effect of any unusually severe winter of the present time on the cattle and other animals of our plains, and the circumstances in which the latest fossil remains of horses are discovered; the manner of preservation and petrifaction of the latter being similar to that obtaining in the so-called bone licks of much more recent date.

Letters were read from Professors Alphonse Milne-Edwards and Joseph Prestwich and the Marquis de Saporta acknowledging their election as Corresponding Members; and also from Prof. Henri Milne-Edwards acknowledging election to Honorary Membership.

General Meeting, April 4, 1883.

The President, Mr. S. H. Scudder, in the chair. Thirty persons present.

The following paper was read:

GENERA OF FOSSIL CEPHALOPODS.[1]

BY PROF. A. HYATT.

Univalve shells may be generally spoken of as cones, which may be either straight, curved, or coiled; and the coiled may be either loosely coiled, or close coiled; either in the same plane, or a descending spiral. The shell-covered Cephalopoda are straight, ex. Orthoceras; arcuate, ex. Cyrtoceras; loose coiled, ex. Gyroceras; close coiled, ex. Nautilus.

The larger number of the more ancient shell-covered Cephalopoda are straight cones. These predominate in the Silurian over the arcuate, which are often merely varieties of species of the straight cones, as demonstrated by Barrande, and as may be observed in all good collections. The young of nautilian shells are identical with the adults of the arcuate and gyroceran, and in different series repeat their forms, sutures, shell markings and

1 This paper is preliminary to a monograph which will appear in the Memoirs of the Museum of Comparative Zoology.

the outlines of their whorl in transverse section. They are in succession, first, arcuate, then gyroceran, and lastly nautilian or close coiled.

In several series genetic lines of adult forms may be followed, which lead by gradation from arcuate, cyrtoceran forms to close coiled nautilian shells, the whole showing a connected series of transitions in the form and outline of section, sutures, structure, and position of siphon, and shell ornaments and apertures. In some cases these graded series are in accord with the chronological record, the straight appearing first, the arcuate either in company with them or later in time, and the gyroceran and nautilian latest.

We cannot of course claim that such perfect evidence has been found even in the larger number of the following series. In some of them, certainly, it is not an over statement to say that the chronology of the evolution of form, the development of the individual, the gradations in the adults, and the general differential characteristics all tell the same story, and are decisive for the opinion, that in all the larger series of shell-bearing Cephalopoda the nautilian shells belong to several distinct series and arose independently from straight cones through the intermedium of a graded series of arcuate and gyroceran or closely coiled forms. The generic terms, Cyrtoceras, Gyroceras and Nautilus are really only descriptive terms for the different stages in the development of an individual, and also the different stages in the development or evolution of the series of adult forms in time. In other words, each of these genera as now used, include representatives of all the different genetic series of Tetrabranchs, which are either young shells in the corresponding stage of growth, or adult shells in the corresponding stage of evolution.

Our qualifications do not apply to the theoretical correllations, which may be observed between the development of the individual in all its stages and the different forms of the group to which it belongs; these are very nearly perfect. It is impossible to imagine the exact correspondence which exists between the transformations of an individual during its growth and the different adult forms of its own group, of the larva to the more ancient forms, of the adolescent stages to the lower forms of its own genus or family, except upon the theory of descent with modifications.

The forms of the earliest fauna agree in their general aspect owing to the proximity of the septa, but they do not agree in structure, or in their embryos.

The embryo in the Nautiloidea is a shrivelled protoconch, which may have been rounded at first but must have become shrunken and shrivelled after the animal passed out of it and into the apex; it does not contain the siphonal coecum, and when broken away left a narrow cicatrix on the apex, the opening closed by a layer of shell. The umbilical perforation is an opening through the centre of the whorls of even the most completely coiled modern Nautilus, the hereditary mark of its uncoiled ancestry.

The siphon may be near the venter, but the funnels rarely, if ever, break the continuity of the suture.[1] The funnels of the siphon are simple posterior prolongations of the septa. The sutures are entire, they never have marginal lobes and saddles or more than two lateral lobes; the ventral lobe is usually undivided or simply V-shaped when it occurs,[2] the dorsal lobe is, also, usually undivided, but may be divided in rare cases by saddles, the annular lobe when it occurs is undivided.[3]

The siphon is variable in position, but the larger number of ancient genera have the siphon ventral or near the convex side. It shifts in nearly all the series to near the centre, or dorsal side of the centre in the higher and often later occurring nautilian forms.

The Ammonoidea have a globose protoconch, containing the coecum of the siphon, and when broken away it leaves the apex open. There is no umbilical perforation, except in the lowest and earliest of the Goniatitinae, the Nautilinidae. Some of this family have straight apices or young, others among them have arcuate and gyroceran stages, without the orthoceran, while the most closely coiled species in the adult are also close coiled in the larva and do not have arcuate and gyroceran stages. The higher Nautilinidae and all the succeeding genera have close coiled whorls in the earliest stages, with exceedingly rare exceptions,

[1] Except, perhaps, in the Prochoanoids?

[2] It may become divided by a broad saddle, the median saddle in rare cases.

[3] Except in Trematodiscus and similar forms, where a median saddle is developed.

only occurring in the Devonian and Carboniferous, and the umbilical perforation is reduced to a mere depression on either side of the broad neck of the protoconch.

The siphon is so near the venter that the funnel invariably breaks the continuity of the sutures with a slight lobe. The funnels of the siphon are not simple continuations of the septa, except in the Nautilinidae, and most forms of Goniatitinae. In some Goniatitinae, and all other Ammonoidea, a collar is formed around the siphon in addition to the funnel, the collar being open and directed forwards.

The sutures are entire in most of the Goniatitinae, but in some species of the higher and later occurring carboniferous Goniatitinae marginal lobes and saddles begin to be formed, and in nearly all the remaining genera of later periods, these are characteristic. There are two lateral lobes which arise in the Goniatitinae by gradation from the simple lateral lobe of the Nautilinidae and in the higher forms an indefinite number of auxiliary lobes and saddles. The ventral lobe is undivided only in the Nautilinidae, and in all other series of forms there is a median saddle, the sutures of this invariably divided by a minute funnel lobe.[1]

The dorsal or inner side is occupied by a saddle in the Nautilinidae as is the case very generally among the lower forms of the different series of Nautiloids, all the remaining Goniatitinae have a broad dorsal lobe, which is divided by small saddles as in the exceptional forms of the Nautiloidea.

The annular lobe is absent among the Nautilinidae, as it is also universally in the lower forms of the different series of Nautiloids.[2] It is present, but undivided, in the remaining Goniatitinae, and is divided by a median saddle only in the higher forms after the expiration of the Paleozoic.

The appearance of a decided dorsal lobe correllates usually with the closer coiling of the whorls and the development of an impressed dorsal zone. This enables us to see, that the impressed zone is due to coiling, and also to define the gyroceran and nautilian forms.

[1] I have found some rare exceptions, adult stages of abnormal varieties with continuous sutures over the venter as in the young of some Ammonites, Embryology of Ceph., Bull. Mus. Comp. Zool., Vol. III, p. 110, fig. 1. These facts show that we are right in calling the minute central lobe on the venter, the funnel lobe.

[2] Except some of the Endoceratidae according to Dewitz.

Thus, we can say, that a given form is still gyroceran though the whorls may touch in coiling, as long as the dorsum is rounded and gibbous, but if the dorsum has the impressed zone, it must be considered nautilian. This distinction enables us to add to the peculiarities of the Silurian fauna already noted by other authors (viz., the prevalence of straight, large siphoned forms, and those with septa closely approximate), the additional characteristic of the great rarity of true nautilian forms.

M. Barrande has claimed that there was no approximation between the ancient forms of the Nautiloidea and Ammonoidea.

We cannot understand the facts detailed above on any other supposition than the direct and independent derivation of the Nautilini from a straight cone. We think farther that this straight cone must have been a close ally and ancestor of the straight orthoceran-like Bactrites of the Silurian. This form agrees closely in all its characters with the young of the simplest known forms of Goniatites. The gyroceran and tubular whorls, and peculiar sutures and siphons of the young of Mimoceras are very similar to those of Bactrites. The series of the Nautilinidae is, therefore, similar and parallel to that of any one series of the Nautiloids. It must have been independently derived from a straight cone similar to Bactrites. All the remaining ammonoids are more concentrated in development, and skip the orthoceran, cyrtoceran, and gyroceran stages of their evolution in time. They are evidently descendants of the close coiled Nautilinidae and the evidence here is very strong that the whole order of Ammonoidea arose from a single organic centre of distribution, the Nautilini of the Silurian. The succession in time, the evidence of gradation in structure, and the development, exactly accord with this statement. Nautilinidae, Goniatites, triassic transition forms of Ammonitinae and the true Ammonites of the Jura form a perfect progressive series.

The main difficulty in the way of the theory that Ammonoids and Nautiloids belonged to the same stock and were derived both from the same common ancestor laid in the assumed universal absence of a protoconch in the latter. We have found the protoconch in several species of straight cones, and its absence in others can be readily accounted for. It was a useless hollow

appendage and probably also on account of its conchiolinous structure easily separated from the thicker calcareous shell of the apex. To close the evidence it only remains to point out the close affinities of the Bactrites for Orth. pleurotomum Barr. Syst. Sil. pl. 296 of Bactrites for the young of Mimoceras (Gon.) compressum Beyr. Sand. Verst. Nass. pl. 11, and the straight young of Agonatites (Gon.) fecundus, sp. Barr. Syst. Sil. pl. 11, fig. 4.

The existence of the protoconch also removes a serious objection to the derivation of the Belemnoidea from the straight cones. We propose to remove another by homologizing the plug on the truncated cone of Orthoceras with the guard of the Belemnites. We find that the central trace compares with the pseudosiphon of the plug, and that the bilateral formation of the plug is similar to that of the guard. This indicates to our mind, not the existence of two secreting organs like the arms of Argonauta, which stretched back over the shell of Orthoceras, as supposed by Barrande, but on the contrary an organ probably the homologue of the dorsal fold of the mantle in Nautilus. This could readily have been larger than in Nautilus and covered in the whole shell, and been divided into two secreting lobes at the posterior end.

We are thus able to account for the inclosure of the shell among the Belemnoidea and the deposition of the guard, for the openness of this sac as shown by Branco in the transitional form, Aulacoceras of the Trias, and for its final closure as permanent sac among typical Belemnites without calling to our aid any extraordinary modifications of the known organs of Nautilus. The succession here would be Orthoceras, Silurian, Aulacoceras and Belemnites, Triassic.

The Sepioidea appear to be connected with Orthoceratites through Gonioceras, which resembles the broad internal shell of the Sepia officinalis in the striae of growth and differs from all other forms of Nautiloidea in this respect. It has also septa whose outlines approximate to the outlines of the calcareous layer in the interior of sepia shell, or cuttle bone. Gon. occidentalis Hall, Rep. Geo. Surv. Wiscon., 1861, p. 47, has shell and septa, and the outlines of the form are also similar to Sepia, being broadly fusiform, and much compressed. The loss of the protoconch can be accounted for in these forms in the same way that we can account for the resorption and loss of the siphon and

degradation of the septa to a mere succession of calcareous layers. Namely, the shell having become internal and these parts being useless they gradually disappeared. They were first degraded, and then lost out of the roll of hereditary characters, the shell itself following in the same train, and disappearing at last in the higher and more specialized Octopods. We thus have Goniocceras in the Silurian, Paleoteuthis a true Sepioid, Devonian; Loligidae or Teuthidae, Jurassic; Octopods recent.

To clinch this evidence we can refer to the work of Lankester, "Development of the Pond Snail," in which he shows that the pen sac is not an enlargement of the shell gland, but must have been derived from a secondary sac formed by some extension of the mantle, which inclosed the shell and became a permanent addition to the organization, and we differ from this author only in imagining this inclosure as due to the extension of the dorsal flap of the mantle, as in Nautilus, instead of to two flaps of the mantle as in Aplysia.

We regard these two orders as distinct from each other but as forming a division together, which we can designate as a sub-class under the name of Dibranchiata equivalent to Professor Owens order of the same name. It is, however, not yet clear that they arose from the same type among the straight cones, though that they both came from some straight Orthoceras seems to be indicated by all the evidence now in our possession.

If now we return to the Nautiloidea and Ammonoidea we find these two orders to be unitable as having external shells a common form of embryo and chambered shell, the chambers pierced by a siphon; that they possess similar structures, similar imbricated layers in the shell, and similar external deposits; that they exhibit parallel series of forms in the independent reproduction of the nautilian shells out of straight cones, and of the parallel modifications described above among the Goniatitinae. There is, therefore, every probability that they have been properly united by Prof. Richard Owen as Tetrabranchs. We, however, prefer to consider this a sub-class with two orders according to the classification proposed by Prof. Louis Agassiz.

We have, after much observation, found that genetic affinities on a large scale are best exhibited by the siphon, particularly by the funnels of the septa, which are more invariable than any other parts of the shell.

Following out the history of these parts the Nautiloids can be subdivided into the following general genetic groups, [1] Holochoanoida, those having long funnels which completely close the intervals between the septa. We can subdivide this group into Prochoanites, those with funnels of septa turned forwards, ex. Bathmoceras, Metachoanites, those with funnels turned backwards and completely closing up the walls of the siphon, which has no intervening connective wall, ex. Endoceras, and Trocholites. [2] Ellipochoanoida, those with short funnels and the siphon completed by an intervening connective wall of distinct structure from the septal funnels.

There are many of the Orthoceratites which have funnels of considerable length like those above noted as transitional to Bactrites. These are, as shown by M. Barrande, directly connected with the extremely short funneled group of the Actinoceratidae. We, therefore, divide the Ellipochoanoida into the true Microchoanites, which embrace the Actinoceratidae and most of the true Nautiloids, including Nautilus, and the Macrochoanites.

The Macrochoanites may be said to include Bactrites and such straight forms as are transitional to Ammonoidea and all the Nautilinidae, and also the Clymeninae which have similar long funnels. The advantage of this name in trying to present natural relations is evident because we can thus bring all the forms which are transitional from Nautiloids to Ammonoids into one group, and present them under one descriptive name. In our classification we have, for obvious reasons of convenience, included some of the true Orthoceratites among the Macrochoanites, since there are some, as we have said, which can properly be included with Bactrites.

In the more complicated forms of Goniatitinae, while the young are quite generally macrochoanitic, the later larval stages and the adults are universally short funnelled. These short funnels are, however, quite distinct from the short funnels of the Nautiloids, and we propose to class them in with the next type to which they are transitional. The collar is present in all the higher forms or true Ammonitinae, and has been observed by Beyrich in one of the typical Goniatitinae, and the forms possessing this modification we propose to assemble under the name of the Cloiochoanites. This collared group, therefore, correlates with the median ventral saddle, which is present in all of these groups, namely all

the Goniatitinae except the Nautilinidae, and all the Ammonitinae, and the funnel lobe is elevated upon it.

An important factor in this classification is the dorsal suture, and we find that the position of a genus may often be determined in any given series by the peculiarites of this part; whether it is present or absent, and whether it has, or has not a small annular lobe, or "spindle lobe," or a small saddle in the median line of the dorsum. All the series, with few exceptions, begin in time with arcuate forms which have dorsal saddles, and are succeeded by nautilian shells with dorsal lobes, and then these acquire the median annular lobes; if they retain saddles on the dorsum, the dorsal lobe invariably appears in descendants, but is apt to be divided by a small saddle in place of an annular lobe. So far as we know, the annular lobe appears in no species earlier than the Devonian.[1] The "endosiphon," here spoken of for the first time by that name, is the internal tube long known in Actinoceras, and lately demonstrated in Piloceras by Dawson, as having its own proper walls. To this we can add a similar apparatus observed in two good specimens of Endoceras, and also noted by the author in some specimens of Sannionites..

Among Nautiloidea there are no series traceable directly to arcuate forms after the expiration of the Carboniferous. This is the common story, and we can see that the series must have arisen very rapidly during the Paleozoic, branching out on every side from the common ascending trunk of the straight and arcuate forms. The same is true of the Ammonoidea in the Silurian, but only one short series, the Nautilinidae, arises from the common trunk of the straight cones. The close coiled shells of this series become the stock form for the whole of the Ammonoidea.

The Nautiloidea of the Mesozoic are all nautilian forms and their genetic series do not present the rapid changes of form observed in the Paleozoic, they are all close coiled and have as observed by M. Barrande small umbilical perforations.

This same statement applies also to the Ammonoidea, when near their point of origin in the Silurian their forms are very quickly evolved, but are much less quickly evolved after this period.

The smaller genetic groups in the Paleozoic are distinguished

[1] These statements apply only to Nautiloids. See description of Goniatitinae Nautilinidae, and Agoniatites.

by differences between the sutures which are marked and decided by structural distinctions. Thus the groups of Clymeninnae and Goniatitinae, differ widely in their sutures and position of siphon and smaller groups have also decided structural differences.

In later times the families and in fact the whole of the Ammonitinae are very similar in their sutures. There are, however, many genetic series, in the Jura families, which can be distinguished by the minor details of the outlines of the sutures, but these distinctions are not so marked as in the Paleozoic, and the form of the whorl in section, and costations and ornaments of the shell are decidedly characteristic.

In other words the field of variation is structually decidedly narrower, in the Mesozoic than in Paleozoic, whether we consider the Nautiloidea or Ammonoidea.

We have observed the same phenomena repeated in each formation and in the mode of appearance of all the genera and families. These groups originate suddenly and spread out with great rapidity and in some cases as in the Arietidae of the Lower Lias are traceable to an origin in one well defined species which occurs in close proximity to the whole group in the lowest bed of the same formation. These facts and the acknowledged sudden appearance of the larger number of all the distinct types of invertebrata in the Paleozoic, and of the greater number of all existing and fossil types before the expiration of Paleozoic time, speak strongly for the quicker evolution of forms in the Paleozoic and indicate a general law of evolution. This we think can be formulated as follows, types are evolved more quickly and exhibit greater structural differences between genetic groups of the same stock while still near the point of origin, than they do subsequently. The variations or differences may take place quickly in the fundamental structural characteristics, and even the embryos may become different when in the earliest period, but subsequently only more superficial structures become subject to great variations.

During this investigation we have been able to add to the facts we have already brought forward in support of the law of acceleration, or as we now prefer to designate it, the law of concentration of development. All more generalized or lower types have a direct mode of development and the more specialized or complicated progressive types have, when at the acme of their

development, a more indirect mode of development. The types which are descended from these last have often a mode of development which in many forms is an apparent return to the direct mode of development again.

The first two modes occur in the progressive series, the last can occur only in the highly retrogressive or degraded forms and consists of the following stages, to which naturallists acquainted with the life histories of modern parasites will easily find parallels.

The degraded uncoiled forms of the Nautiloidea and Ammonoidea, wherever they occur, whether in the Silurian or in the Cretaceous, invariably have close coiled young, showing that they were the offspring of close coiled or nautilian shells, that is of progressive forms which have themselves been evolved from a series of straight, arcuate, and gyroceran predecessors. Their uncoiling then is a truly retrogressive character, and this tendency to retrogression is inherited in successive forms in several series. Their whole structure is finally affected, the whorl is reduced in size, and the complication of the sutures and shell at all stages of growth is degraded, until in their development only the close coiled young remain to testify to their exalted ancestry. In other words the forms inherit the degraded characteristics at such an early stage that it effects their whole life except the earliest stages. If we examine any of the progressive series we find that characteristic modifications or variations tend to appear first in the adults, then in successive forms they appear at earlier stages, and finally disappear altogether or become embryonic, and this is the case also with the degraded characteristics, and doubtless when carried far enough even the last fortress of the ancestral characteristics, the larval stages would be invaded and the shell become completely uncoiled and perfectly straight and cylindrical from the earliest age. We have found specimens of Crioceras, in which only a part of the first whorl was close coiled and the embryo of the Baculite, the straight cone of the Cretaceous, and Jurassic Ammonoidea still remains unknown. We have, therefore, in the life of a series heredity acting in such a manner that new characteristics are being continually introduced into the adult and adolescent stages to replace the ancestral ones which have disappeared or been crowded back into the earlier or larval stages.

It is an undoubted fact, as shown by the writer and especially by Barrande and Dr. Branco, that the embryo itself has varied comparatively little throughout time in the Ammonoidea, Nautil oidea, Belemnoidea, and Sepioidea.

But these statements do not apply to the earliest stages in the evolution of these types. During these earlier stages, when they all branched out from the common stock, the embryos of the Ammonoidea and Nautiloidea became quite different from each other, the embryos of the Belemnoids remained like those of the Ammonoids almost exactly similar to those of the Nautilini as shown by Chalmas and Branco, and finally in the Sepioidea the protoconch or embryonic shells changed more completely and soon disappeared. Attention is particularly called to this remarkable fact in the history of the evolution of these forms, that the separation of the orders took place rapidly, and in the embryos as well as in the adults near the origin of the orders, and the comparative invariability of the embryo was confined to the subsequent history of these types after separation.

We have here no space to discuss the apparent reasons for these changes, but we have been able to explain the mode in which they take place. The mode in each case is the earlier or concentrated development of ancestral characters, which as we have said follow the same paths, whether progressive and tending to preserve the characters of the type, or retrogressive and tending to destroy the characters of the type.

We mention the law of concentration of development because in looking at the young in the usual haphazard way, naturalists often do not find the strong marks of affinity which the ordinary modes of studying lead them to anticipate. The law of concentration leads to the disappearance of important characteristics often even in short and comparatively small series. It acts frequently within a small group like the Arietidae, so that the later larval and adolescent stages are exceedingly unlike the same stages in very nearly related species in the same family. Unless they are willing to take a small well characterized group and follow out all its transformations they cannot hope even to understand the remarkable phenomena which are shown more or less in the history of every complete series.

Slaves of the embryological lamp consider that they must asso-

ciate all forms which have similar embryos, and dissociate in classification all forms having different embryos. As a matter of experience, the surest guides of affinity are the adult gradations of forms. These show that the Nautiloidea and Ammonoidea with comparatively distinct embryos are nevertheless closer related than the Belemnoidea and Ammonoidea which have precisely similar embryos, and Sepioidea and Belemnoidea which have very distinct embryos must also closely be affiliated.

The embryos of all these must have been precisely similar at their origin, but they afterwards became varied in the different orders, and we cannot lay down any hard and fast rule by which the embryo becomes an invariable criterion of affinity. We think there is ample reason in the structures of these shells themselves for the embryonic differences, and that it is possible to reconcile them with the affinities indicated by the gradations observed between the adults. These reasons which we have space only to allude to here consists in a series of correlations which are plainly apparent between the adult structures, and the habits of the animals, and the tendencies which the habits have to change the adult structures, and then by the action of the law of concentration in development to change even the embryos, either quickly in time when the habits are widely changed, or more slowly when they vary but slightly with the progress of time. The evolution is a purely mechanical problem in which the action of the habitat is the working agent of all the major changes; first acting upon the adult stages as a rule, and then through heredity upon the earlier stages in successive generations. Thus in the open fields of the periods of their origin they expanded into their different habitats, varying to accomplish this purpose with great rapidity, but once in their appropriate habitat inducements to change or open fields became rarer, and we get as a result comparative invariability. As time rolled on and the earth became more crowded, the variability was reduced to less and less important structural changes, except in the retrogressive types. These exceptions are our best proofs of the action of the habitat. The changes in these retrograde forms are again remarkable for the rapidity with which they take place, and all of these types can be shown to have occupied free fields where they met with new conditions, and to have changed their habits and structures rapidly to accord with these new conditions.

NAUTILOIDEA.

HOLOCHOANOIDA.

Prochoanites.

Bathmoceras, Barr. Syst. Sil., Vol. 2, Tex. 1, p. 74, 3, p. 792, supp. p. 92, equal Conoceras, Bronn.

Nothoceras, Barr., ibid., Vol. 2, Tex. 1, p. 72.

Metachoanites.

Endoceratidae.

Vaginoceras, nobis, type, (Orth.) multitubulatum, sp. Hall. The funnels extend posteriorly beyond the next septum to that from which they originated. The sheaths are very numerous, and continuous, according to Whitfield, with the funnels. Endosiphon unknown.

Endoceras,[1] Hall, Nat. Hist., N. Y., Vol. 1, p. 58. Funnels extend posteriorly only from one septum to the next. Sheaths not very numerous. Siphon not lined with an internal layer. Endosiphon present, but not so thick walled, as in the genera Sannionites or Piloceras, and generally destroyed by fossilization.

Sannionites, Waldheim, Orcyto. Mosc., 1837, equal to Camerooceras, Conrad. Shell has only one large thick-walled sheath, in connection, with the living chamber, not continuous with the funnel of the last septum. The funnels close the intervals between the septa as in Endoceras, but the siphon is lined by an inner, thick, continuous layer of shell, which is composed apparently of the unresorbed upper parts of the successive sheaths. Endosiphon is present, but only preserved in a fragmentary way, and often absent in the fossils.

Piloceras, Salter, as described by Dawson, Can. Nat. Vol. 10, Similar to Sannionites in every essential characteristic, except the walls of the siphon, which do not have the thick inner layer present in that genus, and in the form. This is brevicone, and arcuate, and often annulated, and has an enormous siphon with compressed sheath, and endosiphon ; the latter usually destroyed.

Cyrtocerina, Bill. Geol. Surv. Can., Pal. Foss. Vol. 1, p. 178, is similar in form to Piloceras, but the siphon is empty, in the few

[1] Colpoceras, Hall, Rep. Reg. State. Cab. 1850, p. 181, pl. 5, fig. 2, may be a siphon of Endoceras as stated by Barrande, but we have neglected to study the type.

specimens known. The funnels are as in Piloceras. We consider this genus as still very uncertain, since there are not enough forms known to characterize it properly, or make sure that it did not have sheaths, and endosiphon.

INCERTA SEDES.

Tainoceratidae.[1]

We provisionally include in this group a series of genera which appear to be affiliated by their forms, sutures, and style of ornamentation, though only a few of them are supposed to have holochoanoidal siphons. The sutures have ventral lobes, and no annular lobes until we reach the Mesozoic genera. The whorl exhibits a tendency to grow away from the spiral, but this is not constant and varies in the same species which may be gyroceran, lituitean, or nautilian in its mode of growth in different individuals, or varieties of the three first genera; the remaining genera are more constantly nautilian.

Trocholites, Conrad, Hall, Nat. Hist. N. Y., Vol. 1, p. 192, includes smooth or costated Silurian shells, whorl in section depressed ellipse varying to quadragonal, siphon holochoanoidal, and near the dorsum. Living chamber over one half of a volution in length, with large ventral sinus, lateral sinuses inconspicuous or absent and broad internal saddles. Sutures with ventral, lateral, and broad dorsal lobes, without annular lobes, and some specimens retain the straight outlines of the larva or have slight dorsal saddles. Type, Am. Mus. N. Y. Siphon near the dorsum or subcentral. This genus includes Troch. (Lituites) undatus and angulatus,[2] Saem. Paleontogr., Vol. 3, and other smooth shells with quadrate forms in section which have similar sutures,

[1] The first three genera appear to have holochoanoidal siphons, but these may be really similar in structure to the siphons of Aturia, which misled even M. Barrande, and the genera Enclimatoceras, Hercoglossa and Aturia certainly have ellipochoanoidal siphons. The absence of arcuate and gyroceran forms is also a notable peculiarity.

[2] Lituites, Breyn, and Hortolus Montf. are founded upon species with entirely distinct forms of whorls from either Trocholites or any of these genera. The young of Lit. lituus, according to Lossen Zeit. Geol. Gesell, 1860, pl. 1, is compressed and smooth. The genus appears to be represented in the Calciferous of this country by L. Farnsworthi, Bill. Pal. Fos. Vol.1 , p. 21, fig. 24, and L. imperator, ibid, which have similar whorls and siphon central.

siphon near dorsum and holochoanoidal. Types, Mus. Comp. Zool. This genus also includes Troch. (Lit.) trapezoidale Lossen, Ueber Lit., Zeit. Geol. Gesell, 1860, p. 25, pl. 1, fig. 2, with costae as in Plectoceras, and a median line of tubercles along the abdomen, but the sutures, and siphon as in this genus.

Plectoceras,[1] nobis, includes Silurian species having costae curved posteriorly on the sides and crossing the abdomen as in Trocholites and sutures similar, but with ventral saddles. The whorls quadrate, the abdomens narrower than the dorsum and the sides convergent outwards. The siphons are ventral and holochoanoidal. The young are precisely similar in form, smoothness of the shell and striae of growth, and in sutures to the straight sutured forms of Trocholites. Type, Plect. (Naut.) Jason, sp. Bill., Can. Nat. Vol. 4, 1859, p. 164, Mus. Geol. Surv. Can.

Litoceras, nobis, has similar characteristics and sutures to Plectoceras but the siphon is near the dorsum or below the centre in the adult, and the whorl has broad abdomen and divergent sides and is smooth. The young are until a late stage frequently costated and have the siphon ventral as in Plectoceras. Type, Lit. (Naut.) versutum, sp. Bill. Pal. Foss., p. 259, Mus. Geol. Surv. Can.

Diadiploceras,[2] nobis, includes species of the Devonian, with costae and two rows of tubercles on the sides. Sutures have ventral saddles, and in type the lower row of tubercles is represented by imperfect costae in the later adolescent stages. The whorl in section is quadragonal, and siphons above the centre. Type, Dia. quadratum, sp. Hall, not yet described. Professor Hall's Coll. Albany, N. Y. Diad. (Disc.) inopinatum, sp. Hall, would also answer as type, if the sutures and position of siphon should prove to be similar. Nat. Hist., N. Y., Vol. 5, pt. 2, suppl. pl. 110. Mus. Cornell Univer., Professor Williams' Coll.

Metacoceras, nobis, includes Silurian and Carboniferous species with broad, ventral, lateral, and dorsal lobes but no annular lobes. Siphon near the ventrum or central. Whorls quadrate, sides with one row of nodes along the external border, umbilical

[1] Πλεκτός, twisted or plaited.

[2] Διαδιπλός, doubled.

shoulders smooth but gibbous, the type has this part of the whorls elevated into a ridge. The forms are evidently transitions from the genus Plectoceras to Mojsvaroceras. Type, Meta. (Discus) Sangamonense, M. et W., Geol. Surv. Ill., Vol. 2, pl. 29. Meta. (Lit.) occidentale, sp. Hall from Trenton of Ill. Am. Mus. N. Y., is the transitional type from Plectoceras to Metacoceras.

Tainoceras[1], nobis, includes Carboniferous and Triassic forms with discoidal whorls, section quadrate and closely resembling Mojsvaroceras in every way, having also two lateral rows of tubercles, but possessing on the abdomen two additional rows of tubercles in the later stages of growth, and adults. The siphon is above the centre. The sutures have ventral, lateral, and dorsal lobes but no annular lobes. The young of the type species has not the abdominal tubercles, and is similar in all characteristics to the Mojsvar. (Naut.) Wulfeni. sp. Mojsis. Das. Geb. Hallst. Abhand. Geol. Reich. Vienna, Vol. 6, pt. 1, pl. 7. Type, Tai. (Naut.) quadrangulus, sp. McChesney, Trans. Chic. Acad., Vol. 1, pl. 3, figs. 5–7, in Mus. Comp. Zool.

Mojsvaroceras[2], nobis, of the Dyas and Trias includes the species described by Mojsisovics in Mediterr. Trias Prov. as Temnocheili. These have two rows of lateral tubercles, the form quadrate and very stout, the siphons below the centre, and sutures with ventral lobes, but also according to Mojsisovics with minute annular lobes. Type, M. (Temno.) Neumayeri, Mojsis., pl. 88.

Grypoceras[3], nobis, includes species of the Trias which are described by Mojsisovics, "Das Gebirge um Hallst.," with compressed and more involute whorls than the above, abdomen, however, truncated at some stage of growth, though acute in some species in the later adolescent and adult stages. Siphon below the centre, sutures like the above, but with deeper lateral lobes and narrow V-shaped ventral lobes. The forms have annular lobes according to Mojsisovics. Type, Gryp. (Naut.) mesodiscum, sp. Hauer, Mojsis. ibid., pl. 8. We include in this genus Gryp. (Naut.) haloricum, obtusum and Gumbeli. ibid., pl. 7.

Clydonautilus, Mojsisovics, Mediterr. Trias Prov. p. 281,

1 Ταινία, a head band.

2 Dedicated to Mojsisovics von Mojsvar

3 Γρυπός, hook nosed.

includes similar forms, but more involute than those of Grypoceras, the sutures similar, but with two pairs of lateral lobes. The outer pair arise from division of the ventral lobe by a saddle in the adolescent stages, according to Mojsisovics. The young are apparently identical with Grypoceras, though Mojsisovics states positively, that there is no annular lobe.[1] The siphon is above the centre in the type C. Noricus, but below the centre in some species according to Mojsisovics.

Enclimatoceras,[2] nobis, includes species of the Trias to the Tertiary inclusive, which are connected by the outlines of their sutures. The whorls are involute from an early stage, and compressed. The abdomens are rounded, but become acute in many species. The sutures have prominent ventral saddles flattened in species with rounded abdomens, and acute in those with acute abdomens, never divided by ventral lobes; the lateral lobes are deep, and the lateral saddles well marked. The ventral saddles in the young are broad, and closely resemble the ventrals of the Hercoglossae, as do also the broad, lateral saddles of the later larval stages in some species. There are no annular lobes at any stage in the Triassic according to Mojsisovics. They do not seem to be present in some of the Jurassic and Cretaceous species, at least during the early stages, and are very small in some adults. The Triassic species are nearly related to Grypoceras, according to Mojsisovics figures and descriptions in "Das Gebirge um Hallstatt." The siphon in this type is a little below the centre in the young, though ventral in adults, and this also agrees with the characteristics of Encl. styriacum, sp. Mojsis., of the Trias, and Grypoceras. Nevertheless there is no ventral lobe at any stage, the annular lobe is absent in the Trias forms, and young of later forms; and the siphon in two species is ellipochoanoidal. Type, Enclim. Ulrichi, White Bull. U. S. Geol. Surv. Vol. not announced, Little Rock, Arkansas, Cretaceous, Nat. Mus. Washington.

Hercoglossa, Conrad, Proc. Acad. Sci., Philad., 1855, p. 67 has for its type Her. orbiculatus, sp. Tuomey, which is described

[1] We think this is probably present, but only to be found in the earlier stages. We desire to call attention to the extraordinary parallelism with the higher Goniatites occasioned by the division of the ventral lobe by a secondary saddle, the median saddle.

[2] "Εγκλῖμα, bent or inclined.

as having central siphon, and sutures similar to Her. (Naut.) Danicus. The ventral saddles, and lateral saddles are broad, the lateral lobes deep, but not acute. There are annular lobes in the adults, but none in the young of most species. Siphon central, or subcentral, but never close to the dorsum. The shells are Cretaceous and sometimes costated like those of Cymatoceras.

Aturia, Bronn, Leth. Geog., Vol. 2, p. 1123, equal Megasiphonia D'Orb. Prod. de Pal. Vol. 2, p. 309, includes Tertiary forms, with smooth and involute shells. The sutures have broad, ventral saddles, acute, linguiform lateral lobes, broad, lateral saddles, and dorsal lobes with annular lobes. The siphon is extraordinarily large and close to the dorsum, but the funnels do not affect the sutures. It seems to be truly holochoanoidal according, to Barrande's and Chalmas' investigations; and M. Barrande's great authority, and comparisons of the structure of the siphon of Aturia, and Endoceras led us to represent this genus as perhaps belonging to the Holochoanoida even in our introduction to the present essay. The study of the siphon, however, in Aturia has finally satisfied us that Quenstedt's figure, Die Ceph., pl. 2, fig. 23, of the siphon, though imaginary, presents the typical structure better than Barrande's. Aturia, therefore, has a siphon consisting of the same elements as in the Ellipochoanoida, but with such excessively long funnels, that the connective wall is reduced to a minimum. It is not a reversion to the holochoanoidal siphon, but a morphological equivalent, or representative of the Macrochoanite forms of the early Ammonoidea, and some Nautiloids.

ELLIPOCHOANOIDA.

Microchoanites.

Actinoceratidae.

This family includes genera of longicones and brevicones having the nummuloidal form of siphon, with or without rosettes, and an endosiphon, but the brevicones all have the rosettes[1]. The shells

[1] For convenience sake we have named the separate elements or joints of the endosiphonal deposits, rosettes, each rosette being the annular ring gathered about the edges of the constriction formed by the funnel. Attention is called to the fact that these rosettes are internal to the true sheath deposit, or external wall of the siphon.

are generally smooth but may be either annulated or striated longitudinally. The sutures are generally more arcuate than in the Orthoceratidae, and the cones stouter in proportion to their length.

Actinoceras, Bronn, has several subdivision whose natural order seems to be as follows. Sub-genus Discosorus, Hall, Nat. Hist., N. Y., Vol. 2, pl. 28, includes isolated siphons apparently inseparable from the siphons of Actinoceras, but having some doubtful characteristics. They may be brevicone forms of the Actinoceratidae, as suggested by Barrande. Orth. infelix sp. Bill., seems to be in form at any rate an intermedium to Actinoceras, if the apex or young siphon was broken off, it would be difficult to separate it from Discosorus. Actinoceras, Bronn, Leth. Geog., 1834, equals Ormoceras, Stokes, 1837, Trans. Geol. Soc. Lond. 2 ser., Vol. 5. Conotubularia, Troost, Mem. Soc. Geol. France, ser. 3, pt. 1, p. 89.[1] The rosettes are globular and compressed, always discontinuous. The planes of discontinuity occur between the septa and are marked by tubes and spaces radiating from the long, central tube. This tube was in life occupied by a fleshy sheath at its anterior part, which was derived from the large siphon by shrinkage of its fleshy walls and was continued backwards into a still more shrunken part forming a long endosiphon, but not having a special wall as in Endoceratidae. The endosiphon, or fleshy shrunken siphon, was swollen at intervals between each septum and gave rise to flattened attenuated rings of membrane, which had radii of solid cords, or tubes, and often the ring became partly resorbed and these tubes or cords were alone left between the rosettes. They do not appear to penetrate the true external or sheath wall of the siphon. M. Barrande has already shown all of these facts clearly, we differ only on minor points. That eminent author regarded the rosettes as not homologous with the sheath of Endoceras though secreted by the same organ, namely a modified fleshy siphon. We regard the rosettes as internal, or extra endosiphonal deposits, and the successive sections of the outer wall of the siphon as strictly strictly homologous with the successive sheaths of the endosiphon of Piloceras and Endoceras. The Mus. Geol. Surv. Canda.,

[1] Conilites, Pusch, Polen's Pal. p. 150 is supposed by Barr. and others to be also a synonym of Actinoceras.

contains species which are apparently transitional to Huronia, as stated by Billings, but these species have large endosiphons, and the Actinoceran type of rosettes, and the siphons resemble those of Huronia merely in the external form of the rosettes. The genus is found in the Carboniferous, Act. (Orth.) giganteum, sp. Sow. De Kon. Calc. Carb., pl. 44, and throughout the Paleozoic. From typical Actinoceras the transitions are insensible into the forms of the next group.

Sub-genus Deiroceras,[1] nobis, has the septa more widely separated than is usual in Actinoceras and parts of the siphon between the septa assume a globular form. The rosettes are more irregular in their formation than in that genus, and the cavity of the endosiphon is an irregular narrow tube. The rings, and cords or tubes of the siphon are more abrupt at their junction with that tube, and more attenuated. Actin. (Orth.) crassiventre, as figured by Barr., pl. 237–233, is a transition form to typical Actinoceras. Act. Putzosi, ibid., pl. 211, 235 is very close to the type of this sub-genus, A. (Orth.) python sp. Bill. Mus. Can. Geol. Surv. The transition to Huronia occurs through these forms.

Sub-genus Huronia, Stokes, Trans. Geol. Soc. Lond., ser. 2, Vol. 5, p. 705, is similar to the preceding, but has the septa more widely separated and only the posterior zone of each rosette is globular, the anterior zone of each rosette being tubular, with a swollen rim. It may be, also, that in this sub-genus the endosiphonal rosettes are habitually continuous. The endosiphonal tube is narrow and regular. Passing back to the radical form Actinoceras, we find that M. Barrande has traced a natural series in his preface to his second series of plates No. 245–350, p. 9. In his list, Act. vertebratum, cochleatum, crassiventre, imbricatum, Clouei are in our scheme true Actinocratites, and we draw our artificial generic line between the last species, and Sactoceras exoticum.

Sactoceras,[2] nobis, includes species in which the septa are in most species approximate as in Actinoceras, and the siphon nummuloidal, but much reduced in diameter. This is the result of a reduction in the size of the fleshy siphon near the living

[1] Δειρή, neck.

[2] Σακτός, stuffed.

chamber. The siphon becomes approximately reduced and the rosettes begin to be variable with age, and finally altogether disappear in the adults of extreme forms. Sac. (Orth.) docens, sp. Barr. pl. 250, is a transition form, but we place it in this genus because at an age, when an Actinoceras would have the rosettes large and perfect, this species begins to lose them, and the siphon decreases also. The reduction of the siphon is a degradational senile shrinkage, and it occasions the loss of the rosettes. M. Barrande views this old stage of the siphon as a return to the tubular siphon, but in our opinion we cannot call this a tubular siphon. As a matter of fact it is a modified nummuloidal siphon, as may be seen by comparison with others. Sac. (Orth.) Richteri, sp. Barr. is selected as the type and in the beautiful figures of M. Barrande we may read on plates 318, 322, 323, 349, that the young have an empty nummuloidal siphon, and that the adults have the usual imperfect rosettes of this genus, and that in the old these disappear again leaving the siphon empty. M. Barrande's species with mixed elements, *i. e.*, siphon on one side tubular and on the other nummuloidal are simply species of various groups with imperfectly developed siphon, or unsymmetrical anomalies of development. This genus is well represented in the Silurian, Devonian, and Carboniferous.

Tretoceras, Salt. Journ. Geol. Soc. Lond. Vol. 14, p. 179, has according to that author, Blake's British Cephalopods, and Barrande, conical prolongations, and a siphon which appears in Blake's figures to be microchoanitic. The cones compare closely only with Kayser's deformed Gomphoceras, "Missb. Devon. Gomph., Zeit. Deutsch. Geol. Gesell. Vol. 26, pl. 16. There is a similar central trace figured by Barrande on the casts of Bathmoceras, but reversed in position.

Orthoceratidae.

This family includes longicones with tubular siphons, and septa widely separated. We do not regard the Actinoceratidae as the ancestors of the tubular siphoned Orthoceratidae; but on the contrary, the Orthoceratidae as the normal form and the probable ancestral type. All the nummuloidal siphons are tubular in the early stages. M. Barrande in Syst. Sil. Vol. 2, Text 3, p. 748, has shown conclusively the passage of the Sactoceran forms into this

group, and the evolution of the nummuloidal type from the various groups of tubular siphoned and straight cones.

Orthoceras, Breynius, should we think be confined to straight and comparatively smooth longicones with simple septa and sutures, it equals group 17 of M. Barrande. The author has met with but two species in North America, though doubtless others may exist, since the extreme smoothness of the shell is easily destroyed. The genus is present in all the paleozoic formations and in the Trias.

Geisonoceras,[1] nobis, includes various groups of the banded longicones of M. Barrande. They fade into true Orthoceras, and yet can certainly be distinguished by the transverse markings or bands, which are formed on the surface of the shell. We include in this series, groups 10, 11, 12, 13, 14 of M. Barrande. The young are either smooth or transversely striated. Type, Gei. (Orth.) rivale, sp. Barr., pl. 209, 216, 387. The banded longicones are directly connected by transitional forms with Cycloceras, and with the banded brevicones of the genus Rizosceras. The characteristic bands of the shells and the position of the siphon in some species make a close approximation to Bactrites. Silurian, Devonian, Carboniferous?

Cycloceras, McCoy, Synop. Carb. Foss. Ireland, 1844, includes the transversely striated, Paleozoic longicones, which at some stage of growth have annular costae. The young are invariably smooth, that is, marked only by transverse striae of growth, as in Cyc. (Orth.) Agassizi, sp. Barr., pl. 281, and the annulations are subsequently introduced. It includes group 9 of M. Barrande. Silurian, Devonian, Carboniferous.

Kionoceras,[2] nobis, includes the longicones in which the longitudinal ridges are more prominent than the transverse striae or ridges when these are present and are smooth throughout their entire length. Equal to group 4 of M. Barrande; type, Kion. (Orth.) doricum, sp. Barr., pl. 269. Silurian, Devonian, Carboniferous.

Thoracoceras, Eichw. Bull. Soc. Imp. de Nat. de Mosc., 1844, p. 761, was a name substituted for Melia proposed in 1829 by the

1 Γείσον, a cornice.

2 Κίων, a column.

same author. It includes all those longicone species in which the ridges become spiny, or are roughened by the prominence of the transverse striae or ridges. Silurian? Devonian, Carboniferous.

Spyroceras,[1] nobis, includes the longitudinally ridged longicones, which at some stage of their growth are also annulated. The annular costae are usually large rendering the outline sinuous. The longitudinal ridges are present in the young, and the annular costae are developed later. Includes groups 5, 6 of M. Barrande. Type, Spy. (Orth.) crotalum, sp. Hall. Mus. Geol. Survey, Albany, N. Y. Silurian and Devonian.

Dawsonoceras,[2] includes forms like D. (Orth.) pseudo calamiteum, sp. Barr., pl. 286, and others which have longitudinal ridges in the larva and are annulated, but devoid of ridges in the adolescent and adults. The type is related to the series with large annulations and frilled transverse striae, sometimes with longitudinal ridges, though the young in D. (Orth.) dulce, sp. Barr., pl. 275 have no longitudinal ridges. The apertures have flaring lips as in Halloceras. Type, Daw. (Orth.) annulatum, Mus. McGill College, Montreal.

Rizosceras,[3] nobis, includes the straight cones figured by M. Barrande, Vol. 2, pls. 185–195, having simple sutures, and septa, and banded shells, whorl in section elliptical. The form is remarkably short, and increases very rapidly, the living chamber short, and widely flaring, with shallow ventral sinus. The siphon is variable in position, but is rarely near the centre. Type, Riz. (Orth.) indocile, pl. 185, figs. 1–6. We include in this group. also, such forms as are intimately connected with Rizosceras, like Riz. (Cyrt.) corniculum, pl. 121, sp. Barr., and (Cyrt.) apertum sp. Barr. pl. 146.

The larger part of the forms figured by Barrande, pls. 1–158, belong to our genus Maelonoceras, and to various other groups, pls. 149–153, however, exhibit almost exclusively cyrtoceran, forms with rizosceran affinities. An extreme form of this genus is the Riz. (Phragm.) imbricatum, sp. Barr. pl. 175. This group can also be subdivided according to the character of the siphon,

[1] Σπυρίς, a basket.

[2] Dedicated to Dr. J. W. Dawson of Montreal.

[3] Ρίζα, a root.

whether nummuloidal, or tubular. Its direct connection with Geisonoceras is evident, as well as the intermediate nature of all its characteristics with reference to the Gomphoceratidae.

In this genus, as in Sactoceras, etc., the nummuloidal siphon is preceded by a tubular siphon in the earlier stages of growth, and this shows that we are justified in deriving this group from tubular siphoned orthoceratites, and considering it as transitional to the nummuloidal siphoned group of the Gomphoceratidae. Sometimes the nummuloidal siphon appears to precede the tubular, but in the cases figured by Barrande, and in others, which we have studied, the nummuloidal character was an adult peculiarity, and the so called tubular character was the result of degradation or shrinkage, due to old age.

Gomphoceratidae.

[Equilobates.]

The shells have apertures with median saddles in the dorsal outlines, and, therefore, an equal number of lateral lobes.

Acleistoceras,[1] nobis, includes breviconе forms with a fusiform shape, and partially contracted living chamber. The aperture has large ventral sinus, and a dorsal saddle, and is only slightly smaller in diameter than the living chamber, and the outline is usually subtriangular. The siphon remains ventral, and the form in section is an oval with the dorsum broader than the venter. Silurian, Devonian, and Carboniferous. Type, Acl. (Api.) olla, Saem., Paleontogr. Vol. 3, pl. 19. Mus. Comp. Zool., Cambridge. Apiocera has been used for insects by Westwood, and the original figure of Apioceras by F. de Waldh. Bull. Soc. Nat. de Moscow, Vol. 17, p. 779, pl. 19, fig. 1, is not identifiable.

Gomphoceras, Sow., Murch. Sil. Syst. Vol. 3, p. 620, includes all the straight and arcuate forms, which have symmetrical T shaped apertures; and, therefore, includes Phragmoceras, and the groups Dimorion and Dimeres of M. Barrande.

Tetrameroceras, nobis, includes Silurian species having four lateral sinuses, and equals to the groups Tetramorion, and Tetrameres of Barrande. Type, Tet. (Phrag.) bicinctum, sp. Barr. pl. 51.

[1] Ακλειστος, open.

Hexameroceras, nobis, includes Silurian species having six lateral sinuses in their apertures. Type, Hex. (Phrag.) Panderi, sp. Barr. pl. 48.

[Inequilobates.]

This series differs from the above in having an azygos dorsal sinus in place of the median dorsal saddle of the preceding genera. All the genera are, so far as we know, Silurian.

Trimeroceras, nobis, has only two lateral sinuses in addition to the median sinus. Type, Tri. (Gomph.) staurostoma, sp. Barr. pl. 73.

Pentameroceras, nobis, has four lateral sinuses. Type, Pen. (Gomph.) mirum, sp. Barr. pl. 82.

Septameroceras, nobis, has six lateral sinuses.

Trimeroceras was included by M. Barrande in his group of Trimorion, and Pentameroceras in Pentamorion. Septameroceras is founded upon a species in the Mus. Geol. Surv. Can., S. (Gomph.) inflatum, sp. Bill.

Mesoceratidae.

In this group we include all those brevicones whose short, contracted, bulbous, living chambers, and singular habit of truncating their shells, and general tendency to flatten the abdomino-dorsal diameters of the apertures, and imperfect septa in the living chambers render them very distinct as a group from all other forms except the Asoceratidae.

Mesoceras, Barr. Syst. Sil. Vol. 2, Text 5, p. 198, includes but one species. This has a much flattened aperture and very slight ventral sinus. It is an Acleistoceras without the vertical arm in the T shaped aperture.

Billingsites,[1] nobis, includes Silurian species having stout cones, almost globular on account of their truncation and which have dumb-bell shaped apertures, without ventral sinuses. Type, B. (Ascoc.) Canadense, sp. Bill. Rep. Prog. Geol. Can. 1853–56, p. 310, Mus. Geol. Surv. Can. This species shows that M. Barrande is in error, in supposing that the large posterior part of the living chamber can be considered as the siphon. The three last

[1] Dedicated to the memory of E. Billings.

[2] A fact already noted by Blake, British Foss. Cephalop.

septa are directly continuous with the septa on the dorsal side of the living chamber,[2] and these are merely large dorsal saddles. Associated species have these dorsal saddles separated as in M. Barrande's typical Ascoceras. The direct derivation of Mesosceras from Acleistoceras can hardly be doubted after comparing the apertures and the forms of the short living chambers.

Ascoceratidae.

European Silurian forms generally have annulated whorl, long living chamber, constricted near the aperture. The apertures are either open or obscurely Y shaped, the two arms of the Y being divided by a dorsal saddles, and the basal arm is the ventral sinus.

Aphragmites, Barr. Syst., Sil. Vol. 2, Text 1, p. 366, is regarded by that author as a form of Ascoceras, which has resorbed the imperfect septa in the living chamber. We, however, much prefer this eminent author's first opinion, that it is a distinct genus with simple septa and sutures.

Ascoceras, Barr. Syst. Sil. Vol. 2, Text. 1, p. 334, includes certainly two groups, one with annulated shells, like those of Aphragmites, and bearing relations to this genus similar to those which Billingoceras has to Mesoceras; and one with smoother or banded and striated shells, which have apertures similar to the typical Ascoceras and are in the same genus.

Glossoceras, Barr. ibid., p. 372, has a very slender whorl, and the obscurely Y shaped apertures described above. The species are Silurian, and the forms and markings of these fossils seem to indicate clearly derivation from an annulated stock like the Cycl. (Cyrt.) residuum sp. Barr. pl. 286, which has similar attenuated, annulated whorls, but open apertures.

Ophidioceras, Barr., includes Silurian shells closely coiled in the larval and adolescent stages and open in the later stages. The costated, compressed whorls have some resemblence to those of Ascoceras and the aperture is closely similar to Glossoceras. The shells are truly nautilian in the young and are evidently pathological derivatives of some ancestral nautilian form. The sutures are straight and the abdomen has a blunt keel. They appear to be the survivors of ancient ornamented series of costated shells. We place them provisionally near Ascoceras on account of the Y shaped apertures and form of whorl and costations.

Maelonoceratidae.

This family includes shells with whorls in section ovate, very short living chambers, often more or less compressed or with contracted apertures. The compressed apertures tend to become fusiform, and the contracted apertures become pear shaped. They are of smaller size than the Gomphoceratidae, and do not grade into that group, but have their own radical, open-apertured, cyrtoceran forms, which are included in the genus Maelonoceras. The sutures have ventral, and dorsal saddles, and lateral lobes. The siphons are near the venter and nummuloidal.

Maelonoceras,[1] nobis, includes Silurian species with arcuate cones, whorl in section compressed, ovate, the dorsum wider than the venter. The siphon is near the venter. The sutures have ventral and dorsal saddles, and slight lateral lobes. The living chambers are short, and the apertures vary from entirely open and partially subtriangular to contracted and pear shaped. Type, Mael. (Phrag.) praematurum sp. Bill. Can. Nat. Vol. 5, p. 173, fig. 19. A close ally of this is Mael. (Cyrt.) discoideum, sp. Barr. Syst. Sil. pl. 135. Mael. (Cyrt.) Metellus, sp. Bill. Pal. Foss. p. 191, fig. 175, 176, is an open-apertured species. Mus. Geol. Surv. Can. The genus may have arisen from the same common stock, in Rizosceras but is certainly not a direct derivative of Acleistoceras.

Oonoceras,[2] nobis, includes series of European forms, which seem to arise from arcuate forms with open apertures, but more elongated cones. They are annulated, and have even shorter and more compressed living chambers in proportion to their longer shells. They may either retain the open aperture, or produce a fusiform outline in the opening. Oon. (Cyrt.) acinacies, sp. Barr. pl. 118, Giebeli, pl. 123, exile and letheum, pl. 124, are examples of cyrtoceran, and probably gyroceran forms, and Oon. (Troch.) priscum and clava, pl. 12, oxynotum, pl. 14, anguis, pl. 16, are examples of the closer coiled species There exist, doubtless in other localities, congeneric, close coiled, symmetrical shells. These Silurian forms lead into those with fusiform apertures, such as Oon. (Cyrt.) multiseptatum, Roem. Paleontogr. Vol. 3, pl. 6, fig. 2, and Oon. (Phrag.) sub-ventricosum, sp. D'Arch. et Vern. Geol. Trans. Vol. 6, pl. 30, of the Devonian.

[1] Μηλον, a goat.

[2] Ωὸν, an egg.

Streptoceras, Bill. Geol. Surv. Can. 1866, Antic. Foss. p. 88, fig. 28, appears to be identical with Acleistoceras, but the apertures are more like those of Maelonoceras. The form, however, is very distinct from both of these genera, and the living chambers one-third of the length of the whorl. This would not be important in most series, but in this one it is an extraordinary variation, and is perhaps an indication of essential differences. Mus. Geol. Surv. Can.

Cranoceras,[1] nobis, includes arcuate Silurian species, which have depressed elliptical whorl in section, and are very closely allied to Maelonoceras. The sutures straight, or with dorsal and ventral saddles, and lateral lobes. The siphon is near venter. In the later stages of more curved forms slight dorsal lobes are developed. Cran. (Cyrt.) hospitale, sp. Barr. pl. 151, nigrum, ibid., pl. 127, Turnus, ibid., pl. 483, 484, of the Silurian connect intimately with the Devonian type (Cyrt.), depressum, sp. Goldf., D'Arch. et Vern. Trans. Geol., Soc. Vol. 6, pl. 29, fig. 1, Schultze Coll. Mus. Comp Zool. The type has very short living chamber, and aperture very similar to that of Mael. praematurum, but wider transversely and with deep ventral sinus, as in some species of Acleistoceras. The general form, aspect, size, and siphon as in Turnus.

Naedyceras,[2] nobis, includes forms with whorls in section subtriangular, the dorsum broad and flat, the abdomen depressed, and subangular. The siphon is near the venter and nummuloidal. The sutures as in Cranoceras, but dorsal lobe more pronounced, no annular lobes, and no imprassed zone on the dorsum. The genus includes Naed. (Cyrt.) anormale, sp. Barr. pl. 139, (Naut.) vetustum, ibid., pl. 35, in the Silurian, and also a series of degraded arcuate, and gyroceran, Devonian forms which show degeneration in their trochoceran mode of growth. They are also recognized by Professor Hall, as having marks of nautilian affinities. These characteristics could only have been derived from gyroceran ancestors, like Naed. vetustum. Type, Naed. (Troch.) Eugenium, sp. Hall, Nat. Hist., N. Y., Vol. 5, pt. 2, pl. 58, 59, Mus. Geol. Surv., Albany.

[1] Κρανος, a helmet.

[2] Νηευς, the belly.

Oncoceratidae.

This family includes forms with peculiarly attenuated apices, or young, the whorl increasing in the adult stages very rapidly in size. The living chambers are generally short, and constricted above, but the apertures are open. Siphon is near the venter, and generally, there is a ventral lobe. The young have straight sutures and these are retained in some adults.

Eremoceras,[1] nobis, includes arcuate Silurian species with open apertures, short living chambers, whorl in section elliptical; sutures with dorsal saddles, almost straight lateral sutures and ventral lobes. Type, Erem. (Cyrt.) Syphax, sp. Bill. Pal. Foss., Vol. 1, p. 194, fig. 178, Mus. Geol. Surv. Can.

Clinoceras, Maseke, Zeit. d. Deutsch. Geol. Gesell., Vol. 28, p. 49, pl. 1, includes species similar to Oncoceras but with siphon between the centre, and dorsum; living chamber and aperture similar, but not swollen, and form very slightly arcuate; sutures with a minute annular lobe according to Maseke. Clin. (Cyr). exiguum, sp. Bill. Can. Nat. Vol. 5, p. 172, and Onc. mumiaforme Whit. Geol. Wisc.,Vol. 4, 1873–79, pl. 7, have straight sutures and are closely allied to type of Clinoceras in form.

Oncoceras, Hall, Nat. Hist. N. Y., Vol. 1, p. 197 is similar in form to Clinoceras, but the whorl is more depressed, and the ventral aspect fusiform. It has sutures similar to Eremoceras, but the ventral lobe is often narrow, and pointed. The lateral sutures are deeper, and in some species there are dorsal lobes. Siphon is ventral. The living chamber is constricted near the aperture, and much dilated below. Onc. (Cyrt.) heteroclitum. Barr. Syst. Sil., pl. 118, 475, has the peculiar swollen living chamber of Oncoceras, and ventral siphon. Am. Mus. N. Y.

Hercoceratidae.

This family has, in the normal forms, trapezoidal whorls with abdomen broader than venter, one line of large tubercles along the edge of abdomen, and sutures with ventral and dorsal lobes. Shells not costated.

Ptyssoceras,[2] nobis, includes Silurian arcuate shells with

1 Ἔρημος, alone.

2 Πτύσσω, fold.

single row of large lateral tubercles, sutures nearly straight; siphon ventral, whorl in section depressed elliptical. Type, Ptyss. (Cyrt.) alienum, sp. Barr. Syst. Sil., pl. 127.

Hercoceras, Barr. Syst. Sil., Vol. 2, Text 1, p. 152, includes Silurian gyroceran forms, the type of which is Herc. mirum Barr.; but we also include in the same genus all the allied gyroceran, and trochoceran species, like Herc. (Gyr.) alatum, sp. Barr. pl. 44, and Herc. (Tro.) flexum, sp. Barr. pl. 44, all of which have similar striae of growth, sutures, and ventral siphon.

Anomaloceras,[1] nobis, includes but one Silurian species with a nautilian shell, Anom. (Naut.) anomalus, sp. Barr. pl. 34, which has a nautilian form, more involute than in Hercoceras, with smooth, much depressed whorls; siphon and sutures as in Hercoceras. The one-sided position of the siphon is found also in other cases among Tetrabranchiata, and is not probably a generic distinction.

Temnocheilus, McCoy, Syn. Carb. Foss. Irel. p. 20. Type, T. coronatus McCoy, pl. 4, fig. 15. Cryptoceras D'Orb, Prod. de Pal. Vol. 1, p. 58, has for type, Tem. (Naut.) subtuberculatus, Sandb. Verst. Nass. pl. 12, fig. 3, and is a synonym. It includes all the forms with smooth nautilian shells, trapezoidal whorls in section, the venter very broad, the sides divergent, the dorsum narrow and having always an impressed zone. A row of large nodes occurs along the junction of the sides and abdomen. The sutures have broad, ventral, lateral, and dorsal lobes. There are no annular lobes in the Devonian forms, but they appear in some Carboniferous species, as in Tem. latus, De Kon. Calc. Carb. The siphon is ventral in the Devonian forms, but near the centre in most of the Carboniferous species.

Centroceras,[2] nobis, includes a series of Devonian species with much compressed whorls, abdomen often hollow, sometimes narrow, with one row of tubercles along the edge of the abdomen on either side. The sutures have deep V shaped ventral lobes, deep lateral, and dorsal lobes; no annular lobes in species observed. The dorsum is frequently gibbous, and has an impressed zone only in the more compressed, and more involute species. Cent, (Cyrt.)

[1] Ἀνώμαλος, anomalous.

[2] Κέντρον, a spur.

tetragonum, D'Arch. et Vern., Trans. Geol. Soc. Lond. Vol. 6, pl. 30, has young which are identical with adults of Temnocheilus, and adults similar to those of typical Centroceras, but less compressed. Type, Cent. (Disc.) Marcellense sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 65, 109. Mus. Geol. Surv., Albany.

Rutoceratidae.

Species in this family have exceedingly rough shells. The projecting lips of the apertures are more or less permanent and often form ridges, or lines of projecting spines or nodes. These may be indefinite in number, but there is a general tendency to reduce them to three rows on either side, and, if carried farther, to one line along the edge of the venter. Sutures have saddles on the venter. Siphon is ventral, or near venter.

Zittelloceras,[1] nobis, includes species of arcuate Silurian and Devonian longicones with whorl in section elliptical and an external frilled layer resembling Dawsonoceras, but no costae, and much larger ventral sinus in the aperture, and corresponding deflections of the frilled ridges and lines of growth. Siphon is small, tubular, and ventral. Sutures have ventral saddles, lateral lobes, and dorsal saddles. The living chambers are long, and apertures open. Type, Zitt. (Cyrt.) lamellosum, sp. Hall, Nat. Hist. N. Y., Vol. 1, pl. 41. Amer. Mus., N. Y.

Halloceras,[2] nobis, is confined to the Devonian. The shells have similar frilled layer, flaring lips to the apertures, etc., as in Zittelloceras, but the forms are Gyroceran, or nautilian. The whorl is subtriangular in section. The abdomen is broad, the sides divergent, and the dorsum forms the narrow apex of the section. Thick costae, or rather large nodes are formed along the angles of the sides in the adults. The sutures have ventral and lateral lobes, and in the impressed zone, when this occurs, there may be a corresponding shallow dorsal lobe. The siphon is small, and near the venter. The young are identical with the adults of Zittelloceras. Type, Halloceras (Gyr.) undulatum sp. Hall, Nat. Hist., N. Y., Vol. 5, pt. 2, pl. 53, 54. Mus. Geol. Surv. Albany.

[1] Dedicated to Prof. Karl Zittel of Munich.

[2] Dedicated to Prof. James Hall of Albany.

Rutoceras[1], nobis, includes arcuate, Devonian forms closely allied to Zittelloceras in the imbricated structures, and flaring apertures of the shells, but having three rows of large nodes on either side. The siphon is ventral, but it is large and nummuloidal instead of being tubular, and small. The living chambers are shorter than in Zittelloceras, and the form in section is depressed elliptical. Type is Rut. (Cyrt.) Jason sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 50, and supp. pl. 124. This genus also includes shells similar to the above, but having the gyroceran form, and less rugged surfaces. The abdomen becomes more elevated and slightly narrower, the dorsum slightly flatter, and broader than the venter.

Triplooceras[2], nobis, includes the remarkable Silurian species Tri. (Naut.) insperatum sp. Barr. Syst. Sil., pl. 461, which has whorls in section like those of Rutoceras, and similar sutures, but with very slight ventral lobe, and the typical three lines of tubercles on either side; siphon between centre and venter.

Adelphoceras, Barr. ibid, Text 3, p. 788, et suppl. pl. 459, also Silurian, has three lines of tubercles on either side, and though the aperture is contracted as in Gomphoceras, we include it provisionally in this series. Siphon ventral.

Kophinoceras,[3] nobis, includes Devonian species, which have rough shells as in Rutoceras, and numerous ridges on the abdomen, more or less roughened or broken in adults by nodes formed by the permanent lips of the apertures. The species vary greatly, but are all probably gyroceran, and the normal forms have either two rows of tubercles along the middle of the venter, or a broad raised band as in some Halloceratites. There are also two rows of nodes along the angle of the junction of the sides and abdomen, which are large and persistent. The form in section is more depressed than in Rutoceras, the siphon nummuloidal, and ventral; sutures with ventral saddles, and in one species a small annular lobe. The type, Koph. (Cyrt.) ornatum, sp. D'Arch. et Vern. Trans. Geol. Soc. Lond., Vol. 6, pl. 28, Mus. Comp. Zool., Camb. has three persistent rows of nodes open to the front, or

1 Ρυλστ, a fold.

2 Τριπλόος, three-fold.

3 Κόφινος, a basket.

spout-like as in the tubercles of Rutoceras. The remarkable species with form and tubercles like Temnocheilus, but a ridged abdomen, the Koph. (Naut.) Coxanum, M. et. W. Geol. Ill. Vol. 5, pl. 23, is probably in this genus.

Strophiceras,[1] nobis, includes a Devonian gyroceran form Str. (Gyr.) binodosum, sp. Sand. Verst. Nass. pl. 12, which has a compressed whorl with gibbous tuberculated abdomen, and flattened sides. There are several rows of tubercles upon the abdomen as in Kophinoceras, but also a central row of tubercles. Sutures with ventral, lateral, and dorsal lobes, but no annular lobes. Form probably close coiled. Siphon ventral. The form is peculiar, the young unknown, and we refer the species to this series with great doubt.

Solenoceras,[2] nobis, includes species of the Carboniferous, Dyas, and Trias having remarkably heavy looking quadrate whorls with furrowed abdomens. Sutures, with broad ventral, lateral, and dorsal lobes, and in adults a small annular lobe may appear in some species. Siphons central and nummuloidal. Living chamber is one-fourth to one-half a volution in length, apertures with very deep ventral sinus. The shells are smooth except in the young and some adults of Solen. (Naut.) nodosum, which has a single outer row of large nodes along the sides. Type, Solen. (Naut.) canaliculatum, sp. Owen, Geol. Ken. Vol. 3, pl. 10. Mus. Comp. Zool. This genus[1] includes a series of Dyassic species described by Waagen Pal. Ind., ser. 13, no. 1. Solen. (Naut.) transitoriuum sp. Waag. ibid, pl. 6, fig. 4. They have quadragonal whorls, are costated, and have depressed or furrowed abdomens. Siphons below the centre slightly or central; Sutures with ventral, lateral, and dorsal lobes. Annular lobes?

Phloioceras,[3] nobis, includes the so-called Trematodisci of the Trias described by Mojsisovics in his "Mediterr. Trias Provinz." The shells are ridged longitudinally, and the ridges in the type roughened by transverse striae. Mojsisovics considers them as allies of Naut. cariniferus, and he may be right, but we have placed them in this series on account of the resemblance of gemmatus to Kophinoceras. The sutures have simple, lateral,

[1] **Στροφεῖον**, a twisted rope.

[2] **Σωλήν**, a groove.

[3] **Φλοιὸς**, bark.

ventral, and dorsal lobes, with small annular lobes. Siphon is central or below the centre. Phl. (Naut.) gemmatum, sp. Mojsis. Das Gebrig. Hallst. pt. 1, pl. 3.

Pleuronautilus, Mojsis. Mediterr. Trias Prov. p. 273, includes a series of forms with more or less tuberculated, and costated whorls, with sutures similar to the preceding. The siphon is also below the centre. The young of one species, Pleu. subgemmatum, as figured by Mojsisovics, ibid., pl. 85, is similar to the adult of Phl. gemmatum, and appears to settle the question of affinity. The sutures according to Mojsisovics vary from those having ventral lobes to some having straight ventral sutures in aged specimens. They have annular lobes.

Eudoceratidae.

This family includes forms in which the whorl in transverse section is some modification of the fusiform outline. The abdomen may be flattened, but is never hollow. The siphons are ventral, or between the venter and the centre. There is a constant tendency to reduce the breadth of the dorsum, and increase the venter. No sulcations or ridges are developed in any genus.

Eudoceras, Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, supp. pl. 117, includes straight shells of the Silurian and Devonian, with whorls flattened, sides angular. The sutures have broad, ventral, and dorsal lobes, the ventral lobe deepest; and lateral saddles, which are angular when the sides are angular, and more or less rounded when the sides are rounded. The ventral and dorsal sides of the whorl are equally convex, whorl in section being fusiform. Mus. Geol. Surv. Albany.

Tripteroceras,[1] nobis, has similar forms and sutures to the preceding, but the lateral saddles are acute. The venter is flattened, and broader than the dorsum, which forms the apex of the subtriangular section. The siphon is ventral, and nummuloidal, and the whorl arcuate in the young, though straight in the full grown, and the aspect altogether distinct from the shells of the preceding genus. The young are similar to the adults of Eudoceras. Silurian and Devonian. Trip. (Orth.) hastatum, sp. Bill., Rep. Prog. Geol. Surv. Can. 1853–56, p. 333, Mus. Geol. Surv. Can.

1 Τριπτήρ, a rubbing tool.

Edaphoceras,[1] nobis, includes species with the young arcuate until a late stage of growth, with whorls fusiform in section, and sutures with dorsal, and ventral lobes, and angular lateral saddles as in adults of Eudoceras, but the siphon shifts from the venter, where it is in the larva, to near the centre. Unfortunately the only figured species is the Edaph. (Tem.) niotense, M. et W. Geol. Ill. Vol. 5, pl. 19. This is selected as the type because it is figured, though in our opinion it is not a full grown shell but only the later adolescent stage of a species as yet undescribed in the collection of Mus. Comp. Zool. The adult in this is close coiled, with flattened sides, broad lateral saddles. An impressed zone appears on the dorsum due to close coiling altering the form in section from fusiform to kidney-shaped, and a V-shaped annular lobe appears in the middle of the broad dorsal lobe.

Endolobus, M. et W. Geol. Ill., Vol. 2, pl. 25, p. 307. End (Naut.) Avonensis, sp. Dawson, has all the young stages like the preceding genus, but inherits the annular lobes, shifts the position of the siphon to near the centre, acquires the impressed zone, and changes the form of the whorl to the kidney shape at an earliet stage of the growth. The young have broad ventral lobes, bur the adults develop saddles in the centre of these, and in the type, End., spectabilis, large folds or tubercles appear on the sides. The latest survivor of this series is the End. (Naut.) excavatum sp. D. Orb. of the Jura, Terr. Jurass. Ceph. pl. 30.

Goniocerati dae.

We interpolate this extraordinary group here because its nearest affines are the compressed, straight cones with equal dorsal and ventral sides. This relationship is fully appreciated by Professor Hall who considers his genus Eudoceras as very closely allied to Gonioceras.

Gonioceras, Hall, Nat, Hist. N. Y. Vol. 1, p. 54 has a broad winged shell, which in form and structure, as indicated by the septa and striae of growth, closely resembles the internal shells of Sepia. We think, the facts are sufficient to warrant our assuming this, as probably one of the passage forms from the compressed Orthoceratites, above described, to the true Sepioidea, and possibly a more or less remote ally of Paleoteuthis Dunensis Roem. of the Devonian.

[1] "Εδαφος, a seat.

Apsidoceratidae.

The whorls in section are some form of the sub-triangular, and throughout all the genera there is a constant tendency to sulcate the abdomen and retain the gibbous character of the dorsum. The genera have transverse costae, but no longitudinal ridges. The marked characteristic of the group is, however, the persistence of the large dorsal saddles, which enable us to see, that the dorsal lobe is produced only in the impressed dorsal zone and in this group appears to be due solely to involution. Even when it is replaced by a dorsal lobe in the nautilian species, this dorsal lobe becomes, as in Ephippioceras. subdivided by a small dorsal saddle.

Tripleuroceras,[1] nobis, includes straight cones, whorl in section triangular, or if elliptical, having flattened abdomen. Siphon is near the venter, nummuloidal, large and usually, but not invariably, partly filled with deposits more or less radiatory in structure. Sutures have ventral lobe on the flat abdomen, saddles at the angles, lateral lobes, and dorsal saddles or comparatively straight sutures around the dorsum. One species, Trip. explorator, sp. Bill., has an additional pair of lateral saddles. Silurian and Devonian. Type, Trip. (Orth.) Archiaci, sp. Barr. Syst. Sil., Vol. 2, pl. 251, 480. The dorsal saddles separate this genus from the Eudoceran group and show them to be the radicals of the following series.

Apsidoceras,[2] nobis, includes loosely coiled, smooth, costated or tuberculated gyroceran shells, with flattened abdomens. The whorls in section are triangular, the dorsum forming the internal apex of the outline; siphons near the venter and nummuloidal. The sutures have broad ventral lobes, saddles at the lateral angles, broad lobes on the sides, and dorsal saddles. There is frequently a line of heavy tubercles on each of the lateral angles of the whorls. They are all large shells and the abdomen is frequently hollow or fluted along the centre. They occur from Silurian to the Carboniferous inclusive. Type, Aps. (Lit.) magnificum, sp. Bill. Geol. Surv. Can. Rep. 1853–56, p. 307. Mus. Geol. Surv. Can.

Titanoceras,[3] nobis, includes Silurian and Carboniferous nau-

[1] Τρίπλευρος, three sided.

[2] Αψίς, the felloe of a wheel.

tilian shells similar to the above, but of larger size with a narrow impressed zone on the dorsum, and a corresponding undivided, narrow, dorsal lobe. The sutures have similar ventral, and lateral lobes, but there are a pair of slight lateral saddles near the shoulders. The whorl in section has a narrower abdomen than in Apsidoceras, and longer abdomino-dorsal diameter, and is more compressed or shield-shaped, rather than depressed or triangular in section. Type, Titan.[1] (Naut.) ponderosum, sp. White, U. S. Geol. Surv. Final. Rep. on Nebr. Hayden, p. 236, pl. 3. Nat. Mus.

Ephippioceras,[2] nobis, includes Carboniferous forms with sub-acute prominent ventral saddles, broad lateral lobes, sub-acute lateral saddles near the shoulders, and broad, shallow dorsal lobes. In the American species, and perhaps in all, there is a slight dorsal saddle in the centre of this lobe. The septa in all species are creased, or raised into a median ridge between the two saddles. The aperture of Ephip. clitellarium reminds us of Pteronautilus in its shallow, acute ventral sinus. Type is Ephip. ferratum, sp. Owen, Geol. Kent., Vol. 3, p. 574, pl. 10, fig. 2, a species closely allied to Ephip. (Naut.) bilobatum Sow., De Kon. Calc. Carb., pl. 9 but is less involute. The siphon is below the centre in the late adolescent stages, and above the centre, or central in adults of the type species.

Pteronautilus, Meek, Pal. Up. Missouri, Smith. Contr., Vol. 14, p. 64, includes but one Dyassic species. This has completely involute whorls, and an aperture extended laterally into wings. The ventral sinus of the aperture is singularly acute resembling in this respect that of Ephip. clittellarium. This slight indication of affinity enables us to place the genus provisionally in this series. Type, Pter. (Naut.) Sebachianus, sp. Gein. Dyas, p. 43, pl. 11.

Trigonoceratidae.

The adults of the radical species, and early stages of descendent forms have whorls similar to those of the Apsidoceratidae. There are, however, longitudinal ridges along the edges of the sulcated abdomens in the adults of the radicals, and in the young of descendent forms these are repeated and then followed in

[1] Τιτάν, Titan. [2] Ἐφίππιον, a saddle.

adults by quadragonal whorls. The dorsal saddles are retained, and though dorsal lobes are formed in the nautilian species, these are often subdivided by a minute saddle. Siphon is above the centre.

Trigonoceras,[1] McCoy, Carb. Foss. Ireland, 1844, p. 9, Nautilocerας D'Orb., Prod. Pal. p. 110, is a synonym. Trig. (Gyr.) paradoxicum, DeKon. Anim. Foss., and Gyr. aigoceras, ibid., D'Orbigny's type are the same species, the latter being the young of the former. The young have lateral costae until a late stage of growth. The abdomen is hollow, the junction with the sides angular, the sides themselves gibbous, and the whorl in section consequently shield-shaped, the dorsum forming the acute apex. The adults retain the form, but lose the costae. The siphon is above the centre. The sutures have broad dorsal lobes, saddles at the angles of the abdomen and sides, lateral lobes and dorsal saddles. This genus seems to be directly transitional to Apsidoceras, but we have not yet seen the young. The similarities of this genus and the hollow abdomened forms of the Tribolocerατidae have been frequently noticed by authors, but we do not regard them as indicating a close genetic connection.[2]

Stroboceras, nobis, includes Carboniferous species which are similar to Trigonoceras in their larvae, but elevate the abdomen develop two pairs of lateral ridges, and have gibbous inner umbilical shoulders so that the dorsum becomes broader than the abdomen, and decidedly gibbous. The sutures have broad abdominal saddles, small acute saddles at the lateral ridges, narrow lobes on either side, broad lateral saddles on the swollen or gibbous part of the whorl, and small, sub-acute, dorsal lobes. Apertures are contracted laterally, and dumb-bell shaped. Siphon is half way from the centre to the venter. Type, Strob. (Discites) Hartii. sp. Daws. Acad. Geol. Ed. 3, p. 311, fig. 125, Mus. McGill College.

Trematodiscus,[3] Meek, was finally established by this author in his Invert. Pal. U. S. Geol. Surv. Hayden, Vol. 9, p. 491, with Trem. (Naut.) stygialis of the Carboniferous, DeKon. Anim. Foss., pl. 45, fig. 11 as the type. The larvae are at first stage observed

[1] Στρόβος, a vortex.

[2] See p. 293, Tribolocerατidae.

[3] We propose to change this name to Trematoceras since it was used by Häckel in 1860 for the Radiolaria, and by Eichwald for Bactrites.

similar in form to the larva of Trem. subsulcatum, and later take on the ridges and abdomen as in Strob. Hartii, but develop a broad furrow between the two ventral ridges. This furrow with the two lateral furrows form a trisulcated abdomen, and together with the ventral lobes in the sutures enable us to separate the species from the adults of Strob. Hartii. The siphon is near the venter The small dorsal lobe is first formed in the centre of the dorsal saddle, simple as in Stroboceras. Then a minute saddle arises dividing it into two V-shaped lobes. This genus also includes species with young more evidently similar to the adults of Trigonoceras, as is shown in Gaudry's figure of Trem. (Naut.) subsulcatum, Ench. du Monde Anim. Foss. Prim. p. 174, but which speedily in course of growth elevate the abdomen and develop ridges. In successive stages the ridges disappear, and the abdomen and sides become flattened, forming a whorl which in section is typically tetragonal and similar to Discitoceras. The siphon is near the venter in the young, and shifts to midway between the centre and the venter in the full grown.

Discitoceras, nobis, is equivalent to the genus Discites, McCoy, Synop. Carb. Foss. Ireland, p. 17. It includes species with quadragonal whorls having the abdomen slightly convex, sides flattened, the dorsum very gibbous. There is also a slight impressed, dorsal zone. The young are ridged longitudinally with prominent transverse striae, but though these cross and roughen the ridges, they do not render them subspinous. The sutures have ventral, and lateral lobes, aud broad dorsal saddles with small annular lobes. The siphon is above the centre. The living chambers vary from one-fourth to three-fourths of a volution in length. The aperture has a very deep ventral sinus, with large lateral saddles near the dorsum, and small lateral sinuses The type, Dis. costellatum, McCoy, Op. Cit. pl. 2, fig. 4, was apparently the young of a species similar to his Dis. discors. The name Discites has been used by DeHaan, Walch and Schlotheim for genera of Mollusca, and we, therefore, substitute another name for that first announced by McCoy.

Phacoceras,[1] nobis, has whorls compressed and acute in the adults, but with young similar to the adults of Discitoceras. The

[1] Φάκος, a lentil.

whorls are very involute, and there is a deep, impressed zone of involution on the dorsum. The young sutures are probably similar in outline to those of Discitoceras, but in the adults there are ventral saddles, according to DeKoninck. Type, Phac. (Naut.) oxystomum, sp. DeKon. Calc. Carb. pl. 17.

Aphelaeceras,[1] nobis, includes Carboniferous species allied to Discitoceras until a late stage, but the whorls are more compressed laterally, have hollow abdomens in later stages and adults, and sides more convergent. The forms are gyroceran, and have no impressed zone on the dorsum, which is gibbous, and sometimes projecting along the centre. Sutures, and living chambers and apertures similar to those of Discitoceras. The young appear to have median dorsal saddles, which become divided by slight dorsal lobes during growth. In the adults there is a dorsal lobe, but the median saddle appears to have been absent in the adolescent stage of the single species we have examined. This genus also includes nautilian species, which differ from the typical Aphelaeceras in being involute and in having an impressed zone on the dorsum, but the dorsal lobe similar. Aph. (Naut.) difficile sp. DeKon. Calc. Carb. and disciforme, sp. M. et W., Geol. Ill., Vol. 5, pl. 18, are members of this subdivision.

Subclymenia, D'Orb. Prod. de Pal., Vol. 1, p. 114, differs from Discitoceras in the sutures, and position of the siphon. The sutures have a deep V-shaped ventral, and acute, linguiform first pair of saddles, first pair of lateral lobes narrow, a second pair of small, lateral saddles near the umbilical shoulders, and dorsal saddles, divided by shallow annular lobes with a minute median saddle. The abdomens are hollow and the dorsal region gibbous, as in the adults of Aphelaeceras. The siphon is near the venter, but the funnels do not approach near enough to interrupt the sutures, or affect the depth of the ventral lobes. But one Carboniferous species is known, Subcly. evoluta, sp. Phil., De Kon. Calc. Carb., pl. 45.

Tribolocerati dae.

This family includes shells, which at some stage have longitudinal ridges rendered subspinous by the transverse striae. The whorls in section tend to become depressed, and in the higher

[1] Ἀφελής, smooth.

species have fluted, and often hollow abdomens. The siphon is above the centre in all except radical forms. The sutures acquire ventral, lateral, and dorsal lobes, and annular lobes in the higher nautilian species of Vestinautilus. The radical of this family is Thoracoceras among the Orthoceratidae, and this genus could be very appropriately included in this family. The type is the Thor. Vestitum Eichw. Bull. Soc. Imp. de Mosc. 1844, p. 761, pl. 17. It includes Thor. (Cyrt.) corbulum, sp. Barr. pl. 125 of the Silurian, and several Devonian species, besides the Carboniferous spinous ridged species like Thor. (Cyrt.) canaliculatum, sp. DeKon. Calc. Carb. pl. 33, and also the frequently smooth ridged arcuate forms, like Thor. (Cyrt.) Puzosianum, sp. DeKoninck, which have similar transverse striae though less prominent. The connection between this genus, and Triboloceras is too close to need discussion. A connection with the Trigonoceratidae can also be inferred from the resemblance of the adults of such species as Thor. Puzosianum, and the young of some forms of Trematoceras and Discitoceras. But the connection with Trigonoceras is made very doubtful by the transverse costae of that genus, the form, and the modifications of the dorsal sutures. We incline, therefore, to separate the group at least provisionally from the Trigonoceratidae.

Triboloceras,[1] nobis, includes the remarkable series of gyroceran, Carboniferous species described by De Koninck in his Calc. Carb., which have subspinous ridges in the young until a late stage of growth, and otherwise resemble the adults of Thoracoceras. The whorl in section is more or less depressed, and either biangular with convex abdomen and gibbous dorsum, or approximately triangular with concave abdomen. The siphon is above the centre. The sutures have broad, ventral, and lateral lobes, and dorsal saddles without annular lobes. Type, Tribo. (Gyr.) serratum, sp. DeKonnick, Calc. Carb. pl. 32, fig. 5. Mus. Comp. Zool. The forms range from Tribo. (Gyr.) propinquum, ibid., pl. 33, to Tribo. (Naut.) Meyerianum, ibid., pl. 29.

Vestinautilus, Ryckholt, includes nautilian species of the Carboniferous with depressed subtriangular, or trapezoidal whorls, the abdomens very broad, and the dorsum with an impressed

[1] Τρίβολος, a burr.

zone in the adults of most species. The young in the adolescent stages have a hollow abdomen with keels, or longitudinal ridges on the abdomen, and forms as in the Triboloceras, but the full grown shells usually become convex on the abdomen with fewer ridges, and in old age are rounded and smooth. Vest. multicarinatus, DeKon. Calc. Carb. pl. 30, remains until late in the adolescent stage similar to the adult of Trib. Meyerianum. The genus also contains more involute species. In these the carinations tend to disappear, and the whorls become rounded as in Vestin. globatus and Coyanus, DeKon. Calc. Carb. pl. 31. The development is much concentrated in the last, the ridges being suppressed at an early stage. Vest. (Naut,) Koninckii, DeKon. ibid, p. 139, pl. 30, is cited as the type of Ryckholt's genus.

Koninckioceras,[1] nobis, includes nautilian Carboniferous species with whorls, having a depressed but broad convex abdomen, trapezoidal in section in the adolescent stages, and similar in form to some species of Triboloceras until a late stage of growth. Sutures have slight lobes on the venter or straight, and broad dorsal lobes, but no annular lobes. There is an impressed zone on the dorsum, but the umbilical perforation is very large. Type, Kon. (Naut.) ingens sp. De Kon. Calc. Carbon. pl. 23, Mus. Comp. Zool. Camb. Kon. (Naut.) implicatum, ibid, pl. 13, shows the adolescent stages. The form of whorl and dorsal lobe appears to place the species in the same series with Triboloceras.

Aipoceratidae.

This family is remarkable for the rotund form of the adolescent and adult whorls, and most species have a trumpet-like or flaring aperture. The peculiar heavy ridge of the umbilical shoulders in the nautilian forms is also a marked peculiarity. The siphon is in most forms close to the venter, but in some between the centre and the venter. The Sactoceran peculiarities of the radical species separate the group from any series to which it might have been otherwise referred.

Aploceras D'Orb. Prod. Pal. Vol. 1, p. 112, includes a series of arcuate Carboniferous forms described by DeKoninck, Calc. Carb. These have a brevicone aspect in most species, the shell

1 Dedicated to Prof. L. DeKoninck.

is striated longitudinally with fine closely set ridges even in full-grown shells. The siphon is nummuloidal, and above the centre. The whorls vary in section from rounded to elliptical, and even depressed elliptical outlines. The living chamber in Apl. (Cyrt.) rostratum, sp. DeKoninck, ibid, pl. 35, is contracted slightly at the aperture. The type is Apl. Verneuillianum. sp. DeKon., Calc. Carb., pl. 34. The nearest affines of this genus seem to be in the genus Sactoceras.

Aipoceras,[1] nobis, includes the Carboniferous gyroceran forms of which we know but one species, Aip. (Gyr.) gibberosum, described by DeKoninck, Calc. Carb. pl. 32. This has a similar whorl and is evidently a close affine of Aploceras, but the siphon is tubular, and close to the venter as in Asymptoceras. The smoothness of the shell, also, is transitional to this last named genus, as well as the more compressed outline of the whorl in section. The sutures retain the simple outlines of the arcuate radicals, having slight ventral and dorsal saddles, or nearly straight outlines. Mus. Comp. Zool.

Asymptoceras, Ryckholt, Not. sur Asymp. et Vest. 1852, has for its type, according to DeKon., Calc. Carb. p. 112, Phillips' species of Naut. cyclostomus. Solenocheilus, Meek, is a synonym, having for its type Asympt. (Naut.) Springeri W. & St. J., Tran. Chic. Acad. Vol. 1, p. 124. The whorls increase very rapidly in size, the living chambers are short with flaring, or slightly contracted apertures. The venter is flattened, or slightly hollow along the centre. The sides are more or less gibbous, and the umbilical shoulders project in heavy ridges, or a large pair of tubercles. Upon each side of these are flutes which are specially characteristic. The dorsum is also remarkable for having the centre gibbous as in gyroceran forms, indicating the recent derivation of the genus from more loosely coiled forms. The sutures have broad ventral lobes, saddles at the abdominal ridges, broad lateral lobes, saddles at the umbilical shoulders and dorsal lobes, with small annular lobes. Siphon is near the venter.

The elliptical form of the young whorl, the large umbilical perforation, the simple, fine, smooth, longitudinal ridges, evenly distributed around the whorl, indicate derivation from Aipoceras.

[1] Αἰπύς, lofty or high.

The presence of a pair of large tubercles on the chambers of habitation in some of the species unites them with such forms as Asypm. (Naut.) bifrons sp. DeKon. Calc. Carb. pl. 16. Even the contracted chamber of this species and of Asypm. (Naut.) conspicuum ibid, pl. 19, does not enable us to separate these species.[1]

Nautilidae.

The species of this family have the typical nautilian whorls, ridged in the young, but smooth usually in adults. The sutures, though lobed on the venter in one genus, have generally broad saddles and sutures like those of the recent Nautilus. In several series we traced the appearance of the annular lobe in the sutures, and an internal septal depression, which we have called the cone. The sutural lobe appears in the Devonian, and is inherited in the Triassic genus, Cenoceras, with the cone better developed, and becoming separated from the sutural lobe. In different genera springing from this common type there is a tendency towards concentration in the young, the cones being confined to the earlier stages. Thus in the Jura the cones are still occasionally found in adults, but in the Cretaceous probably very rarely, if at all, and in the Tertiary and present no case of this kind was observed, though they are characteristic of the young. The lobes in the sutures are not exclusively confined to the larval and earlier adolescent stages of growth of recent species, as are the cones, but may be present in adults of the existing Nautilus. In consequence, however, of their separation from the cones, they become easily obliterated in fossils, and are apt to escape observation.[2]

1 Asympt. (Naut.) dorsale is usually considered the type of D'Orbigny's genus Cryptoceras, Prod. de Pal. p. 114, but the species first mentioned by that author on p. 58, Tem. subtuberculatus, should be considered as the type.

2 This is also the history of the same part in other series besides this family and is applicable to all the families of Nautiloids in which the annular lobes appear. The annular lobe of the suture, and the accompanying depression of the septa are almost invariably united in the Paleozoic forms, and the appearance of the cone is very rare. The separation of the two is, however, the rule in the Mesozoic, as detailed above in the Nautilidae. In the Ammonoidea, on the contrary, the lobes and cones appear though very rarely, in Silurian species, and are fully developed in the Devonian Goniatites.

Sphyradoceras,[1] nobis, includes a series of Silurian and Devonian, annulated, costated, and longitudinally ridged species whose close affinity to, and probable derivation from, Spyroceras, will hardly be disputed. Ridges and costae are both present in the young, but in succeeding stages one or the other, or both may disappear. The species are more or less trochoceran in mode of growth, with arcuate and gyroceran forms.[2] They have straighter sutures than in Hercoceras besides the differences of the shell markings, and the position of the siphon varies from near the centre to near the venter. The sutures have either straight sutures, or saddles on the venter, and also saddles on the dorsum. In some species there is a lateral line of tubercles similar to those of Heroceras, but smaller; and the inner lip of the aperture may also occasionally bend upwards as in Hercoceras. Notwithstanding these peculiarities the flattened sides and abdomen of adults and their apertures, which are similar to those of Barrandeoceras; and the compressed elliptical whorls of the young of arcuate species like Sphy. (Troch.) debile sp. Barr. pl. 18, and their central siphon, leads one to associate this genus in the same general series with Barrandeoceras. This group may possibly help us to explain the presence of the longitudinal ridges and annular costae in Barrandeoceras, when more perfect records are available. They may be at present considered a series of shells with slight trochoceran deformation, which is an offshoot of Spyroceras, and possibly nearly related to the ancestral forms of the Nautilidae. Type, Sphy. (Troch.) Clio. sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 59, 111. Mus. Geol. Surv. Albany.

Uranoceras, nobis, includes arcuate and gyroceran forms of the Silurian with large, stout, elliptical, or laterally compressed whorls, abdomen and dorsum convex and about equal in breadth. Siphon is near but above the centre. The sutures have very broad ventral saddles, slight, lateral lobes, and broad dorsal saddles in the early adolescent stages, and acquire very slight ventral and dorsal lobes in the adults of the American species. The siphon is large and nummuloidal, and the peculiar gibbous whorls,

[1] Σφύρας, a cake of dung.

[2] One species, Sphy. (Troch.) nodosum, sp. Barr. pl. 20, fig. 20, appears in only one variety to have had a very faint impressed zone, and may possibly come within our definition of the nautilian shell.

and sutures can be more or less closely compared with the young of Barrandeoceras, the adults of Nephriticeras, and the adolescent of the large Carboniferous forms, like Naut. eximius, and prægravis, DeKon., Calc. Carb. Type, Uran. (Cyrt.) Uranum, sp. Barr. pl. 196.[1] I have met with several specimens of this, or a closely allied species, from Anticosti, Mus. McGill. Coll., Bost. Soc. Nat. Hist., and Mus. Can. Geol. Surv. The exact radicals of this genus are unknown, but it has close relations with Spyroceras in its sutures; and the form of the whorl in U. Uranum is very similar to the laterally compressed and flat abdomened forms of Spyroceras.

Barrandeoceras,[2] nobis, includes gyroceran and nautilian shells with very large umbilical perforations, and compressed, slightly costated or smooth whorls, generally without an impressed zone, though this is sometimes present. The venter is narrower than the dorsum, the siphon near but above the centre, septa deeply concave, and sutures with ventral saddles, lateral lobes and dorsal saddles, without annular lobes. Type, Barr. (Naut.) natator, sp. Bill. Can. Nat. n. s. Vol. 4, Mus. Geol. Surv. Can., The genus also includes the Bohemian forms Barr. (Naut.) Bohemicum, sp. Barr. Vol. 2, Syst. Sil. pl. 32, 33, Sternbergi, ibid, pl. 36, 37, tyrannus, ibid., pl. 38, Sacheri, ibid, pl. 39. Living chamber is about one-half of a volution in length; it is about three-fourths of a volution in length in the type species.

Pselioceras,[3] nobis, includes the series of Dyassic Ophionei, traced by Waagen in his fossils of the Salt Range, Pal. Ind, Ser. 13, pt. 1, Pisces and Cephalopoda. The large umbilical perforation of the type, Psel. (Naut.) ophioneum, sp. Waagen, ibid, pl. 5, fig. 2, shows that it must have been cyrtoceran in the earlier stages for a prolonged period. There is a slight dorsal impressed zone formed, according to Waagen's figures, after the close coiled stage begins, on the first whorl. The resemblance of this genus to the adults of Barrandeoceras natator is very close in the sutures, and form of the larval and adolescent stages. We place it provisionally in the same series, noting, however, that the forms

[1] Barrande has also noted the Nautilius-like aspect of this species.

[2] This genus was dedicated to M. Joachim Barrande, before his death, as a token of respect and admiration for his work upon the fossil Cephalopods.

[3] Ψέλιον, a bracelet.

also resemble the genus Discitoceras in general aspect during the later adolescent and adult stages.

Nephriticeras,[1] nobis, includes Devonian forms with elliptical or broad kidney-shaped whorls. There is an impressed zone on the dorsum at a late stage in the elliptical forms, and in the kidney-shaped whorls this appears at earlier stages. The umbilical perforations are large, and the whorls arcuate until a comparatively late stage of growth in all except the highest smooth forms. Siphon is nummuloidal, and near, but above the centre. The sutures have broad ventral saddles in the adolescent usually with slight ventral lobes in the adults. The lateral lobes are also slight and broad, the dorsal lobes are similar, and have large V-shaped annular lobes in the impressed zone, the last often being very large, and cones are partially formed. The living chambers are from one fourth to half a volution in length and very broad, the increase of the whorl by growth being very rapid. The longitudinal ridges in the radical species, such as Neph. (Naut.) cornulum, sp. Hall, and their arcuate later larval stages, and adolescent gyroceran forms without impressed zones, and central nummuloidal siphons and sutures lead to the conclusion, that the genus sprang from some unknown ridged and probably Devonian form similar to Uranoceras, and Aploceras. Type, Neph. (Naut.) bucinum, sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 60, 109. Mus. Geol. Surv. Albany.

Cenoceras,[2] nobis, includes forms appearing in the Trias, Jura, and Cretaceous, with nummuloidal siphons, flattened abdomens, sides but slightly convex and convergent, the abdomen narrower than the dorsum. The siphon is nummuloidal, and, though near the centre, may be either above or below it. This again in the young occupies a position on the ventral side of the centre in the few forms known. The shells are nautilian from an early stage with decided impressed zones in the adults. The septal cone becomes in this genus separable from the sutural lobe with which it was combined in Nephriticeras. The transitional Triassic species, like Cen. (Naut.) carolinum, and Tintoretti sp. Mojsis. Med. Trias Prov., may have either ventral saddles or lobes in adults, and siphon central or below centre except in the young, and whorls which are not very involute. Jurassic species, though

[1] Νεφρίτης, kidney shaped. [2] Καινός, modern.

with saddles in the young, have almost universally ventral lobes in adults siphon above centre and more involute whorls. The dorsal cones are in some species confined to the larval and adolescent stages, disappearing in adults, whether the annular sutural lobes disappear in adults is difficult to determine in fossils. Type, Cen. (Naut.) intermedium, sp. Sow. D'Orb. Terr. Jurass. Ceph. pl. 27. The resemblance of the Triassic forms to Barrandeoceras is decisive for association in the same series, but there is as yet no evidence that Cenoceras was directly derived from Barrandeoceras. The frequent presence of longitudinal ridges in the young and in some adults, the appearance of the annular lobes at comparatively early stages, and the kidney-shaped whorls of the larvae, also indicate derivation from Nephriticeras rather than Barrandeoceras. We have, however, not yet found the intermediate Carboniferous forms, and these, it must be remembered, may prove to be gyroceran and arcuate shells belonging to the common trunk or stock, but not necessarily to either of the genera mentioned. Some Jurassic species have ridges and transverse striae in the adult shells exactly as in the young of the existing Nautilus.

Cymatoceras,[1] nobis, includes Cretaceous species of the Radiati, remarkable for their transverse costae. The abdomens are rounded and the sides gibbous, though the whorls become compressed in adults of some species. The sutures have large ventral saddles, shallow lateral and dorsal lobes. The siphons are usually sub-central. Annular lobes and cones are present in the larval and adolescent stages, but disappear in adults. The young, as noted first by D'Orbigny, are devoid of costae, these appearing on the second, or even third whorl in some species. The ventral sutures are distinctly lobed in the later larval stages, the saddles developed later in the adolescent and adult stages. Doubtless at still earlier stages than those observed by us, the suture presented the usual larval ventral saddles. Type, Cym. (Naut.) pseudo-elegans, sp. D'Orb. Terr. Cretac. Ceph. pl. 8.

Nautilus,[2] includes forms of the Jura, Cretaceous, Tertiary

[1] Κῦμα, a wave.

[2] Reexaminations of the young of this genus have satisfied the author of errors in former views with regard to the funnels. The funnel of the second septum extends to the opening of the coecum of the first septum on the ventral, but not on the dorsal

and Present, which have tubular siphons, rounded abdomens precisely as in the more radical or lower species of Cymatoceras, and are separable from this genus only by the absence of tranverse costae at all stages. The young sutures in some Cretaceous species, Naut. Dekayi, for example, have first ventral saddles, then in later stages ventral lobes, and in the adults ventral saddles are developed. We have, also, not yet seen a full grown shell among Jurassic species, which had the annular lobes though they are sometimes retained until the latest adolescent stages. The abdomen is sometimes flattened, as in Cenoceras, but the young even in such species have gibbous, or kidney-shaped whorls, they also invariably present longitudinal ridges, which in some species, may even be said to be slightly subspinous. The sipon in the young is between the centre and the ventral side, and in the Jurassic species retains this position in the adults. In Cretaceous species it appears nearer the centre. In the Tertiary species there seems to have been no lobe developed on the venter at any stage, and in the recent species, all three of which we have examined, there is, also, no abdominal lobe at any stage. The adult lobed stage of the Jurassic progenitors is skipped in accordance with the law of concentration of development in descendent forms, and the larval saddles are perpetuated without change throughout life. The young of the modern Nautili do not resemble the adults of Cymatoceras or of Cenoceras, and in our opinion have only one nearly related form, the ridged adults of Nephriticeras. We have to go back to the later larval and adolescent stages of the transition forms of the Jura in order to see that there may have been direct connection between the genera Cenoceras and Nautilus, and some of the facts indicate that the separation of the two genera may have taken place in the Trias. Thus, Naut. striatus, sp D'Orb. and inflatus, ibid, Terr. Jurass. both have the typical form of this genus and ventral saddles. Though the siphons are above the centre, and the annular lobes are retained until a late stage, as in Cenoceras of the same period, they do not resemble them so closely in their aspect as they do the lower forms of the Triassic Ceno-

side. The funnel at this stage is, therefore, macrochoanitic, but not holochoanoidal as formerly supposed. The funnel of the third septum is much shorter. The microchoanitic characteristic appears to be due to the length of the chamber and not to any great difference between the length of these first two funnels.

ceratites, like C. carolinum sp. Mojsis. Med. Tr. Prov. pl. 83. N. elegans, Meek, and N. laevigatus are, however, transitional between this genus and Cymatoceras, and connect them closely. Thus we are obliged to regard the last as an offshoot of the genus Nautilus or of Cenoceras.

MACROCHOANITES.

(Transitiones.)

This group necessarily includes forms which belong to both Nautiloidea and Ammonoidea so far as their embryonic stages are concerned. Thus Bactrites, so far as we know, is a true Nautiloid shedding the protoconch and presenting the cicatrix on the apex of the conch or true shell, as figured by Barrande. Syst. Sil. pl. 490, from drawings made by the author. The ventral sutures are interrupted by the funnels as in Ammonoids, and the sutures are otherwise similar to those of Mimoceras and Anarcestes in some forms. These resemblances are precisely similar to those habitually occuring only between closely allied, parallel series in the two orders, which have been traced to a common radical. The inference is unavoidable, therefore, that we are here dealing with forms which have all sprung at no very remote period from an ancestor with a slender whorl, and striae of growth and sutures like those of the simpler and purely orthoceratitic forms of Bactrites. Having found it impracticable to introduce the curious aberrant forms of the Clymeninae in any other way, we have placed them in the form of a note.[1]

Bactritidae.

Bactrites, Sandb. Leonh. et. Bron. Jahrb. 1841, p. 240, is really a synonym for Trematodiscus, Eichw., Bull. Soc. Imp. Nat. de Moscow, p. 200, but it seems inexpedient to try now to restore the original applications of these names. One cannot compare Bactrites and Mimoceras compressum without being struck by the close affinities of the two forms, and feeling disposed to join Quenstedt in his, at that time, daring thought, that these two forms were closely allied, and bore to each other the same relation as the straight Baculites and the associated coiled Ammoni-

[1] See "Note" p. 312.

tes, Die Ceph. p. 64 pl. 1, 3. We, however, necessarily include in Bactrites, such transitional forms as Bact. (Orth.) pleurotomum, sp. Barr. pl. 296, Xanthus, Endymion, and caduceus, pl. 297, and many other similar Silurian and Devonian forms. These have the striae of growth raised into a saddle on the dorsal side, and the siphon central, or when near the side, ventral as in Bactrites. These forms, also, either have straight sutures or inclined sutures, Bact. (Orth.) fasciolatum pl. 319, and Bact. (Orth.) obliqueseptatum, sp. Sand. Verst. Nass. pl. 18; but they do not have ventral and dorsal saddles as in the compressed forms of Bactrites. Compare for example Bact. (Orth) Paris and eximium, sp. Barr. pl. 412, with the similar compressed Bact. carinatus, sp. Munst. Sand. Verst. Nass. pl. 17. Sandberger and Barrande agree in their observations and in their opinion, that the ventral lobe is due to the approximation of the funnels to the side in Bactrites, and the facts support this conclusion. The Silurian forms we have mentioned are evidently the radicals of Bactrites, and we can only account for their affinities in form, in the transverse striae, and sutures with Mim. compressum by referring both to the common stock and imagining them as the more direct descendants of that stock, which must have had banded shells similar to those of Geisonoceras. The aspect of the apex in two specimens of Bactrites Hyatti, in the Museum of Munich, show that Bactrites is probably a true Nautiloid in the earliest stages, but this distinction has lost much of its value since the discovery of the protoconch in some of the straight cones. It leaves us still at liberty to give due weight to the transitional characteristics of the later stages. And we must, also, in this connection call attention to the important transitional character of the cicatrix, which is shown in our figure of Bactrites on M. Barrande's pl. 490. The cicatrix is unusually large and indicates a protoconch with a larger neck than is usual among Nautiloids. We have seen some, perhaps, even larger in proportion, but they are exceptional as M. Barrande shows in his figures. These facts show, that the ventral lobe of Bactrites is an independent production in this series of straight cones. At the same time we should not forget that such parallelisms occur only in nearly related series, which are descended from the same common stock. At least this has been our experience in all the series we have traced, and we are, there-

fore, disposed to translate this case in the same way. The artificial line between Ammonoidea and Nautiloidea can be placed between this group and Geisonoceras, with which the shells and characteristics of the transitional forms blend, or between Bactrites and Mimoceras according to the weight one is disposed to give to the characteristics of the apex.

AMMONOIDEA.

We have already noted the characteristics of this order, but we find it necessary to add the following remarks.

In each group of Goniatitinae there are forms, with whorls depressed and with outlines semilunar in section, which are similar to Parodiceras and Anarcestes and resemble these genera also in having undivided ventral lobes. There are also in these radical genera and in other genera, either in the adults or in the larvae, forms having simple sutural outlines like those of Parodiceras with slight rounded saddles, and broad, shallow, angular lobes. There can be but little risk of error, therefore, in assuming that the genus Parodiceras is the organic centre of the Devonian forms, and the immediate radical of all Goniatitinae except the Primordialidae. The Primordialidae appear to be directly derived from Nautilinidae, and we have not been able to trace any descendants. This result shows that the genus Anarcestes is probably the genetic centre of distribution, the stock form in the phylum of the Ammonoidea, or the first with undeniably Ammonoidean form and characteristics, the immediate radical, while, as we have noted above, the group of Bactrites and Geisonoceras are the distal radicals.

Dr. Branco has worked out very valuable results with regard to the law of concentration of development among Cephalopods, but has failed to appreciate their meaning or to note the fact that others had tried to explain similar results. He confirms views first published by the author, that the larvae of the Goniatites and Ammonites have simple sutures, and the ventral lobes undivided in the early stages, and that these lobes become divided only in later stages, and farther, that the more ancient forms remain longer in the simple or goniatitic stage with undivided ventrals, than the later forms. He alludes also (Pal-

eontogr. Vol. 3, 1880–81, p. 29) to the well known and frequently described increase of complication in the sutures which takes place during growth in every individual, and then shows that the earlier or goniatitic stages are abbreviated in the young of the mesozoic Ammonitinae. He is thus able to compare this process of the abbreviation in later species of the earlier ancestral characters and correlate its progress with the similar progressive complication, which takes place in the adult forms in time. He then inquires if this progress in the sutures in adults is an accident, "ein reiner Zufall," or if it stands in definite or causal hereditary relation to the concentration or shortening of the simpler or Goniatitic stages of the sutures in the more recent forms.

We think that it would have been no injury to his thorough and remarkable embryological contributions, if he had noted more fully our remarks on the nautilian character of the first septum in the Goniatites and Ammonites, and of the additional fact that every Goniatite passed through a nautilinian stage, and every Ammonite through a goniatitic stage. Dr. Branco was perhaps misled by our figure (Embryol. of Cephalopods, pl. 3, fig. 3) which has an accidental ventral fissure in the first septum. We distinctly state on page 86, however, that this was due to the "violent removal of the shell," and describe the first septum as having an entire ventral saddle in both Goniatites and Ammonites on pages 61, 64. These and other facts such as the earlier inheritance of siphonal coecum in the protoconch of the Ammonoidea, which Dr. Branco erroneously rejects, are due to the law of concentration and acceleration in development, or the shortening of the earlier stages of development in more complicated and later occuring species. The same author's supposition that the degenerate forms cannot be distinguished as such, but may be cited as facts against this theory shows that he has not understood the close coiled embryos of these forms, and is either not acquainted with the researches of Quenstedt, or has failed to consider then worthy of his attention. When an author takes high ground in favor of any special method one has a right to expect unusual freedom from error. Dr. Branco's method, however, has not enabled him to escape the usual fate of authors, whether fact-worshippers or theorists. He has misinterpreted

the most important fact of the embryology of the Nautiloids, the cicatrix, and failed in correlating the resemblances between the embryos of Nautiloids and Ammonoids, and in correctly distinguishing their differences.

We appreciate his work very highly, and we gladly acknowledge discoveries properly belonging to him, and these are, the distinctions of the Asellate, Latisellate, and Angustisellate types of embryo among Ammonoids. The progression of the embryo through the concentrated and accelerated inheritance of ancestral characters was previously stated by ourselves, and his remarks on this point are simply confirmatory, though more fully stated, more completely worked out, and more richly illustrated.

Goniatitinae.

This sub-order may be characterized by the possesion of smooth shells marked principally by transverse striae, and open apertures similar to those of Nautiloidea. The large ventral sinuses of the apertures of nearly all the species show, that they must have possesed powerful hyponomes, or fleshy ambulatory funnels, and were animals which had similar habits to those of Nautiloids, capable of crawling efficiently on the bottom or of swimming by the use of the hyponome. The sutures are entire, with a few notable exceptions, in the later forms. The funnels change from the macrochoanitic form to a short transitional form, and in some species in later formations acquire the true ammonitoid collar, or in other words, become completely cloiochoanitic.

The ventral lobes are undivided, and similar to simple funnel lobes only in the Nautilinidae and Magnosellaridae. In the remaining families genera may have undivided or divided ventrals in the same family, or exclusively divided ventrals as in the Primordialidae. The dorsal or inner sides are occupied by saddles only in the gyroceran form, Mimoceras, and the uncoiled or gyroceran larvae of higher forms. The Nautilinidae have a broad dorsal lobe in the impressed zone, but no annular lobes except in one genus, Agoniatites. All the remaining genera have annular lobes, so far as known, except the transitional species from Anarcestes to the Magnosellaridae included in the genus Parodiceras. The annular lobes are undivided so far as known, the true siphonal saddles having no corresponding dorsal saddles as

among the Ammonitinae. Silurian forms are notable as having sutures with undivided ventrals of the simplest type, shallow primitive outlines to the first pair of saddles, primitive first lateral lobes and dorsal sutures with broad lobes or saddles, but no annular lobes, and the funnels are machrochoanitic. There are exceptional genera, but these are very rare. Devonian forms have the large magnosellarian lateral saddles, and transitional characters in the forms, septa, and outlines of the sutures, which are advances towards the Ammonitinae. The ventral lobes when divided are apt to be very broad and the siphonal saddles large. In the Upper Devonian and Carboniferous there is a tendency to narrow the ventral lobe and produce smaller siphonal saddles, and divide the first pair of saddles and also the magnosellarian saddles into smaller lobes and saddles. Forms having marginal lobes and saddles, which make near approaches to the Ammonitinae occur only in the Carboniferous.

The abrupt appearance of the Goniatitinae in the later Devonian and earlier Carboniferous formations of North America, and the absence of radical forms of the group of Nautilinidae in the Silurian indicate that they were migrants from European sources and not autocthonous.

Nautilinidae.[1]

This family includes forms with gyroceran and nautilian whorls, and sutures with simple lateral lobes either throughout life or until a late stage of growth. There is a dorsal lobe in the impressed zone, which is due to the involution of the dorsal saddle suture, which is present in the larva. There is no annular lobe except in the more aberrant forms. The ventral lobe is a true funnel lobe in the lower species, becoming a wider ventral lobe in the higher species, as in Pinnacites. The funnels are long and tapering, and in species with approximate septa seem to be continuous, though really ellipochoanoidal. The shells are banded with transverse striae, but otherwise smooth, and the apertures have a ventral sinus, which may be in exceptional transitional forms like Mimoceras quite small, but are usually large.

[1] On p. 256 mention of the Magnosellaridae as having undivided ventrals and of the fact that the dorsal saddles were confined to the lower forms of Nautilinidae was accidentally omitted.

The young are asellate, the first suture having no ventral saddle, according to Branco. The larvae in some forms are cylindrical and open whorled, but in all the higher forms closed, and, though still asellate, have the broad form of the ammonitic embryo.

Mimoceras[1] includes two well known species of true Goniatites, but these are separable from Bactrites in no essential characteristic, except the presence of a permanent protoconch upon the apex. The septa have simple concave lateral sutures, and dorsal saddles without annular lobes, the whorls have no impressed zone, and the shells are, therefore, not really truly nautilian in form, but gyroceran; and even the compressed whorls are similar to those of some Bactrites. The ventral lobe is a simple funnel lobe, as in Bactrites, and it divides the ventral saddles in the same way. Their characteristics, and the protoconch ally them, however, even more closely with Anarcestes and oblige us to place them in the Nautilinidae. This evidence appears to need but one more link, the finding of a Bactrites with a globular protoconch. Type, Mimoc. (Gon.) compressum, sp. Beyr. Sandb. Verst. Nass. pl. 11, fig. 4; also, Mim. (Gon.) ambigena, sp. Barr. Syst. Sil. pl. 3, 12, and possibly Gon. Dannenbergi, Beyr. Verst. d. Bay. Rheins, Ueberg. pl. 1, fig. 5.

Anarcestes, Mojsis. Mediterr. Trias Prov. p. 181, was pointed out by that author but insufficiently defined, and a list of species given in a note, the only characteristic cited being the living chambers, which are said to be long. The genus is also characterizable by the broad semilunar whorl, the abdomen broader than the dorsum, this peculiar form is present in the later larval stages, and is maintained even in excess in some very involute species in which the abdomen in consequence becomes excessively broad, the sides very narrow, and the umbilicus very deep. There are some discoidal species, like Anar. crispus sp. Barr. pl. 9, fig. 31, with rounded whorls until a late stage of growth, but most of the species depart from the tubular outline at a very early age. Sandberger shows that in one variety of Anar. subnautilinus the first whorl is gyroceran, and Branco, in the same species, demonstrates, that variety vittiger is close coiled. Compressed whorls occur in some Silurian species, such as Anar. neglectus,

[1] **Μῖμος**, a mimic.

sp. Barr., but the compressed forms are more numerous in the Devonian than in the Silurian, like Anar. circumflexifer, and subnautilinus Sandb. Verst. Nass. pl. 11. The closest affinites exist between the young of Anar. subnautilinus, and the adults of Mimoceras, and it seems probable that this genus is directly derived from the gyrocean Mimoceratites, whether through the intermedium of Silurian or protozoic, transitional forms, we do not yet know.

Heminautilinus, nobis, includes species with whorls similar to those of Anarcestes, but with angular lateral lobes in the adults. The species figured by Munster as Gon. hybridus, Ueber Clym. pl. 3, fig. 6, is the type. This figure enables us to see that the species was a form having the sutures of Mimoceras and Anarcestes until far advanced in the adolescent stages of growth.

Agoniatites, Meek, Paleont. Explor. 40th, Paral. Vol. 4, p. 99, equals Aphyllites, Mojsis. Med. Trias Prov. p. 181. The last author designates the living chambers as shorter than in Anarcestes. Agon Vanuxemi, sp. Hall, Nat. Hist. N. Y. Vol. 5, pt. 2, pl. 59, has this part of whorl fully two-thirds of a volution in length. Agon. bicaniliculatus, sp. Sandb. Verst. Nass. pl. 11, in the least involute variety fig. 5, has it about the same length, and in the involute variety fig. 5, c-g, it is about one half of a volution. In this last variety the septa are so closely set, that the funnels of the siphon appear to be holochoanoidal, but close inspection brings out the thin connective wall of the siphon which distinguishes the ellipochoanoidal siphon of these groups. This connective wall is hard to demonstrate, both from its closeness to the shell, and the small size of the posterior ends of the funnels. The sutures have deep lateral lobes, and more prominent saddles than in Anarcestes; internally the septa are deeper than in Anarcestes, and rise to a shallow concavity near the venter. The dorsal lobe is to be found in the zone of impression, but is very shallow has an elevated suture, and is entire, without annular lobes. Comparison between Mimoceras and Anarcestes, and the larva of Agon. Vanuxemi show that the dorsal lobe, as in Nautiloids, is correlative with the closer coiling of the shell, and is really a sutural depression dividing the large dorsal saddles of the larva. The umbilical saddles of the sutures are formed by the increase in breadth of the zone and the accompanying dorsal lobes, and in-

crease in proportion to the deeper involution of the whorls, as in some Nautiloids. Agon. fecundus, sp. Barr. Syst. Sil. pl. 11, is less involute, and shows how closely the larval shells repeat the adult peculiarities of the parent gyroceran form, Mimoceras. In fig. 4, occurs the extraordinary variety with straight larval apex, which leaves us in no doubt, that these shells must have had a remote ancestor with a straight cone in the adult stage. Agon. fidelis and verna sp. Barr. pls. 8, 9 and Vanuxemi, Hall, exhibit species with the highly concentrated development common in the more involute, and compressed shells which generally terminate the series we have studied. They have skipped the larval peculiarities of the gyroceran stage, and become close coiled and even involute on the first or second whorl. Agon. tabuloides, sp. Barr. pls. 4, 244, exhibits in the section figured a decided annular lobe, showing that this may occur in some Silurian species of the Ammonoids, though usually a Devonian characteristic of both Ammonoids and Nautiloids. Another curious fact is that it has the internal depression we have called the cone, which among the Nautiloidea is not in our experience fully developed until after the Carboniferous, and certainly must have been rare, if it occurred in other forms in the Paleozoic.

Pinnacites, Mojsis. Med. Trias Prov. p. 181, was merely mentioned by that author and the type given, as the Pin. emaciatus sp. Barr. of the Silurian. We have not examined the type, but in the Mus. Comp. Zool. there exist fine specimens of the Devonian form which does not differ apparently from its Silurian ally. The highly compressed and acute whorl becomes excessively involute at an early age, and we were able to follow the sutures far enough to see, that in the larva the natural decrease of involution must bring about the disappearance of the umbilical lobes, and reduce the sutures to the outlines of Agoniatites. The abdomen is also broader in the young and the whorl in section is identical with the adults of Agoniatites, and these facts indicate direct derivation from the latter. The septa of the adults are double concave in correspondence with the lateral lobes, the internal surface being divided by ridges corresponding to the lateral saddles. There is a broad dorsal lobe, with two small, widely separated dorsal saddles, the impressed zone is very deep, and there is no annular lobe, unless the broad median lobe may be so considered

Celaeceras[1], nobis, includes only Cel. (Gon.) praematurum, sp. Barr. Syst. Sil. pl. 522. It is unique among Silurian forms in the sutures, which possess outlines similar to those of the more complicated Devonian and Carboniferous forms. There is in Barrande's figures, though not described by him, ventral saddles, similar to the saddles of Pinnacites and on either side are two deep lateral lobes similar to those of Glyphioceras. The first pair of lateral saddles are large and hastate, and the second pair of lateral saddles broad and rising rapidly to the umbilicus. The shell is not very involute, showing that it is a member of a larger series, which probably had both less involute and also possibly some more involute members. The inner lateral saddles associate it with the Agoniatites rather than Anarcestes. We regard it as having probably the same relations to Agoniatites, that Heminautilinus has to Anarcestes. The young, as in Heminautilinus, will probably be found to repeat the parent form until a late larval stage in some species. M. Barrande repeatedly alludes to this species as one of his best illustrations of anachronic species, or species which are out of place in time; which more closely resemble succeeding forms of more complicated structure than those of the fauna in which they occur. To us they are simply highly specialized forms, which have adopted habits similar to those of the species they resemble, and have been accordingly modified in their adolescent and adult stages, but still retain in their larval and adolescent stages the marks of their recent origin from the lower forms with which they are associated. We have accordingly named this form, the racer

[Note.]

CLYMENINAE

This group has characteristics which are so evenly balanced that we should have found it difficult to decide whether it was Nautiloid or Ammonoid, if it had not been for the protoconch, and the young sutures, which are shown by Branco in the Paleontogr. Vol. 8, 1880, pl. 8, fig. 1. The sutures in the young have ventral lobes, and the broad ventral saddles of the group are developed later. It is, therefore, an Ammonoid, but we cannot say that the young resemble the lower Goniatites, since the first suture of the only species known, in place of being asellate, or straight, has a broad saddle as in the higher Goniatites. A still more remarkable peculiarity, if general, is, as stated by Branco the absence of depressions on either side of the neck of

[1] Κέλης, a racer.

Cloiochoanites.

[Transitiones.]

The transitional forms of the Goniatitinae, which have the short type, or partly cloiochoanitic funnel elevated upon a median

the ovisac. These are the remants of the umbilical perforation, which are present in the young of all other close coiled Ammonoids. These characteristics, and the dorsal position of the siphon, and the presence of deep annular lobes, are differences of great importance and show that we must place the series above the Nautilinidae. The forms are evidently highly concentrated in development, but descendants probably of the same stock as Anarcestes. The adult forms and the sutures of Cyrtoclymenia are very similar to those of Anarcestes and indicate this derivation. The group appears to have had a very narrow distribution chronologically and geographically, and was probably a highly specialized series with exceptionally rapid evolution in some open fields of the Devonian. So far as I know, not a species of this group has yet been found in North America, those described heretofore are now known to be Goniatites. The author has spent considerable time in the study of this group and divided them into genera, but these can only now serve as the basis of appreciative criticism for the elaborate work of Dr. Gumbel, Ueber Clym. Paleontog. Vol. 11, p. 83, 1863. This author's sub-groups are equal to our genera, and most of his varieties are what we should call species. We, therefore, use his names in this value without making any claim to the credit of having originated them. This extraordinary series shows the phenomena of quick evolution in three series of forms. Cyrtoclymenidae with a series beginning with an Anarcestes-like form and passing through discoidal and compressed to quadragonal costated forms. Cymaclymenidae, a similar parallel series but with more complex sutures, and Gonioclymenidae also a similar series, but with more involute forms than the last, and the sutures becoming ammonitic with median ventral lobes and saddles divided by a pair of marginal lobes. The whole range of the transformations of the Goniatitinae are paralleled in this short series, whose principal differential characteristic is the dorsal position of the siphon. We have had no opportunity of studying the siphon but Dr. Gumbel's group of Euclymenia with imperfect siphons appear to us like the imperfect siphons which occur not infrequently among Nautiloids, the connective wall being destroyed by maceration. The Nothoclymeniae are apparently those with longer, larger funnels and thicker connective walls. Dr. Gumbel's figure of Cly. speciosa gives the funnels as if terminated by a darker colored connective wall.

CYRTOCLYMENIDAE.

The sutures are simple with broad undivided ventral saddles, rounded or incomplete shallow lateral lobes and only rarely internal saddles on the sides. The siphon is tubular and small.

Cyrtoclymenia includes species with depressed semilunar whorls in section, similar to those of Anarcestes. The sutures are similar, but the ventral saddles of the Clymeninae are present, though rounded, and the lateral lobes are also rounded. Type, Cyrt. angustiseptata, Gumb. pl. 15.

Oxyclymenia includes forms with discoidal shells, compressed and more or less involute whorls. The larval depressed whorls of Cyrtoclymenia have disappeared from the adult stages. The sutures have ventral saddles more prominent than in that genus, and in some species the angular lateral lobes are deeper, but there are no large lateral saddles. Type, Oxy. laevigata, ibid, pl. 16, also undulata, pl. 17, and Dunkeri, pl. 16.

siphonal saddle are not separable from congeneric forms having undivided ventral lobes. The Primordialidae have very large siphonal saddles carrying short, collarless funnels, and the Magnosellaridae have undivided ventral lobes. The funnels are small and elevated upon the first pair of saddles in most of the Magnosellaridae and these so closely simulate siphonal saddles as to deceive the most accurate observer.

Platyclymenia, nobis, includes species with similar sutures to Cyrtoclymenia, but the whorl is discoidal as in the Oxyclymenia and it differs from both of these in having costated whorls, which are in section sub-quadragonal Platy. annulata, ibid, pl. 15, fig. 11, and includes, also pl. 18, fig. 12, spinosa, pl. 16, fig. 1, and binodosa, pl. 19, fig. 1, though the latter has an internal lateral saddle.

CYMACLYMENIDAE.

The forms have undivided ventral saddles, and two pairs of lateral lobes, the first pair angular and the second pair in the umbilicus and rounded. The siphon is transitional to the large siphoned species of the next family.

Cymaclymenia includes species with forms similar to those of Cyrtoclymenia, but more compressed and involute. The sutures have prominent ventral saddles, and two lateral lobes with two umbilical or dorsal lobes on either side of the annular lobe. Type, Cym. striata, ibid, pl. 18, and bilobata, pl. 19. These forms in their siphons and their sutures connect Cyrtoclymenia with the larger siphoned groups, the Nothoclymeniae of Gumbel, which begin with the next genus.

Sellacymenia includes species with whorls compressed, sub-quadragonal and precisely similar to Platyclymenia but the sutures are similar to those of Cymaclymenia and the siphon also according to Dr. Gumbel is large and complete. Type, Sel. angulosa, pl. 19.

GONIOCLYMENIDAE.

The ventral saddles are divided by median lobes, and by a pair of marginal lateral lobes. There are also two lateral lobes on either side. The siphon is large, and the funnels conical.

Cryptoclymenia, nobis, includes but one species. This has the form of Cyrtoclymenia and enables us to connect the series of genera having ventral lobes, with this radical genus. The sutures have median lobes dividing the large ventral saddles, and two pairs of lateral lobes. Type, Crypt. Beaumonti ibid, pl. 20, fig. 5.

Cycloclymenia includes an extraordinary discoidal species with numerous, slowly growing whorls. The sutures have the ventral saddles divided by median lobes.

Gonioclymenia includes species with quadragonal whorls, sometimes costated as in Sellaclymenia and Oxyclymenia but they have median ventral lobes, and two pairs of lateral lobes and large siphons. Type, Gonio. speciosa, ibid, pl. 20, and also subarmata and intermedia ibid, pl. 21. The Gon. pessoides V. Buch, and bilmpressus, ibid, Gon. et Clym. pl. 1, probably are true Clymeninae as stated by Gumbel, and may be species of this genus.

Discoclymenia includes Clymenia Haueri, which has sutures very similar to those of the preceding, but the lobes are more numerous, and the annular lobes broad. The whorls are much involved and compressed in the adult with a deep impressed zone.

The similarity of the funnels and funnel lobes to those of the Nautilinidae, may be seen in Sandberger's figures in Jahrb. d. Nass. Ver. f. Naturk. Vol. 7, 1851, pl. 2. The Glyphioceratidae and Proleceanitidae have undivided ventral lobes in the lower or transitional genera, and divided ventral lobes and cloiochoanitic funnels in the higher and later occurring forms. Triainoceras and Pronorites, have transitional ventral lobes which may be considered as undivided, and all the remaining genera have the short, collarless type of funnel. The excessively short, rapidly narrowing funnels, and the similar character of the breaks which they make in the sutures of the ventral side, is a marked, and highly interesting peculiarity, and led to our designating the whole group at first as Epichoanites.[1] We supposed that all the following genera could be included in this group, and farther characterized as having simple funnels without collars.

Dr. Branco, however, in Zeit. Deutsch. Geol. Gesell. 1880, p. 607, note, made us aware that Beyrich's observation on Glyph. (Gon.) sphaericum, and Sandberger's figure of Glyph. (Gon.) crenistria Verst. Nass. pl. 5, fig. 1, showed that the siphonal collar was present in both of these species. Branco's statement that our definition of a collar may be regarded as a mere question of opinion cannot be sustained. The microscope makes it evident that the fore-reaching part of the septum is not like the posterior part. The fore-part is an open collar around the siphon, while the hinder part is a true funnel, interrupting the siphon as in our figure, Embryo. Ceph. Bull. Mus. Comp. Zool. 3, No. 5, pl. 2, fig. 15. Sometimes also as in the cases above cited, and in the type of Schistoceras described farther on, it is easy to see with unassisted eyes, that the true funnels below and the collars above are distinct from each other.

Primordialidae.

This group which is closely allied to the Nautilinidae, possese remarkable interest as the most primitive series in which many of the essential differentials of the Ammonitinae first make their appearance. The ventral lobes are very large, and are divided by

[1] We are not yet satisfied that this would not be a convenient descriptive designation for the whole of the Cloiochoanites [Transitiones] or all the Goniatitinae, except the Nautilinidae.

median siphonal saddles which carry the funnel lobes. The development of the sutures has been followed out by Branco, Sandberger, and the author, and all agree that these median saddles arise in the centre of the primitive ventral lobes. The two arms of the primitive ventral lobe become widely separated, and appear in the later stages of growth, like true lateral lobes. The first pair of saddles are large and rounded, though in the higher and more involute species, often angular. The ridges from these cross the septa and have corresponding dorsal saddles on either side of the annular lobe. The young are asellate, as first stated by Dr. Branco, and the first sutures and radical forms indicate direct derivation from the same stock as Anarcestes. While still in the broad whorled anarcestian stage, the septa are nautiloidian or concave, but when the deep ventral lobes and large lateral saddles are formed, the septa become ammonitoid or convex along the median line. The funnels, which are also anarcestian in the young, become shortened as the siphonal saddles arise and assume the ammonitoidal aspect, though no collars are developed. The funnel lobes are variable in size, and may be absent in some specimens, as in two of Gephuroceras lamed in Coll. Mus. Comp. Zool. This variation has been also observed by Sandberger in this same species and in same variety with one of the above cited instances namely, lamed Var. cordatus, Jahrb. d. Nass. Ver. f. Naturk. Vol. 7, 1851, pl. 3, fig. 21, 22. The early larval sutures have broad dorsal lobes, which become narrowed into annular lobes in later stages correllatively with the development of the ammonitoid septa, and especially with the development of the first pair of lateral saddles. We adopt Beyrich's name of Primordialidae as more significant than that subsequently given by Sandberger.

Gephuroceras,[1] nobis, includes species with discoidal young, whorls with broad and more or less flattened abdomens in the adolescent stages, and the sides divergent as in Manticoceras. There is a decided resemblance to the adults of this genus especially to Man. latidorsatum, but the larval and adolescent stages in the radical species are separable by means of their flattened abdomen and less rapidly growing whorls. The adult whorls become

[1] Γέφυρα, a bridge.

compressed and subacute in several species, but retain their open umbilici except in the most involute species. In these, however, the larvae remain sufficiently constant to enable us to recognize the genus. The serrated or costated abdomens of the young of several forms, is also in marked contrast with Manticoceras. The depth of the ventral lobes causes the septa to assume a convex aspect, but the median line remains concave until a late stage of growth. The large lateral saddles when first formed, and until a comparatively late stage in radical species, have no corresponding dorsal saddles, these arise later as two minute saddles in the dorsal lobe, on either side of the annular lobe. The species are Geph. (Gon.) calculiforme, Beyr. Sandb. Verst. Nass. pl. 8, fig. 9–9a (not 9c–d), aequabile, Beyr. Gon. Mont. Rhen. pl. 2, fig. 1, and also Sandb. pl. 8, fig. 10, to which last also belong Sandberger's figures 9c–d mentioned in brackets above, Hoeninghausi, D'Arch. et Vern. Trans. Geol. Soc. Vol. 6, n. s. pl. 25, and Buchii, ibid, pl. 26, fig. 1, serratum, sp. Sandb. pl. 9, fig. 8, planorbe; sp. Sandb. pl. 9, fig. 3, forcipifer, sp. Sandb. pl. 6, fig. 3, discum, Roem. Nordw. Hartz. Paleontogr. Vol. 6. pl. 13, fig. 35 (not pl. 6, fig. 7) and bisulcatum ibid, pl. 6, fig. 8, acutum, Keyser, Dom. Schief. Verh. Mimneral. Gesell. St. Petersb. 1844, pl. A fig. 6. In America we have seen only Geph. (Gon.) complanatum, sp. Hall, Nat. Hist. N. Y. Vol. 5, pl. 70, fig. 6–12, and the Type, Geph. sinuosum, ibid, pl. 70, fig. 73–75, Mus. Geol. Surv. Albany.

Manticoceras,[1] nobis, includes species with compressed and often very involute whorls, which are, however, directly traceable by the closest gradations into forms with broad whorls, open umbilici, and an aspect similar to that of Anarcestes. The young are invariably less discoidal than in Gephuroceras, the abdomens rounded, and the sides divergent outwardly. A close resemblance to Agoniatites bicaniliculatus, or tuberculosocostatus [2] occurs in the costated young and in the sutures and form of Mant. tripartitum until a late larval stage. The adult sutures have the same general aspect as those of Gephuroceras, but the septa in the compressed involute forms become more decidedly convex. The

[1] **Μαντικός**, prophetic.

[2] This is a costated species of Agoniatitites, which we have supposed to be equivalent to Sandberger's figure Verst. Nass. pl. 2, fig. 3. It also resembles costulatus D'Arch. et Vern. Trans. Geol. Soc., pl. 26, fig. 3.

lobes remain rounded until later stages of the growth, the funnel lobes are generally smaller, the larger lateral saddles are also more persistent and retain their forms unchanged even in the extreme old stages of the largest specimens. The species are as follows, Manti. (Gon.) latidorsatum, Sandb. Verst. Nass. pl. 8, fig. 8, tripartitum, ibid, fig. 7, lamed, fig. 4, 6, are all regarded by Sandberger as varieties of lamed, but they can be distinguished by their development from each other. Manti. (Gon.) intumescens, Beyr. Rheins. Ueberg. pl. 2, fig. 4, Sandb. ibid, pl. 7, Manti. (Gon.) complanatum, pl. 8, fig. 5, the latter a variety of lamed Sand. both have in adults excessively acute, and involute whorls. Manti. (Gon.) bisulcatum, sp. Keyser, Dom. Schief, Verh. Min. Gesell. St. Petersb. pl. A, fig. 7, seems to be in this genus. In America we have found, Manti. (Gon.) simulator, sp. Hall, Nat. Hist. N. Y. Vol. 5, pt. 2, pl. 69, fig. 1, 2, Pattersoni, ibid, pl. 72, fig. 1–5, Gon. Goniolobus, Meek, Geol. Expl. 40 Parall. Vol. 4, pl. 9, fig. 5, may possbly be a greatly modified Carboniferous form of this genus with closely approximated septa. Type, Manti. simulator, sp. Hall, Mus. Geol. Surv. Albany.

Magnosellaridae.

This family is distinguished by the early development and undivided outlines of the magnosellarian saddles, which induced Sandberger to designate the group as the Magnosellares. The ventral lobes are primitive and undivided, and in the lower forms are small, and really mere funnel lobes breaking the outlines of the ventral suture. This is a purely nautilinian character and the first pair of saddles also retain a similar primitive aspect, but in the higher forms tend to split up and form a first pair of lateral lobes and a second pair of saddles. The first pair of saddles have no correspondent on the dorsum but the second pair have corresponding dorsal saddles when they are present, as in Maenoceras and Sporadoceras. These facts justify the opinions of Mojsisovics, and others that the sutures of this genus are approximate to those of the Nautilini, and our own observations indicate closer affinity for Anarcestes, than for any other genus. The figures given by Sandberger in Jahrb. d. Nass. Ver. f. Naturk. Vol. 7, 1851, pl. 2, of Parodiceras biarcuatum, and amblylobum illustrate this affinity for Anarcestes, especially since these two have

no annular lobes on the dorsum. The septa are concave as in the Nautilini in the larvae, but become convex internally after the rise of the magnosellarian saddles. The magnosellarian saddles, besides their prevalence in the Devonian species and in the larvae of later forms, are notable as resembling the similar large saddles of some of the Nautiloids, as in the young of Enclimatoceras, and the rise of the septa dorsally in some of the Anarcestes group.

Parodiceras,[1] nobis, includes species with whorls in section semilunar, sutures with very broad, generally flattened, and primitive forms of the first pair of saddles, lateral lobes shallow and mostly angular, the magnosellarian saddles, often rising, as in the young of Tornoceras above the level of the first pair on the venter. Our opportunities for study in this genus have been limited but we have been able to see that some species have very small annular lobes and others, as figured by Sandberger in Jahrb. d. Nass. Ver. Naturk. above quoted, had probably no annular lobes. These characteristics of the septa and the general aspect of the adults are transitional from Anarcestes to Tornoceras. In Branc. umbilicatum according to Sandberger's figure, in Jahrb. Nass. Ver. Vol. 7, 1851, pl. 2, fig. 9, there are slight saddles on the dorsum corresponding to the first pair on the venter, while in biarcuatum and amblylobum there are none. The first named species is directly transitional from Parodiceras to the genus Brancoceras.

The young are stouter than in Torn. auris and they also inherit the semilunar and involute whorls at early larval stages. Parod. curvispina is discoidal and biarcuatum, planilobum, angulatum are all more involute species figured by Sandb. Verst. Nass. pl. 10, but the last is laterally compressed. Parod. amblylobum, ibid, pl. 10, fig. 8, and pl. 4, fig. 5, has a compressed whorl in the later larval stages. Parod. oxycantha Sandb. pl. 10, fig. 3, in some specimens shows a decided tendency to division of the ventral saddles as in Maenoceras bifer. Parod. (Gon.) sublineare Munst. Ueb. Clym. et Gon. pl. 4, fig. 5, according to Munster's figure is transitional to the simpler sutures of Parod. (Gon.) undulosum, sublaevis, and globosum, sp. Munst. Ueber Clym. et Gon. pl. 4. We have found but one species in this country, the

1 Πάροδος, transition.

type of our genus, Parod. (Gon.) discoideum, sp. Hall, 13, Rep. on State Cabinet and also Nat. Hist. N. Y. Vol. 5, pt. 2, pl. 71, fig. 1–13.

Tornoceras,[1] nobis, includes species which are similar to Parodiceras, but have compressed whorls, and annular lobes. The sutures have rounded saddles on the venter and rounded lateral lobes with the typical magnosellarian saddles of the family. The first pair of saddles have no corresponding saddles on the dorsum, and the annular lobes are situated immediately between the large dorsal saddles corresponding to the magnosellarian saddles. The ventral lobes and sutures in the larval stages are similar to the adults of Anarcestes. The stage at which the ventral saddles are in a primitive condition has close resemblance to the older stages of Parodiceras. Sandberger's figures of Torn. (Gon.) circumflexum, Verst. Nass. pl. 10, fig. 9, and auris, pl. 10 a, fig. 19, and Hall's figure of the young of uniangulare show this very well. The effect of the lateral saddles in elevating the internal parts of the septa and the concavity of the outer parts of the same sutures, which remain concave throughout life, are well shown in Sandberger's figures of Torn. auris, pl. 10, a, fig. 4, 5. Torn. (Gon.) discum, sp. Roem. Nordw. Hartz. Paleontogr. Vol. 3–pl. 6, fig. 7, and auris, ibid, pl. 6, fig. 11, both have sutures even in late stages, perhaps adults, very similar to those of Anarcestes, according to Roemer's figures. Torn. auris, sp. Sandb. pl. 10 a, fig. 12, and Var. pl. 10, fig. 11–12, together with Var. pl. 10 a, fig. 18, 19, make together a series which we include under the same name. Var. undulatus, pl. 10, fig. 17–19, also belongs to this species. Torn. (Gon.) retrorsum, sp. Von Buch, has a stout variety similar to auris, the typical variety undulatus Sandb. pl. 10 a, fig. 7, has morecompressed whorls than auris even in larval stages. The young in both of these varieties are smooth, and exhibit no signs of the raised and costated abdomen of auris, though here and there, specimens with reversionary characteristics occur. Var. typus. Sandb. pl. 10, cannot be separated in the larva or adults from the above. Torn. acutum, sp. Sandb. pl. 10, fig. 10, pl. 10 a, fig. 2, can be separated by the sub-acute whorl of the adolescent stage and the breadth of the later lobes and narrow

[1] **Τόρνος**, circular or rounded.

ventral saddles. In America we find Torn. (Gon.) Mithrax, sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 69, bicostatum, ibid, pl. 72, fig. 8–10, and the type, Torn (Gon.) uniangulare ibid, pl. 71, 72.

Maeneceras,[1] nobis, includes forms in which the first pair of saddles are broad, somewhat flattened, and during growth tend to become subdivided. The inner angles become subacute, and small marginal lobes appear between the outer angles and the ventral lobes. These changes may take place late in the life of theanimal or be inherited at comparatively early stages in accordance with the lawof concentration of development in the more complicated species. The dorsal sutures change correllatively, and acquire a pair of subacute dorsal saddles on either side of the annular lobe as in Sandberger's Maen. terebratum, Verst. Nass. pl. 5, fig. 3 d. Sandberger's figure 4 of Maen. bifer, and his figure 5 c of Maen. (Gon.) delphinum show, that as in Sporadoceras the dorsal saddles were connected with a second pair of saddles, and not probably with the primitive saddles. The larval stages, are identical in form and sutures with Parodiceras. Maen. (Gon.) bifer, sp. Sandb. ibid, pl. 9, fig. 4, is closely allied to Parod. oxycantha but has the genetic characters of this genus in the later larval stages. Maen. (Gon.) terebratum, sp. Sandb. ibid, pl. 5, fig. 3, exhibits all these characteristics, and the changes in the first pair of saddles described above at still earlier stages. The adult form of this species is the Maen. (Gon.) acuto-laterale Sandb., pl. 6, fig. 1b. The whorl in this stage is no longer rounded, but subacute, and the first pair of saddles are completely divided by rounded lobes. We have studied the intermediate adolescent stages of this species, and have been able to connect the two figures quoted by a fine specimen precisely intermediate in size and all its characteristics. Coll. Mus. Comp. Zool., type Maen. acuto-laterale, sp. Sandb.

Sporadoceras,[2] nobis, includes species which like Maeneceras have additional saddles developed from the division of the first or primitive pair of saddles, but these are generally pointed in adults and the first and second pairs of lobes hastate. The forms of the shells still remain similar to those of Parodiceras and Maeneceras and the magnosellarian saddles are undivided. A

[1] Μήνη, a crescent.

[2] Σποραδός, scattered.

specimen in the Col. Mus. Comp. Zool. either identical or closely allied to Spor. bidens exhibits primitive saddles incompletely divided although the shell is about 4.3 cent. in diameter. The ventral lobes, and the first pair of marginal lobes are still comparatively small and are elevated upon the large primitive, larval saddles. This genus also as in the preceding shows two dorsal saddles which arise in correlation with the formation of the additional second pair of saddles, and are connected with them by ridges traversing the septa. The first pair of saddles have no correspondents on the dorsum. Sandberger's figure of Spor. bidens, pl. 8, fig. 11, illustrates these observations completely. The annular lobe is deep and undivided. Spor. (Gon.) bidens, sp., Sandb., pl. 8, fig. 11, bilanceolatum, ibid., pl. 9, fig. 7, and Spor. (Gon.) contiguum, sp. Munst. Clym. et. Gon. pl. 3, fig. 8, orbiculare, ibid, pl. 5, fig. 4, cucullatum, sp. Von Buch, Gon. et Clym. pl. 1, fig. 4, Hoeninghausi, sp. Von Buch. Ueber Amm. et Gon. and Munsteri, ibid, pl. 2; fig. 4, 5, also Sand. pl. 5, fig. 2, are examples of this genus. Type, Spor. bidens, sp. Sandb.

Glyphioceratidae.

This family includes forms having whorls semilunar in section and discoidal shells, with some more compressed and involute forms. The ventral lobes are undivided in the lower transitional forms which connect the family directly with Parodiceras, among the Magnosellaridae, but in the higher genera they are divided by siphonal saddles with cloiochoanitic funnel lobes. The first or primitive saddles are on the venter, the first or primitive lateral lobes are contracted in breadth, deep, and often angular, the magnosellarian saddles are undivided in some genera and divided in others by a single pair of wide, shallow, angular lobes. The primitive, or first pair of saddles have corresponding saddles on the dorsum, on either side of the deep, undivided, annular lobes. The development and outlines of the sutures, and the ventral lobes exhibit the close affinities of this family for the Magnosellaridae, and the still younger stages, as described by Branco, show their affinities for the Nautilinidae, especially Anarcestes.

The septa are convex along the median line, in all the genera except in the transitional genus Brancoceras. The development of the siphonal saddles is similar to that of the Primordialidae, but

the gradations of the forms and sutures are unmistakable and connect them genetically with the genus Parodiceras. The siphonal saddles are evidently in this and other families purely representative characteristics arising from the tendency to divide the primitive ventral lobes. Within the families, however, it is evident that the siphonal saddles are inheritable after they have been introduced, and become fixed in the organization. In each of the three sub-families, the siphonal saddles are in accordance with this law first independently generated, and then become fixed.

The essentially representative character of the division of the lobes and saddles when first introduced in each series is especially well exhibited in the Dimorphocerae. In this tribe the ordinary outlines of the sutures of this family are modified by the introduction of marginal saddles, which sub-divide the lobes, as among the more recent Ammonitinae. After careful investigation, we can find no evidence for the supposition that the recent Ammonitinae acquired their similar modes of dividing the lobes by direct inheritance from such highly involute Carboniferous species. On the contrary there is strong evidence that the Triassic Ammonitinae sprang from discoidal shells with forms of whorl more closely resembling the primary radical Anarcestes.

If we analyze the forms of Triassic species, as they have been published by Mojsisovics in his classic work Med. Trias., Prov. we are at once struck by the prevalence in every series of a certain proportion of discoidal forms, and by the fact that these are repeated in the young of the more involute forms of the same series, as is not infrequently noted by Mojsisovics himself in his descriptions. Some genera like the Sphingites among Arcestidae and Tirolites, and Xenodiscus may have all, or nearly all the species discoidal, but as a rule the variation from these forms to much more involute, or completely involute forms takes place in the same genus, and is useful only in distinguishing the species. The discoidal or less involute forms are always the simplest in the structure of the sutures, as well as larval in their own series; witness again Sphingites and Xenodiscus, also such single species as are found in the group of Trach. furcosa, and Monophyllites.

Arcestes, Dyas, and Trias, so far as we know, is the only group as a whole, which possesses in the adults the depressed larval

form of the Silurian Anarcestes, which we also recorded as occuring in nearly every group of the Goniatitinae and at the morphological base of the groups of the Clymeninae. This form of whorl has almost disappeared in the Trias and its place is taken by quadragonal derivatives, like Xenodiscus, and the compressed helmet shape, which we have designated as the secondary larval forms. Whatever form we may admit into the category of secondary larval radicals, they must in all cases be discoidal, with open umbilici; and either themselves, or their immediate ancestral forms must be shells, without spines or prominent outgrowths, though they may be costated, as in Sandbergeoceras, the immediate radical of the Prolecanitidae. The exact agreement between the sutures and forms, and their development both in the series and in the individual is not in the Trias substantiated by the observed geological positions of many species, in fact the occurence of Monophyllites, Sphingites, and Ceratites Sturii and the secondary radical, Dinarites Mohammedanus and other instances are directly against these views. This, however, does not at all alarm us, if there is any truth in the theory of descent, we feel sure that the clue lies in the development of the individuals which occupy the lower morphological borders of each series, and exhibit in their forms, sutures, and shells, the nearest approach to the primary radicals of the Silurian or Cambrian.

The Paleozoic or primary radical is Anarcestes, and its depressed whorl becomes larval in the more involute forms of all the genetic series with which we are acquainted among the Paleozoic Goniatitinae, being absent from the early stages only in forms with gyroceran young, and it is inherited by all forms above the Carboniferous, at the earliest stage of the formation of the apex or conch.

The discoidal secondary radicals are unquestionably the nearest allies of this primary radical, which occur in the Devonian, and these in their turn have a similar relationship with the Dyassic and Triassic species having similar discoidal forms and simpler sutures than other more involute shells of their several groups. We can, therefore, with the reservation, that the connections have not been actually made, state that a great change takes place in the Dyas, and that here or about the time of the end of the Paleozoic the secondary larval radicals, or Mezosoic helmet-

shaped with more complicated lobes and saddles like Monophyllites, Ceratites Sturii, Dinarites Mohammedanus, and the less involute, smooth, similar, forms of Gymnites, Ptychites, perhaps also Pinacoceras, and Ophiceras begin to be more numerous and to replace the Paleozoic radicals as generators of distinct genetic series. Psiloceras, though in the Jura, belongs, we think to this class of radical forms.

The tertiary radical forms of the Jura and Cretaceous are often highly ornamented and complex in their sutures, but they are also discoidal, like all other larval radicals and they give rise to progressive series of more involute forms as we have tried to demonstrate in several families, and numerous genera. Following out Häckel's nomenclature which we regard as truthful and expressive, these categories of radicals can be very appropriately designated as the Epacmatic, and Acmatic radicals, and when as is often the case, the Acmatic forms become the radicals of degenerative series of uncoiled forms, we propose to call them Paracmatic radicals.

[Gastriocerae.]

Brancoceras,[1] nobis, includes species of the Devonian and Carboniferous with undivided, ventral lobes, rounded or spatulate first pair of saddles, broad, abrupt, magnosellarian saddles, and only one pair of often hastate lateral lobes. The spheroidal form of the shell, the deeply involute, and semilunar whorls show close affinities for Parodiceras. The adult stages still continue to have the septa concave along the centre, and only convex in the region of the magnosellarian saddles. The annular lobes are large and undivided, and the first pair of saddles have corresponding saddles on the dorsum. The dorsal sutures have also large saddles corresponding to the magnosellarian saddles as in the Magnosellaridae and three lobes. The internal sutures are, therefore, precisely similar to those of Sporadoceras, but the external sutures have one pair less of lobes and saddles, and in that genus the first pair of saddles on the venter have no correspondents on the dorsum. The closest connection evidently exists between this genus and Munsteroceras, which have similar outlines in the sutures, and rounded first lateral lobes as in this

[1] Dedicated to Dr. W. Branco.

genus. Bran. (Gon.) sulcatum, sp. Munst. Ueber Clym. et Gon. pl. 3, fig. 9, ovatum, ibid, pl. 4, fig. 1, lineare, ibid, pl. 5, fig. 1, subsulcatum, ibid, pl. 5, fig. 2, and Ungeri, Munst. Beitr. are all good examples of this genus. The type, Bran. (Gon.) Ixion sp. Hall, Nat. Hist. N. Y., Vol. 5, pl. 78, which is a close ally, if not identical, with Bran. (Gon.) rotatorium, DeKon. Calc. Carb. pl. 47, fig. 12, has young, ibid, pl. 73, fig. 12, which are similar in their globular shells, and in their sutures to the adults of the more spherical species of this genus. Branc. umbilicatum, sp. Sandb., has external sutures very similar to those of Parodiceras and is mentioned in the description of that genus.

Munsteroceras,[1] nobis, includes species of the Upper Devonian or Lower Carboniferous which resemble Brancoceras closely in form but are more discoidal. The siphonal saddle is small or larval in shape and is developed in the centre of a deep, often straight-sided ventral lobe. The first or primitive saddles are on the venter and spatulate in outline. The magnosellarian saddles are undivided on the sides in the lower species of this group, but a curious and instructive variation takes place in American forms. Munst. parrallelum has the outer suture of the magnosellarian saddle depressed posteriorly below the level of the inner suture of the corresponding dorsal saddle. An acute lobe is thus formed on the edge of the umbilicus, and a small saddle rises inwardly from this towards the zone of compression, and is visible near the edge of the umbilicus in Munst. Oweni. In Gastrioceras this lobe becomes more important, and in Paralegoceras it is a lateral lobe, and plainly visible on the sides. In the upper Devonian, according to Hall, we find Munst. parallelum, nobis, equals Oweni var. parallela, Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, fig. 1, 2, pl. 73, the members of this genus are Munst. (Gon.) Whitei, nobis, equal Oweni, sp. White, Geol. Ind. Ann. Rep. 2, 1880, Pal. pl. 7, fig. 3, 4 (Gon.) tumidum, sp. Roem. Paleontogr. Vol. 3, pl. 13, fig. 3, 4 (Gon.) implicatum, sp. Phill. Geol. York. pt. 2, pl. 19, fig. 24, 25, reticulatum, ibid, fig. 26–32, excavatum, ibid, fig. 33–35, complanatum, DeKon. Calc. Carb. pl. 46, fig. 4, inconstans, ibid, pl. 48, fig. 4–9, truncatum, ibid, pl. 48, fig. 2, 3, implicatum, ibid, pl. 50, fig. 2. The forms are all more involute than Munst. Whitei,

[1] Dedicated to the memory of Georg, Graf zu Münster.

which is a discoidal shell. Type, Munst. parallelum, sp. Hall, Mus. Geol. Surv. Albany.

Gastrioceras,[1] nobis, includes species with open umbilici and whorls in section semilunar or trapezoidal. The abdomen is wider than the dorsum and the sides often costated. The larvae always have whorls semilunar in section, and similar in form and sutures to the larvae of Brancoceras during the stage before the generation of the siphonal saddles. The siphonal saddle is developed as in the Primordialidae, but is not usually so large or broad as demonstrated by Branco and confirmed by our own observations. The sutures at earlier stages and the whorls have the usual similarity to those of the adults of Anarcestes. The adolescent and adult stages have deep, straight-sided ventral lobes and siphonal saddles which are often more or less prominent and angular. The first pair or primitive saddles are on the venter and often spatulate making the sutures similar to those of Munsteroceras, while the general aspect of the shells is representative of Glyphioceras. The magnosellarian saddles are divided at the shoulders of the whorls with acute lobes, and internally are flanked by saddles rising rapidly to the zone of impression as in Munsteroceras. Gast. (Gon.) Listeri, sp. Phill. Geol. York. pl. 20, fig. 1, of the Carboniferous and Marianus, ibid, pl. 27, fig 2, and Jossae, sp. M. V. K. Russ. and Ural Mts. pl. 26, fig. 2, both from the Dyas are European examples of this genus, and in this country we find Gast. (Gon.) Kingii, sp. H. W., U. S. Geol. Surv. Expl. 40th Parall. Vol. 4, pl. 6, fig. 8, and (Gon.) globulosus, sp. M. W., Geol. Surv. Ill., Vol. 2, pl. 30, fig. 2.

Paralegoceras,[2] nobis, is similar to Gastrioceras in its sutures, but the whorls are compressed, and the sides smooth in the cast. The sutures are similar also to our genus Schistoceras, but the broad, shallow, angular second lobes, and the peculiar internal saddles show closer affinities for Gastrioceras and Munsteroceras. It is apparently a compressed Carboniferous form directly connected with Gastrioceras. The only species known to us is the Paral. (Gon.) Iowense, M. et W. Geol. Ill, Vol. 2, pl. 30, fig. 3, from the coal measures.

[1] Γάστρις, a pot-belly.

[2] Παραλέγω, I lie by the side of.

[Prionocerae.]

Prionoceras,[1] nobis, includes species with broad, acute, straight-sided, undivided, ventral lobes similar in outline to the first pair of saddles, and the first pair of lobes. The magnosellarian saddles are undivided. The young of these shells, if they had the same mode of development as other Goniatites must have had more rounded first pair of saddles at some stage of growth, and this would render the sutures at this stage similar to those of some forms of Parodiceras. The immediate affinities, however, connect them with Brancoceras, from which genus we should not have dared to separate Prionoceras, but for the artificial necessity of showing clearly the genetic relations of this genus and Glyphioceras. The species differ from Brancoceras only in the acuteness of the first pairs of saddles and lobes, and their peculiar pyramidal shape. The type is Pri. (Gon.) divisum Munst. Ueber Clym. et Gon. pl. 4, fig. 6, of the Devonian. This species and Pri. Belvalianum, De Kon. Anim. Foss. pl. 49, fig. 5, and Calc. Carb. pl. 50, figs. 8–10, have sutures similar, in their undivided ventral lobes, and lateral outlines, but the first pair of saddles on the venter are pyramidal in shape, like those of Glyphioceras, and are evidently transitions to this last genus.

Glyphioceras,[2] nobis, includes species with whorls in section semilunar, trapezoidal or compressed, the abdomens broad and convex, the sides divergent outwardly, and frequently costated. The sutures are remarkable for the acute, angular outlines of the lobes and saddles in the adolescent and adult stages, and the large size and frequently bottle-shaped siphonal saddle. There are exceptions to the angularity of the lobes in some species, which retain the early larval form of the outlines of the sutures in their later stages of growth, but in these, the rapidly narrowing ventral lobes, and the large size of the linguiform first lateral saddles enables one to refer the species to their proper genus. In their later larval stages the sutures are not distinguishable from those of Munsteroceras, with which also the forms of the whorl agree equally closely. The siphonal saddles are small, and occupy only the apex of the straight-sided, deep ventral lobes, and the first pair of saddles are spatulate, and the lateral lobes and magnosellarian saddles are precisely as in that genus.

[1] Πρίων, a saw.

[2] Γλυφίς, the notch in an arrow.

Notwithstanding the extraordinary development of the siphonal saddles, there is no corresponding division in the annular lobe, which is subacute and entire in outline. The first pair of saddles have corresponding but smaller and less acute saddles on the dorsum, and the magnosellarian saddle is also nearly as prominent as on the venter. The umbilical shoulders are occupied by rounded lobes. All the known species are found in the Carboniferous and have the pyramidal form of siphonal saddle. The funnels are surmounted by collars which can be seen on good casts of Glyph. sphaericum and which closely simulate the collars of Schistoceras.[1]

It seems evident that Prionoceras is the intermedium between this genus and the common family radical, Brancoceras. The young of Glyp. obtusum, as figured by DeKon. Calc. Carb. pl. 47, shows the relation of the group to the more remote radical Parodiceras with which the sutures agree quite closely except in the siphonal saddle.

Glyph. (Gon.) crenistria, sp. Phill. Foss. Corn. Devon. pl. 50, fig. 234, spiralis, Rom. Nordwest–Harzegeb. Paleontoger. Vol. 3, pl. 8, fig. 15, carbonarium, Buch. Ueber Goniat. pl. 2, fig. 9, sphaericum, Calc. Carbon., pl. 47, fig. 3–5, striatum, Sow. Min. Conch., trans., pl. 53, fig. 1, striolatum, Phill. Geol. York. pt. 2, pl. 19, fig. 14–19, truncatum, Rom., Nordwest–Harzegeb. Paleontogr. Vol. 3, pl. 13, fig. 30. The shells in this section of the genus are involute but the umbilici open, and the whorl semilunar in section. The ventral lobe has a distinct siphonal saddle, which divides it into two acute terminations, the first pair of lateral saddles are inclined towards the umbilicus, and often acute, first pair of lateral lobes also acute, the magnosellarian saddles are undivided.

The second section includes the following, Glyph. (Gon.) obtusum, sp. Phill. Geol. York. pt. 2, pl. 19, fig. 10–13, micronotum, ibid, pl. 19, fig. 22, 23, platylobum, ibid, pl, 20, fig. 5, 6, stenolobum, ibid, pl. 20, fig. 7–9, Barbotanum. M. V. K., Russ. and Ural, pl. 27, fig. 3, diadema, ibid, pl. 27, fig. 1, complicatum, Kon. Calc. Carbon. pl. 50, fig. 4, nitidum Phill. ibid. pl. 20, fig. 10–12. These shells have similar sutures, but the saddles are often slightly rounded or linguiform, and the whorls compressed. The siphonal saddles are smaller, and larval in shape and proportion. All of the first list except spiralis occur in the lowest beds of the Carboniferous, and

[1] See also p. 315, and p. 336.

those of the second list in the formations, up to the Lower Coal Measures of Bigsby and Etheridge.

[Dimerocerae.]

Dimeroceras,[1] nobis, includes a single species, Dim. (Gon.) mamilifer, sp. Sandb. Verst. Nass. pl. 5, fig. 5, which has rounded first pair of saddles on the venter, rounded first lateral lobes, and an additional pair of shallow, broad, angular, lateral lobes near the umbilical shoulders, generated by the division of the magnosellarian saddles. The ventral lobes are undivided and this species is evidently a transitional from Brancoceras to Pericyclus.

Pericyclus, Mojsis. Mediter. Trias. Prov. p. 141, includes two Carboniferous species which were designated by that author without description. The spatulate first pair of saddles and the additional, broad, angular, lateral lobes, which arise from division of the magnosellarian saddle give the sutures exactly the aspect of those of Dimeroceras. The genus can be separated only by the divided ventral lobes, and costations. Type, Peri. (Gon.) princeps, DeKon. Anim. Foss. and Calc. Carbon. pl. 49, fig. 1.

[Dimorphocerae.]

Homoceras,[2] includes only the curious species (Gon.) calyx, sp. Phill. Geol. York. pl. 20, fig. 22, 23. This has trapezoidal whorls, like those of Gastrioceras, and sutures which are quite similar to those of Glyphioceras. The form is, however, dwarfed with sutures still more like those of Nomismoceras, which has similar dwarfed forms. The siphonal saddles are small, the ventral lobes broad, and open, the first saddles and lobes rounded, and the magnosellarian saddles short, undivided, and rounded. The sutures show the species to be in the same series as Nomismoceras, but the highly depressed, trapezoidal form of the whorl obliges us to separate it from that genus. Gon. mutabilis Phill. ibid, pl. 20, fig. 24, 25, not fig. 26, may also belong to this genus, but there are no sutures as yet known.

Nomismoceras,[2] nobis, includes a series of dwarfed forms with compressed whorls, open umbilici, resembling in minature the larger forms of the Prolecanites but differing from these

[1] Διμερής, in two parts.

[2] Ὅμός, like, [3] Νόμισμος a coin.

decidedly in their sutures. The ventral lobes are divided, and very broad and large, the lateral sutures generally are very like those of the second section of the genus Glyphioceras with which the forms are evidently closely allied, but the small siphonal saddles, and the larger size, and rounded outlines of the first pair of saddles, and the aspect of the magnosellarian saddles are differences of some importance. Nomismoceras (Goniatites) spirorbis Phil. Geol. York., pl. 20, fig. 51–55, rotiformis Phil. ibid, pl. 20, fig. 56–58, paucilobus Phill. ibid, pl. 20, fig. 36–38, platylobus Rom. Nordwest. Harzge. Paleontogr. Vol. 3, pl. 13, fig. 32. The whorls are discoidal, compressed, and helmet shaped in section in the first two species, and involute, compressed, and subtrigonal in the last two. Nom. paucilobus in form and sutures, is intermediate between the discoidal forms of this genus and Dimorphoceras.

Dimorphoceras,[1] nobis, includes Carboniferous species with involute compressed whorls, and sutures quite distinct from those of Nomismoceras on account of their peculiar siphonal saddles, narrow first pair of saddles and divided lobes, but resembling them closely in their magnosellarian saddles, and general aspect. They are in fact, only more complicated and modified examples of the same style of sutures, the lobes having ammonitic marginal saddles in place of entire outlines. They have a narrow, prominent, siphonal saddle, and minute funnel lobe, the arms of the ventral lobe on either side of this, are divided by one or two minute marginal saddles, the first lateral saddle prominent spatulate, the second lateral lobe divided like the arms of the ventral, the magnosellarian saddle broad and undivided. But two species are known to us, Dim. (Gon.) Gilbertsoni, Phil. Geol. York., pl. 20 fig. 27–31, Looneyl. Phil., ibid, pl. 20, fig. 32–35.

Prolecanitidae.

This family can be distinguished by the absence of the great magnosellarian saddles, which are so completely divided as to be more or less unnoticeable in adults, though visible as an underlying outline in some radical species, and in some larval forms such as Sand. Chemungense. The number of lobes and saddles varies greatly, but there are never less than two pairs of large, lateral

[1] Δίμορφος, double formed.

lobes in adults exclusive of the inner series of auxiliary lobes and saddles. One pair of lateral lobes, the outer pair of the adult stages, arises out of the division of the first pair of saddles in Prolecanites, and several pairs in Beloceras, but whether this may be considered exclusively the method of generation cannot be stated now. The primitive pair of lateral lobes are generally deepest and may be distinguished by this character. The general form of the matured lobes is hastate and the saddles club-shaped, but the Belocerae,the lowest or radical sub-family, and the lower or radical species of Triainoceras have simple flexuous outlines in the sutures. The ventral lobes are, as in other families, undivided in radical genera and species; and divided in higher forms of each tribe or sub-family group. The first pair of saddles have corresponding saddles on the dorsum, and there are deep, undivided, annular lobes. The dorsal suture is divided not only by this pair of saddles, but has additional pairs corresponding closely to the number of saddles and lobes on the exterior in all the broad whorled genera; except the umbilical lobes, which as in all the Goniatitinae have no correspondents. The radical genera appear to approximate to Sandbergeoceras and this genus is not traceable to Parodiceras, so far as we know. The other radical forms, however, like Sandbergeoceras Chemungense and Phar. tridens have lobes and saddles, which indicate derivation from Magnoselaridae, and we have accordingly referred the group provisionally to this radical. This family is very interesting also, because we can directly trace a connection with Jurassic forms, and see that the phylliform marginal saddles of Lytoceras and Phylloceras are probably derived through Monophyllites of the Trias from Prolecanitidae. The line is evidently an unbroken one to Ptychites and we think these and the Phylloceratidae can be distinguished by the excessive division of the lobes, the attenuated and deeply cut saddles and the peculiar form of the siphonal saddles and their close relations to the first pair of saddles taken in connection with the phylliform marginal saddles, and the tendency to produce additional external saddles, and lobes, and numerous auxiliary lobes and saddles. We shall probably in forthcoming publications separate this whole series, including Arcestes from the Ammonitinae and Goniatitinae, under the name of Prolecanitinae.

[Belocerae.]

Sandbergeoceras,[1] includes species with peculiar saddles and obes, which are variable in number and larval in their outlines. The shells are discoidal, the form of the whorl in section is depressed, semilunar, the abdomen broadest, and there are costae from an early stage of growth. The ventral is undivided according to Sandberger's figures, and the funnel lobes break the suture with a peculiar tubular prolongation of the tips of the lobes, and with slight shoulders or minute incipient saddles on either side, like those in the undivided ventrals of Brancoceras. These are transitional to the minute siphonal saddles observed in the ventral lobes of Triainoceras, present in the lower Devonian forms. The species are Sandb. (Gon.) tuberculosocostatum, sp. Sand. Verst. Nass., pl. 4, fig. 1; and Sandb. (Gon.) Chemungense, sp. Hall, Nat. Hist., N. Y., Vol. 5, pt. 2, pls. 69 and 74. The last species has sutures which show it to be closely allied to Prolecanites. Though very simple in outline, they would not have been sufficient to separate it from Prolecanites but for the presence of costations on the whorls.

Beloceras,[2] nobis, includes only one species but the most remarkable and in many characteristics the most instructive of Devonian forms. The additional lobes and saddles are very numerous and have entire margins and are apparently only limited in number by the breadth of the whorl. They are partly derived from division of the ventral or primitive ventral saddles, and partly from the division of the magnosellarian or umbilical saddles. It must also be observed that here as in other forms the primitive pair of lateral lobes are marked by their greater size, and their earlier development.

Sandberger has traced the mode of genesis of the lobes and saddles in his text and in figure of Beloc. (Gon.) multilobatum, sp. Beyr., and Branco, Paleontogr., Vol. 27, ser. 3, pl. 6, fig. 6, has shown the process in its earlier stages. His figures and statements, however, do not make it perfectly clear, that the first pair of saddles are true primitive saddles, though they certainly seem to have a close resemblance to those of Maenoc. bifer. Mojsisovics in his "Gebirge um Hallstatt, p. 43 and 69 refers the type of

[1] Dedicated to Prof. Guido Sandberger. [2] Βελος, an arrow.

this genus to his genus Pinacoceras, from which, however, it is separable by the characteristics given above, and by the very simple flexuous lobes and saddles of the adolescent stage, which resemble those of Sandbergeoceras.

[Sageceraе.]

Medlicottia, Waagen, Paleontol. Indica., ser. 13, pt. 1, p. 39, and p. 83, equals part of Sageceras as formerly defined by Mojsisovics. The lobes are divided by single linguiform marginal saddles, and the second species named below has trifoliate, or divided saddles, though the first pair and the marginal lobes have the same form as in Orbignyanum. The ventral lobes are deep and apparently undivided, the first pair of saddles are narrow long, and the margins cut by several lobes and saddles growing progressively longer internally. The numerous auxiliary lobes are generated apparently as in Beloceras from the marginal divisions in the outlines of the first pair of saddles, and from the division of large magnosellarian saddles near the umbilicus. We only know of two species which can be properly included in the genus. They are Medlic. (Gon.) Orbignyianum, sp. M. V. K. Russ and Ural Mts., pl. 26, fig. 6, and Medlic. primas, Waagen, Pal. Indica., ser. 13, pt. 1, p. 39 and 83, pl. 2, fig. 7, both Dyassic forms. Mojsisovics has pointed out the probable connection of this group with Beloceras and Sageceras in his Med. Trias. Prov. p. 183, and in this we also concur. There is no proof in support of Branco's opinion, that forms like these with divided lateral lobes can be separated from true Goniatitinae, but the contrary appears to be evident in all forms of the Carboniferous, Dyas, and Trias.

Sageceras, Mojsisovics, Mediterr. Trias. Prov. p. 187, Das Gebir. um Hallst. p. 69, is a Triassic genus, which, as shown by this author's admirable figures, has the closest relations of affinity with both Beloceras and Medlicottia. The lobes are more numerous than in Medlicottia and are divided by small saddles, which are themselves slightly denticulated, showing a nearer approximation to the marginal saddles and lobes of Ammonitinae than any other Goniatite except Cyclololus. Of the three species mentioned by Mojsisovics, two S. Haidingeri, sp. Hauer, and S. Walteri, sp. Mojsis. are European. In America Sag. Gabbi, Mojsis.,

equals Sag. Haidingeri, Gabb. Geol. Calif. Pal. Vol. 1, pl. 5, fig. 8–10. This genus is separable from Medlicottia by the flattened outlines of the first pair of saddles, and from Beloceras by its divided lateral lobes. We do not feel sure that the ventral lobes are undivided, though here as in Beloceras the generation of the auxiliary lobes and saddles on the venter is similar to the same process in Maeneceras, which takes place in the outlines of the first pair of saddles. These saddles and the sutures generally are similar to Beloceras. while the form of the whorl and abdomen show close affinity for Medlicottia.

Lobites, Mojsisovics, Das. Gebir. um Hallst. pt. 1, p. 155 and Med. Trias. Prov. p. 176 are apparently distorted or retrograde forms with sutures similar to those of this family. Whether they are really members of this family and can be traced to an origin in genera like Popanoceras or Sageceras or some allied groups, we have no proper means of ascertaining. Mojsisovics regards them as genetically connected with Maeneceras delphinum in which the living chamber is similar, having a contracted shape which appears at first sight to justify this opinion. We, however, can regard such resemblances as genetically important only when species are similar in the sutures, and also found in closer relations in time.

[Prolecanites.]

Prolecanites, Mojsisovics, Med. Trias. Prov. p. 199, includes species with more or less discoidal forms, smooth, compressed whorls and a variable number of lobes and saddles. The ventral lobes are undivided. The lobes are hastate and the saddles club-shaped. The first pair of saddles become divided to form an additional pair of lobes and saddles and the auxilliary lobes and saddles are formed by division of the magnosellarian saddles. According to this author the type is Prol. (Gon.) mixolobum, sp. Sandb. Verst. Nass. pl. 3, fig. 13, not pl. 9, fig. 6, which is a Pronorites. Besides the species enumerated by Mojsisovics we include in the same genus also Prol. (Gon.) lunulicosta, sp. Sandb. ibid., pl. 3, fig. 14 with five pairs of lateral lobes and saddles. As we have remarked above on p. 333, Sandb, Chemungense, sp. Hall, Nat. Hist., N. Y., Vol. 5, pt. 2, pl. 69, makes a very near approach to this genus.[1]

[1] Lecanites, Mojsisovics, Mediter. Trias. Prov. p. 200, which has for its type Lec. glaucus, ibid. pl. 30, is described by the author as genetically connected with Pro-

Pharciceras,[1] nobis, this genus can be readily separated from Sandbergeoceras which it very closely resembles in form, and in the general aspect of the sutures, by means of the divided ventral lobes and the smoothness of the whorls. Phar. (Gon.) tridens sp. Sandb. Verst. Nass. pl. 4, fig. 2, is discoidal, and (Gon.) clavilobum ibid. pl. 8, fig. 3, is very involute. There are two pairs of lateral lobes in tridens and a small umbilical lobe, and two pairs of dorsal lobes, and in clavilobum Sandberger figures four pairs of lateral lobes. Phar. (Gon.) multiseptatum, as figured by Quenstedt, Die Ceph. pl. 3, fig. 3, is a member of this genus.

Schistoceras,[2] nobis, includes a single species which is not figured or described, but can be readily distinguished by its large, bottle-shaped, siphonal saddle. This is the only characteristic by which it differs from Prolecanites. The two arms of the ventral lobe are widely separated, and there are only three pairs of lateral lobes and a small umbilical lobe with two pairs of dorsal lobes. The lobes are hastate, and the saddles more rounded and club-shaped, as in Prolecanites. The first pair of saddles have dorsal correspondents and the annular lobe is deep [and acute. The young is costated and the sutures closely resemble those of Pharciceras tridens, from which this form is apparently directly derived.

[Triainocerae.]

Triainoceras,[3] nobis, includes but one species which can be separated from Sandbergeoceras only by reason of the transitional condition of the ventral lobe. This has a trident shaped division caused, as in other forms and especially as in Pronorites, by the development of two small pointed saddles on either side of the large funnel lobe, in place of the development of a large median saddle carrying up with it the funnel lobe as in most other genera of Goniatitinae. This genus shows that Pronorites was derived directly from the radical Sandbergeoceras, and that its resemblances to Prolecanites were due to parallelism and, therefore,

lecanites, but we find this connection doubtful. Undoubtedly the sutures have quite similar outlines, but if we compare them with those of Celtites, pl. 28, fig. 5, there is a very close agreement, indicating the same stock rather than the more remote one of Prolecanites.

[1] Φαρκίς, a wrinkle.

[2] Σχιστός, cleft.

[3] Τρίαινα, a trident.

could not have been inherited directly from that genus. The only species known to us is the Triai. (Gon.) costatum, D'Arch. et Vern., Geol. Trans. Lond., 2 ser. Vol. 6, pl. 31, fig. 1. This has sinuous outlines in the sutures with undivided rounded lobes and saddles, and costated whorls very similar to those of Sandb. tuberculoso-costatum. It can be separated from Pronorites by these same characteristics.

Pronorites,[1] described by Mojsisovics in Mediter. Trias. Prov. p. 200, includes an exceedingly interesting series of dwarfed forms, which present the marginal divisions of the lobes and saddles subsequently characteristic of the Ammonitinae. Genetic connection with the Prolecanitidae seems to be assured by the aspect of the sutures. The form of the whorl, and the later larval sutures have the aspect, number of lobes and saddles, and apparently the same mode of developing the outer first pair of saddles from the first pair of saddles, as in the Prolecanitidae. The lobes are hastate, the saddles linguiform, the ventral is not fully divided by a siphonal saddle. The divisions are, in their incipient stages, like minute points or saddles on either side of the large funnel lobes. Thus the apex of the ventral is trilobate. The saddles are rounded, but the first lateral lobes are subdivided by two incipient saddles in Pron. mixolobus, according to DeKoninck, a fact not verifiable in our specimens of this species. There is only one marginal saddle in the first lateral lobe of Pron. cyclolobus. The species, so far as known, are Pron. (Gon.) cyclolobus, sp. Phill. Geol. York. pl. 20, fig. 40–43, mixolobus, ibid, pl. 20, fig. 43–47.

Popanoceras,[2] nobis, includes species of the Dyas, which are very closely allied to Pronorites, but have more complicated sutures, and approximate more closely to the Ammonitinae. The whorls are more involute and compressed, and are also costated,

1 *Norites*, Mojsis., Med. Trias. Prov., p. 201, is described by that author as genetically connected with Pronorites. We are forced to differ again from this able authority, since the affinities between these forms are due to larval stages of the sutures, which are equally characteristic of Carnites, and some other genera. The form of whorl of Norites and the outlines of the sutures appear to us, as to Griesbach, to be closer to those of Sageceras. Norites is not very remote from Longobardites, which in our opinion is in the young similar to the genus Prolecanites both in form of whorls, and in modes of generating lobes and saddles. It seems to us possible that the derivation of the group may have been from the lower forms of the Prolecanitidae but not from Pronorites.

Πόπανον, a round, flat cake.

or marked by furrows. The lobes and saddles are numerous and club-shaped. The ventral lobes are divided by prominent narrow, siphonal saddles, carrying small funnel lobes. Three or more pairs of lobes are divided by marginal saddles, either single or double, the terminations of the lobes being either bifid or trifid.

Popan. (Gon.) Kingianum, M., V., K., Russia and Ural, pl. 27, fig. 5, Koninckianum, ibid, pl. 26, fig. 4, Soboleskyanum, ibid, pl. 26, fig. 5. The extreme form is the Popan. (Arcestes) antiquum, sp. Waagen, Foss. of Salt. Range, Pal. Ind. ser. 13, 1, pl. 1, fig. 10, and this is a close ally of Waagen's Cyclolobus Oldhami.[1]

[Remarks.]

Xenodiscus Waagen, is discoidal and similar to Ophiceras, Griesbach, Rec. Geol. Surv. India, Vol. 13, pt. 2, pl. 3, and this is transitional to Otoceras, ibid, pl. 2, which is highly involute. These Dyassic forms are the immediate radicals of the Triassic Ceratitinae. The annular lobes are divided by minute saddles, and the sutures are distinctly ceratitic and cannot be closely compared with any of the Goniatitinae. The Ceratitinae also in our opinion include, Hungarites, Ceratites, Dinarites, Tirolites, Arpadites, Beneckia, Meekoceras, Kipsteinia, Balatonites, Trachyceras, Celtites, Badiotites, Proceltites, Lecanites, Carnites, Tropites, Acrochordiceras, Helictites, and Choristoceras. The larvae of these, and many adults, show sutures similar to those of Nannites, Mojsis. pl. 39, and to the Dimerocerae among Goniatitinae. If this view is admitted, the Magnosellaridae and Glyphioceratidae will become the distal Paleozoic radicals of the Ceratitinae of the Dyas and Trias, and the Ammonitinae be confined to Psiloceras and Aegoceras, and their descendants in the Jura. These two genera must be regarded as offshoots of the Prolecanitidae, with either Gymnites or Monophyllites as the immediate radicals.

[1] Cyclolobus, Waagen, Pal. Ind. ser. 13, 1, p. 21, has for the type Cycl. Oldhami ibid., pl. 1, fig. 9. This genus is very important since it enables us to show the gradations by which the Prolecanitidae approximate to Arcestes, Ptychites, and Monophyllites. Cyclolobus is a true Ammonite and cannot be separated from the Triassic groups we have mentioned either by its form or sutures; and the phylliform marginal saddles, which are so persistent in the succeeding forms begin to make their appearance in this species. They enable us to connect Cyclolobus with Monophyllites, and the last with the groups of Lytoceras and Phylloceras. Mojsisovics regards the phylliform saddles as having no genetic significance. We think the facts are against him in this opinion, and that, on the contrary, there are strong evidences of the direct descent of the Phylloceratidae from the Prolecanitidae.

General Meeting, April 18, 1883.

Vice-President, Mr. F. W. Putnam, in the chair. Nineteen persons present.

Mr. Wm. M. Davis read a paper on the causation of gorges and waterfalls in glaciated regions. Mr. Davis also spoke of the results of an excursion to Becrafts Mountain, on the Hudson. The Helderberg limestones were supposed to overlie unconformably the older sandstones, although the evidence was unsatisfactory and not nearly as clear as would be supposed from the diagram given by Mather, in 1843, in the Geology of New York.

Annual Meeting, May 2, 1883.

The President, Mr. S. H. Scudder, in the chair. Thirty persons present.

The following reports were presented: —

Report of Alpheus Hyatt, Curator.

It was rightfully imagined when the present plan of arrangement was adopted, that the greatest obstacle in the path of any attempt to show the natural relations of the products of the earth would be the department of Mineralogy. It has been found, however, that though the separation of minerals from the mother rocks on account of their purer composition and definite forms, is artificial, still this separation has its logical uses.

It enables us to explain with directness and precision the relations of all the elements, and their strictly inorganic compounds, and prepares the mind for the consideration of the more complicated aspects of the Geological and Biological collections. Mineralogy acts as the vehicle for the conveyance of all the preparatory facts in Physics and Chemistry, which are essential for our purposes.

While we cannot find such definite marks of gradations in minerals as among animals and plants there are in nearly every division of minerals, even with their present entirely artificial and probably unnatural classification, such distinctions as those of Anhydrous and Hydrous groups, the simple Sulphides and double