Pl. A, Figs. 4 and 5; the septa are shown on Pl. C, Fig. 1, at the second, third, fourth, and fifth. On some specimens the metanepionic substage ended with the fifth septum.

Paranepionic. — Hyatt¹ says that the paranepionic substage in the later ammonoids begins with the division of the ventral lobe, and continues as long as only goniatite characters are shown. In *Schloenbachia oregonensis* the sixth septum has a divided ventral lobe and two lateral lobes, like *Glyphioceras* (or *Goniatites* s. str.). This is shown on Pl. C, Fig. 1. If we follow Hyatt's definition the paranepionic stage will have to be subdivided, for there are three well-marked goniatite stages in it, the *Glyphioceras*, *Gastrioceras*, and *Paralegoceras* stages. In a recent paper² the writer has shown that *Glyphioceras* in its ontogeny goes through as a larva the stages *Anarcestes* and *Tornoceras* (*Parodoceras*); as a youth it is a *Prionoceras*, and takes on its own characters at a diameter of about 6 mm. J. M. Clarke³ says that *Tornoceras* and *Parodoceras* are distinct genera, but that they appear along with *Anarcestes* early in the Devonian, and, therefore, are probably not descendants from that genus, but have a common origin with it. If this is the case the genealogy of the *Glyphioceratidae* will have to be revised, as will also the nomenclature of the chief genus of the family, for E. Haug⁴ has recently shown that *Goniatites* de Haan must be retained for the group of *G. sphaericus* Martin, while *Glyphioceras* Hyatt may be retained for the group of *G. diadema*.

Glyphioceras stage. — Now *Schloenbachia oregonensis* goes through these same preliminary stages, but is so greatly accelerated that it reaches the glyphioceran stage at the end of the first quarter of a coil from the protoconch, and at the sixth septum, as shown on Pl. C, Fig. 1. The early part of this stage is shown on Pl. A, Figs. 4 and 5, one-half coil, first eight septa, and diameter 0.58 mm.; Fig. 6 shows a little more advanced glyphioceran stage, development of the septa from the third to the tenth, diameter 0.64 mm.; Figs. 7 and 8 show

¹ "Phylogeny of an Acquired Characteristic," p. 416.

² *Proc. Calif. Acad. Sci.*, Series 3, vol. i; *Geol.*, No. 3, 1897, "Development of *Glyphioceras*," etc.

³ "Naples Fauna (Fauna with *G. Intumescens*) in Western New York," *16th Ann. Rep. State Geologist of New York*, p. 109, 1898.

⁴ "Études sur les Goniatites," *Mém. 18, Paléontologie, Soc. Géol., France*, 1898, p. 27.

it with nine septa, diameter 0.68 mm., and three-quarters of a coil; Fig 9 shows this same stage at a little over three-quarters of a coil, diameter 0.74 mm., and its septa are shown on Pl. D, Fig. 1. These figures show a gradually increasing height of the whorl as compared with the width. The glyphioceran stage lasts up to a diameter of 1 mm., and about one and one-quarter coils, near the end of which stage, at diameter of 0.80 mm., a deep sulcation or constriction makes its appearance; this distinctively glyphioceran character was observed on a large number of specimens near the end of the first whorl, and never after that.

Gastrioceras stage. — Near the beginning of the second whorl, at diameter of a little over 1 mm., and after the appearance of the constriction, the umbilicus begins to widen, until at diameter of 1.20 mm. it is proportionally wider than in any species of *Glyphioceras*; this is shown on Pl. A, Figs. 10 and 11, one and three-eighths coils, and is transitional to *Gastrioceras*, a genus especially characteristic of the Upper Carboniferous. A somewhat larger specimen, diameter 1.33 mm., one and five-eighths whorls, is shown on Pl. A, Figs. 12 and 13. As the size increases the shape becomes more decidedly gastrioceran, as shown on Pl. A, Figs. 14 and 15, one and seven-eighths coils, diameter 1.65 mm.; the septa of this are seen on Pl. D, Fig. 2. This stage corresponds to that group of *Gastrioceras* that lacks the umbilical ribs and has the second lateral lobe on the sides of the shell, as in *Gastrioceras illinoisense* Miller and Gurley,¹ of the Coal Measures.

Paralegoceras stage. — The gastrioceran stage lasts from near the beginning of the second whorl, diameter a little over 1 mm., up to two and one-eighth whorls, diameter 2.15 mm., when a third lateral lobe appears on the umbilical border; then the whorl becomes higher and narrower, and the whole aspect of the shell is like *Paralegoceras* Hyatt, a genus especially diagnostic of the Upper Carboniferous, and supposed to be a direct descendant of *Gastrioceras*.² This stage is shown

¹ *Bulletin XI, Illinois State Mus., N. H.*, p. 42, Pl. V, Figs. 6-8, 1896.

² For the relations of *Glyphioceras*, *Gastrioceras*, and *Paralegoceras*, see paper by the writer, "Marine Fossils from the Coal Measures of Arkansas," *Proc. Amer. Phil. Soc.*, vol. xxxv, No. 152, 1896.

on Pl. B, Figs. 1 and 2, and the septa on Pl. D, Fig. 4, although the third lateral lobe is considerably exaggerated, on account of a mistake in drawing. But even if the third lateral lobe were entirely lacking the stage might still be referred to *Paralegoceras*, according to the usage of Hyatt. Throughout this, as in all preceding stages, each coil embraces about two-fifths of the preceding. By reference to the table of stages of growth, the widening umbilicus and flattening whorl may be traced just as in the drawings of the successive stages. This substage is short, lasting only half a coil, from diameter 2.15 mm. up to two and five-eighths whorls, diameter 2.70 mm.

The decrease in relative size of the siphon in the larval stages may be seen from the following figures:

At the first septum the siphon is 48 per cent of height of the whorl.					
At one-quarter of a coil	"	"	35	"	"
" one-half	"	"	32	"	"
" three-quarters	"	"	25	"	"
" one and one-quarter coils	"	"	24	"	"
" one and one-half	"	"	23	"	"
" one and three-quarters coils	"	"	22	"	"
" two coils	"	"	20	"	"
" two and one-half coils	"	"	17	"	"

NEANIC OR ADOLESCENT.

Ananeanic.—When an ammonite in its development has taken on characters that the goniatites never had, it may be said to have completed the larval stage and to have begun the adolescent. At the end of the *Paralegoceras* stage, diameter 2.70 mm., about the middle of the third whorl, the abdomen becomes sharpened and somewhat higher, and a keel appears. The smooth sides, simple goniatitic septa, and ventral keel all remind one of the Triassic genus *Styriles*¹ Mojsisovics. This stage is shown on Pl. B, Figs. 3 and 4, diameter 3.10 mm., three whorls, with the beginning of the keel at diameter 2.70 mm.; the septa are seen on Pl. D, Fig. 4.

¹ "Das Gebirge um Hallstadt," *Abhandl. k. k. Geol. Reichsanstalt*, Wien, Bd. vi, p. 264, 1893. The ontogeny of this genus is not described here, and we do not know that it really goes through the preliminary development of the *Glyphioceratidae*.

Schloenbachia oregonensis remains in this stage about a quarter of a revolution, up to the diameter 3.15 mm., two and seven-eighths whorls; then without any other change in characters the first lateral saddle suddenly becomes indented, as shown on Pl. B, Figs. 5 and 6, diameter 3.71 mm., and the projection of the septa on Pl. D, Fig. 5. This stage does not correspond to any known genus, but the characters have the nature of Lower Triassic genera, and so it may be referred to some unknown form of that age; it may be provisionally called the *Parastyrites* stage. At diameter of 4.00 mm. the rounded abdominal shoulders become angular, forming keels. The *Parastyrites* stage lasts about half a revolution, to near the middle of the fourth whorl.

Metaneanic.—At diameter 4.5 mm., three and three-eighths whorls, ribs appear suddenly on the sides, faint at first, but rapidly becoming distinct; this is figured on Pl. B, Fig. 7, diameter 5.60 mm., three and seven-eighths whorls. At first the ribs, which branch out from nodes on the umbilical shoulders, reach only to the abdominal angles. This stage usually ends with the fourth whorl, at diameter a little over 7 mm., thus lasting about five-eighths of a coil. Near the end of the fourth whorl the septa, which up to this time have persisted in their simple goniatitic character, become slightly digitate, or ammonitic; this is shown on Pl. E, Fig. 1, diameter 6.00 mm., and Fig. 2, diameter 6.40, a little over four coils.

Paraneanic.—Near the beginning of the fifth whorl, at diameter between 7 and 8 mm., the ribs begin to form knots on the abdominal keels and the nodes on the umbilical shoulders grow stronger. The height of the whorl, in proportion to its width, grows more pronounced, and, instead of a sharpened abdomen with a keel, the abdominal shoulders become higher and more angular, and the ventral keel rises little above them. At the same time the septa become more ammonitic, as shown on Pl. E, Fig. 3, diameter 8 mm., four and one-half whorls, and Fig. 4, diameter 9.20 mm., four and three-quarters whorls. This stage lasts up to a diameter of about 12 mm., five whorls. The ribs and the nodes on the abdominal shoulder keels become gradually stronger, and the whorl grows

TABLE OF STAGES OF GROWTH.

PHYLEM-BRYONIC.	NEPIONIC OR LARVAL.									
	ANA-, TO META-, TO PARANEPIONIC.					PARANEPIONIC.				
	<i>Glyptoceran</i> substage.	<i>Glyptoceran</i> substage.	<i>Glyptoceran</i> substage.	<i>Glyptoceran</i> substage.	<i>Glyptoceran</i> substage.	<i>Glyptoceran</i> substage.	<i>Glyptoceran</i> substage.	<i>Glyptoceran</i> substage.	<i>Glyptoceran</i> substage.	Transition from <i>Glyptoceran</i> to <i>Gastricoceran</i> .
<i>Protoconch</i> .	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.
Diameter	mm. 0.38 = 1.00	mm. 0.64 = 1.00	mm. 0.68 = 1.00	mm. 0.73 = 1.00	mm. 0.79 = 1.00	mm. 0.88 = 1.00	mm. 1.08 = 1.00	mm. 1.17 = 1.00	mm. 1.20 = 1.00	mm. 1.40 = 1.00
Height of last whorl	0.43 = 0.80	0.45 = 0.39	0.48 = 0.41	0.49 = 0.39	0.49 = 0.39	0.41 = 0.38	0.41 = 0.38	0.43 = 0.37	0.43 = 0.37	0.33 = 0.37
Height of last whorl from the preceding	0.38 = 0.19	0.43 = 0.23	0.40 = 0.29	0.40 = 0.29	0.40 = 0.29	0.31 = 0.29	0.31 = 0.29	0.33 = 0.25	0.33 = 0.25	0.33 = 0.27
Width of last whorl	0.48 = 1.14	0.55 = 0.94	0.58 = 0.96	0.54 = 0.79	0.53 = 0.72	0.62 = 0.61	0.62 = 0.59	0.59 = 0.51	0.63 = 0.52	0.63 = 0.52
Involution	0.07 = 0.12	0.10 = 0.16	0.10 = 0.14	0.09 = 0.13	0.09 = 0.13	0.10 = 0.10	0.10 = 0.09	0.13 = 0.12	0.07 = 0.06	0.07 = 0.06
Width of umbilicus	0.17 = 0.29	0.13 = 0.20	0.15 = 0.22	0.14 = 0.19	0.14 = 0.19	0.23 = 0.27	0.34 = 0.31	0.43 = 0.37	0.49 = 0.40	0.49 = 0.40

PHYLEM-BRYONIC.	NEPIONIC OR LARVAL.									
	PARANEPIONIC.					PARANEPIONIC.				
	<i>Gastricoceran</i> substage.	<i>Gastricoceran</i> substage.	<i>Gastricoceran</i> substage.	<i>Gastricoceran</i> substage.	<i>Gastricoceran</i> substage.	<i>Gastricoceran</i> substage.	<i>Gastricoceran</i> substage.	<i>Gastricoceran</i> substage.	<i>Gastricoceran</i> substage.	End of <i>Gastricoceran</i> substage.
<i>Gastricoceran</i> substage.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.	1 whorl.
Diameter	mm. 1.33 = 1.00	mm. 1.32 = 1.00	mm. 1.32 = 1.00	mm. 1.32 = 1.00	mm. 1.32 = 1.00	mm. 1.32 = 1.00	mm. 1.32 = 1.00	mm. 1.32 = 1.00	mm. 1.32 = 1.00	mm. 1.32 = 1.00
Height of last whorl	0.48 = 0.34	0.55 = 0.36	0.61 = 0.36	0.68 = 0.37	0.71 = 0.33	0.71 = 0.33	0.71 = 0.33	0.71 = 0.33	0.71 = 0.33	0.71 = 0.33
Height of last whorl from the preceding	0.30 = 0.26	0.40 = 0.30	0.51 = 0.30	0.50 = 0.29	0.57 = 0.27	0.57 = 0.27	0.57 = 0.27	0.57 = 0.27	0.57 = 0.27	0.57 = 0.27
Width of last whorl	0.66 = 0.49	0.65 = 0.42	0.76 = 0.46	0.81 = 0.47	0.85 = 0.44	0.86 = 0.43	0.86 = 0.43	0.86 = 0.43	0.86 = 0.43	0.86 = 0.43
Involution	0.12 = 0.09	0.12 = 0.07	0.10 = 0.06	0.10 = 0.06	0.12 = 0.08	0.14 = 0.06	0.15 = 0.07	0.19 = 0.08	0.21 = 0.08	0.21 = 0.08
Width of umbilicus	0.50 = 0.37	0.62 = 0.41	0.59 = 0.35	0.66 = 0.38	0.76 = 0.40	0.87 = 0.41	0.90 = 0.40	0.93 = 0.38	1.11 = 0.40	1.11 = 0.40

	NEANIC OR ADOLESCENT.						EPHEBIC OR ADULT.	
	ANANEANIC.		METANEANIC.		PARANEANIC.	ANEPHEBIC.	METEPHEBIC.	
	<i>Parastyraxes</i> stage.		<i>Parastyraxes</i> stage.					
	<i>Styraxes</i> stage.	<i>Parastyraxes</i> stage.	<i>Parastyraxes</i> stage.	<i>Parastyraxes</i> stage.				<i>Schloenbachia</i> .
Diameter.....	2.90 whorls.	2.18 whorls.	3.71 whorls.	3.71 whorls.	4.20 whorls.	5 whorls.	5½ whorls.	6 whorls.
Height of last whorl.....	1.02 = 1.00	1.14 = 1.00	1.26 = 1.00	1.26 = 1.00	1.20 = 1.00	1.24 = 1.00	1.54 = 1.00	22.25 = 1.00
Height of last whorl from the preceding.....	0.79 = 0.35	1.14 = 0.35	1.26 = 0.34	1.26 = 0.34	1.20 = 0.37	1.24 = 0.37	1.54 = 0.38	9.00 = 0.40
Width of last whorl.....	0.79 = 0.27	0.99 = 0.31	1.01 = 0.27	1.01 = 0.27	1.20 = 0.30	1.24 = 0.30	1.54 = 0.38	9.00 = 0.40
Involution.....	1.07 = 0.36	1.04 = 0.32	1.22 = 0.32	1.22 = 0.32	1.60 = 0.28	1.60 = 0.28	1.85 = 0.25	7.28 = 0.32
Width of Umbilicus.....	0.23 = 0.08	0.15 = 0.05	0.25 = 0.07	0.25 = 0.07	0.37 = 0.07	0.37 = 0.07	0.90 = 0.07	5.00 = 0.22
	1.14 = 0.39	1.22 = 0.38	1.41 = 0.38	1.41 = 0.38	2.14 = 0.38	2.14 = 0.38	5.40 = 0.35	1.72 = 0.07
					2.82 = 0.39	2.82 = 0.39	5.40 = 0.35	7.64 = 0.34

CROSS-SECTION. ADOLESCENT STAGE. (Figured on Plate C, Fig. 6.)

	EMBRYONIC.		NEPIONIC OR LARVAL.				NEANIC OR ADOLESCENT.			
	<i>Phyllobrya</i> .		<i>Glyptoceras</i> .		<i>Gastrioceras</i> .		<i>Paralogoceras</i> .		<i>Parastylites</i> .	
	<i>Proboconch</i> .		1 coil.		1½ coils.		2 coils.		3 coils.	
	½ coil.	1 coil.	1½ coils.	2 coils.	2½ coils.	3 coils.	3½ coils.	4 coils.		
Diameter	mm. 0.56	0.88	mm. 1.21	1.64	2.36	mm. 3.30	4.52	6.25	mm. 11.31	
Height of last whorl	0.25	0.35	0.41	0.55	0.83	1.13	1.53	2.24	1.81	
Height of last whorl from the preceding	0.09	0.17	0.33	0.45	0.66	0.93	1.23	1.81	1.59	
Width of last whorl	0.48	0.50	0.63	0.75	0.86	1.03	1.13	1.59	0.43	
Involution	0.11	0.08	0.09	0.10	0.16	0.20	0.30	0.43	1.86	2.50
Width of umbilicus	—	0.13	0.28	0.68	1.00	1.33	1.86	2.50		

CROSS-SECTION. ADULT. (Figured on Plate C, Fig. 7.)

	EMBRYONIC.		NEPIONIC OR LARVAL.				NEANIC OR ADOLESCENT.				EPHEDIC OR ADULT.	
	<i>Phyllobrya</i> .		<i>Glyptoceras</i> .		<i>Gastrioceras</i> .		<i>Paralogoceras</i> .		<i>Stylites</i> .		<i>Parastylites</i> .	
	<i>Proboconch</i> .		1 coil.		1½ coils.		2 coils.		3 coils.		3½ coils.	
	½ coil.	1 coil.	1½ coils.	2 coils.	2½ coils.	3 coils.	3½ coils.	4 coils.	4½ coils.	5 coils.	5½ coils.	6 coils.
Diameter	mm. 0.65	0.90	mm. 1.23	1.61	2.25	mm. 3.10	4.30	6.00	mm. 12.35	15.40	mm. 22.25	
Height of last whorl	—	—	—	—	—	—	—	—	—	—	—	
Height of last whorl from the preceding	—	—	—	—	—	—	—	—	—	—	—	
Width of last whorl	—	—	—	—	—	—	—	—	—	—	—	
Involution	—	—	—	—	—	—	—	—	—	—	—	
Width of umbilicus	—	—	—	—	—	—	—	—	—	—	—	

Schloenbachia.

steadily higher and narrower, changing gradually to the adult characters, but with no sudden change to mark the stage.

EPHEBIC OR ADULT.

It would be purely artificial to divide the adult stage into the three subdivisions ana-, meta-, and paraphebic, for the change is too gradual. Near the beginning of the sixth whorl, at a diameter of 12 mm., the nodes on the shoulder keels grow stronger and form continuations of the ribs, bending forwards over the intervening space to the ventral keel, and finally notching it. Since most species of *Schloenbachia* have this character this may be considered as the beginning of the adult period. These characters are seen sometimes as early as four and three-quarters whorls, diameter of 10 to 11 mm. A general description of the adult stage has already been given under the diagnosis of the species. The adult septa are figured on Pl. E, Fig. 5, at diameter 18.20 mm., and a cross-section of an adult specimen on Pl. C, Fig. 7, diameter 22.25 mm.

SYNOPSIS OF RESULTS.

Schloenbachia oregonensis is a remarkable species, in showing its descent so well through its ontogeny; the only other species of which larval stages have been figured, *S. varicosa* Sowerby, figured by Branco in *Palaeontographica*, vol. xxvi, Pl. E, Fig. 4, shows the glyphioceran character at the third septum, the *Anarcestes*, *Tornoceras*, and *Prionoceras* stages being omitted by acceleration of development. The omission of stages occurs just at this point, between the protoconch, which is always constant in any one group, and the larval stages. A kindred form, *Oxynoticeras oxynotum*, reaches the glyphioceran stage at the second septum, having skipped the preceding stages, but going through the *Gastrioceras*, *Paralegoceras*, and *Styrites* stages just as does *Schloenbachia oregonensis*. This seems to the writer to have been due to the hatching of different genera or species at different stages of growth, the omitted stages corresponding to a period when the animal remained in the egg after formation of the protoconch.

Schloenbachia oregonensis in its development repeats the history of *Anarcestes*, *Parodoceras*, and *Prionoceras* in the first five septa and one-quarter of a coil from the nautiloid protoconch; then for about one whorl it is a *Glyphioceras*; for about one and one-quarter whorls it is a *Gastrioceras*; then for a little more than one-quarter of a revolution it is a *Paralogoceras*, and at two and five-eighths coils ends its goniatite history, takes on a keel, and becomes an ammonite, but one like the simpler ammonites of the Permian and Lower Trias. The ananeanic stage lasts up to three and three-eighths whorls, that is, about three-quarters of a revolution; the metaneanic stage lasts up to the end of the fourth whorl, and the paraneanic to near the end of the fifth whorl. With the beginning of the sixth whorl, at diameter of about 12 mm., the shell begins to take on its own proper characters, and is then in the ephebic stage, although adults grow to at least 30 mm. in diameter, and probably larger.

The larval stages may be compared with considerable certainty to ancestral Paleozoic genera, but the Mesozoic genera to which the adolescent stages might be compared are probably mostly unknown as yet, although they will be found among trachyostracan descendants of the *Glyphioceratidae*, and not among the *Prolecanitidae*.

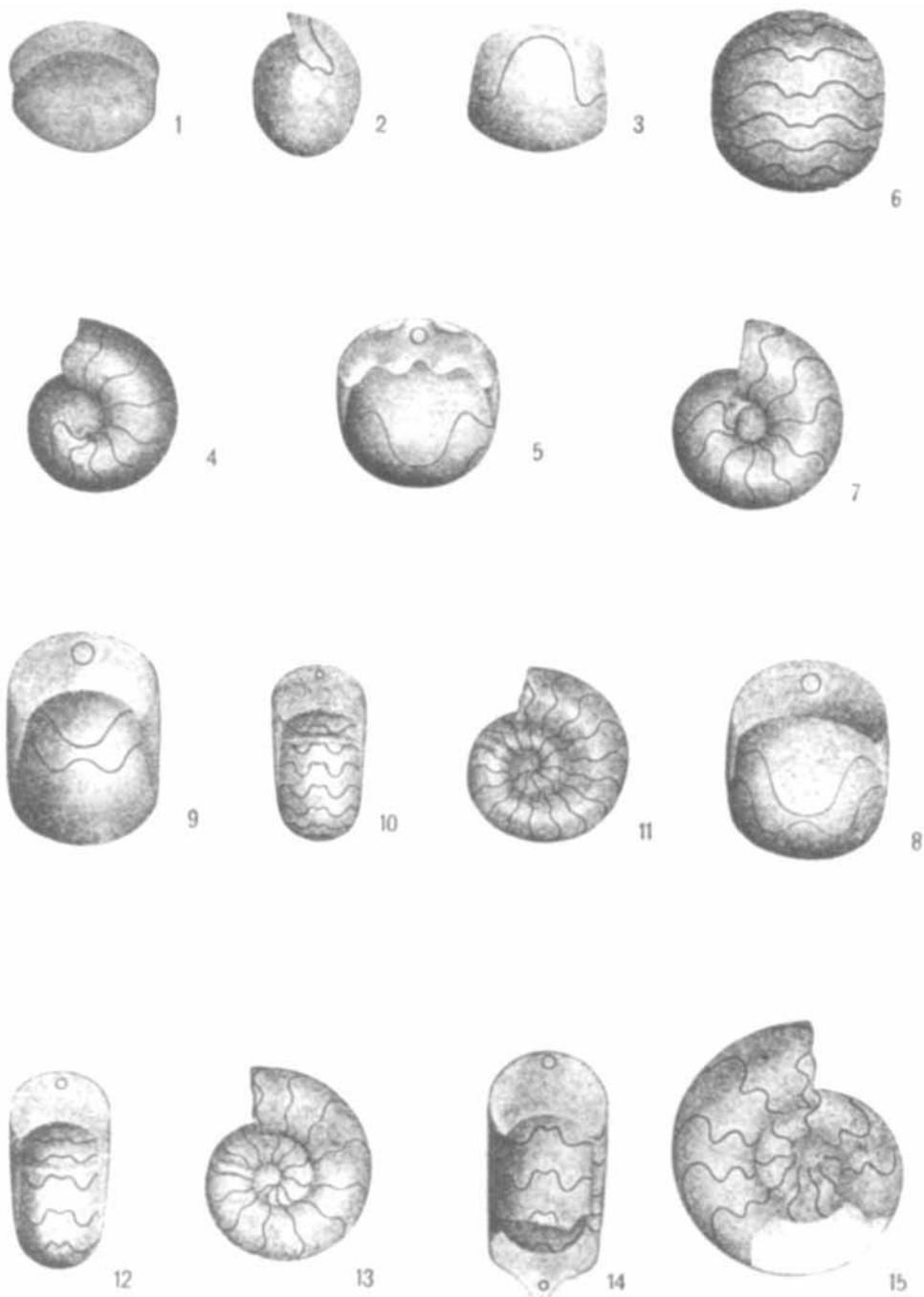
No more striking demonstration of the law of acceleration of development, or tachygenesis, is possible than where a shell in its larval history hastens through, in two and five-eighths whorls, and in growth up to 2.70 mm., generic changes from *Anarcestes*, *Parodoceras*, *Prionoceras*, *Glyphioceras*, *Gastrioceras*, and *Paralogoceras*, an amount of development that its ancestors required the time from the Lower Devonian to the end of the Carboniferous to accomplish. In the succeeding adolescent stages the changes are not nearly so rapid.

Another fact brought out by the investigation of many specimens is that individual variation increases greatly with the advance of the stage. Thus all protoconchs and most chambered stages are alike up to the end of the larval period. After that the uniformity ends, for in the adolescent period the ribs begin at various sizes, as does also the digitation of the septa. And in the acquirement of adult characters still greater

variation was observed, not only in time, but also in the characters themselves, so that one would be inclined to make several species out of one, were it not for the transitions between the varieties. A parallel study of the ontogeny of two nearly related species has shown just these same facts, only in greater degree, for specific variation is only individual variation carried to extremes.

EXPLANATION OF PLATE A.

Schloenbachia oregonensis Anderson.FIGS. 1-3. Protoconch, phylembryonic to ananepionic. $\frac{4}{1}^0$.FIGS. 4 and 5. Phylembryonic to paranepionic; diameter 0.58 mm.; one-half whorl, first eight septa, glyphioceran stage at the sixth. $\frac{4}{1}^0$.FIG. 6. Paranepionic, glyphioceran substage; diameter 0.64 mm.; third to tenth septa, five-eighths of a whorl. $\frac{4}{1}^0$.FIGS. 7 and 8. Phylembryonic to paranepionic, glyphioceran substage; diameter 0.68 mm.; three-quarters of a whorl, nine septa. $\frac{4}{1}^0$.FIG. 9. Paranepionic, glyphioceran substage; diameter 0.74 mm.; seven-eighths of a whorl. $\frac{4}{1}^0$.FIGS. 10 and 11. Paranepionic, transition from glyphioceran to gastrioceran substages; diameter 1.20 mm.; one and three-eighths whorls. $\frac{2}{1}^0$.FIGS. 12 and 13. Paranepionic, transition from glyphioceran to gastrioceran substage; diameter 1.33 mm.; one and five-eighths whorls. $\frac{2}{1}^0$.FIGS. 14 and 15. Paranepionic, gastrioceran substage; diameter 1.65 mm.; one and seven-eighths whorls. $\frac{2}{1}^0$.



EXPLANATION OF PLATE B.

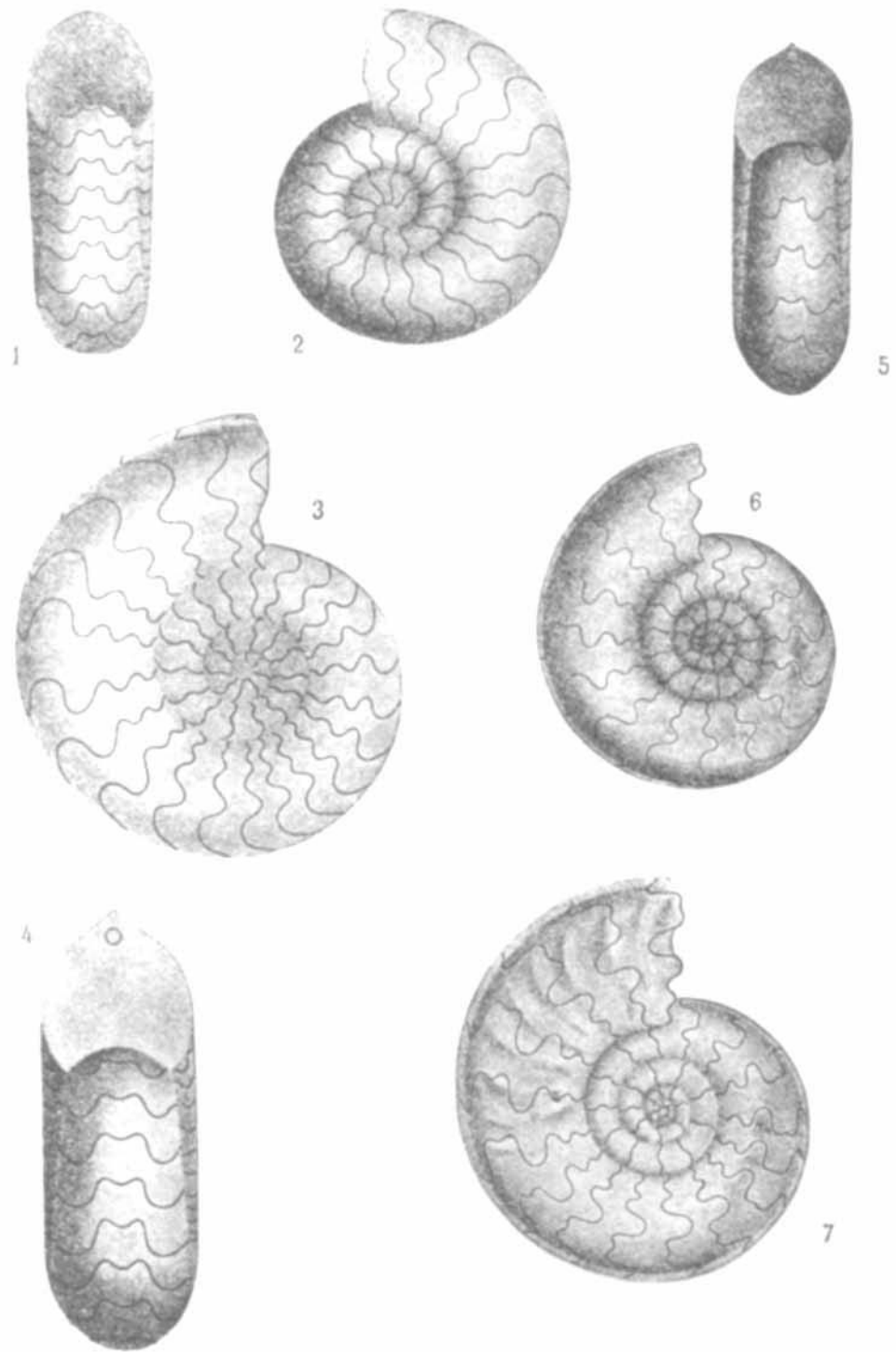
Schloenbachia oregonensis Anderson.

FIGS. 1 and 2. Paraneopionic, paralegoceran substage; diameter 2.25 mm.; two and three-eighths whorls. $2\frac{3}{8}$.

FIGS. 3 and 4. Ananeanic, *Styriles* stage; diameter 3.10 mm.; two and seven-eighths whorls. $2\frac{7}{8}$.

FIGS. 5 and 6. Ananeanic, *Parastyrites* stage; diameter 3.70 mm.; three and one-fourth whorls. $3\frac{1}{4}$.

FIG. 7. Metaneanic, advanced adolescent stage; diameter 5.60 mm.; three and three-quarters whorls, showing beginning of ribs at diameter 4.70 mm. $3\frac{3}{4}$.



EXPLANATION OF PLATE C.

Schloenbachia oregonensis Anderson.

FIG. 1. Protoconch of *Schloenbachia*, showing the first six sutures of the attached coil. Enlarged thirty times.

FIG. 2. Larval stage of *Schloenbachia*, diameter 0.68 mm.; thirty times enlarged; three-fourths of first whorl. *2a*, side view; *2b*, front view.

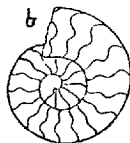
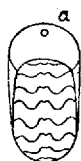
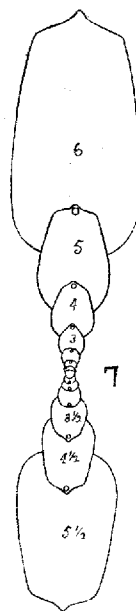
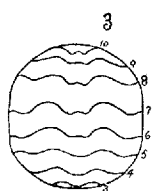
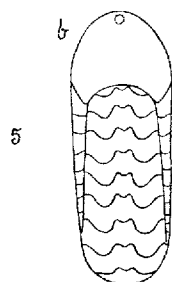
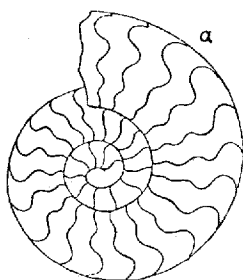
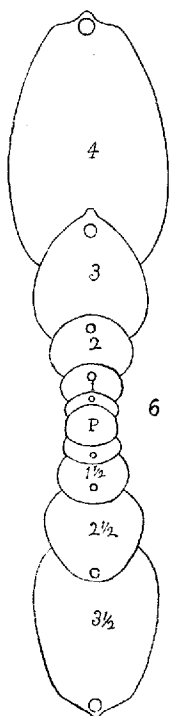
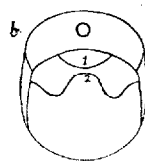
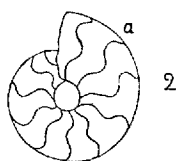
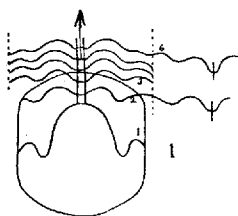
FIG. 3. Larval stage of *Schloenbachia*, diameter 0.64 mm.; thirty times enlarged. Showing sutures from the third to the tenth. From above.

FIG. 4. Larval stage of *Schloenbachia*, diameter 1.20 mm.; fifteen times enlarged; one and one-half whorls. *4a*, front view; *4b*, side view.

FIG. 5. End of larval stage of *Schloenbachia*, diameter 2.25 mm.; fifteen times enlarged. *Paralegoceras* stage. *5a*, side view; *5b*, front view.

FIG. 6. Cross-section of *Schloenbachia*, diameter 6.25 mm.; fifteen times enlarged; four whorls. Adolescent stage. The protoconch is seen in the center *P*.

FIG. 7. Cross-section of *Schloenbachia*, 22.25 mm.; three and one-half times enlarged; six whorls. Adult stage.



EXPLANATION OF PLATE D.

Schloenbachia oregonensis Anderson.*Development of the septa.*

FIG. 1. Septum at seven-eighths whorl; diameter 0.75 mm.; glyphioceran stage; paranepionic. $\frac{4}{1}^0$.

FIG. 2. Diameter 1.70 mm.; gastrioceran stage; two whorls; paranepionic. $\frac{4}{1}^0$.

FIG. 3. Diameter 2.50 mm.; paralegoceran stage; two and one-half whorls; paranepionic. $\frac{4}{1}^0$.

FIG. 4. Diameter 3.00 mm.; *Styrites* stage; two and seven-eighths whorls; ananeanic. $\frac{4}{1}^0$.

FIG. 5. Diameter 3.80 mm.; three and one-eighth whorls; *Parastyrites* stage. $\frac{2}{1}^0$.

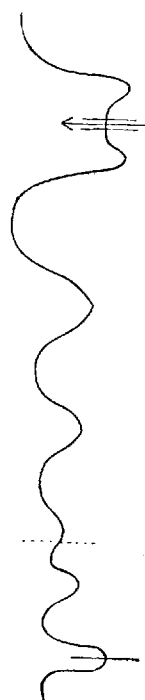
FIG. 6. Diameter 4.86 mm.; three and one-half whorls; neanic. $\frac{2}{1}^0$.



6



5



4



3



2

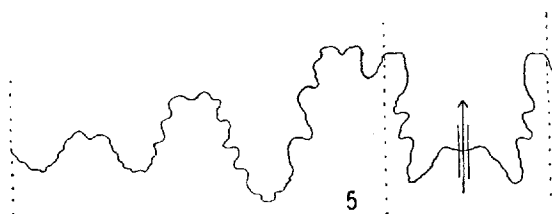


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EXPLANATION OF PLATE E.

Schloenbachia oregonensis Anderson.*Development of the septa.*

- FIG. 1. Diameter 6.00 mm.; about four whorls; metaneanic. $\frac{1}{4}$ ⁵.
- FIG. 2. Diameter 6.40 mm.; metaneanic. $\frac{1}{4}$ ⁵.
- FIG. 3. Diameter 8.00 mm.; paraneanic; four and one-half whorls. $\frac{1}{4}$ ⁵.
- FIG. 4. Diameter 9.20 mm.; paraneanic; four and five-eighths whorls. $\frac{1}{4}$ ⁵.
- FIG. 5. Diameter 18.50 mm.; metephebic, early adult; about five and three-quarters whorls. $\frac{7}{8}$.
- FIG. 6. Diameter 5.60 mm.; three and three-quarters whorls; front view of Fig. 7, on Pl. IV. $\frac{7}{8}$.
- FIG. 7. *Glyphioceras* (*Muensteroceras*) *oweni* Hall. *Pal. N.Y.*, vol. v. Part II. Pl. 73, Fig. 6, for comparison with the young stage of *Schloenbachia oregonensis*. $\frac{1}{2}$.
- FIG. 8. *Glyphioceras* (*Muensteroceras*) *oweni* Hall. Loc. cit., Fig. 3, adult, $\frac{1}{2}$, for comparison.



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