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HIMALAYAN FOSSILS.

VOL. IV.

HE FAUNA OF THE SPITI SHALES.

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VICTOR UHLIG,

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HIMALAYAN FOSSILS.

VOLUME IV.

THE FAUNA OF THE SPITI SHALES.

BY

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INTRODUCTION.

Some years ago Dr. Franz Ed. Suess and myself were entrusted with the working out of certain Jurassic fossils, which formed part of the collections sent to Vienna for palæontological description by the late Dr. W. King and Mr. C. L. Griesbach, successively Directors of the Geological Survey of India. Dr. F. Suess and I began in common the examination of these fossils, but subsequently changes of domicile and other circumstances so interfered with the continuation of this work in common that we agreed to divide the labour as follows. The main mass of the material, the fauna of the world-renowned and much disputed Spiti shales, fell to my lot, while Dr. F. Suess undertook to work independently at the fauna from the beds below the Spiti shales.

The material available for the description of the Spiti fauna is uncommonly rich, consisting as it does of the Gerard, Stoliczka, Griesbach, Diener, and von Krafft collections. A part of it, as is well known, was already made the object of palæontological investigation many years ago: thus Henry F. Blanford worked at the Gerard collection in 1863:[1] and F. Stoliczka described his own finds in 1866.[2] But we owe a very notable enrichment of the Spiti fauna more especially to the united exertions of C. L. Griesbach, C. Diener, and C. S. Middlemiss (on the occasion of a journey to that district) in 1892; and yet the wonderfully successful results obtained by these collectors do not appear to have exhausted the faunal wealth of the Spiti shales, since that excellent observer Dr. A. von Krafft, whose premature decease we all deplore, was able in 1898 to bring back with him many a new specimen from those strata.

[1] "On Dr. Gerard's collection of Fossils from the Spiti Valley in the Asiatic Society's Museum," Journal of the Asiatic Society of Bengal, vol. XXXII (1864), page 124, Calcutta.

[2] "Geological Sections across the Himalayan Mountains, with an account of the formations in Spiti," Memoirs of the Geological Survey of India, vol. V (1866), pages 1—152.

Taking into consideration the abundance and the great geological importance of the Spiti fauna, the significance of which has busied the minds of the most eminent Jurassic geologists, and considering that it remains nevertheless a subject of controversy, it appeared to me essential to aim at the greatest possible completeness and to investigate not only such material as had been placed in my hands, but also to study, as far as I could, whatever specimens of that fauna were to be found in other museums. In this respect two collections were of especial importance: those brought back by Colonel Strachey (the specimens on which the "Palæontology of Niti" is based),[1] and the Brothers Schlagintweit collection, described by A. Oppel.[2] Thanks to the courtesy of the Museum Directors to whose charge these valuable specimens have been committed, I was enabled to have access to this important part of the Spiti fauna. Geheimrath K. von Zittel of Munich allowed me to make use of Oppel's original specimens; while the British Museum authorities forwarded to me plaster casts of the specimens described in the "Palæontology of Niti," of such excellent workmanship that I could afford to dispense with the originals.

Many of the old figures of the Spiti fossils proved to be unusable, or, to say the least, inadequate; and therefore it was found necessary to refigure many previously described species and type-specimens. Moreover, the descriptions and systematic attributions of the old species left so much to be desired, that complete re-description was found unavoidable.

The description of the species, and the discussion of the genera which is involved therein, forms the first main portion of the present monograph. The second portion comprises, besides a few historical remarks, a discussion of the stratigraphic, faunistic, and palæontographic relationships and the conclusions deduced therefrom.

Before proceeding to the description of the species I feel impelled to discharge one obligation, and that is, to express my warmest thanks to all co-workers who have made this work possible, and have given it their ungrudging support.

Mr. C. L. Griesbach, late Director of the Geological Survey of India, not only consented to have this monograph brought out in such a form as to do it full justice, but he moreover showed extreme patience during the necessarily slow progress of a task from which my attention was often distracted by other duties. I am therefore beholden to him in no small measure, and would wish here to assure him of my gratitude. I have also to acknowledge my obligations to Mr. L. L. Belinfante for the care and trouble he bestowed upon the translation into English of my paper.

I have next to thank Geheimrath Dr. K. von Zittel and Curator Dr. Max Schlosser for so kindly sending to me Oppel's original specimens; as also Dr. Henry Woodward and Mr. George C. Crick for their donation of plaster-casts. I am, moreover, under obligations to Geheimrath Dr. von Branco for having sent to me specimens from the Berlin Natural History Museum. To my honoured colleague

[1] "Palæontology of Niti in the Northern Himalaya Jurassic Rocks: Cephalopoda," by H. F. Blanford, Calcutta, 1865.

[2] "Über ostindische Fossilreste aus den secundären Ablagerungen von Spiti und Gnari Khoranm in Tibet," Paläontologische Mittheilungen, IV, Munich, 1863.

and master, Edward Suess, I am indebted for the pains he took to be of assistance to me, and to the Directors of the K. K. Geologische Reichsanstalt and of the Geological and Palæontological Department of the Naturhistorisches Hofmuseum in Vienna I owe many thanks for the liberal manner in which they helped me in the matter of literary aid.

Finally, it appears to me fitting and right that gratitude should be expressed to the artists who have devoted their talents to the illustration of this work, among others Mr. W. Liepoldt (unhappily now deceased), Mr. A. Swoboda, and especially that most painstaking artist, Mr. Rudolf Mayer.

VICTOR UHLIG.

VIENNA;
October 1901.

DESCRIPTION OF THE SPECIES.

A.—AMMONOIDEA.

Although of late years several systematic classifications of the Ammonoidea have been put forward, which in some respects are found to coincide, no universally satisfactory agreement has yet been reached with regard to this group of Cephalopoda, so rich in forms, so difficult of sub-division. Consequently it has appeared advisable in the present work not to tie one's self down to a particular classification, but to set forth the descriptions of the various forms in an unclassified sequence, while indicating their approximate position in the most generally accepted system.

An introduction is prefixed in the case of each genus, recapitulating and emphasizing the most important generic distinctions of the forms described therein.

Dr. Franz Ed. Suess, at the time when he was my assistant in Prague, worked conjointly with me at the description of numerous species belonging to the genera *Oppelia*, *Phylloceras*, *Haploceras*, *Spiticeras*, *Astieria*, and *Hoplites*; unfortunately it has been found impossible to indicate his share in the work more prominently than by appending his name to the new species here mentioned and to the new sub-genus *Spiticeras*.

PHYLLOCERAS, Suess.

The genus *Phylloceras* is represented in the Spiti Shales by only two species, *Phylloceras strigile*, Blanford, and *Phylloceras plicatius*, sp. nov. While the last-named form may be recognized at the first glance as a member of the *Phylloceras heterophyllum* group[1] so widely distributed in the Alpine-Mediterranean region, *Phylloceras strigile* appears to be an entirely strange form. It is true that it shows some relationship with the Alpine *Phylloceras infundibulum* and *Phylloceras ladinum*, but its development is so distinctive that it cannot be fitted into any of the Alpine series of *Phyllocerata*.

Both species are of extremely rare occurrence in the Spiti Shales, only one specimen of *Phylloceras plicatius* and two of *Phylloceras strigile* having been obtained up to the present.

PHYLLOCERAS PLICATIUS, sp. nov.

(Plate II, fig. 5.)

The external shape of the flat, discoidal, narrowly umbilicated shell cannot be determined with precision, as it is on one side completely involved in the matrix. There is, however, no room for doubt that this species belongs to the flattest types of the genus, and in that respect is indistinguishable from *Phylloceras plicatum*, Neumayr.

The ornament consists in *Phylloceras plicatius* of fine, but sharp-cut, closely packed lines, which on the umbilicus are barely recognizable, but as they trend outward they become gradually more distinct. They exhibit in the circumference

[1] Compare Neumayr, "Jurastudien," Jahrb. d. geol. Reichsanst., 1871, vol. XXI, page 308.

of the umbilicus a slight forward inclination, and in the lower portion of the sides they curve round in a radial direction, in such wise that they follow a slightly sinuous course. Besides these fine costæ, there are flattish flexures or ribs strictly parallel to the fine costæ (which pass over them evenly), and increasing in prominence outwardly. They begin partly in the lower portion of the sides and partly higher up; frequently a short rib is intercalated between two longer ones, but sometimes two long ribs follow one another in immediate sequence, and sometimes more than one short rib is intercalated between them. Sometimes, again, among the secondary ribs intercalated between two long primary ribs, some may be short and others long, though in no case do they attain the length of the primary ribs. With regard to the fine thread-like costæ which mantle over the entire shell, those which pass along the middle of the flat ribs are more prominent than the others. The external periphery is unfortunately so much weathered that it is impossible to determine whether the flat ribs course over it in undiminished prominence or not.

The lobal line is indeed not clearly recognizable, but sufficiently so to show that it is without doubt of the Phylloceratan type. The form and the number of the large and distinct saddle-leaves indicate that the lobal line is not characterized by the extreme foliation peculiar to the Cretaceous types. Among all the Phyllocerata thus far known the species nearest to that herein described are probably *Phylloceras plicatum*, Neumayr,[1] and *Phylloceras præposterium*, Font. Besides the general resemblance in external shape, there is very marked similarity of ornamentation. In both *Phylloceras plicatum* and *præposterium*, as well as in our species, fine, costate striæ and broad, flat ribs are observable. But while the latter in *Phylloceras plicatius* may be traced up to the external periphery and up to that point increase in prominence, they die away in *Phylloceras plicatum* without reaching as far. Moreover, in the last-named species, the intercalated short ribs are wanting, and neither ribs nor costal striæ have so markedly sinuous a course as in *plicatius*. These differences must prevent us from assigning the Indian species to *Phylloceras plicatum*. In fact, *Phylloceras præposterium*, Fontannes,[2] is a nearer ally to our species. In it the flat ribs are somewhat longer than in *Phylloceras plicatum*, although they do not extend so far towards the external periphery as they do in *Phylloceras plicatius*. The intercalation of shorter and less prominent secondary ribs is well shown, though not so marked as in the species here described. Yet these differences would hardly justify specific differentiation, were it not for the divergence in character of the fine, thread-like costæ. In *Phylloceras præposterium* these are much more numerous and more closely packed than in *Phylloceras*

[1] Jahrbuch d. k. k. geol. Reichsanstalt, 1871, vol. XXI, page 313, Pl. XII, fig. 7, and Pl. XIII, fig. 2.

[2] "Description des Ammonites des Calcaires du Crussol," 1879, page 2, plate I, fig. 2. Fontannes rightly supposed that a species from the *Acanthicus* beds of the Székler district described by F. Herbich,—*Phylloceras leptoptychum*—("Széklerland," pl. I, fig. 5, p. 141) is identical with *Phylloceras præposterium*. He was only induced by the greater length of the ribs and the broader umbilicus of Herbich's figure to refrain from uniting the two species. An examination of the original specimen, most kindly sent to me by Prof. J. von Szadeczky, proved that in reality the broad ribs are no longer than in *Phylloceras præposterium* and that the umbilicus is much narrower than in the figure. There is consequently no reason for separating *Phylloceras leptoptychum* from *Phylloceras præposterium*. Similarly, *Phylloceras consanguineum*, Gemmellaro ("Sopra alcune Faune giuresi," etc., p. 177, Pl. XV, figs. 2, 3), is to be regarded as a synonym of *Phylloceras præposterium*.

plicatius. Moreover, in the former species they are all of equal fineness, while in the latter the thread-like costæ which run along the medial line of the broad ribs are markedly more prominent than those that lie between the ribs. This differentiation of the thread-like costæ, unknown alike in the *Phylloceras præposterium* of Southern France and in that of the Carpathians and of Italy (*Phylloceras consanguineum*, Gemm.), gives to *Phylloceras plicatius* a very characteristic appearance and thereby facilitates its separation from other species.

In respect of the more markedly sinuous course of the ribs, our species is reminiscent of *Phylloceras Kudernatschi*, Hauer,[1] but it diverges therefrom in its lesser thickness and in the greater number and prominence of the ribs. So too our species differs from the nearly allied *Phylloceras Kunthi*, Neum., in the much greater number and length of its ribs.

Finally, we may be permitted to recall here yet another species, from the Indian Upper Cretaceous, namely, *Phylloceras Surya*, Forbes sp.[2] Evidently it is one of the Upper Cretaceous descendants of the group of *Phylloceras plicatum*. The excessive denticulation of the lobal line of *Phylloceras Surya* shows that it is specifically distinct from *Phylloceras plicatius* and is indeed an indication of the wide gap that separates these species. Even when the lobal line is not preserved, it is not possible to confound one with the other, as *Phylloceras Surya* possesses less sinuous main ribs which are already prominent at the umbilicus, and less numerous but longer intercalary ribs; moreover, the shell assumes a more acutely angular section at the external periphery than is the case in *Phylloceras plicatius*.

Phylloceras plicatius comes from the middle horizon of the Spiti Shales of Shalshal; only one specimen has been obtained: to it adheres more than a half of the ultimate volution of the body-chamber. The diameter of the specimen must have exceeded 100 millimetres.

PHYLLOCERAS STRIGILE, Blanford sp.

(Plate I, fig. 1 *a*—*c*, fig. 2 *a*, *b*; Plate III, fig. 6)

1863. *Ammonites strigilis*, Blanford, Journ. Asiat. Soc., Bengal, vol. XXXII, Pl. III, fig. 1, page 1026.
1866. *Ammonites strigilis*, Stoliczka, Mem. Geol. Surv., India, V, page 95.

Of this very remarkable species there lie before us the two specimens from the Gerard Collection which have been mentioned in the memoirs of Blanford and Stoliczka. The exact locality whence they were obtained remains, it is true, unknown, but there can be no doubt (in presence of the affirmation of both the authors cited) that they were got from the Spiti Shales. The specimen wherein the body-chamber is preserved entire is cut through the middle,[3] and measures 52 millimetres in diameter; at the (oral) aperture it is about 26 mm. thick. In the other specimen the foremost portion of the body-chamber is broken off; it has a diameter of 46·3 mm. and a thickness of 24 mm.

[1] See Jahrbuch k. k. geol. Reichsanstalt, 1871, vol. XXI, p. 310, pl. XII, fig. 4.
[2] *Cf.* especially F. Kossmat, "Indische Oberkreide," Paläontologische Beiträge, Vienna, vol XI, plate XVI, fig. 1. and page 150
[3] The other half is to be found, according to Blanford, in the British Museum.

The somewhat tumescent shell has an almost closed funnel-shaped umbilicus (the umbilical wall dipping gently inward), which passes gradually into the flatly curved sides. The external periphery at the body-chamber is markedly flattened off and set off against the sides, it is rounded in the chambered portion of the shell, passing gradually into the sides.

The chambered part of the shell seems to be perfectly smooth, and it is only at the commencement of the body-chamber that costæ begin to make their appearance. They are not very prominent at first, but they become very marked farther on, beginning at the umbilicus as fine, flattish striations, and then quickly increasing in prominence at the sides. On the sides these costæ, affecting a helicoidal arrangement, form slightly-arched, forwardly concave curves; between the sides and the external periphery they swell up into ridges, and are prolonged far forward on the periphery. Here, in the later stages, they rise in the middle into high, anteriorly convex ridges, which slope like the tiles of a roof steeply backward and gently forward. Between the median swellings and at the edges of the periphery the costæ are slightly depressed, and this contributes largely to the flattening off of the external periphery. The costæ number about 16.

In one specimen one of the anterior costæ exhibits some irregularity: it disappears on the side and starts again farther forward. In this same specimen, furcation is just indicated in another costa on the external periphery. In the cast one may observe alongside the costæ fine, hair-like lines of growth which course parallel with them.

The body-chamber takes up about two-thirds of the ultimate whorl. At the lip of the aperture, which unfortunately is not preserved entire, a notable enfeeblement of the ornamentation is to be observed. The two foremost costæ, for example, are but slightly developed, and they are much closer set than the others. On the other hand, the lines of growth become more prominent.

The lobal line, as Stoliczka has already remarked, is clearly of the Heterophyllidan type. Although the imperfect state of preservation of the fossil makes it difficult to trace the finer details, the more important characteristics are very plainly seen. Among these may be classed the length of the external lobe, which is hardly inferior to that of the first lateral lobe, and the small size of the saddle-leaves. The lateral rami of the first lateral lobe are but little shorter than the terminal ramus. The outer saddle and the first lateral saddle are divided by a deep secondary lobe into two portions, which again are each divided into four or five terminal folioles.

The extreme denticulation of the saddles, and the consequently narrow habit of the saddle-leaves, is an indication that we must seek for the allies of this species among Tithonian and Neocomian forms. In this respect *Phylloceras infundibulum*, d'Orb., *Phylloceras Rouyanum*, d'Orb., and more especially *Phylloceras ladinum*, Uhl., show the greatest number of points of resemblance. In its main characteristics the lobal line, especially with regard to the length of the external lobe, agrees remarkably well with that of our species; moreover, the shape of the shell and the costation show a certain similarity. The inner smooth whorls of *Phylloceras strigile* are hardly distinguishable from those of *Phylloceras Rouyanum*. The costæ

especially in *Phylloceras ladinum*, Uhl., exhibit on the external periphery a thickening which recalls *Phylloceras strigile* with a steep posteriorly directed inclination and a flattening in the anterior direction. Moreover, the costæ of *Phylloceras ladinum* show at the external periphery a forward prolongation. Finally, the enfeeblement and closer setting of the costæ at the apertural margin is a character common to both species. If, on the one hand, these concordant characteristics prove that *Phylloceras strigile*, which at the first glance is a strikingly peculiar form, is nevertheless by no means so isolated as it appears, on the other hand there are sufficiently far-reaching differences between all these species to prevent us from considering their mutual relationship as very close. The funnel shape of the umbilicus is much more distinct in *Phylloceras infundibulum*, the flattening off of the external periphery is not to be seen, and the costæ have no such forward inclination as in *Phylloceras strigile*, rather are they inclined backward, and instead of being anteriorly prolonged at the external periphery they are set diagonally. Then, in *Phylloceras infundibulum* small intercalary costæ (which are absent in *Phylloceras strigile*) appear between the longer main costæ. The peculiar fine, wavy lines which in *Phylloceras infundibulum* course over the shell, especially in the neighbourhood of the later chamber-septa, have not been demonstrated as present in the Indian species. This circumstance, however, may possibly be due to the fact that the Indian fossils are preserved only in the form of casts. We recognize, then, in *Phylloceras strigile* a number of well-marked uncommon characteristics, which do not appear to allow of its inclusion in the Alpine-Mediterranean group of forms to which *Phylloceras infundibulum* belongs.

So far *Phylloceras strigile* has been recorded only from the Spiti Shales, and in the Alpine-Mediterranean province apparently not a trace of this remarkable species is to be found. For that matter, it is by no means of common occurrence even in India. To all appearances *Phylloceras strigile* is a representative of a specifically Indian branch of the *Phylloceras* stem, and up to the present it is the only known representative of that branch.

LYTOCERAS, Suess.

The genus *Lytoceras* is represented by only one species, already known to Oppel and Blanford,—*Lytoceras exoticum*, Oppel (=*alatum*, Blanford). This form belongs to the group of *Lytoceras Eudesi*, d' Orb., which is widely spread and highly developed in the Mediterranean province.

The isolated occurrence of *Lytoceras exoticum* furnishes no material for systematic remark but thanks to its excellent state of preservation (whereby certain delicate parts of the shell have been retained unimpaired) it has been found possible to study certain peculiarities of the shell-structure and the mode of growth which are far from devoid of interest. This would appear to be the opportunity, freed as we are for a time from the trammels of specific description, to look more closely into these peculiarities. While it is true that the available material is limited in quantity, it must be remembered that such well-preserved specimens are

rare, and we feel therefore justified, nay, called upon, to make the utmost use of what lies in our hands.

In *Lytoceras exoticum* there are on each whorl sixteen to twenty "callose" primary costæ, which terminate in a high, thin perpendicular ridge: in number they correspond with the septations. As a rule, such ridges or callosities are looked upon as the *reliquiæ* of former apertural margins, and it is presumed that each of them during the periodic pauses in siphonal growth which were utilized for the building up of septal walls, formed for a considerable time the apertural margin. Now, the specimens of *Lytoceras exoticum* which are available, show that, while it is perfectly true that there is some connexion between the perpendicular ridges and the old apertural margins, this connexion is expressed in another way than that just indicated.

In the specimen figured in Plate I, figure 3, the body-chamber is preserved right up to the apertural margin. It occupies about two-thirds of the ultimate whorl, and its cross-section appears to increase more rapidly in area just before the aperture. This circumstance makes it manifest that the apertural margin seen in the specimen is the final definite margin—in a word, that the specimen is to be regarded as full-grown, even though it does not attain the size of that figured in Plate I, figure 4. The apertural margin follows the course of the lines of growth, and consequently forms on the inner periphery a tongue-shaped appendage which is prolonged rather far forward, covering the external periphery of the immediately preceding whorl. With the apertural margin is associated a shallow groove, bordered by slight nodosities: next to this come a few striations more strongly marked than the others that are to be observed on the cast. On the other hand, no perpendicular ridge is to be found at the apertural margin, a point of which we may assure ourselves on looking at Plate I, figure 3, at the restored figure (fig. 1),

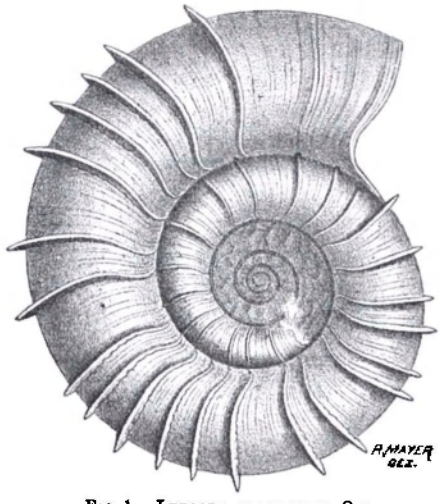


FIG. 1.—LYTOCERAS EXOTICUM, Opp.
Restored figure of a complete specimen, showing the margin of the mouth-opening.

and the sketch (fig. 2). Yet such a ridge, denticulated at the base, does occur 29 millimetres behind the apertural margin, and, reckoning inwards, on all the other primary costæ that are separated by somewhat shorter interspaces. Some of these ridges have been preserved entire, as, for instance, the first one behind the apertural margin, shown in Plate I, figure 3 *c*, and in text-figure 3. But for the most part, all that remains to show the size and position of these ridges is a well-defined hollow.[1]

For the sake of greater clearness, we will call here the first section of the body-chamber, between the definite apertural margin and the first ridge, *a*; and the second section, between the first and the next succeeding ridge, *b* (see text-figures 1 and 2). On looking more closely at shell section *b*, it becomes plain beyond a shadow of doubt that two shell-layers are to be distinguished here: (1) one a fine inner layer which passes uninterruptedly over the foremost portion of the shell *a*, thinning gradually as it approximates to the apertural margin; and (2) over this a somewhat thicker outer layer which, being bent upward, forms the ridge, and does not pass on to the foremost portion of the body-chamber *a* (see text-figures 1 and 2).

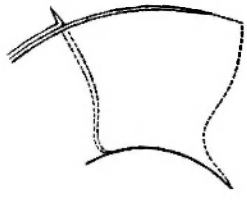


FIG. 2.—LYTOCERAS EXOTICUM, Opp.
Section through the body-chamber to illustrate the two layers of shell.

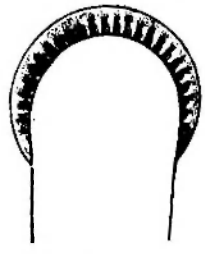


FIG. 3.—LYTOCERAS EXOTICUM, Opp.
View of a crest-like rib.

Of course all the remaining portions of the shell that lie farther inward, so far as they are preserved, exhibit both shell-layers: it is only the foremost section (*a*) that is deprived of the outer layer. Like in most of the *Lytocerata*, especially the fimbriated forms, the shell is comparatively soft. The outer layer, to which the ridges belong, appears on the whole, and especially at the base of the ridges, to be somewhat stronger than the inner layer: the last-named is, however, conspicuously strengthened at the internal or columellar periphery of the whorls. With the unaided eye, or even with a magnifying-glass, no structural difference between the two layers is discernible, but this need not prevent us from inferring that originally there was a difference. In its present condition the shell exhibits crystalline structure, but unfortunately not sufficient material is available to admit of its examination under the microscope.

[1] This high, knife-edged ridge is of such delicacy that we need hardly wonder at its obliteration during the processes of fossilization in the majority of cases, where the conditions were less favourable to its preservation than those that attended the deposition of the Spiti Shales. It was probably either broken or dissolved away, leaving only a costal callosity behind it. So it is that in most of the species allied to *Lytoceras exoticum*, merely the serrated costæ are known, but not the ridges that really surmounted them. That a similar obliteration did not take place also in respect of the apertural margin in *Lytoceras exoticum*, but that this margin was always smooth, is clearly and unmistakably proved by the state of preservation of the specimen, and the absence of any undulating plication.

The foregoing recital of facts shows at all events that the final apertural margin of *Lytoceras exoticum* was not surmounted by a ridge. As the shell advanced in growth ridges did certainly surmount the provisional apertural margins, even up to the penultimate margin, but not beyond it, so far as we can judge. Further, the characters of the specimen herein described indicate *that the deposition of the outer layer and the ridges must have proceeded from the outside.* This layer served evidently to strengthen the extremely thin, fragile shell. The deposition of the outer layer can have only taken place through the medium of organs capable of protrusion. One might picture to one's self a ventral fold of the mantle, wrapped around the sides and the ventral periphery, and protrusive. A more likely supposition, however, is that the outer layer was deposited by specially adapted brachia, such as those in *Argonauta*.

In the case of many ammonites it would be somewhat difficult to imagine how the shelly layer could be externally deposited by protrusive organs; take, for instance, those that were provided with calcareous opercula, and especially those whose apertural margin was drawn out into a ventral appendage. This appendage would have been a serious obstacle to the protrusion of brachia or such like organs, and so, too, would have been the *Aptychus* operculum. Indeed, the operculum would have been an absolute superfluity in those ammonites, which in the process of building up their shell would require to be perpetually, or at any rate for long intervals at a time, protruding a portion of the soft organism outside the shell. In *Lytoceras* these difficulties need not be reckoned with, for not only is that group of ammonites characterized by the absence of an operculum or *Aptychus*, but the ventral appendage is also wanting, and the apertural margin, just as in the primitive genera *Goniatites* and *Nautilus*, runs diagonally over the external periphery.

If we assign the deposition of the outer layer and of the serrated ridges to specially adapted brachia, as in *Argonauta*,[1] then the undulatory plication of the costæ is easily explicable, for this would be a consequence of a plicatory tendency in the cuticle of the brachia, and there is no difficulty in granting such an assumption.

At what particular stage of growth the animal began to reinforce the shelly layers is not easy to determine. We must reckon here with three different possibilities: deposition of the external layer took place either before each progressive stage, or else thereafter, that is, subsequent to the completion of the new chamber, or finally, during the formation of a new chamber. In the first alternative, the ridges could at any rate have served for some time as an apertural margin. Considering the extreme delicacy of the shell, hardly calcified at all at the anterior margin, it would be of advantage to the inhabitant thereof that the strengthening of the external layer should be completed before that particular advance in growth had come to an end. Yet, advantageous as this condition would be, the probabilities do not tell in favour of it. The organs concerned with the deposition of the

[1] The analogy with *Argonauta* seems the more obvious, that of late years G. Steinmann has again brought into vogue Suess' old conception of *Argonauta* as a descendant of the Ammonites. See G. Steinmann, "Vorläufige Mittheilung über die Organisation der Ammoniten," Berichte der Naturforschergesellschaft zu Freiburg im Breisgau, vol. IV, pt. 3, page 121, 1888.

external layer (presumably brachia) would in this case, at the beginning of each period of septation, have to be extruded very far backward, and then to be gradually retracted, which would have certainly been very irksome for the animal. The second alternative is perhaps still less probable, for in that event the animal would have been compelled to vary the extent of the protrusion of the brachia, and would have missed the advantages appertaining to a timely strengthening of its extremely delicate shell.

If, as a matter of fact, the position of the outer layer was a function of the brachia, then the consolidation of the previously built section of the body-chamber (*b*) could very well go on concurrently with the further extension of the shell (*a*), and the deposition of the outer layer would proceed at the same rate as that at which the foremost section of the body-chamber was being pushed forward. The animal would have thereby this advantage that the brachia would be always extruded at the same distance from the body of the organism. As it is now practically admitted on all hands that the progression of the ammonite-animal and its shell did not take place in the posterior direction, but must have gone forward gradually, there is nothing in this connexion to diminish the probability of the third alternative.

In many ammonites broader and more pronounced striæ of growth occur between finer and more closely set striations. This would seem to indicate that the gradual progression and building-forward of the whorls did not take place at a constant, unvarying rate, but that sometimes the pace was slower, sometimes faster. The conditions may well have been similar in the matter of the deposition of the outer shelly layer of *Lytoceras exoticum*. Here, between every two primary ridges are one or two slightly crumpled costæ, less prominent than the primary ribs, and yet rather more pronounced than the ordinary uncrumpled intercalary bands. These costæ, too, were surmounted by ridges, but such ridges are much more delicate and much lower than those characterizing the primary costæ at the former apertural margins. It is evident that the deposition of these feebler ridges took place during the short occasional pauses or retardations inevitable in the process of shell-growth. The primary ridges, however, were built up during those longer intervals, wherein siphonal growth was at a complete standstill, while the living organism was busied with the old septal walls and with internal thickening of the shell. If this picture of the process of shell-growth in *Lytoceras exoticum* is correct, then all the successive apertural margins, not merely the final one, were smooth so long as they served as such, and ridges only appeared upon them when their functions as apertural margins had ceased, and the shell had been built out beyond them.

The fact that the shell consists of two distinct layers has been established in the case of many cephalopods. In this respect the shell with the structure of which we are most intimately acquainted is that of the recent *Nautilus*, studied in great detail within the last few years by A. Appelöf.[1] If the two layers in *Lytoceras exoticum* correspond with those in *Nautilus*, then we should regard the inner layer in *Lytoceras exoticum* as the pearly stratum, and the outer, with its serrated ridges,

[1] "Die Schalen von Sepia, Spirula, Nautilus: Studien über den Bau und das Wachsthum," Svenska Vetenskaps-Akademiens Handlingar, 1892, vol. XXV, with 12 plates.

as the porcellanous stratum. In *Nautilus* the porcellanous layer is secreted by the marginal portion of the mantle, and the pearly layer by the inner mantle. The latter statement (as to the pearly layer) holds good of *Lytoceras exoticum* also, but the outer layer in *Lytoceras* could only have been deposited by the marginal mantle if the latter had been provided with a posteriorly extensible duplication at the sides and at the ventral periphery. The adaptation of the brachia to this function appears, as already mentioned, to involve at any rate less constraint. While in *Nautilus* the porcellanous layer is pushed as far forward as the pearly layer, nay, even slightly overlaps it at the apertural margin,[1] in *Lytoceras exoticum* the deposition of the outer layer is always behind-hand, and that of the pearly layer is in advance of it by the interval represented in the progress from one old septal wall to the next.

In forms which are so wide apart as *Lytoceras exoticum* and *Nautilus*, it is not very surprising to find that the process of shell-growth differs considerably. Far more impressive is the fact that much more nearly allied forms, as, for example, *Lytoceras immane*, Oppel, differ essentially in their mode of growth from *Lytoceras exoticum*. In the former species just as in the latter the whorls are ornamented by numerous thickenings of the shell, distinguished indeed from the sharp-cut ridges by their arcuate form and even by a tendency to curve round posteriorly, but corresponding all the same with the septations. These shell-thickenings are the old apertural margins. As Neumayr[2] has shown, *Lytoceras immane* was characterized by an aperture widening out into a trumpet shape, the margin of which was directed away from the siphonal cavity proper, and curved over upward and somewhat posteriorly. In the forward growth of the organism it could not then build up the new portion of the shell by deposition at the apertural margin proper, but only at the point where the trumpet-shaped widening of the latest aperture began. At each stage of advance, there was a trumpet-shaped widening of the shell at the anterior extremity of the organism, while at the hinder extremity a septal wall arose, and thus was formed a shell, which on its otherwise smooth whorls bears callosities (folia) at regular intervals (corresponding to the septations), curving round posteriorly, and representing, as a matter of fact, the former apertural margins. In the process of petrifaction most of the original folia were destroyed, leaving behind more callosities or costæ, which on the sides show the posteriorly directed curvature.

In *Lytoceras immane* each such ridge had provisionally the functions of an apertural margin. Such was not the case in *Lytoceras exoticum*, where the apertural margin was smooth and did not overlap the spiral siphonal cavity. In *Lytoceras immane* the apertural widenings are directly continuous with the siphonal wall, and were secreted by the same organ as it (mantle and mantle-margin): they in fact represent merely the outermost marginal portions of that wall. In *Lytoceras exoticum*, on the other hand, the ridges were the outcome of external deposition on the shell.

In the specimen of *Lytoceras immane* described by Neumayr from the Tithonian Limestone of Stramberg, the foremost portion of the shell, between the ultimate and

[1] See Appelöf, *op. cit.*, page 78.
[2] Beiträge zur Paläontologie Oestorreich-Ungarns, vol. III, page 101, plate XX.

penultimate apertures, is extraordinarily fragile, much compressed, and highly eroded. Neumayr explained this as due to incomplete calcification of the anterior-most chamber of the shell, and compared this portion with the imperfectly calcified, corneous section of the shell observed in various species of *Helix* when in process of growth. J. Pompeckj proposed another explanation: supposing that the death of the animal took place after the outer porcellanous layer had been built forward over the anterior-most chamber but before the inner pearly or nacreous lining was completed, then in the process of fossilization the more fragile portion of the shell would be easily compressed and distorted [1]

In *Lytoceras exoticum* also the shell becomes gradually thinner towards the ultimate apertural margin, so much so that it all but disappears at the outermost margin. Yet Pompeckj's explanation will hardly apply to this form, for here the anterior-most section of the shell consisted only of one layer, and if the structure of this is so remarkably fragile at the aperture proper we may reasonably assume that there was an antecedent corneous layer at the outermost margin. Perhaps this precisely constituted one of the differences between *Lytoceras exoticum* and *Lytoceras immane*.

It is a matter of common knowledge that the Lytocerata form a well characterized, distinctive group. Indeed, among all the multifarious forms of ammonites, few groups are so well knit and so sharply marked off as that of the Lytocerata. If, nevertheless, within this group extraordinary differences of important organic relationships are demonstrable, the conclusions of those observers who are inclined to look upon the organization of ammonites as highly variable are thereby justified. So, too, those palæontologists who have separated off a number of sub-genera from the typical genus may appeal to the same argument as their justification. Variations in the form of the aperture, such as those that we have been considering in *Lytoceras immane* and *Lytoceras exoticum*, would, in the case of recent molluscs, have led undoubtedly to generic differentiation. Although, of course, we admit that the classification of fossil forms should be based on exactly the same systematic principles as that of recent forms, it appears on practical grounds desirable to proceed with somewhat greater caution and circumspection in the case of the fossil forms, if only because those specimens are rare indeed wherein the parts which are decisive from the point of view of organic relationships are preserved.

LYTOCERAS EXOTICUM, Oppel sp.

(Plate I, figs. 3 *a—d*, 4 *a—c*.)

1863. *Ammonites exoticus*, Oppel, Paläontologische Mittheilungen, I, pl. 76, figs. 5 *a—c*, p. 278.
1865. *Ammonites alatus*, Strachey MS., Blanford, "Palæontology of Niti," Calcutta, p. 70, pl. A VIII, figs. 3 *a—b*.
1866. *Ammonites alatus*. Stoliczka, Mem. Geol. Surv., India, vol. V. p. 110.

The largest specimen of this interesting species that lies before us is unfortunately not preserved entire; it must have attained a diameter of at least 134 mm. The

[1] "Ueber Ammonitiden mit 'anormaler Wohnkammer,'" Württemberger Jahreshefte, 1894, page 275.

specimen in question, figured in Plate I, figure 4, measures 64·5 mm. in diameter, with an umbilical breadth of 30 mm. The breadth of the volution at the anterior extremity is 23 mm., and the height 21 mm. At the immediately succeeding whorl the height of the volution at the anterior end is 38 mm., and the breadth 43·5 mm. From these circumstances it may be inferred that the process of growth in this species is comparatively slow, and that the shell consists of almost circular whorls, which are not much broader than they are high. In the two fragments also on which Oppel based his species, and in Blanford's original specimen as well, the breadth of the volution is slightly greater than the height. Besides these, I have examined another specimen, which, so far as its ornamentation is concerned, coincides perfectly with the true *Ammonites exoticus* (*alatus*), but in it the height of the volution instead of being less than, is almost exactly equal to, the breadth. This specimen has a portion of its apertural margin preserved, its diameter is about 86 mm. and umbilical width 38·5 mm. (see pl. I, fig. 3). As no other specimen of this particular form is available, it is impossible to say for certain whether it belongs to a distinct species, or whether it is allied as a passage-form to the true *Lytoceras exoticum* and is to be regarded as a variety of that species. The differences being comparatively unimportant, the latter hypothesis appears more probable, and for that reason this specimen also is provisionally assigned to *Lytoceras exoticum*.

The ornamentation of this species consists of two kinds of costæ; that is, of fine, straight intermediary costæ, hardly distinguishable from the lines of growth, and of bolder, undulating primary costæ. On each whorl there are never less than from 16 to 20 primary costæ, but the number of the finer intermediaries is not exactly determinable: it varies greatly, according to the breadth of the intervals between the primaries. The costæ and lines of growth at the inner periphery are acutely pointed forward, curve round radially over the sides, and run diagonally across to the external periphery, taking even a somewhat posteriorly directed trend at the body-chamber. On that part of the specimen which is preserved in the form of a cast, the fine intermediary bands all but disappear, and even the primary costæ leave an extremely shallow groove defined by slight callosities. On the ultimate whorl the shell has mostly broken away, but excellently preserved impressions enable us to form a good idea of the ornamentation. It is seen here that each primary costa is surmounted by a high ridge continuous with the shelly substance which completely surrounds the nearly circular whorls. The strong, clean-cut grooves which these ridges left in the matrix furnish unmistakable evidence as to their size and position. At one point only (see fig. 3 *c*) the shelly portion of a ridge has been well preserved, and here it is seen that the ridges, assuming a wavy plication at the base, pass on the external margin into a nearly smooth, even surface. They are nearly perpendicular to the shell, and such slight inclination as they show is in the posterior direction. From the umbilicus towards the sides they increase rapidly in breadth, and course, without diminution in prominence or height, over the external periphery. The demarcation between the undulate-plicate primary costæ and the straight, non-plicate intermediaries is not altogether abrupt, for there are some few

costæ, less prominent indeed than the primaries, but more so than the other intermediaries, and such costæ, moreover, are crumpled or plicate at the base. They, too, are surmounted by ridges, much lower and smaller altogether than those which cap the primary costæ. The ridges on the last-named, on the body-chamber of the specimen represented in figure 3, attain nearly one-sixth of the height of the volution. In the larger specimen the height of the ridges on the body-chamber is not exactly known, but their thickness at the base is 0·6 mm.

On the inner whorls of our specimens the shell is in part preserved, but the costal ridges are no longer to be seen. On closer inspection, however, the clean-cut grooves left in the matrix after dissolution of the calcareous lamellæ will be noted, and so we may infer that the primary costæ of the inner whorls also were surmounted by such ridges: thus it was that Blanford was induced to choose the very descriptive specific name of *alatus*. The accompanying restoration (text-figure 1) constitutes an attempt to represent the shell as it appeared in the life of the animal: unfortunately the crests or ridges are made to look too massive and heavy. In reality, the shell of this form must have had a very light and graceful appearance. It is difficult to determine whether on the external periphery of the inner whorls the ridges were lower, as in *Lytoceras immane*, or whether during the progress in growth of the organism they were re-absorbed into the shelly substance or perchance broken off. Direct observation of the internal periphery of the remnants of the body-chamber only allows us to ascertain that the costal ridges of the preceding whorls impressed markings on the internal periphery, which are still recognizable as shallow grooves on the cast. The shell is considerably thicker on the internal periphery than on the sides. The primary costæ do not correspond in number with the septations.

In the specimen represented by figure 3 the body-chamber is preserved up to the apertural margin. It takes up two-thirds of the ultimate whorl: immediately before the oral aperture the lumen appears to widen somewhat. The apertural margin follows the trend of the lines of growth, and therefore forms on the internal periphery an anteriorly protrusive tongue-shaped appendage which overlaps the external periphery of the preceding whorl. A shallow groove, bounded by slight callosities, runs along the apertural margin, and next to it come some rather more prominent bands (intermediary costæ?) than are usually to be observed on the cast. There is no ridge-like plication at the apertural margin: the first such plicate costa appears at a distance behind the margin which corresponds to the interval occupied by the advance of the animal from one septal wall to the next. Although the shell at the apertural margin has not been preserved we may safely infer, from the cavity left betwixt the cast and the impression, that the shell between the apertural margin and the first costal ridge must have been of excessive tenuity; perhaps, indeed, in the anterior-most portion, close to the apertural margin, it was but imperfectly calcified. Further, it is clearly seen here that the deposition of the costal ridges took place externally. The remarkable relationships of the apertural margin and the characteristics of the shell form the object of certain comparative observations which have found their place in the introductory description of the genus.

The lobal line consists of the external and internal lobes and the two lateral lobes. The internal lobe, characteristically cruciform, and the septal lobes have been already described by Oppel. The external lobe is but little shorter than the lateral lobe: both lateral lobes are very symmetrically paired.

Lytoceras exoticum was very imperfectly described by Oppel from a small chambered fragment and from a portion of the body-chamber. Both of these specimens have been examined by me. The first of these exhibits the cruciform internal lobe and the lobal apices of the anterior septation, as well as the saddle-folia of the posterior septation. The lobes of the specimen have been correctly picked out with colour, but the draughtsman appears to have reconstructed the quite impossible lobal line attributed to this species in the "Palæontologische Mittheilungen," by a series of erroneous combinations.[1] Much more complete is Blanford's description, founded on far better specimens, but so, too, the beautiful drawing, which we owe to him, "is a restoration compiled from too fragmentary external casts." Thanks to the kindness of Dr. Henry Woodward and Mr. George C. Crick, I have before me excellent plaster casts of the Blanford specimens, which agree in every respect with my own specimens. Although Blanford's description is more complete and the name which he has chosen, *alatus*, is more truly descriptive, yet, according to the rules of priority, Oppel's name must be upheld.

Blanford, Oppel, and Stoliczka rightly assign the species here described to the group of *Lytoceras Eudesi*, d'Orb., and *Lytoceras Adelæ*. *Lytoceras Eudesi* differs more particularly by its narrower umbilicus, much more rapid growth, and less numerous but more prominent plications in the primary costæ. With regard to *Lytoceras Adelæ*, d'Orb.,[2] the external forms and conditions of growth of the shell would certainly allow of its identification with *Lytoceras exoticum*, had not D'Orbigny emphasized the absence of plicate costæ. Moreover, the distinction between primary and secondary costæ is reduced to vanishing-point on the inner whorls. Moreover, the specific diagnosis of *Lytoceras Adelæ* stands urgently in need of revision. In *Lytoceras Adeloides*, Kudern., the number of denticulations at the primary costæ is still smaller, being only from 2 to 4 on either side, as K. von Zittel[3] has already remarked. Another similarly allied form was described by M. Neumayr[4] from the Oxfordian of the Carpathians under the designation of *Lytoceras* n. sp. ind. aff. *Adeloides*: this seems to be more particularly differentiated from our species by the smaller number of serrated (or denticulated) costæ.

Lytoceras rex, Waagen, from Cutch,[5] is distinguished by its much higher whorls and the absence of any differentiation of the costæ on the inner whorls. Under the name of *Lytoceras cf. subtilis*, E. Favre[6] describes a species from the

[1] Quenstedt has already noted the erroneous character of this lobal line; see "Ammoniten des Schwabischen Jura," vol. III, page 1113.

[2] "Cephal. jurass," pl. CLXXXIII, page 494.

[3] Jahrbuch d. k. k. geol. Reichsanstalt, 1868, vol. XVIII, page 603; see also *ibid.*, 1881, vol. XXXI.

[4] "Jurastudien," Jahrbuch d. k. k. geol. Reichsanstalt, 1871, vol. XXI, page 364.

[5] "Jurassic Fauna of Kutch: Cephalopoda," Palæontologia Indica, ser. IX, vol. I, page 36 and pl. VIII, fig. 1.

[6] "Zone à *Amm. acanthicus* dans les Alpes de la Suisse et de la Savoie," page 22, and pl. II, fig. 2.

Alps of Switzerland, which, so far as its costation is concerned, agrees very well with *Lytoceras exoticum*; but the whorls are higher than in our species. Furthermore, *Lytoceras montanum*, Opp., from the Tithonian of the Mediterranean, appears to be very nearly related to the species here described. It is true that lamellar costal ridges are unknown in *Lytoceras montanum*, but that is a matter that may well be dependent on the state of preservation of the specimen. The form of the shell in that species is singularly like that of *Lytoceras exoticum*, and the differences must be sought in the much greater number of the plicate primary costæ on the body-chamber and in the absence, remarked by K. von Zittel,[1] of plicate or crumpled costæ on the innermost whorls (up to a diameter of 50 mm.) of *Lytoceras montanum*. It seems possible that *Lytoceras typum*, Milaschewitz,[2] from the Neocomian of the Crimea, is an ally of the Indian species, but as the Crimean form is only known as a cast, it is not in our power to determine this point definitely. Moreover, *Lytoceras typum* is more strongly involute than *Lytoceras exoticum*. Finally, it may well be that *Lytoceras anisoptychum*, Uhlig,[3] belongs to the same group as our species. The differentiation is an easy matter, as *Lytoceras anisoptychum* possesses more strongly embracing whorls and more prominent primary costæ, these being more closely set on the inner whorls and less closely set on the foremost portion of the ultimate whorl, than in *Lytoceras exoticum*.

Lytoceras exoticum has been obtained from the following localities: Laptel in Gnari Khorsum (Oppel's specimens); Tangtat, north of Kibber (Stoliczka); and Chidamu (Diener). The specimens figured here come from the last-named locality. Altogether, it would appear that seven specimens of this species have been found.

HAPLOCERAS, Zittel.

The genus *Haploceras* is represented in the fauna of the Spiti Shales by two species only. One of these, *Haploceras Dieneri*, belongs to a hitherto unknown group of forms, for which a new genus ought to be established. With regard to the relationships which exist between that remarkable species and other *Haplocerata*, we may refer to the observations which accompany the description of *Haploceras Dieneri*. As the sole available specimen of *Ammonites Dieneri* is in so bad a state of preservation as to forbid a complete generic diagnosis, the foundation of a new genus has been provisionally avoided, and deferred until better material allows of more searching investigation. The designation of *Amm. Dieneri* as *Haploceras* must, therefore, be regarded as purely provisional.

The other Haploceratan species from the Spiti fauna, *Haploceras indicum*, sp. nov., is very closely related to the Mediterranean *Haploceras Staszyci*, Zeuschner. That *Haploceras indicum* belongs *sensu stricto* to the genus *Haploceras* is assuredly demonstrated by its shape and ornamentation, and more especially by its very

[1] K. von Zittel, "Fauna des älteren Tithon," page 45, pl. II, figs. 3 and 4.
[2] Bull. Soc. Imp. Natural. de Moscow, 1877, pl. I, fig. 8, page 113.
[3] "Cephalop. d. Wernsdorfer Schichten," Denkschr. k. Akad. d. Wissensch. Wien, 1863, vol. XLVI, page 66, pl. IV, fig. 7, and pl. XIV, fig. 9.

characteristic lobal line. Unfortunately *Haploceras indicum* also is represented only by a single, badly preserved specimen which does not permit of a sufficiently complete characterization of the species. Nevertheless, we could hardly allow ourselves to overlook it here, if only because of the relationship which it indicates to the fauna of the Mediterranean Province.

HAPLOCERAS DIENERI, sp. nov.

(Plate VII, fig. 9 *a*, *b*.)

Dimensions :—

Diameter	49·3 mm.
Width of umbilicus	14·2 „
Height of the ultimate whorl	21·1 „
Thickness of the ultimate whorl	12·8 „

The volutions of the flatly discoidal shell overlap each other by about one-half and lay open a fairly broad umbilicus. The sides are slightly domed, and pass (without a distinct umbilical margin) into the low, gently sloping umbilical wall. The external periphery is narrow, slightly acute (cuneiform), rounded. The cross-section of the volution is nearly oval, the greatest thickness being about or just a little below the centre of the whorls. The innermost whorls appear to be smooth. On the ultimate whorl crescentic costæ make their appearance, beginning as extremely fine striations in the lower portion of the sides and only assuming more prominence above the slightly marked spiral groove which is here very undulating and trending far forward. As they approach the external periphery they become feebler again and die away without actually reaching the periphery. Somewhat below the middle of the shell, a slight spiral groove is observable at the starting-point of the crescentic costæ, but it seems to be restricted to the body-chamber. The external portion of the aerial chambers, as far as one can judge, is smooth. At the beginning of the body-chamber are two rounded, somewhat flat, callosities, which take up the whole breadth of the external periphery, the lines of growth curving over them. Some of the lines of growth, moreover, appear to swell up into slight protuberances farther forward on the external periphery. One half of the ultimate whorl, which is (unfortunately) not preserved entire, belongs to the body-chamber, the apertural margin of which is unknown.

The lobal line consists of the two lateral lobes, the external lobe, and three auxiliary lobes. The external lobe is somewhat shorter than the first lateral, and is divided by so broad a secondary saddle that its two rami lie upon the sides of the shell. The first lateral has a slender, slightly crooked form, broadening out somewhat forward, with three short lateral rami on either side, and a slender terminal ramus. The external lateral rami are longer than the internal, thus the lowermost external lateral ramus is more than double as long as the lowermost internal lateral ramus. Moreover, the external lateral rami branch off from the stem somewhat deeper down than the internal. On account of this, as well as owing to the

circumstance that the lowermost and median external lateral rami converge one towards the other, the first lateral lobe has a very characteristic appearance, which can hardly be so well described in words as it is rendered in the accompanying drawing of the lobe. On the other hand, in the second lateral, much shorter than the first, the internal lateral rami branch off much lower down than the external, and so the second lateral is slightly bent in opposition to the curvature of the first. The auxiliary lobes have much the same form as the second lateral, they decrease rapidly in size and slope down to the suture. Their lateral offshoots are reduced to small denticulations. The external saddle is fairly broad, and is divided pairwise by a secondary lobe. The first lateral saddle projects uncommonly far forward, and it also is divided into two by a secondary lobe, the inner division lying somewhat higher than the outer. The lobal denticulations are for the most part somewhat blunted and rounded off.

FIG. 4.—HAPLOCERAS DIENERI, n. sp.

Sutures of the specimen from Chidamu figured on pl. VII, fig. 9.

Ammonites Dieneri, sp. nov., occupies an isolated position in the Spiti fauna. There is not a single form among those so far known (from that area) that could be regarded as nearly related to it. Nor do we find even among European forms very many points of resemblance with this species. It is true that the lobal line in its main features recalls the lobes of the Tithonian Haplocerata, such as *Haploceras verruciferum*, *H. Staszyci*, etc. The curiously bent form of the two laterals, the manner in which the rami branch off from these, and more especially the marked anterior projection of the first lateral saddle, characterize our species in common with the Tithonian Haplocerata. Other points of resemblance are the broad umbilicus, the form of the shell, the ornamentation, and the general habit of the external periphery. The thickening at the point where the body-chamber begins recalls, moreover, in some respects *Oppelia*; but the nodes on the external periphery of the *Oppeliæ* are invariably more numerous, and in none of the species hitherto known do they present characteristics which could imply any relationship with *Amm. Dieneri*.

The typical Tithonian Haplocerata, such as *Haploceras elimatum*, *H. tithonicum*, *H. Staszyci*, *H. verruciferum*, *H. carachtheis*, *H. leiosoma*, possess, as we know, practically smooth sides. On that account alone, it would be impossible to regard *Ammonites Dieneri* as nearly related to these forms. On the other hand, somewhat closer resemblances may be traced between it and a small group of Haplocerata (in the broader sense) from the Alpine-Carpathian *Acanthicus* beds, such as *H. Balanense*, Neum., *H. tenuifalcatum*, Neum., and *H. jungens*, Neum.[1] These forms possess highly undulate sickle-shaped costæ projecting far forward on the external periphery, and to them we may add *H. propinquum*, Waagen,[2] from the lowest beds of the Katrol Group.

[1] Neumayr, "*Acanthicus* Schichten," page 162.
[2] "Jurassic Fauna of Cutch," page 45, pl. XI, fig. 4.

But then these forms also (the lobal line of which is unfortunately not known) are distinguished by the absence of nodes at the beginning of the body-chamber and the presence of diagonal plications at the external periphery, so that it is not here either that we can hope to trace the connexion of *Ammonites Dieneri* with the Haploceratan stem. What our species has in common with *Haploceras fialar*, Oppel, are the slight spiral groove on the sides, and the markedly undulate crescentic costæ. *H. fialar* is differentiated from *Amm. Dieneri* by its numerous little external nodes, but the extremely small size of these and our defective knowledge of its lobal line forbid any closer comparison.

Finally, we might also trace resemblances with *H. asemum*, Oppel sp. from the Tithonian. For that remarkable species and *H. Poparelli*, Canav., *H. Wöhleri*, Opp., and *H. carachtheis*, Zeusch., M. Canavari[1] established a few years ago the genus *Eurynoticeras*. But we cannot bring *Ammonites Dieneri* into that group, because the costæ in these types instead of curving forward at the external periphery, curve backward.

We conclude, then, not only that *Ammonites Dieneri* constitutes a new species, but that it is assignable to a new group of forms unknown as yet in detail. For this new group, which is probably connected with the Haploceratan stem, a distinct generic designation must be found. As, however, we are not in a position to diagnose with sufficient accuracy this new genus from the single available and badly-preserved specimen, and so to define clearly its relationship to the other Haplocerata, it appears preferable to designate provisionally this interesting form as *Haploceras*, and to postpone the establishment of a new genus until more ample investigation can be made on the basis of more abundant and better material.

The single specimen of *Haploceras Dieneri* was found at Chidamu (Coll. Diener).

HAPLOCERAS INDICUM, sp. nov.

(Plate III, figs. 2 *a—d*.)

The single available specimen measures 50 mm. in diameter, the umbilical width being 10·6 mm., and the height of the volution at the anterior extremity of the test 23·5 mm., while its breadth is 16·5 mm. Half of the ultimate whorl belongs to the body-chamber, which, however, is not preserved entire. The test is discoidal, with a somewhat narrow umbilicus and slightly domed sides, which pass gradually into the rounded external periphery. The rounded umbilical wall does not dip very steeply inward.

The ornamentation consists of slight crescentic striations, still traceable on the cast, but clearly marked only on the external periphery, over which they course

[1] "Fauna degli Strati con *Aspid. acanthicum* di Monte Serra," Palæontographia Italica, vol. II (1896), page 46. According to Prof. K. von Zittel (*teste* Canavari, *op. cit.*, p. 47) *H. asemum*, *H. Wohleri*, and *H. carachtheis* are passage-forms between *Haploceras* and the *Oppeliæ*. Since, however, as far back as the Inferior Oolite, *Oppelia* and *Haploceras* constitute distinct, well-marked groups, it does not seem very probable that these species of the uppermost Jura are passage-forms from *Haploceras* to *Oppelia*, but rather that we are dealing here with "convergence-phenomena."

diagonally, and especially at the anterior portion of the body-chamber. Although the septal striations are not preserved entire, they are in parts so clearly discernible that, by carefully piecing together different portions of three septations, the complete course of the lobal line may be reconstructed. The siphonal lobe is very short, the first lateral saddle is characterized by its length and high position, and is unequally divided by a slanting secondary lobe into a small depressed portion and a larger and higher portion. The last named is in its turn divided by a shorter secondary lobe. The second lateral lobe has a characteristically unsymmetrical structure owing to the abnormal development of the external lateral ramus, a want of symmetry repeated in the auxiliary lobe, which latter shows rapid diminution in size. This lobal structure is so characteristic that it leaves no room for doubt as to the proper attribution of the species to *Haploceras* in the strictest sense, an attribution the certainty of which is enhanced by the form and ornamentation of the test.

Haploceras Staszyci[1] is so nearly allied to the species just described that we were at first disposed to look upon the Indian specimen as a local variety of *Haploceras Staszyci*. The former is differentiated from the latter, however, by a somewhat greater umbilical width, lower umbilical wall, more markedly rounded external periphery, somewhat lesser thickness, but more especially by the prominence of the crescentic striations. Whether a small keel was present (as in specimens of the shell of *Haploceras Staszyci*) cannot be ascertained, as the shell in our specimen is not preserved.

The differences just enumerated are indeed of small account taken singly, but taken as a whole they give to the Indian form so distinct a character that it is impossible for us to ignore its divergence from *H. Staszyci*. Among the numerous specimens from the Tithonian of the Carpathians which lie before us, no single one shows any trace of an approximation to the Indian form. This circumstance it is that mainly determines us, despite the comparative insignificance of the distinctive differences, to place the Indian specimen in a new species.

Detailed discussion of its relationship to other allied species seems hardly called for. Perhaps the nearest, after *Haploceras Staszyci*, are *Haploceras elimatum* and *Haploceras Erato*. The last-named species differs by reason of its flatter test and broader umbilicus, and *H. elimatum* is so clearly distinguished by the more cuneiform shape of its external periphery and its greater thickness in the umbilical region, that confusion with our species is highly improbable. On the other hand, it must be borne in mind that M. Neumayr has mentioned a *Haploceras*, sp. indeterm., from the *Acanthicus* beds of Transylvania, as being distinguishable from *H. Staszyci* by its lesser thickness.[2] Whether this form is perchance more closely allied to the Indian species than the typical *Haploceras Staszyci* cannot be determined at present.

As only one specimen, and that rather badly preserved, lies before us, we are unfortunately not in a position to characterize fully our new species. It, never-

[1] Compare especially K. von Zittel, Paläontologische Mittheilungen, vol. II, pt. II, "Fauna der älteren Tithonbildungen," plate III, figures 2—6, and page 50.

[2] Neumayr, "*Acanthicus* Schichten," Abhandlungen der k. k. geol. Reichsanstalt, vol. V, page 161.

theless, we have ventured to assign a specific name to it, the geological significance of this form is what has impelled us to do so. Isolated though it may be in regard to the rest of the Spiti Fauna, it furnishes a link with the Mediterranean Province.

Haploceras indicum was found in the middle division of the Spiti Shales in Chojan (Coll. Diener).

HECTICOCERAS, Bonarelli.

The forms which are here described under the generic name of *Hecticoceras* belong to the small, well-defined group of *Amm. Kobelli*, Opp.

On account of its striking *bifrons*-like characteristics and its isolated occurrence, *Amm. Kobelli* has repeatedly attracted the attention of investigators. Its occurrence has been variously commented on, but to W. Waagen belongs the credit of having dispelled certain unjustifiable doubts as to its existence and of having shown that *Amm. Kobelli*, Opp., occurs also in the Jurassic of Cutch, where it is found on the horizon of the Middle Katrol Group.[1]

The resemblance between *Amm. Kobelli* and *Amm. bifrons* has often been pointed out, and indeed the similarity is so remarkable that it cannot possibly be ignored. On closer examination, however, certain significant divergences are revealed. The least important among them, connected with the external periphery and the ornamentation, will be dealt with in detail in the course of the specific description of *Amm. Kobelli*. At this point we shall confine ourselves to the far more important differences manifested in the lobal lines. In *Amm. bifrons* the lobes have simple, rather long, acutely pointed denticulations. In *Amm. Kobelli*, on the other hand, we find distinct lateral rami, short, it is true, but terminating in blunt, somewhat rounded denticulations. The second lateral lobe is much less highly developed in *Amm. bifrons* than in *Amm. Kobelli*, and the saddles are not much sub-divided, whereas in *Amm. Kobelli* they are divided by rather long secondary lobes. Further, the first lateral saddle in *Amm. Kobelli* is far higher placed than in *Amm. bifrons*; and, finally, in the lobal line of the former species three auxiliary lobes may be counted, while in that of the latter species there is only one auxiliary lobe. On the whole, then, the lobal structure of *Amm. Kobelli* represents a higher stage of development than that of *Amm. bifrons*. Without being of absolutely fundamental importance, the difference is sufficient to forbid any closer correlation of *Amm. Kobelli* with *Amm. bifrons*.

Those very peculiarities of lobal structure which differentiate *Amm. Kobelli* from *Amm. bifrons* indicate its approximation to the well-known group of the Hectici, for which Bonarelli[2] has established the generic designation of *Hecticoceras*. The character of the external periphery and the general form of the Hectici correspond in every respect with those of the *Kobelli* group; and, in regard to the ornamentation, the resemblance in certain forms (as, for example, in *H. Brighti*) is so

[1] "Jurassic Fauna of Kutch," page 72.

[2] "Hecticoceras, novum genus Ammonidarum," 1893, Parona et Bonarelli, "Sur la Faune du Callovien inférieur de la Savoie," Chambéry, 1895, page 100.

marked that it would want but a little deepening of the spiral groove to achieve complete identity with the features of the *Kobelli* group.

On these grounds I am unable to concur unreservedly in Waagen's opinion that "no other species, excepting *H. bifrons*, can be compared with the Indian form,"[1] for I believe that the relationship of the *Kobelli* group with the Hecticí is also worthy of attention. The similarity in lobal structure more particularly impels us to seek in this direction, rather than in that of *H. bifrons*, the natural connexion whereby the distinctive and isolated *Kobelli* group may be linked on to the multiform stock of the Harpocerata. This is no newly-broached opinion, for Bonarelli, when establishing the genus *Hecticoceras*, included *Amm. Kobelli* in that group of forms. Certain varieties of that species, described by Waagen, were erected by Bonarelli into a new species under the name of *Amm. Kobelliformis*; and thus he included both *H. Kobelli* and *H. Kobelliforme* in the genus *Hecticoceras*, in the subgeneric division of *Lunuloceras*. Yet, despite all the resemblances of the *Kobelli* group with the Hecticí, there is a certain amount of divergence, which appears to be greater, for example, than the difference between *Lunuloceras* and *Hecticoceras* (*sensu stricto*); and this divergence would perhaps justify us in founding at least a subgenus for that remarkable group.

Its isolated occurrence, however, makes the separation of the specific from the generic characteristics a matter of such great difficulty, that we deem it advisable to refrain, for the present at least, from establishing either a new genus or a subgenus. This may be the more easily dispensed with that, until more numerous forms of the group are known and among them passage-forms of earlier geological age, the provisional inclusion of the *Kobelli* group with *Hecticoceras* is the simplest and most reasonable solution.

In order to make this discussion as exhaustive as possible, it may be added that, in some respects, the *Kobelli* group is allied also to the *Canaliculati*. The deep-cut spiral groove, the sicular or crescentic ornamentation, and more particularly the lobal structure, show a certain approximation which deserves attention, on account of the very slight difference in geological age of the two groups. The more pronounced development of the auxiliary lobes, the narrowness of the umbilicus, and especially the presence of a carina beset with granular prominences in the *Canaliculati*, would appear, however, to weigh against the supposition of a very close relationship between them and the *Kobelli* group.

The absence of ornamentation on the inner whorls might perhaps be regarded as a sign of retrogressive evolution; but against this we may set the extreme development of the lobes and the great variety of forms in the group.

So far as we are at present able to form a definite opinion with regard to the *Kobelli* group, it appears to us to be a small, specifically Indian ramification of the great Harpoceratan stem, from which it branches off close to the Hecticí, and in Upper Jurassic times assumes an outwardly similar form to that assumed in Upper Liassic times by the small offshoot of *Harpoceras bifrons*. We should then have here

[1] "Jurassic Fauna of Kutch," page 74.

an example of that extraordinary "convergent evolution," designated by Koken as "iterative specific evolution."

The occurrence of the *Kobelli* group is thus far restricted to the Katrol Sandstone of Cutch and the Spiti Shales. At present, only the following species are known: *H. Kobelli*, Oppel; *H. Kobelliforme*, Bonarelli; *H. latistrigatum*, sp. nov.; and *H.* sp. nov. indet. Of these, *H. Kobelliforme* occurs in the Katrol Sandstone, *H. latistrigatum* and *H.* sp. nov. indet. in the Spiti Shales, while *H. Kobelli* is common to both formations.

HECTICOCERAS KOBELLI, Oppel sp.

Ammonites Kobelli, Oppel. Palæontolog. Mittheil., vol. II, pl. LXXVI, figs. 1 and 2, page 273.
Harpoceras Kobelli, Waagen's "Jurass. Cephalopoda of Kutch." Palæontologia Indica, 1875, ser. IX, vol. I, page 72, pl. XIII, figs. 11 and 12.
Hecticoceras (Lunuloceras) Kobelli, Bonarelli, "Hecticoceras nov. gen. Ammonidarum," Modena, 1893, page 96.

My knowledge of this species is based only upon Oppel's two original specimens, and if therefore I am able to add anything to former descriptions it is because the figure in the "Palaontologischen Mittheilungen" cannot be regarded as entirely trustworthy. Oppel, as just mentioned, had at his disposal two specimens of *Amm. Kobelli*, the smaller (chambered up to the end) measuring 43·5 mm. in diameter, and the larger (in which the ultimate whorl probably belonged in part to the body-chamber) measuring 65 mm. Of the last-named, however (fig. 1 of Oppel), there is only an impression of both sides preserved in a geode, and so the figure was made up from a cast. The shell of the inner whorls had been broken away from the impression, so that here the cast reproduces the characteristics of the shell-surface and its curious growth-striations, whereas at the outer whorl the shell remained upon the test, and so the artificial cast here corresponds to a natural cast.

The comparison of a cast and of the original specimens with Oppel's figures shows first of all that the carina and its associated grooves are much too prominent in the drawing (fig. I).[1] Further, the edge which limits downward the spiral groove of the sides is made somewhat too sharp in the lateral view (fig. 1*a*) and on the other hand not sharp enough in the apertural view (fig. 1*b*). The lower portion of the whorls between the spiral groove and the suture appears, in the figure in the "Palaontologische Mittheilungen," to be slightly domed and to have a sharp umbilical edge, whereas, as Oppel himself stated by way of correction in the text, it is in reality slightly depressed and ends off against the suture with a rounded, ribbon-like prominence instead of a sharp edge. Finally, even the lobes are incorrectly represented. The lateral denticulations and rami in Oppel's figure all terminate in fine

[1] In this respect Oppel's description affords more trustworthy guidance than the figure: "Dorsal surface of the cast rounded in the young stage, without any especially prominent carina. At the diameter of 50 mm., however, a broad, low, rounded carina makes its appearance centrally on the dorsal surface, and is unaccompanied by lateral grooves."

points, whereas in reality they are rounded off. And then the first lateral saddle is not placed high up enough. Thus Oppel's beautiful figures, although as a whole giving a fairly good picture of the species, are defective in certain particulars, and therefore it does not seem superfluous to re-figure in this publication Oppel's original specimens.

The smaller specimen shows, as Oppel truly observed, that the development of the carina took place at a later stage of growth. At a diameter of about 23 mm. the external periphery begins to assume a cuneiform shape, although its median portion is still rounded. Gradually the external periphery tends more and more to the wedge shape, while the shell becomes markedly flattened on each side of the median line. Then a blunt carina makes its presence little by little apparent, becoming quite prominent at a diameter of about 44 mm. This prominence is much more marked at the ultimate whorl of the larger specimen: here the carina is well raised above the neighbouring shell-surface, so that it appears to be accompanied by two narrow lateral grooves.

Where the shell is preserved, the peculiar course of the sicular growth-striations may be followed up without difficulty. From the suture they incline diagonally forward, and then suddenly curve round backward in a crescentic undulation. At the point where they curve round, there arises somewhere about the middle of the sides a fairly broad spiral groove, which appears in the natural cast to be rather more deeply cut than on the shelly surface—a circumstance to which Waagen has already called attention. The lower portion of the whorls exhibits no ornamentation beyond that of the growth-striations; but the upper portion is beset with well-marked, rounded, sicular costæ which curve round very sharply backward: these vanish at the limit between the sides and the external periphery. The first traces of the sicular costæ appear at the diameter of about 22 mm., and simultaneously with these the spiral groove begins to show plainly. This groove, as the organism advances in age, deepens and broadens continuously, and its lower margin increases regularly in prominence. The greatest breadth of the cross-section is at first about the middle of the sides, but later on it coincides with the lower edge of the spiral groove. The smaller specimen exhibits at its anterior extremity precisely that stage wherein the greatest breadth is passing into the region of the lower edge of the spiral groove. In the larger specimen this edge becomes yet more prominent, although it is still far from comparable in prominence with that of *H. latistrigatum*. The umbilicus is so broad that the involution spiral courses above the spiral groove. The sides at the inner whorls are slightly and fairly evenly domed. With advancing growth, however, the upper portion of the sides becomes flatter and appears to be better set off against the cuneiform external periphery; while the lower portion between the spiral groove and the suture is somewhat depressed, and is limited by a rounded, cordon-like prominence at the suture. That the ultimate whorl of the larger specimen belongs already in part to the body-chamber may be inferred from the circumstance that on the inner side of the shell, which still clings to the impression, no trace of septations can be recognized.

The lobal line consists of the external lobe, the two laterals, and probably three auxiliaries, of which, however, the two last are very small. The lobes are fairly broad and are furnished with somewhat long lateral rami which terminate in blunt-ended denticulations. The external lobe is very short and broad, the second lateral being feebler and of less regular structure than the first. The auxiliaries are at about the same height as the second lateral lobe. The saddles are broad, and the principal lateral saddle is characterized by its remarkably high position.

Waagen's specimens of *H. Kobelli* from Kutch agree on the whole very well with Oppel's specimens, on the assumption that we leave out of count Waagen's figure 12, which represents a widely divergent form. Probably Bonarelli was right in separating this off from the typical species, and making of it a species to itself under the name of *Hecticoceras Kobelliforme*. Supposing that we take as a basis the apertural views of Waagen's figures, the sole difference appears to consist in the more pronounced doming of that part of the shell that lies between the spiral groove and the suture. As, however, Waagen's specimens are somewhat smaller than those from the Spiti Shales, and as Waagen in his text emphasizes the similar inclination of the shell towards the suture and the presence of a rounded umbilical margin, the postulated difference would seem to have no real existence, or at most would be so slight as to constitute no obstacle whatever to the attribution of this form to *H. Kobelli*.

The differences between *H. Kobelli* and *H. latistrigatum*, sp. nov., are enumerated under the last-named species.

Oppel's specimens of *H. Kobelli* were obtained at Shangra, east of Puling in Gnari Khorsum. In Kutch *H. Kobelli* occurs, according to Waagen, in the middle Katrol Sandstone.

HECTICOCERAS LATISTRIGATUM, sp. nov.

(Plate II, fig. 4 *a—e*, and Plate III, fig. 5.)

Of this species three specimens lie before us. The largest, chambered up to the end, has at the diameter of 64 mm. an umbilical width of 27 mm., the height of the volution being 20·8 mm., and the thickness 13·2 mm. The test forms a very broadly umbilicated, flat disc, the whorls of which are beset on the sides with a broad and deeply cut spiral groove. The upper lip of this groove is less pronounced than the lower lip, which is indeed so prominent that the whorls show here their greatest thickness. In the natural cast the spiral groove appears somewhat more deeply incised than on the shell. As early as the diameter of 9 mm. the first traces of this spiral groove may be observed, and with the increasing size of the shell it becomes *pari passu* broader and deeper. At the anterior extremity of the largest specimen the spiral groove occupies a quarter of the height of the volution. In contrast with the early appearance of the spiral groove the sicular costæ come on very late. One specimen, 32 mm. in diameter, is still almost entirely smooth; in another specimen the first sickle-shaped costæ make their appearance at a diameter of about 40 mm.:

and in the third specimen, too, they are not observable until the diameter of 38 mm. is reached. These costæ are set wide apart, they are rounded, very prominent, and curve round most markedly backward. Certain remnants of the shell indicate that the growth-striations followed the same course as in *H. Kobelli*. At first they are inclined very markedly forward, but they curve round just as far backward at the spiral groove.

On the inner whorls of the test the sides pass gradually into the cuneiform external periphery; but on the costate anterior portion the delimitation between the sides and the external periphery is emphasized by the almost immediate disappearance of the costæ. Simultaneously the external periphery takes on here the wedge-like form, while the shell on both sides of the median line is clearly flattened off. In fact, the "wedge" of the periphery terminates in a rounded blunt carina, which, however, so far as may be inferred from the largest specimen, makes no prominence and is unaccompanied by grooves. The cross-section at the inner whorls is a high oval, thinning to a wedge externally, and somewhat depressed on both sides in the neighbourhood of the spiral groove. It is only on the outer whorl that it undergoes a radial change, owing to the considerable deepening of the spiral groove, the marked protrusion of the lower lip of the same, the cuneiform flattening of the external periphery, and the advanced development of the carina. The lower portion of the shell, between the spiral groove and the suture, is symmetrically domed on the inner whorls, and it is only in the anterior part of the ultimate volution that this doming becomes less pronounced, and the fairly even surfaced shell inclines gently towards the umbilicus.

The septal wall exhibits, besides the external lobe and the two lateral lobes, three small auxiliary lobes. The external lobe is somewhat short, and its rami are widely divergent. The first lateral lobe, of approximately triangular shape, is fairly broad high up, and contracts symmetrically towards its termination. It ends in a rather short central ramus, flanked on each side by three short lateral rami. The second lateral lobe is much shorter than the first, and lies at the lower lip of the spiral groove. Of its lateral rami the lower alone are highly developed, the upper forming simply small denticulations. While the second lateral lobe, like the first, appears to have an approximately triangular shape, the two first auxiliary lobes are narrow and have merely a few small denticulations. The third is close up to the suture, and forms one simple denticulation. The auxiliary lobes exhibit a slight but none the less clearly marked upward trend to the suture. The external saddle is divided by a secondary lobe into a smaller outer portion and a larger inner one, the last being itself subdivided by a smaller secondary lobe. The first lateral saddle lies much higher than the external saddle and is diagonally divided by a secondary lobe. Moreover, the lobes are characterized by the blunt, rounded shape of the denticulations.

H. latistrigatum approximates very closely to *H. Kobelli*, yet the divergences between the two forms are so plainly visible as to preclude the possibility of assigning them to one and the same species. *H. latistrigatum* is not so stout as

H. Kobelli: in both forms the greatest thickness is at the lower margin of the spiral furrow; while, however, in *H. Kobelli* the upper portion of the whorls shows but little diminution of the maximum thickness, in *H. latistrigatum* the whorls above the spiral furrow diminish markedly in thickness. The spiral furrow in *H. latistrigatum* is much broader, its lower margin much sharper and higher, and the carina much feebler than in *H. Kobelli*. The crescentic costæ in *H. latistrigatum* are much wider apart and less numerous than in *H. Kobelli*. At the same diameter, on one half of the ultimate whorl there are in *H. Kobelli* fourteen and in *H. latistrigatum* only nine costæ. In the last-named species that portion of the shell which is comprised between the spiral furrow and the suture is but slightly domed, if at all, and exhibits no sutural protuberance. The same area in *H. Kobelli*, on the other hand, is somewhat depressed, and there is a slight excrescence at the suture. In *H. latistrigatum* the costæ begin later and the spiral furrow earlier than in *H. Kobelli*. Finally, the lobes also exhibit certain differences: thus, the lateral lobes are generally more cuneiform in *H. latistrigatum*, and the auxiliary lobes trend more markedly up to the suture than in *H. Kobelli*. *H. Kobelliforme*, Bonarelli, shows a more distant relationship, as in this form the costæ are still more closely set than in *H. Kobelli*.

The specimen figured here comes from the "Middle horizon" of the Spiti Shales of Chidamu. In addition to this, we have before us three smaller specimens enclosed in one and the same geode from Svikia (Southern Hundes): they agree in the closest possible manner with the first-named specimen.

HECTICOCERAS, sp. nov. indet.

(Plate LVIII, fig. 5 *a—d*.)

A fragment 24·5 mm. in diameter represents a new species, but is, unfortunately, in too defective a state of preservation to admit of its being used as the basis for the establishment of a new species. The spiral furrow is strongly marked, and as early as a diameter of about 11 mm. can be recognized on the internal cast. Even at a diameter of 24·5 mm. crescentic costæ are still undeveloped. The test, at a diameter of about 5 mm., gives a low cross-section for the volution, rounded towards the periphery and at the sides. Later the volution increases rapidly in height, and at a diameter of 24 mm. the cross-section is flatter and indicates a higher aperture than in *H. Kobelli* and *H. latistrigatum*. The external periphery is cuneiform and bluntly carinate. The sides are flatly domed betwixt the spiral furrow and the suture. The lobes are in no wise different from those of *H. Kobelli* and *H. latistrigatum*. We are, unfortunately, not in a position to trace the evolution of the ornamentation and the carina in larger specimens, and so we cannot assign a new name to this species. Nevertheless, the form of the whorls indicates sufficiently that it is specifically different from *H. Kobelli* and *H. latistrigatum*.

The specimen comes from Svikia.

OPPELIA, Waagen.

The first to be described of the Oppelias of the Spiti Shales was *Ammonites acucinctus*, Strachey. The original representation was very defective and later descriptions, so far from mending matters, have only intensified the confusion. The true original *Amm. acucinctus* was mixed up with forms which indeed bear great outward resemblance to it, but in their completely distinct lobal line these species betray their kinship with quite another group of Oppelias, the Tenuilobata (*Streblites*, Hyatt). The majority of the specimens described by Blanford in the "Palæontology of Niti" as *Amm. acucinctus* in reality do not belong to that species, but to various Tenuilobata. In this case even F. Stoliczka[1] failed in his wonted gift for detecting natural relationships, for he grouped together with *Amm. acucinctus* three species of Tenuilobata, namely, *Amm. Adolphi*, Oppel, *Amm. substriatus*, Oppel, and *Amm. Lymanni*, Oppel. Stoliczka's comparison of *Amm. acucinctus* with *Amm. Pichleri*, Oppel, was not altogether erroneous, as both species are assignable to the genus *Oppelia* in its broadest sense: but he was here just as far away from the right track towards a better comprehension of these forms, as Quenstedt was in his disquisitions upon them.[2] Of far greater value and correctness was K. von Zittel's remark[3] when he drew attention to the "astonishing similarity" between *Oppelia zonaria* of Stramberg and *Oppelia Adolphi* and the Tenuilobata. Unfortunately this hint, which, if it had been followed up, might have led to important conclusions in regard to the character of the Spiti fauna, appears to have escaped the notice of both Neumayr and Nikitin when engaged in their investigation of the fauna. Thus Neumayr confines himself to the not especially apposite remark that *Opp. Lymanni* is allied to *Opp. falcula*, Quenst.;[4] while Nikitin[5] contents himself with the conclusion that *Amm. Adolphi*, Oppel, *substriatus*, Oppel, *Lymani*, Oppel, *nivalis*, Stoliczka, and *acucinctus*, Blanford, all belong to the genus Oppelia, and cannot be identified with any European species.

A closer examination of the rich material which lies before me very soon led me to the inference that the Oppelias of the Spiti Shales are of extremely various types, all of which will repay careful study. *Opp. acucincta* seems to be a perfectly independent type, betraying no close relationship with any of the other forms of the Spiti fauna. So, too, *Opp. nivalis* is an isolated type. Then again, the multifarious forms which have been confused with *Opp. acucincta* make up a group of themselves, joining on to *Opp. Adolphi*, Oppel, and very closely related to the European Tenuilobata. Finally, we may link on to the Oppelias (in the broadest sense), as the representative also of an independent group, the form

[1] Mem. Geo. S[illegible], India, vol. V, Calcutta, 1868.
[2] "Ammoni en des schwäbischen Jura," vol. III, page 118.
[3] "Cephalop. der Stramberger, Schichten," page 89.
[4] Neues Jahrb. für Min., etc., 1890, vol. I, page 153.
[5] Neues Jahrb. für Min., etc., 1889, vol. II, page 123.

which is here described as *Œcotraustes adelus*. A glance at the accompanying text-figure (fig. 5) will show clearly how various is the lobal structure of these different types.

Consequently, the Oppelias of the Spiti fauna may be classified as follows:—

I.—Group of *Oppelia Adolphi*, Oppel (*Ammonites pictus*, Quenstedt; Group of the Tenuilobata, Oppel; *Streblites*, Hyatt), represented by the undermentioned forms:—

Oppelia (*Streblites*) *Adolphi*, Opp.
" " *Kraffti*, sp. nov.
" " *Griesbachi*, sp. nov.
" " *planopicta*, sp. nov.
" " sp. nov. indet.
" " *indopicta*, sp. nov.
" " *Himalayana*, sp. nov.
" " *substriata*, Oppel sp.
" " aff. *substriata*, Oppel sp.
" " *Lymani*, Oppel. sp.
" " n. sp. indet. aff. *Lymani*, Oppel.
" " *punctatopicta*, sp. nov.
" " *sphenodoma*, sp. nov.
" " *platydoma*, sp. nov.
" " *leptodoma*, sp. nov.
" " *domocrenata*, sp. nov.
" " *pygmæa*, sp. nov.
" " *adunata*, sp. nov.
" " sp. nov. indet.

II.—Group of *Oppelia acucincta* (*Oppelia, sensu stricto*), represented by only one species:
Oppelia acucincta, Strachey, sp.

III.—Group of *Oppelia nivalis* (*Neumayria*, Bayle), represented by only one species:
Oppelia (*Neumayria*) *nivalis*, Stoliczka sp.

IV.—Group of *Oppelia* (*Œcotraustes*) *adela*, represented by only one species:
Oppelia (*Œcotraustes*) *adela*, sp. nov.

I.—Group of Oppelia Adolphi (Streblites, Hyatt).

We may begin a more detailed discussion of the *Oppelias* with the group of *Oppelia Adolphi*. That this group is closely connected with the European Tennilobata is unmistakably demonstrated by the concordance of the lobal structure, ornamentation, external shape of the test, development of the carina, and form of the body-chamber. In two species, *Oppelia indopicta* and *Opp. Adolphi*, the similarity to such European species as *Opp. Frotho*, Oppel, and *Opp. zonaria*, Oppel, is so great, that very close study indeed is necessary in order to convince one's self that these forms are specifically distinct. The lobal line consists, in the group of *Oppelia Adolphi* and in the European Tenuilobata, of the external lobe, the two laterals and four to five auxiliary lobes. In the forms possessing a high aperture five auxiliary

lobes are known, the fourth of which occurs at the umbilical margin and the fifth at the umbilical wall. In the forms possessing a low aperture, on the other hand, the number of auxiliary lobes is limited to four, and the ultimate auxiliary lobe is merely developed as a simple unbranched denticulation at the umbilical wall. The position of the septations is such that a tangent laid at the saddle-folia diverges but little from the radial direction. The auxiliary lobes do not incline towards the suture, but remain at the same level as the second lateral lobe, or else rise somewhat higher. The first lateral saddle projects a little forward, and more so in some forms than in others. The lobes and saddles generally are very constricted, but, at the same time, their rami are so widespread and dichotomize so repeatedly that the entire disc, with the exception of the external periphery, is covered by a close extremely elegant network of lobal ornamentation.[1]

The external lobe is unusually short, while the siphonal protuberance which divides it into two is comparatively broad. The narrow stem of the first lateral does not terminate in a prominent unpaired ramus, but splits at its posterior extremity into two sub-symmetrical pairs of rami. The external pair consists of two combined external lateral rami; the inner is formed by the junction of the terminal ramus proper with the internal lateral ramus. These pairs of rami, in the large forms, such as *Opp. Kraffti*, *Opp. Adolphi*, *Opp. Griesbachi*, are linked on to the main stem by the intermediary of a short intercalary ramus. In the smaller forms, such as *Opp. Lymani*, the rami are more crowded together and branch off all at the same point direct from the stem of the first lateral. The external pair of rami, which may occupy all the space up to the external periphery, is always more wide-spreading than the internal pair. In the larger forms it may push its extremities even behind the rami of the external lobe, near to the median line of the external periphery. In the smaller types, too, the external pair of rami approximate to the external lobe, but without reaching as far as the extremity of that lobe. The stem of the first lateral appears very frequently to be somewhat bent or broken.

The second lateral differs entirely in its general facies from the first lateral. Here, besides smaller lateral rami and denticulations, there is an external and an internal main lateral ramus, the former of which branches off farther forward than the latter. The terminal ramus is not connected with a lateral ramus, but forms the immediate continuation of the lobal stem. The auxiliaries are similar in shape to the second lateral, and diminish gradually in size and complexity as they approach the suture. The saddles are uniformly narrow and excessively denticulated. Each saddle is divided up by one long and two short secondary lobes.

The extremities of the lobes, which in most ammonites are directed either backward or sideways, show in these forms often enough a tendency to bend round forward. The ramuli of the lobes, the extremities of which are thus bent, are at the same time mostly denticulate at the anterior margin and unbroken at the posterior

[1] To this characteristic may be ascribed Schlotheim's choice of the name *Amm. pictus*, which Quenstedt has used for all the European Tmuilobata in the sense of a generic designation.

margin (compare text-figure 5). This peculiarity is very strongly marked in some

FIG. 5.—SUTURES OF THREE OPPELIÆ FORMS OF THE SPITI FAUNA—
(*a*) Sutures of the Tenuilobata or *Streblites, Hy.* (Sutures of *Oppelia Kraffti*, n. sp.)
(*b*) Sutures of the *Opp. acucincta* group. (Sutures of *Opp. acucincta.*)
(*c*) Sutures of Neumayria. (Sutures of *Neumayria nivalis*, Stol.)

of the larger forms, such as *Opp. Adolphi, Kraffti, planopicta*, etc., and especially so at the ramuli of the secondary lobes. In the smaller forms, such as *Opp. Lymani, domocrenata*, etc., the very minuteness of the denticulations prevents this characteristic from ever being conspicuous.

The differences in the lobal line bear chiefly on the number of the auxiliaries (four or five), the degree of ramification, the manner in which the pairs of rami are joined to the stem of the first lateral, the more or less extensive spread of the external pair of rami of the first lateral, the more or less forwardly projecting position of the first lateral saddle, the presence or absence of a forward bend in the several lobal extremities. On the whole, these differences are of but little moment when comparison is made with other groups; and it is especially worthy of notice that even such small forms as *Opp. adunata* and *domocrenata* exhibit a highly ramified lobal line, the general structure of which is fairly concordant with that observed in the larger forms.

The test, in all species belonging to this group, is flatly discoidal, and possesses a narrow external periphery and a rounded umbilical margin. The larger forms have a narrow umbilicus and a high aperture, the smaller have a somewhat broader umbilicus and low apertures. Up to the diameter of about 6 to 10 millimetres the whorls are somewhat broader than high and always exhibit a rounded cross-section. Later on, the whorls increase far more rapidly in height than in breadth, and the cross-section becomes gradually oval, the longest diameter being the vertical. The sides are sometimes flatly domed; sometimes flattened off. The greatest thickness

in the majority of species is somewhat below the middle of the side, more rarely it approaches the umbilical margin.

The ornamentation consists of comparatively flat and feeble crescentic costæ, wherein as a general rule the "sinuis" at the external portion of the sides are more highly developed than the "limbs" on the inner portion. In one species alone, *Opp. indopicta* (Plate III, fig. 3), are certain "limb-parts" (of the costæ) much thickened. The costæ die away in all the Indian forms of this group hitherto known without giving rise to tubercles between the sides and the external periphery. In most of the species, somewhere about the middle of the sides is either a slight spiral swelling or a slight spiral furrow; and in *Opp. Griesbachi* there are to be recognized in addition fine, short, spiral striations which are in some respects similar to the striations observable in *Strigoceras Truellei*, but are neither so highly developed nor so regular.

On the external periphery is a finely serrated carina, which at the body-chamber is traceable on the internal cast as well, but at the other chambered portion can be seen only on the shell. As this carina together with the fragile shell is often lost in process of fossilization, the pneumatic chambers often seem quite smooth at the external periphery, or at most show very scant traces of a granulate carina. Towards the anterior extremity this carina shows a diminution in prominence, which in certain species, such as *Opp. Lymani*, is observable only just before the apertural margin, but in others is observable at the very beginning of the body-chamber. In some of the dwarf forms, such as *Opp. adunata*, the granulate carina is very little marked indeed.

More detailed study of the characters of the serrated carina is only possible in the case of one species,—*Opp. Krafftí*. A splendidly preserved specimen, collected by A. von Krafft in Kuti, has the carinal space infilled with a grey spathose mass which is superposed on an opaque, dark, somewhat fibrous layer, and is covered by a fine, blackish, shelly layer (see text-figure 6). On closer inspection it is noticed that the above-mentioned dark, fibrous layer passes into the inner shelly layer of the sides, and therefore probably corresponds to the nacreous layer; while the fine layer overlying the carinal mass passes into the outer shelly layer of the sides or the porcellanous layer. Consequently the carina of *Opp. Krafftí* is similar in character to the so-called "hollow carina" of the Dorsocavata and certain Oppelias of the Inferior Oolite, the structure of which has been described in detail, notably by M. Vacek.[1] While, however, the carinal space in the Inferior-Oolite forms is hollow, and in the fossil condition is filled with stony matrix, we find here a spathose mass filling up the carina, a substance probably not directly of mineral origin but secreted by the living organism.[2] Unfortunately it was impossible to conduct

FIG. 6.—KEEL OF OPPELIA KRAFFTI. Magnified (appr. ⅔).

[1] Jahrbuch d. k. k. geol. Reichs., 1887, page 311.

[2] In the cavities of the Spiti Ammonites various mineral masses have been deposited, none of which, however, is comparable with the spathose mass infilling the carina of *Opp. Krafftí*.

an investigation by transmitted light, as the carina is in part preserved in only one specimen. On account of its exposed situation it is generally broken off, although in several specimens the thick peripheral sub-layer of the carina is still adherent. In the small forms, where the external carina consists merely of a "string-course" of small serrations, its general structure was doubtless somewhat simpler: but even this point could not be determined with certainty owing to the want of suitably preserved material. A thickened peripheral sub-layer has not been observed in these smaller forms. Below the row of serrations is a relatively broad sipho.

With regard to the development of the body-chamber, three different types may be distinguished, without laying, however, very great stress on the sharpness of the distinction: small forms with lateral auricular appendages, small forms with broad lateral appendages, and large forms without auricular appendages. In the last-named the peripheral portion of the body-chamber takes on a broad, rounded shape, and in many species even a rather flat shape, while the greatest breadth or thickness is shifted to the peripheral portion of the test. This change in the cross-section is especially striking in those forms wherein the beginning of the body-chamber is preceded by an unusually marked cuneiform tendency of the external periphery, as, for example, in *Opp. sphenodoma*. The serrations of the external carina, as already mentioned, lose gradually in prominence on the body-chamber; in some species, indeed, they nearly or entirely disappear. The ornamentation shows on the whole no very important changes. Just before the apertural margin the costæ of some species, such as *Opp. Kraffti*, fade away into fine striations. In that species too, as in *Opp. sphenodoma* and *Opp. Griesbachi*, the umbilical wall increases markedly in height immediately before the apertural margin. The length of the body-chamber in the larger forms is equivalent to about two-thirds of the ultimate whorl. The apertural margin has a parallel course to that of the crescentic costæ, is accompanied by a slight constriction, and forms on the peripheral portion a slightly projecting ventral appendage. Auriculate appendages are not known to exist at the apertural margin of the larger forms.

In the smaller species the body-chamber is equivalent to little more than half a whorl, and there is no perceptible difference between the cross-section of the pneumatic chambers and that of the body-chamber. Some few among the smaller forms, such as *Opp. pygmæa* and *Opp. leptodoma*, exhibit an apertural margin characterized by a deep constriction and drawn out into slender auriculate appendages, while the ventral appendage is thrust out like a collar. Moreover, there is one small species, *Opp. adunata*, the apertural margin of which is furnished with broad lateral appendages. We are unable, then, to make any very hard-and-fast rule of differentiation between small auriculate forms and large non-auriculate forms. Besides, a gradual passage may be traced from the large forms to the smaller, and down to the smallest, in such wise that a sharp line of demarcation cannot be drawn at any point. Constriction or "doubling up" in the body-chamber has not been observed so far in any Indian species.

Although it is true that the Indian forms, on account of the generic characters

common to them all, fall naturally into a well-defined, closely-knit group, when looked at separately they are seen to strike out very different paths of evolution. *Opp Adolphi*, *Kraffti*, *planopicta*, and *Opp.* sp. nov. indet., are remarkable for their large test with a high aperture, for their relatively prominent ornamentation, for the extraordinary ramification of their lobes, and especially for their high-ridged serrated carina, and thickened median line. From among European species we may place beside this small sub-group *Amm. zonarius*, Opp., from Stramberg, which also possesses a test with a high aperture and a prominent serrated keel. Whether, however, *Amm. zonarius* grows to the same size as the forms of our sub-group and builds up a similar body-chamber is at present a moot point, as only small individuals have been found hitherto of the Stramberg species. With *Opp. Adolphi* and *Kraffti* we may also correlate *Opp. Griesbachi* as a fairly large form possessing a high aperture, but the carina in it is by no means so well developed. *Opp. planopicta* bears a fairly prominent but not distinctly serrated keel, and thus we see that even within this small sub-group considerable divergences are manifest.

Opp. Himalayana with its strong costæ, its flat umbilical wall, and its oval cross-section, is a completely isolated type. Neither from India nor from Europe can any known form be cited as following the same evolutionary path. As another type that stands apart among the Indian forms we may mention *Opp. indopicta*, but then its relationship to a European species, *Opp. Frotho*, can be traced, although there is no question of a completely parallel evolution. The Indian form betrays none of that tendency to the formation of tubercles on the peripheral portion of the sides observable in the European species; moreover, the broad primary costæ become more prominent on the body-chamber of the Indian form, instead of dying away as in the European. Be this as it may, *Opp. indopicta* does furnish proof of an evolutionary tendency in the Indian fauna closely analogous (in the full sense of the term) to that observed in the European Tenuilobata.

The low-mouthed, broadly umbilicate, smaller types it is, however, that seem to have most especially flourished in India. Among these *Opp. sphenodoma* approximates closest to such high-mouthed forms as *Opp. Griesbachi*, but it exhibits points of intimate relationship with *Opp. Lymani* and the nearest allies of that species,—*Opp. punctatopicta* and *platydoma*. Here, too, *Opp. substriata*, Opp., and aff. *substriata* form a small sub-group by themselves, a sub-group of which, unfortunately, too little is known.

Finally, the dwarf forms remain to be mentioned, and among these, too, marked differences are evident. *Opp. dimocrenata* and *adunata* have a comparatively narrow umbilicus and high aperture, the first-named species exhibiting strong serrations, and the last-named only feeble serrations. The body-chamber of *Opp. adunata* bears no auriculate appendages, while *Opp. pygmæa* and *leptodoma* are provided with such appendages. Another form which seems to stand entirely apart, showing no relationship to any other type, is *Opp.* sp. nov. indet. (Plate VI, fig. 9.) It diverges much more widely from the main stem of our group than the other dwarf forms, but, unfortunately, it is only very imperfectly known.

It seems clear that the Tenuilobata of the Spiti Shales formed a group of far-reaching and multifarious ramifications, of which, however, only a very few types are so far known to us. This circumstance, as well as our ignorance of the precise chronological range of these forms, constitutes at present an insurmountable obstacle to a precise delineation of their phylogeny or to the investigation of their evolutionary development.

The evolution of the Tenuilobata in Europe seems to have followed just as many various directions. Here, however, a more closely-knit group is formed by those three well-known species described by Oppel under the names of *Amm. tenuilobatus*, *Frotho*, and *Weinlandi*, but by Quenstedt as *Amm. pictus compressus*, *p. costatus*, *p. nudus*, *p. serrulatus*, and *p. tegulatus*. Closely allied to these are *Opp. Gætanoi*, Fout., *Opp. folgariaca*, Opp., *Opp. levipicta*, Font., and probably, also, *Opp. steraspis*, Opp., and *steraspidoides*. Essentially different, on the other hand, are the so-called "semiformes," among which we should enumerate *Opp. Darwini*, Neumayr, *Fallauxi*, Opp., *semiformis*, Opp., and perhaps, too, *Opp. Gemmellaroi*, Zitt. Another type apart is the already mentioned *Amm. zonarius*, Opp., and so also the little *Opp. macrotela* with its flexed or "doubled-up" body-chamber.

If now we compare the development of the European and the Indian Tenuilobata, we find some few analogies counterbalanced by undoubted divergences. We have already dealt with the relationships between *Opp. zonaria* and *Opp. Adolphi* and *Kraffti*; and those between *Opp. Frotho* and *Opp. indopicta*, and we have been fain to admit that they constitute examples of analogous, if not absolutely identical, evolutionary tendencies. It is quite otherwise, however, with the remaining forms. In Europe, the semiformes, by the fact that at the beginning of the body-chamber they develop tubercular knobs and at the external periphery a deeply-cut furrow, strike out an evolutionary path upon which none of the Indian forms ever entered. On the other hand, the forms of the *Lymani* group, so richly developed in India, are up to the present totally unknown in Europe. Dwarf forms occur in the eastern as in the western area of distribution. While, however, the European dwarf type of the Tenuilobate stem, *Amm. macrotelus*, has a strikingly flexed body-chamber, no such tendency is apparent in the Indian dwarf-species *Opp. pygmæa*, *adunata*, *leptodoma*, and *domocrenata*. Nothing representing the specific line of evolution of *Opp. Himalayana* has hitherto been found in Europe.

These facts, the bearing of which may well be modified by future discoveries, do not convey the impression that the Indian and European Tenuilobata followed an identical course of evolution characterized by continuously parallel changes of form. Rather do we gain the impression that the evolution in each region was characterized by a partial and long-enduring isolation (from the other region) which allowed of the genesis of local or provincial tendencies to mutation, and admitted, even along the same lines of mutation, of the development of vicarial forms (as, for example, *Opp. indopicta* and *Frotho*). We need not here suppose that the

faunas were actually hedged off one from the other by a land-barrier. The bathonic conditions of life and the separation of the areas of evolution by facies which would tend to check the distribution of ammonites, combined with the vast distances that stretched between those areas, would amply suffice to explain the phenomena that we have been discussing. We should gain a clearer insight into this matter if a larger number of Tenuilobata happened to be known from the Katrol Group of Cutch. Unfortunately, one species alone has been so far described from that group, namely, *Opp. plicodiscus*, Waag.[1] It is true that this form, by its very slightly domed sides and by the absence of tubercles, appears to be more nearly related to *Opp. indopicta* than to *Opp. Frotho* or *tenuilobata*, but then the specimen described by Waagen is too small and too insignificant to permit of any definite conclusions being based upon it.

In the Spiti Shales the Tenuilobata, although more numerous than other Oppelias, are really among the less common occurrences. The same statement holds good in regard to Europe, for, notwithstanding the wide distribution of the Tenuilobata in the Upper Jurassic of Central Europe and the Mediterranean, they are never remarkable for the abundance of individuals, and indeed on the whole they are considered to be rather scarce. In the light of present-day knowledge, the geographical distribution of the Tenuilobata appears to be somewhat restricted. In a Jurassic region, which may be regarded as neighbouring India, namely, East Africa, no Tenuilobata have been so far discovered. It is true that G. Müller[2] described under the name of *Opp. Futtereri* a form from German East Africa which exhibits a striking resemblance to *Opp. tenuilobata*. But that author very distinctly describes it as possessing a long external lobe, and it should therefore be associated with certain species from the Dogger, such as *Opp. mamertensis*. Whether some few of the forms described by Steuer[3] from the Tithonian of Argentina, such as *Opp. perlævis*, for instance, are related to the Tenuilobata, cannot be determined with certainty, as the figured lobal line of *Opp. perlævis* permits of various interpretations. Those forms from the *Acanthicus* beds of Russia which A. Pavlow[4] has described under the names of *Opp. tenuilobata* and *Weinlandi*, most certainly do not belong to the Tenuilobata, for the lobes figured by Pavlow are entirely different from the Tenuilobata lobal line. The proper attribution of *Opp. sublevipicta*, Sinzow[5] from Batraki is doubtful, as the lobal line has not been figured.

W. Waagen[6] and M. Neumayr[7] regarded the Upper Jurassic Tenuilobata as the descendants of *Opp. subtililobata*, Waagen, from the Callovian. The similarity of the lobal line of the external shape, ornamentation, and body-chamber, leaves no room for doubt as to the correctness of this opinion.

[1] "Jurassic Fauna of Kutch," page 56, and pl. X, fig. 5.
[2] "Versteinerungen d. Jura u. d. Kreide" (Sep. Corr.) from "Deutsch-Ost-Afrika," vol. VII, p. 522, and pl. XV, fig. 1.
[3] "Argentin. Jura-Ablagerungen," Pal. Abhandl., vol. VII, page 73.
[4] "Les Ammonites de la zone à Asp. acanthicum," Mém. Com. Géol. St Petersb., vol. II, No. 3, page 88.
[5] Carte géol. gén. de la Russie, Sheet 93 (Saratow Penza), Mém. Com. Géol., vol. VII, pl. II, fig. 20.
[6] "Formenreihe d. *Amm. subradiatus*, Beneckes," Beiträge II, page 226.
[7] "*Acanthicus* Schichten," Abhandl. d. geol. Reichs., vol. V, page 163.

Since then M. Vacek[1] has described from still lower beds from the Oolitic Limestones of San Vigilio (that is, from the base of the Dogger) certain Oppelias among which *Opp. gracililobata*, Vac., more especially shows the first intimation of those main characteristics of the lobal line that are distinctive of the Tenuilobata, namely, conspicuous shortness of the external lobe and dichotomous ramification of the first lateral. Even admitting that the gap between *Opp. gracililobata*, Vac., and *Opp. subtililobata*, Waag., is greater than that between the last-named form and the Tenuilobata proper, we shall not be over-rash in linking *Opp. gracililobata*, Vac., with the Tenuilobata and Subtililobata as the oldest hitherto known ancestral form.

In much the same way as the Tenuilobata are associated with *Opp. subtililobata* and *gracililobata*, *Opp. acucincta* is linked on to the group of *Opp. subradiata*, Sow., and *Opp. subaspidoides*, Vac. Here also the concordance of the main features of the lobal line, of the ornamentation, and of the body-chamber furnishes ample evidence of their genetic association. We are then dealing with two series of forms which come in at the base of the Dogger as definitely separated types, unconnected by intermediary forms; and the independent evolution of which can be followed (with some interruptions, the greatest covering the lapse of time between the Callovian and the Kimmeridgian) right up to the end of the Jurassic period. This evolution is distinguished by a remarkable parallelism: both series of forms take on in Upper Jurassic time a serrated instead of a simple linear keel. This parallelism, which may be said to bring about a peculiar convergence, is the more noteworthy that it is by no means a unique phenomenon among the ammonites; it occurs repeatedly in the case of several types, and E. Haug[2] has drawn attention to numerous examples of the phenomenon.

Although we feel bound to admit, therefore, that the Tenuilobata and the Subradiata sprang from the same original stock, it seems inevitable that a systematic classification should give due prominence to their independent evolution by means of distinct generic designations. A. Hyatt[3] established the name *Streblites* especially for *Amm. tenuilobatus*, and, in order to avoid overloading the nomenclature with new names, I employ Hyatt's designation of *Streblites* for the entire group of the Tenuilobata, as I understand it, and as I have diagnosed it in detail in the foregoing pages. I include in it not only the Indian forms here to be described, but also the European Tenuilobata and *Amm. macrotelus*. The last-named species is called *Cyrtosiceras* by Hyatt, who therefore separates it from *Streblites*: this alone is sufficient to show that Hyatt's view of the genus *Streblites* does not altogether agree with mine.[4]

[1] "Fauna von Cap San Vigilio," Abhandl. d. geol. Reichs., vol. XII, page 83.

[2] "Monogr. d. Gattung *Harpoceras*," Neues Jahrb. f. Min., etc., 1885, page 126.

[3] "Text-Book of Palæontology," by K. von Zittel, London, 1900, page 569.

[4] *Amm. macrotelus* from Stramberg possesses (as I have assured myself by examination of the original specimen) exactly the same lobal line as *Opp. lonaria*. But in the figure of this remarkable species, a lobal line, different in some essential respects, is shown; and as Hyatt establishes his genus *Cyrtosiceras* without a word of explanation, we are left in doubt as to whether, in thus establishing a new genus, he was guided by the apparent difference of the lobal line or not.

II.—Group of OPPELIA ACUCINCTA.

We have already discussed the misunderstandings to which this remarkable species has given rise. On looking at the text-figure 5, *a*, which illustrates the sutures of a *Streblites* and of *Opp. acucincta*, the fundamental difference between these lines will be clearly seen. Both rami of the external lobe of *Opp. acucincta* are widely separated by a broad external saddle, and extend as deep down as, or even deeper than, the first lateral, whose broad "trunk" bears sub-symmetrical rami. The first lateral saddle projects far forward, and is divided by a slanting secondary lobe into a smaller, lower, external, and a larger, higher, inner half. In the main this lobal structure is identical with that which characterizes *Opp. subradiata*, Sow., *fusca*, Qu., *aspidoides*, Opp., *latilobata*, Waag., *plicatella*, Gemm., *undatiruga*, Gemm., *pleurocyma*, Par. et Bon., and *subaspidoides*, Vac. This concordance, coupled with the similarity in ornamentation and shape of the test, surely entitles us to regard *Opp. acucincta* (as already mentioned) as the Upper Jurassic continuation of the series of forms represented by *Opp. substriata*. We have also discussed in the foregoing pages the parallelism in the evolution of this series and that of the *Streblites*; but whereas the last-named are represented in the Upper Jurassic by a great number of forms, *Opp. acucincta* remains quite isolated in India, and no form allied to it has been so far recorded in Europe.

In view of the isolated occurrence of *Opp. acucincta*, a detailed description of its characteristics, such as that which we devoted to the *Streblites*, would appear to be superfluous. The reader may be referred to the specific diagnosis, and we shall confine ourselves here to pointing out that it is not only in the lobal line that *Opp. acucincta* is differentiated from the *Streblites*, but also in the structure of the keel. While in *Streblites* the external periphery of the chambered portion is keelless and smooth in the internal cast, in *Opp. acucincta* the serrations of the keel may be traced even on the internal cast of the pneumatic chambers. We miss then here that thickening of the shell and that mantling of the external periphery of the pneumatic chambers with nacreous substance, which in the *Streblites* causes the internal cast of the pneumatic chambers to be outwardly smooth and rounded.

The question of generic designation is rather more difficult in the case of *Opp. acucincta* than in regard to the series of forms which have been considered in the foregoing pages. The name *Oppelia, sensu stricto*, should be reserved for the group of the Subradiata, as Waagen in establishing the genus *Oppelia* had that group of forms above all in mind.[1] Whether, however, it is advisable to apply to the Upper Jurassic mutations the same generic designation as to the forms from the Dogger is not easy to determine at present, as only one Upper Jurassic mutation is known, and that is *Opp. acucincta*. Its isolated occurrence tells against the establishment of a new sub-genus, and so the wisest course would appear to be to abstain, at least provisionally, from giving a new name to this form, and to assign it tentatively to the Subradiata as *Oppelia, sensu stricto*.

[1] Formenreihe des *Amm. subradiatus*, *op. cit.*, page 250.

III.—Group of Oppelia nivalis, Stol.

Unfortunately this group is represented only by a single badly-preserved specimen. As far as the defective state of preservation allows specific diagnosis to go, it may be gathered that *Opp. nivalis* is most nearly allied to the group of *Opp. compsa*. The lobes (see text-figure 5) differ entirely both from those in *Opp. acucincta* and in *Streblites*, while in their main characteristics they agree with the true Flexuosa. The sole difference consists in the more slender and more symmetrical structure of the first lateral of *Opp. nivalis*. Whereas in Europe the Flexuosa are among the most frequent occurrences in the Malm, their distribution in India appears to have been very restricted. Hitherto, only one species has been recorded from the Himalayas, and two from the Jurassic of Cutch (*Opp. trachynota* and *cachensis*, Waag.).

There are not inconsiderable divergences between the Flexuosa and the Subradiata and Streblitidæ. Of this fact Bayle[1] was the first to take account, establishing as he did for the Flexuosa the genus *Neumayria* (*non* Neumayria, Nikitin), and this designation has already been widely used in the literature of the subject. Consequently we shall apply to *Opp. nivalis* the sub-generic name of *Neumayria*.[2]

IV.—Group of Oppelia (Œcotraustes) adela, sp. nov.

Oppelia adela cannot be brought into association with *Streblites* nor with the Flexuosa. It is a completely independent form, which can be linked at no point with any previously known species, and so perhaps its erection into a separate genus might be desirable. The available material, however, consisting as it does of a single specimen without the body-chamber preserved, hardly permits of exact generic diagnosis, and we must therefore pretermit the establishment of a new genus. By designating provisionally this form as *Œcotraustes* we intend merely to emphasize the fact that it does not belong to the high-apertured, true Oppelias, but probably to the small, deformed, degenerescent types.

The classification of these so-called "cripple-forms," despite the establishment of a number of generic names, is still in dire confusion, and the relationship of most of them to their nearest allies has not yet been worked out. Just as the dwarf-form of *Amm. macrotelus* and the small forms here described are most intimately connected with the high-apertured Streblitidæ, and are linked with them into a natural chain of which no part is properly separable from the remainder, so, probably, are the other dwarf-forms allied to large, high-apertured types. But at present this association is only recognized in the very smallest degree, and to make it clear it would be necessary to work up these forms (so widespread in the Upper Jurassic of Europe) in a "monographic" fashion, an arduous labour which so far no one has been found

[1] "Explication de la Carte géologique de France," 1881, pl. 92.

[2] In the English translation of Zittel's "Outlines of Palæontology," at page 570, A. Hyatt transferred Haug's designation *Ochetoceras*, which had been proposed by that author for the group of *Amm. hispidus* and *canaliculatus*, to the completely different type *Amm. flexuosus*: the reasons for this transference are not known.

willing to undertake. So long, however, as that task remains unaccomplished, palæontologists will build here on very insecure foundations and, in fact, will of necessity confine themselves more or less to hypotheses. The isolated occurrence of *Opp. adela* in the Spiti Shales affords no ground for a more detailed discussion of classificatory questions or of the "sexual hypothesis."[1]

In the more recent Ammonite literature the endeavour to establish more strictly limited genera makes itself increasingly felt. This endeavour (which, unfortunately, has been much discredited by the excessive "splitting" wherein certain specialists indulge, and has been thereby much obstructed) proceeds from the perfectly justifiable assumption that under a given generic name should be grouped all that naturally belongs together, whether through passage-forms or through the concordance of the most essential characteristics. In agreement with this point of view we have here, so far as possible, classified under distinct sub-generic designations all such groups of forms as are manifestly self-contained. If, however, we have stood by the old generic name of *Oppelia*, this apparent contradiction arises from the persuasion that our knowledge of those practically innumerable forms that belong to the genus *Oppelia* in the sense of Neumayr and Zittel is by no means sufficiently advanced to allow of a natural classification. Under these circumstances the old generic designation of *Oppelia*, which unites related forms into one great though multifarious group, cannot as yet be dispensed with.

Oppelia (Streblites) Adolphi, Oppel sp.

(Plate II, figs. 1 *a*—*d*.)

Ammonites Adolphi, Oppel, Paläontologische Mittheilungen, I. page 270, plate LXXV, fig. 1 *a*, *b*.

This species was erected by A. Oppel on the basis of two specimens, whereof one was figured in the Paläontologische Mittheilungen. An examination of Oppel's specimens has convinced me that his second one is more nearly allied to *Opp. Griesbachi* than to the figured specimen of *Opp. Adolphi*, and that it is differentiated from the latter by the peculiarity of its lobal structure. This specimen will be further considered in dealing with *Opp. Griesbachi*.

The remaining material at my disposal includes no specimen that can be regarded as specifically identical with Oppel's original type, and so we are restricted in our study of this species to Oppel's own specimen. Unfortunately this is preserved only as an internal cast, is partly compressed, and is chambered up to the end. It is true that a nearly allied species, *Opp. Kraffti*, is in some degree helpful in supplementing the defect. This species lies before us in the shape of a fine example, wherein the keel and the body-chamber are preserved, thus enabling us to form a tolerably accurate notion of the similar structures in *Opp. Adolphi*.

[1] In the more recent deliverances on the sexual hypothesis, which has found many supporters in France, Waagen's observations on the subject appear to have been overlooked, wherefore it is fitting that here express reference should be made to them (see "Formenreihe des *Amm. rubradiatus*," *op. cit.*, pages 236—238).

As Oppel's figure of *Opp. Adolphi* is somewhat schematic and largely a restoration, it has been found advisable to refigure here the original specimen.

Opp. Adolphi has a flatly discoidal test, with high-apertured, rapidly increasing, extremely involute volutions, the greatest girth of which lies at the lower third, or at the point where the lower passes into the middle third of the height of the volution. The whorls are very slightly domed at the sides, and are flattened off towards the external periphery. The umbilicus is narrow, with a steep umbilical wall and a rounded umbilical margin. From the umbilicus outward radiate flat costæ with a slight anterior inclination. Up to the middle of the sides they follow a straight course, but on the external half of the sides they undulate slightly in a crescentic fashion. Towards the periphery the costæ become somewhat more prominent: some of them bifurcate or else short secondary costæ are intercalated between them. At the middle of the sides is a slight spiral inflation, and a barely recognizable strengthening of the costæ may be traced thereat. Some costæ are more widely separated, others more close set. The external periphery is comparatively broad, fairly well marked off from the sides, and in the middle blunted off or flattened. In the internal cast it is smooth, but, on the analogy of the very closely allied *Opp. Kraffti*, we may safely infer that the shell was provided with a high, ridge-shaped, serrated keel. Moreover, on the specimen itself, a remnant of the keel can just be traced where the ultimate whorl emerges from the volution, and the foremost preserved septation embraces the preceding whorl. Here the ramifications of the internal lobe beset the keel. We cannot, indeed, assert that the keel itself is preserved, but it is indicated by a hollow space between the ramifications of the internal lobe.

The main features of the lobal line were correctly represented by Oppel: it is an excellent example of the characteristic Tenuilobate line. As we have already described in detail, in the introductory diagnosis of the genus, such characters of this lobal structure as are common to all the species, we may confine ourselves in this place to the consideration of those peculiarities which are specifically distinctive of the lobal line of *Opp. Adolphi*. Among these are the highly complicated denticulation of the lobal line and very marked development of the external lateral rami of the first lateral. The extremity of the upper external lateral ramus extends up to or rather beyond the extremity of the short external lobe. The ramifications of the external pair of rami of the first lateral reach nearly up to the median line. The "stem" of the first lateral broadens out considerably forward, and the intermediary branches, whereby both pairs of rami are joined to the posterior extremity of the stem of the first lateral, are beset with comparatively long lobal ramuli. The first lateral saddle does not project very far forward. Dimensions can only be stated approximately, as in the available specimen the external portion of the test is in part broken away and compressed. At a diameter of about 91 mm. the width of the umbilicus is 8·3 mm., the height of the ultimate whorl 51 mm., and the greatest thickness 23·3 mm.

Among the species so far recorded from Europe, none is more nearly allied to *Opp. Adolphi* than *Opp. zonaria*, Opp. sp., from Stramberg, and K. von Zittel has

already pointed out the astonishing similarity of these species.[1] Ornamentation, shape of the test, lobal structure, and carination, are all in the main concordant. But in *Amm. zonarius* the greatest thickness is at the umbilical margin, while in *Amm. Adolphi* it is somewhat above that. Moreover, the number of intercalary costæ is notably greater in *Amm. zonarius*. The extremities of the external pair of rami of the first lateral stricia in both species behind the terminal ramus of the external lobe, but in *Amm. zonarius* the ramification of the lobal line is much less complicated.[2]

Among the Indian forms, the most nearly related to our species are *Opp. Kraffti* and *Opp. Griesbachi*: the differences will be dealt with in the respective descriptions of those species.

Opp. Adolphi comes from Raj Hoti, in Gnari Khorsum. The specimen is preserved in the Palæontological Museum at Munich.

Oppelia (Streblites) Kraffti, sp. nov.

(Plate IV, fig. 1 *a—d*; Plate V, fig. 1 *a—d*; Plate XLIII, fig. 1 *a—c*.)

Dimensions:—

	Chambered specimen, Plate IV, fig. 1.	Specimen with body-chamber, Plate XLIII, fig. 1.
Diameter	125 mm.	150 mm.
Width of umbilicus	12·6 „	16 „
Height of the ultimate whorl	71 „	77 „
Thickness of the ultimate whorl	16·5 „	21 „

Test flatly discoidal, made up of high-apertured, rapidly increasing, extremely involute volutions. The whorls are slightly domed at the sides, and show in the chambered portion their greatest girth a little below the middle. Thence the elongate, oval cross-section narrows perceptibly towards the external periphery, less so towards the umbilicus. Umbilicus very narrow, with a steep umbilical wall, and rounded umbilical margin. The ornamentation consists of flat costæ which radiate outward from the umbilicus, or take a somewhat anteriorly-directed course; on the external half of the sides they assume a slightly crescentic form. Towards the external periphery the costæ become stronger, and some of them bifurcate or else short secondary costæ are intercalated between them. At the middle of the sides arises a flat spiral inflation, and the costæ concurrently increase to an equal degree in prominence. In one of the large specimens (Plate IV, fig. 1) a portion of the inner volution is laid bare at a point which corresponds to a diameter of about 45 mm. In this way we ascertain that our species, up to that diameter at any rate, was even on the shell almost smooth, and covered merely with fine striations. The smallest of the available specimens (Plate V, fig. 1) confirms this view, as it exhibits only feeble crescentic lines, which are indeed somewhat more prominent on the external periphery. Only two or three costæ are exceptionally well-marked.

[1] Paläontologische Mittheilungen, II, "Cephalopoden der Stramberger Schichten," page 89, Plate XV, fig. 4.

[2] But perhaps this last difference may arise from an error in the drawing of *Amm. zonarius*.

Before the commencement of the body-chamber the costæ take on the form of fairly broad but flat plications, which are also strongly developed on the posterior portion of the body-chamber. On the anterior portion they diminish gradually in prominence, passing into fine, close-set, slightly undulating, crescentic striations. The narrow peripheral portion of the pneumatic chambers appears to be devoid of a keel in the internal cast, and to be bluntly flattened off at the median line. In the specimen figured on Plate IV, fig. 1, the external periphery seems to be marked at certain points by a dark band (similar to that described by K. von Zittel in *Amm. zonarius* from Stramberg). This circumstance led us to suppose that our species, as that just named from the Tithonian of the Carpathians, was beset with a serrated keel. The supposition was, as a matter of fact, amply confirmed by the specimen that A. von Krafft discovered in the year 1898 (Plate XLIII, fig. 1), in which the external periphery on the chambered portion is capped by a high, finely serrated keel (compare text-figure 6). This keel is underlain by the dark band, and it is clearly marked off from the remainder of the shell. The insufficiency of available material unfortunately precludes us, however, from more detailed investigation regarding this carinate structure, which falls away easily and is therefore rarely preserved; and we must perforce restrict ourselves to the few observations of which the specimen in question (by means of a chance fracture) allows. Thereby we are enabled to see plainly that the dark band at the base of the keel is neither more nor less than a much thickened continuation of the nacreous layer of the sides. The keel itself also is mantled by an extremely tenuous dark shelly layer which appears to be continuous with the outer shelly layer of the sides, but is sharply marked off from the sides. Finally, one can distinguish the inner mass of the keel, differentiated as it is by its lighter coloration and coarsely spathose structure from the tenuous outer shell and the thicker nacreous band. On the body-chamber, the keel all but vanishes, the only trace of it being a very slightly domed rather broad median band capping the broadly rounded external periphery (see Plate XLIII, fig. 1 *c*): at the points where the shell has been preserved this band exhibits much the same form and character as on the internal cast.

We may conclude, then, that the keel of *Opp. Kraffti* has very similar features to those of the hollow keel of *Opp. subaspidoides*, Vac., from San Vigilio, so fully described by M. Vacek.[1] While, however, the keel of the Southern Alpine species was hollow, and in the petrified condition is consequently filled with stony matrix, in *Opp. Kraffti* the space corresponding to the carinal cavity of the Dorsocavati is infilled with a crystalline spathose substance. Whether this is the outcome of later mineral deposition or of a secretion which took place during the lifetime of the organism, I could hardly venture to determine from the available material, but I hold the latter hypothesis to be the more probable. The body-chamber is markedly distinct from the chambered portion of the shell. Not only is the serrated keel absent, not only does the costation undergo the change already

[1] "Einige Bemerkungen über den hohlen Kiel der Falciferen," Jahrb. der k. k. geol. Reichs., vol. XXXVII (1887), page 311.

mentioned, but the cross-section takes on the form so well known in the European Tenuilobata: that is, the external periphery seems to be broadly rounded and somewhat flattened off, while the greatest girth is shifted to the external portion of the test. The specimen wherein most of the body-chamber is preserved exhibits at the anterior extremity a rather sudden broadening of the cross-section in the neighbourhood of the umbilicus as well as also farther outward (see Plate XLIII, fig. 1 *c*). From this we may well conclude that the final apertural margin was situated not very far from that point: on which assumption the body-chamber would be equivalent to between $\frac{1}{4}$ and $\frac{1}{3}$ of a whorl.

The lobal line is much and finely ramified. The external pair of rami of the first lateral starts as in *Opp. Adolphi* behind the short external lobe, and its extremities reach almost up to the median line. The stem of the first lateral is very slender and long, and does not broaden out forward, nor does the first lateral saddle project forward.

Opp. Kraffti is a form of considerable size. The body-chamber specimen of 150 mm. diameter is even surpassed by the specimen that is chambered up to the end, as this with its body-chamber must have attained a diameter of at least 190 mm. *Opp. Kraffti* is so closely related to *Opp. Adolphi* that it was only after considerable hesitation that I could bring myself to regard the former as a species distinct from the latter. The fact that *Opp. Adolphi* is somewhat stouter and possesses a somewhat broader external periphery and less globose sides than *Opp. Kraffti* would hardly justify specific differentiation of these forms, were it not for divergences in the lobal structure. *Opp. Kraffti* exhibits shorter but far more closely-set ramifications than *Opp. Adolphi*, as may be seen, not only at the extremities of the lobal rami, but also at the point where the pairs of rami branch off from the stem of the first lateral. In the latter species the stem of the first lateral broadens out so much forward that the foremost lateral ramus which penetrates the peripheral saddle is all but isolated, and does not appear to start from the stem of the first lateral at all. In *Opp. Kraffti*, on the other hand, this same stem is narrow anteriorly, and the foremost external lateral ramus branches off from it in the most unmistakable fashion. This divergence, slight though it be, is common to all known specimens of *Opp. Kraffti*, and, connecting it with the above-mentioned differences in the shape of the test, one is impelled to the conclusion that union of *Opp. Kraffti* and *Opp. Adolphi* into one and the same species would be unadvisable. Moreover, there is every probability that the difference of these species would be still more apparent if specimens of *Opp. Adolphi* with the body-chamber were forthcoming.

Opp. Grossouvrei, sp. nov., is differentiated from *Opp. Kraffti* by its smaller size, feebler ornamentation, less prominent carination, less complex lobal ramification and divergent structure of the body-chamber. A comparison with *Opp. zonaria* is rendered somewhat difficult by the small size of the specimens obtained from the Tithonian of the Carpathians. It is true that, on the whole, the ornamentation and the structure of the umbilicus are similar, and that the lobes also are very much alike. The well-defined, hollow, serrated keel of *Opp. Kraffti* leaves, on falling away, a thick, broad band on the external periphery, exactly as in *Opp. zonaria*.

And yet we cannot bring these two forms into the same species, as the whorls of *Opp. zonaria* are completely flattened off, and are beset with far more numerous intercalary costæ. The greatest girth in *Opp. zonaria* is in the neighbourhood of the umbilical margin, while in *Opp. Kraffti* it is almost exactly at the middle of the test.

Opp. Kraffti occurs in the shape of three specimens from the following localities: Chidamu, Kuti (Upper and Middle Spiti Shales), and Spiti.

OPPELIA (STREBLITES) PLANOPICTA, sp. nov.

(Plate III, fig. 4 *a—d*.)

Dimensions :—

Diameter	77·8 mm.
Width of umbilicus	5·6 „
Height of the ultimate whorl	43·8 „
Thickness of the ultimate whorl	17·4 „

This species, unfortunately represented only by a single specimen chambered up to the end, is so very closely allied to *Opp. Adolphi* that we may dispense with a detailed description and content ourselves with enumerating the differences between them. The test of *Opp. planopicta* is flatter and more narrowly umbilicate, the sides are more flattened off, the external periphery is narrower and more distinctly marked off from the sides, than in *Opp. Adolphi*. The costation shows a comparatively slight divergence therein, that the costæ on the inner portion of the test are somewhat feebler while the spiral line is more markedly developed than in *Opp. Adolphi*. The difference of the carination, however, is considerable: while in our species the keel is a mere "ribbon," so to say, defined by not very prominent longish protuberances, in *Opp. Adolphi* the keel is high and serrated. Finally, there are differences in the lobal structure: in our species the lobes are more delicate, the ramifications more slender, less numerous and less closely set than in *Opp. Adolphi*.

The foregoing divergences, when considered as a whole, give a distinctive character to *Opp. planopicta* and justify its erection into a separate species.

The specimen was found at Sirkia, South Hundes.

OPPELIA (STREBLITES) GRIESBACHI, sp. nov.

(Plate V, fig. 2 *a—c*, fig. 3 *a—c*, fig. 4 *a*, *b*; Plate VI, fig. 1 *a—c*, fig. 2 *a—d*, fig. 4 *a—d*, fig. 5 *a*, *e*.)

Dimensions :—

Diameter	103·5 mm.,	76·5 mm.,	55·8 mm.,	48 mm.
Width of umbilicus	8·5 „	7 „	5·3 „	4 „
Height of ultimate whorl	56·5 „	43·5 „	31·5 „	28·7 „
Thickness of ultimate whorl	22 „	77·3 „	13·6 „ abt.	11·6 „

The test is flatly discoidal, very narrowly umbilicate. The umbilical wall is somewhat low, very steep, dipping inward all but vertically, clearly marked

off from the sides by a rounded umbilical margin. The sides are very slightly domed, the external periphery is narrow, converging to a wedge shape outwardly, and beset in the chambered portion with a finely serrated keel: this keel diminishes in prominence at the body-chamber, and gradually disappears altogether. The serrations of the keel are plainly visible only on the shell, the internal cast exhibiting a smooth periphery. The extremely tenuous shell is beset on the inner whorls with fine crescentic striations, which become more marked as the test increases in size. Somewhere about the middle of the sides a very slight spiral protuberance is observable, and on better preserved specimens, on the external portion of the shell, between the spiral inflation and periphery, may be noticed fine, closely-set, short striations which course approximately parallel with the external margin. The body-chamber takes up about two-thirds of the ultimate whorl. Shape and ornamentation undergo here a change, much as in the body-chamber of *Opp. Adolphi*. The ornamentation becomes more prominent, and some of the crescentic costæ form (especially at the peripheral portion of the shell) fairly broad though flat protuberances. The keel with its serrations dies gradually away; the external periphery takes on a broadly rounded form, and simultaneously the greatest thickness is shifted somewhat farther outward. The apertural margin (which is preserved in the specimen figured in Plate V, figure 4) runs parallel with the lines of growth and the costæ, and thus its shape is on the whole slightly crescentic. At the external periphery, too, the apertural margin does not project more markedly forward than the lines of growth. Auriculate appendages are wanting: on the other hand, a slight constriction is observable on the external periphery behind the apertural margin.

The aperture is somewhat broader than is consistent with normal growth, because here the umbilical wall is disproportionately heightened, and the shell, more especially at the external periphery, rises slightly outward.

The Tenuilobate character of the lobal line is an unmistakable feature of all the specimens, although the more minute details of the lobal structure are clearly preserved in only three of them. The lobal line of *Opp. Griesbachi* is very similar to that of *Opp. Adolphi*, although the ramification of the lobes is somewhat less complex in the former, and the external pair of rami does not reach up so near to the external lobe and to the median line as in *Opp. Adolphi*.

The specimens included in the species here described differ vastly in size. The largest specimen, as well as the middle-sized and smaller ones, possesses a body-chamber. The general characters of this body-chamber, and especially the breadth of its cross-section and the rounded, non-carinate, external periphery, show that even the smaller specimens may be regarded as full-grown. The difference in size between the largest and the smallest specimen is so considerable that it might almost appear to justify specific differentiation, did we not also possess a specimen midway between the two extremes: this naturally makes it difficult to group these forms into a large and a small species, and furnishes good grounds for declining to consider differences in size as specific character.

The ornamentation and the breadth of the umbilicus also show considerable

variations. Thus, the specimen from Jandu figured in Plate VI, figure 1, exhibits much more strongly developed ornamentation on the body-chamber than any of the specimens; while the form from the district south of Shalshal, figured in Plate VI, figure 2, is characterized by an especially narrow umbilicus and cuneiform external periphery. Owing to the circumstance that these forms betray no other abnormalities than those just mentioned (which are not, after all, of capital importance), it was found possible to include them in *Opp. Griesbachi.* It may well be, however, that future finds of more abundant and better preserved material, will give rise to the specific differentiation of such forms.

Opp. Griesbachi is nearly allied to *Opp. Adolphi* and *Opp. Kraffti*, but is easily distinguished from both of them by its feebler costation, narrower, less flattened off outwardly, and more markedly cuneiform external periphery, and less complex lobal structure. The most striking difference, however, is in the structure of the keel. In *Opp. Kraffti*, and perhaps even more markedly so in *Opp. Adolphi*, the keel is broad based on the external periphery, and sharply marked off as a high ridge, while in *Opp. Griesbachi* it is a mere "string course" of comparatively fine serrations. Whereas in *Opp. Kraffti* the keel even on the body-chamber is indicated by a slightly protuberant band, it vanishes utterly on the body-chamber of *Opp. Griesbachi*, and we can only point to a sort of emphasizing of the lines of growth along the median line of the external periphery as the last trace of the keel left on the anterior portion of the body-chamber.

Among the European Tenuilobata *Opp. Weinlandi*, Opp., is a variety that shows great similarity to our species.[1] In *Opp. Weinlandi*, however, the outer periphery of the body-chamber is more markedly flattened off, and is plainly separated from the sides by two distinct rims, which is not the case in *Opp. Griesbachi.*

Two specimens come from Chidamu (Diener Collection), one from the district between Chidamu and the Kiangur Pass, one from Sirkia, South Hundes, two specimens from Jandu, Sherik River, Hundes, and one from the district south of Shalshal.

In connexion with the foregoing description we may be allowed to refer to yet another specimen, which was placed by Oppel under his *Amm. Adolphi.* It does indeed show most extraordinary resemblances with that species, and perhaps still more so with *Opp. Griesbachi.*

Chambered up to the end, it measures about 60 mm. in diameter, is somewhat compressed and so badly preserved that not all its characteristics are determinable with certainty. As regards the ornamentation, there seems to be no essential difference from *Opp. Griesbachi.* At the posterior portion of the ultimate volution, however, there is below the median line of the shell a markedly prominent costal inflation, which is similarly noticeable in a specimen of *Opp. Kraffti* (plate V, fig. 1) but is so far unknown in *Amm. Griesbachi.* But what lends to this specimen a more particular interest is the peculiar alteration in the lobal line at the anterior extremity of the test. The first lateral exhibits at the posterior extremity characteristics

[1] See P. de Loriol, "Monographie paléont. des Couches de la Zone à *Amm. tenuilobatus* de Badenn," Mém. Soc. Pal. Suisse, vol. III, pl. III, figs. 3 and 4, page 34.

similar to those of *Amm. Adolphi* and *Griesbachi*: it possesses a long, narrow stem with luxuriant ramifications, and the external pair of rami approximates closely to the external lobe, broadening out markedly. At the anterior extremity, on the other hand, the stem of the first lateral is somewhat shorter and broader, the external pair of rami is widely separated from the external lobe, in such wise that the external saddle has a fairly broad "body," while the lateral rami (especially the lower among these) are short and stunted, and end up abruptly against the preceding septation.

This alteration in the lobal line is probably in part due to the more rapid succession of the septal walls at the anterior extremity of the ultimate whorl. This is known to take place in many ammonites immediately before the building up of the final body-chamber, but the phenomenon is not, as a rule, accompanied by so far-reaching a metamorphosis of the lobal line as that just described. This is the more striking in the specimen that we have been considering that other specimens, both of *Amm. Adolphi* and *Amm. Griesbachi*, exhibit the normal lobation right up to the body-chamber. Only in the less nearly allied *Opp. sphenodoma* do we discern at the ultimate lobal line a stunting of the lateral rami of the first lateral similar to, but less conspicuous than, that here described. Probably we are dealing with a pathological specimen in this instance, but the incomplete preservation enhances the difficulty of arriving at a definite conclusion; and we will therefore content ourselves with recording the specimen, and defer any further attempt at explanation until fresh finds have thrown additional light on the subject.

The specimen in question belongs to the State Palæontological Collection at Munich, and comes from Shangra (Gnari Khorsum).

Oppelia (Streblites), sp. nov. indet.

(Plate VI, fig. 6 *a—c*.)

An unfortunately imperfect specimen represents a new species which is nearly allied to *Opp. Adolphi*, *planopicta*, and *Griesbachi*. The ornamentation consists of fine crescentic lines, which become stronger as they go outward. The keel, as far as one may infer from certain remnants of the shell, was very high and prominent. The sides are plainly flattened off, and rather sharply marked off from the external periphery. This latter is carinate, even on the internal cast. Umbilicus comparatively broad, with a steep umbilical wall and a rounded umbilical rim. Lobes as in *Opp. Griesbachi*.

The form here described approximates to *Opp. planopicta* by the flattening off of its sides, the clearly marked off cuneiform external periphery, and its highly developed carination; but union with that especially narrowly umbilicate species is impossible in view of the broad umbilication of our species. The same characteristic separates the latter also from *Opp. Griesbachi* and *Adolphi*; an additional divergence from *Opp. Adolphi* is the simpler ramification of the lobes, and an additional divergence from *Opp. Griesbachi* is the stronger carination. From the still more broadly umbilicate forms than it, such as *Opp. Lymani*, Opp., our species is distin-

guished by the characters of the lobal line, the flattened off shape of the sides, and its higher cross-section.

The specimen is too imperfectly preserved to admit of its being used as the basis of a new species. It comes from Spiti Valley.

OPPELIA (STREBLITES) HIMALAYANA, sp. nov.

(Plate VII, fig. 7 *a—c*.)

Dimensions :—

Diameter	78·8	mm
Width of umbilicus	12	,,
Height of the ultimate whorl	39	,,
Greatest thickness of the ultimate whorl	20	,,

Test discoidal, slightly cuneiform at the external periphery. Cross-section of the whorls high oval; greatest thickness somewhere about the middle of the whorl. External periphery narrow and much rounded. Umbilicus narrow with a rather steeply inward dipping umbilical wall. Umbilical rim rounded, not prominently developed. The ornamentation consists of crescentically undulating costæ, which are but feebly indicated up to the middle of the whorls, though they stand out prominently on the external portion of the shell, take on a broadly inflated form, and are somewhat markedly inclined backward. Near to the external periphery the crescentic costæ curve round forward almost imperceptibly, and die away here without reaching the external periphery. Between every two of the more prominent and longer costæ are intercalated one or sometimes two secondary costæ. These intercalary costæ become first clearly visible on the external third of the shell, but they may often be traced in the form of fine striations right up to the umbilicus. The median line of the external periphery is at those points where the shell has been preserved ornamented with closely set tubercles, which broaden and flatten out towards the anterior extremity of the specimen and are set further apart. In the middle of the sides at the spot where the costæ become more prominent and the test assumes its greatest thickness, a feeble spiral line makes its appearance. The body-chamber is unknown.

The lobal line is structurally of the Tenuilobate type, though, comparatively speaking, not highly ramified. The external pair of rami of the first lateral does not reach behind the short external lobe. The first lateral saddle is set rather high. On the sides three auxiliary lobes are developed, the fourth being at the umbilical rim and umbilical wall. The species here described occupies, so far as we know at present, rather an isolated position. Neither among the Indian nor among the European forms can any be found that could be closely conjoined with *Opp. himalayana* into one group. The latter is distinguished from *Opp. Adolphi* by the high oval shape of its cross-section with the greatest girth at the middle of the whorls, by tho character of its broad costæ, the form of its peripheral tubercles, and the greater simplicity of its lobal line. The greater breadth of its costæ and the greater thickness of the test cause this ammonite to resemble in some respects the

flexuose Oppelias, such as *Opp. vaiphensis*, Loriol,[1] and *Opp. flexuosa*,[2] but no other points of relationship can be traced between it and them.

Of this interesting species we possess, unfortunately, but one specimen, chambered up to the end, and mainly preserved as an internal cast. It comes from Spiti Valley.

Oppelia (Streblites) indopicta, sp. nov.

(Plate III, fig. 3 *a—c*.)

The single available specimen, when its body-chamber was complete, must have attained a diameter of 110 mm. Unfortunately, however, the body-chamber is only partly preserved, and is broken off at the external periphery, so that the dimensions can only be determined at the beginning of the body-chamber. Here the diameter measures 67·5 mm., breadth of umbilicus 9 mm., height of volution 29·7 mm., and thickness 13 mm. The flatly discoidal, narrowly umbilicate test has very slightly domed sides, a much rounded external periphery, and a low but very steep, almost vertical, umbilical wall which is marked off from the sides by a distinct rim. The whorls have a very high aperture, and their cross-section is a high oval, the greatest breadth of which is somewhere about the middle of the sides. On the ultimate whorl are eight broad, low, somewhat forwardly inclined costæ, radiating from the umbilicus and on the chambered portion of the test dying away somewhere about the middle of the sides. Besides this variety of costæ, the shell bears a large number of fine, closely-set, but not very prominent, crescentic radial costæ on the external portion of the sides.

These short costæ become, as they course outward, more strongly marked, and die away where the sides pass into the external periphery. Between every two broad primary costæ there are on an average eleven short intercalary costæ. The external periphery appears to be quite smooth on the internal cast, but where remnants of the shell have been left adherent it is seen that a finely serrated keel runs along the median line of the external periphery.

The body-chamber, as we have already said, is not preserved complete, nevertheless certain remarkable peculiarities may be noted in it. The broad, flat, primary costæ, instead of dying away here at the middle of the sides, continue up to the external periphery. The intercalary costæ appear to be less closely set, and some few arise by furcation at the middle of the sides.

Since the peripheral portion of the body-chamber is not preserved, it is impossible to ascertain whether the external periphery was flattened off. This appears, however, very probable, on the analogy of such nearly related forms as *Opp. Griesbachi* and *Kraffti*. With regard to the keel, it can only be asserted that at the beginning of the body-chamber the serration is still well marked.

The highly denticulate lobal line consists of the external lobe, the two lateral lobes, and four auxiliary lobes on the sides. A very small fifth auxiliary lobe must

[1] Mém. Soc. paléont. Suisse, vol. XIII, pl. I, fig. 6, page 30.
[2] Quenstedt, "Ammonit. des schwäbischen Jura," vol. III, page 861, pl. XCIII, fig. 32.

have existed at the umbilical wall. All the saddles are split by secondary lobes. The external lobe is very short, and higher set than the lateral ramus of the first lateral lobe. The first lateral lobe possesses a very narrow, crooked "body," whence branch off narrow, highly ramified, lateral rami. The two main lateral rami dichotomize in turn, and the external pair of rami is more strongly developed and somewhat higher set than the internal. The external pair of rami lies deeper than the external lobe. The much smaller second lateral lobe is differentiated from the first by the relatively more pronounced protrusion of the terminal ramus, and the feebler development of the lateral rami. The auxiliary lobes, both in form and ramification, correspond to the second lateral lobe, and diminish in size and complexity towards the suture.

If the lobal line just described establishes beyond a shadow of doubt the attribution of this species to the Tenuilobate group, the ornamentation appears at the first glance to identify it absolutely with *Opp. Frotho*, Opp.[1] On each whorl of that species also eight flat primary costæ are seen, and between them (just as in *Opp. indopicta*) ten or eleven intercalary costæ. Moreover, the lobal line—as a rule, indeed, poorly represented in European forms—exhibits no essential differences. On closer examination, however, one recognizes certain notable divergences from *Opp. Frotho*. For example, the umbilicus in *Opp. indopicta* is much broader, the primary costæ do not give rise to any tubercles on the sides as in *Opp. Frotho*; then, too, the slight external tubercles are wanting which in *Opp. Frotho* form the continuation of the primary costæ on the external periphery. But of still greater significance are the differences in the structure of the body-chamber, especially when we remember that the body-chamber of *Opp. Frotho* is similar to that of *Opp. tenuilobata*.[2] In the European species the broad primary costæ die away at the body-chamber, while in the Indian form they become more strongly marked there than on the pneumatic chambers, and continue up to the peripheral margin. Taking all these differences into consideration, it is inadmissible to unite our species with *Opp. Frotho*, Opp. *Opp. tenuilobata*, Opp., is somewhat more remote, for, in addition to the divergences already emphasized, the greater number of primary costæ in *Opp. tenuilobata* must be taken into account. Slightly domed sides, a relatively broad umbilicus, and strongly marked costæ denote the near relationship of *Opp. plicodiscus*, Waag.,[3] to our species. In the form from the Katrol Group, not only are the "stems" but the "siculæ" of the crescentic costæ very prominent, and a serrated keel is noticeably absent. The absence of serrations, however, may be due to the state of preservation of the fossil; and with regard to the difference of costation, it is not by any means impossible that such may be accounted for by the different stages of growth of *Opp. indopicta* and *plicodiscus*. But although we may predicate

[1] Palæontolog. Mitth., I, Plate 50, fig. 1, p. 199; F. Fontannes, "Amm. Calc. Crussol," plate III, fig. 7, p. 24.

[2] This is, at any rate, extremely probable, since *Opp. Frotho* is differentiated from *Opp. tenuilobata* merely by the smaller number of its costæ. Hence by many authors it is regarded as a poorly costate variety of *Opp. tenuilobata*. The figures given by P. de Loriol and Quenstedt, as well as numerous specimens in the State Palæontological Collection at Munich, show that the primary costæ die out on the body-chamber of *Opp. tenuilobata*, while on the other hand numerous crescentic costæ become more strongly marked on the peripheral portion of the sides.

[3] "Jurassic Fauna of Kutch," p. 56, plate X, fig. 5.

a very near relationship between these two species, we are unable to assert their identity on the basis of such material as is at present available. The most that we can do is to place them close together in the same group.

Opp. indopicta comes from Jandu, Hundes (Coll. Griesbach).

OPPELIA (STREBLITES) SUBSTRIATA, Oppel sp.

(Plate II, fig. 3 *a—c*.)

Amm. substriatus, Opp. Paleontolog. Mitth., I, page 271, plate [illegible], fig. [illegible].

Of this species we possess unfortunately only Oppel's original specimen, an internal cast of small size, chambered up to the end, permitting therefore of a but imperfect diagnosis of the species. At a diameter of 41·5 mm., the width of the umbilicus is 7·5 mm., the height of the volution 21·5 mm. and the thickness 13·4 mm. The characteristic which mainly differentiates this form from nearly allied species is the rounded-rectangular shape of the cross-section, the greatest breadth of which lies somewhat above the middle of the whorls. The sides are markedly flattened off, and, gradually rounding, pass into the narrow, domed, external periphery. At the sides is a fairly deep-cut spiral furrow. The umbilicus is comparativly broad, the umbilical wall steep, almost perpendicular, with a well-marked umbilical rim. The ornamentation consists of slight crescentic striations, which are better exhibited on the shell than on the internal cast. Above the median line of the shell, secondary costæ are intercalated; at the anterior extremity two costæ swell up into vesicular inflations on their inner portion. As, however, the test is broken off at this point, it is impossible to determine whether these inflations die away again, or whether they mark the beginning of a definite change in the ornamentation. The external periphery is quite smooth on the internal cast; at one point a small remnant of shell is adherent, but it also fails to yield evidence of a keel or of serrations. We may consequently infer that at the stage of growth reached by this specimen there was no marked serration of the external periphery. The body-chamber is not known. The lobes follow very closely one upon the other, and cover the entire shell with their ramifications. They coincide more especially with those of *Opp. Griesbachi*. The external pair of rami of the first lateral is strongly developed, but does not approximate so closely to the median line as in *Opp. Adolphi* and *Kraffti*. On the sides three auxiliary lobes are recognizable, and the fourth is at the umbilical wall.

Quenstedt[1] thought that *Opp. substriata* was nothing but the inner volution of *Opp. Adolphi*. This supposition is, however, quite erroneous, because *Opp. substriata*, although imperfectly known, undoubtedly represents a distinct species. The broad umbilicus, the low whorls, the rounded external periphery, but more especially the shape of the cross-section and the lobes and the absence of a prominent keel, are undoubted evidence of the specific differentiation of *Opp. substriata*, not only from *Opp. Adolphi*, but also from *Opp. Kraffti* and *Griesbachi*. By the breadth of

[1] "Amm. des schwab. Jura," III, page 1116.

its umbilicus and the form of its whorls *Opp. substriata* approximates to *Opp. Lymani*: yet these species are not identical, for *Opp. Lymani* is easily distinguishable from *Opp. substriata* by its more markedly domed whorls, prominent external tubercles, and divergent lobal line. *Opp. punctatopicta*, sp. nov., possesses a broader umbilicus, a more flattened-off external periphery, besot with small tubercles, and a somewhat flatter test. Consequently it would be difficult to confuse it with *Opp. substriata*. That species, moreover, is much bigger than *Opp. punctatopicta*, since the latter, at the same diameter as that at which *Opp. substriata* is still completely chambered, exhibits the body-chamber.

Among the European forms *Amm. Gmelini*, Opp., shows some resemblance to the species here described, the shape of the test being very much the same. *Amm. Gmelini* has much coarser and more prominent costæ than *Opp. substriata*, but the spiral furrow so deep-cut in the sides of the latter is wanting in the former. Finally, if we may judge from Oppel's figure, the structure of the lobal line is so divergent that one is impelled to infer that *Opp. Gmelini* belongs to quite another group than *Opp. substriata*. *Opp. lochensis*, Opp., represents the same line of mutation as *Opp. substriata*, but in the former species also the divergent structure of the lobes excludes the possibility of near relationship.

The sole available specimen of *Opp. substriata*, Oppel, comes, according to that author, from Shangra, near Puling, in Gnari Khorsum.

Oppelia (Streblites) aff. substriata, Oppel.

(Plate V, fig. 6 *a—c*.)

An internal cast, chambered up to the end, and about 41 mm. in diameter; approximates very closely to *Opp. substriata*, but differs from it so markedly in certain characteristics that the available scanty material does not permit of our attempting to refer it to that species. The sides are not flattened off as in *Opp. substriata*, but are evidently domed, and they exhibit no spiral furrow. The test is somewhat more cuneiform at the external periphery and the costæ are rather more prominent than in *Opp. substriata*. At one point there is an inflation of the costæ similar to that observed at the anterior extremity of *Opp. substriata*. An external keel cannot be traced; on the other hand, the costæ course at the anterior extremity over the external periphery and appear at that point to thicken slightly. The lobes are similar to those of *Opp. substriata*.

The true significance of this form cannot at present be fully understood. It seems probable, however, that a bigger specimen would exhibit more clearly its specific distinctness from *Opp. substriata*, Opp., than does the small specimen here described. Still this view is subject to the reservation, that more abundant material might possibly yield evidence of a passage from one form into the other.

Being then uncertain as to the exact position of this form, we have thought it undesirable to add another new and also insufficiently known species to the already existing and imperfectly known *Opp. substriata*; and we have therefore described

the aforesaid specimen merely as *Opp.* aff. *substriata*. A more precise determination of the species is necessarily deferred until better preserved specimens are obtained.

Opp. aff. *substriata* comes from Spiti Valley.

Oppelia (Streblites) Lymani, Oppel sp.

(Plate II, fig. 2 *a—e*; Plate VII, fig. 1 *a—c*.)

Ammonites Lymani, Oppel, Palæontolog. Mittheilungen, vol. I, page 272, plate LXXVI, fig. 3 *a—c*

Ammonites Lymani was founded by Oppel on two specimens, whereof, unfortunately, only the larger one (that not figured by Oppel) lies before me. The smaller one, as Dr. Max Schlosser kindly informs me, is not now to be found in the State Palæontological Collection at Munich. The larger specimen does not entirely fit in either with Oppel's figure or with his description: it is more narrowly umbilicate, has a higher aperture and less numerous thickened costæ than the small type-specimen. There is, then, just a possibility that Oppel's specimens belong to two different species. As, however, the differences here enumerated are of secondary importance, it is thought advisable to adhere to Oppel's view of their identity, and to regard the specimen figured here in Plate II, figure 2, as the type of *Amm. Lymani*.

In this specimen the diameter measures 51 mm., the width of the umbilicus 11·5 mm., the height of the ultimate whorl 23·8 mm., and the greatest thickness 14·3 mm. The sides are very slightly domed, and are separated from the steep umbilical wall by a prominent umbilical rim. The external periphery is in the chambered portion, and at the beginning of the body-chamber narrow and cuneiform, but broadens somewhat at the anterior portion of the body-chamber, becomes more rounded, and even a little flattened off. The serrations of the median keel are comparatively prominent; they increase in prominence up to the anteriormost third of the body-chamber, decreasing thence towards its anterior extremity. At the body-chamber the serrations of the external periphery are recognizable even on the internal cast, but they can only be traced on the shell in the chambered portion. The ornamentation consists of fine crescentic costæ, whereof some few are very strongly marked at the external portion of the body-chamber. Over the middle of the sides courses a simple spiral inflation. At the body-chamber the greatest breadth of the cross-section is shifted slightly outward as in other Tenuilobata. But this, so far as one can judge from the imperfectly preserved specimen, is indeed slight in amount.

The ramification of the lobal line is less markedly developed than in the forms of the *Adolphi* group, on account, perhaps, of the smaller size of our species. The stem of the first lateral is not quite so crooked, and the external pair of rami is less prominent than in *Opp. Adolphi* and *Kraffti*. The terminal ramus of this first lateral takes here the form of an immediate prolongation of the stem, and the inner lateral ramus branches off at the same point from the stem as the terminal ramus.

Amongst the material that lies before us, there is only one specimen that can be assigned to the same species as Oppel's type. It is figured on Plate VII, figure 1, and exhibits a portion of the body-chamber which is, however, unfortunately compressed. Consequently the body-chamber appears to be at the external periphery much more markedly wedge shaped than it really is.

Perhaps we ought to assign to *Opp. Lymani* the form described by Blanford in the "Palæontology of Niti" as a distinct variety of *Amm. acucinctus* under the name of *Amm. mundus*, Strach. Ms. (Plate XVIII, fig. 2, *non* fig. 1; *non* Plate XIX, fig. 4). The figure in the "Palæontology of Niti", to judge from the plaster cast which lies before me, can scarcely be described as a happy restoration. Some few costæ appear to be more prominent and similar to those of *Amm. Lymani*. The umbilicus is broad, the sides slightly domed. The external periphery does not show any clearly marked tubercles in the plaster cast, nor can the lobal line be seen. We are therefore unable to determine with certainty whether *Amm. mundus* should be regarded as a distinct form or should be placed under *Amm. Lymani*. For the designation *Amm. Lymani* priority can at any rate be claimed, as the manuscript-name *Amm. mundus*, Strachey, was published in the "Palæontology of Niti" subsequent to the publication of the Palæontologische Mittheilungen.

Opp. Lymani differs so completely from the high apertured forms, such as *Opp. Adolphi*, *Kraffti*, *Griesbachi*, that it is hardly necessary to describe the divergences in detail. From *Opp. substriata*, Opp., we distinguish *Opp. Lymani* by the more prominent serration of its external periphery, its broader umbilicus, its narrower and more markedly cuneiform external periphery, the shape of its cross-section, and the structure of its lobal line. In *Opp. substriata* the greatest breadth of the cross-section in the chambered portion is in the external half of the whorls, while in *Opp. Lymani* it is in the internal half. From *Opp. sphenodoma*, sp. nov., we distinguish *Opp. Lymani* by the development of the serrations at the body-chamber, its more distinctly cuneiform periphery, domed sides, somewhat broader umbilicus, and dissimilar lobal structure. The differences which it exhibits from *Opp. punctatopicta* are enumerated in the description of that species.

Oppel's original specimen of *Opp. Lymani* comes from Gieumal in Spiti, and the second specimen from Jandu, Hundes.

Oppelia (Streblites), sp. nov. indet., aff. Lymani, Oppel.

(Plate VI, fig. 8 *a—c*.)

A small chambered fragment represents a species which is very nearly related to *Amm. Lymani*. The whorls have a similar cross-section to that observed in *Amm. Lymani*, and their sides are similarly domed, but they are still more widely umbilicate and lower. But what is most conspicuous is the greater girth of the chambered portion at the same level of the volution. The ornamentation consists of feeble crescentic costæ, whereof some few are rather more prominent than the others. This strengthening of the costæ, however, does not take place in their

external portion, as in *Amm. Lymani*: instead of affecting the "siculæ," it affects the inner portion or the "stems." External tubercles are wanting, as the specimen is a chambered internal cast. The innermost whorls have a rounded cross-section, and it is only when the diameter of 8 mm. has been attained that the height begins to increase more rapidly than the breadth, and the cross-section becomes oval. The lobes are very similar to those in *Amm. Lymani*, except that the first lateral appears to lie somewhat farther apart from the external lobe and to possess a rather stouter stem.

The differences which we have been considering show that we are in all probability dealing here with a form which cannot be placed under *Amm. Lymani*. As, however, the body-chamber and the features of the external periphery are unknown, the species cannot be adequately diagnosed. We think it advisable, therefore, to refrain from founding a new species, and to content ourselves with the foregoing brief description.

Opp. sp. nov. indet., aff. *Lymani*, comes from Niti.

Oppelia (Streblites) sphenodoma, sp. nov.

(Plate VI, fig. 3 *a—d*.)

Of this species only one specimen is forthcoming, but it is in such perfect preservation, and shows such marked characteristics, that it may well serve as the type of a new species.

It measures 58 mm. in diameter, and the width of the umbilicus is 11·5 mm. The height of the body-chamber reaches 27 mm. at the anterior margin, and the greatest thickness is 14·8 mm. In the chambered portion the sides are slightly domed, the external periphery is narrow, and the cross-section oval. Before and at the beginning of the body-chamber the test assumes at the external periphery a very marked cuneiform shape, but this tendency to a "wedge" quickly dies away on the body-chamber. At the anterior portion of the body-chamber the sides are perfectly plane, the external periphery slightly domed, the umbilical wall dips vertically inward, and the umbilical rim is very strongly marked. The greatest girth, which in the chambered portion lies somewhat below the middle of the sides, shifts at the body-chamber gradually more outward, so that at the apertural margin it seems to be displaced into the peripheral half.

The ornamentation consists of feeble crescentic costæ, whereof some, distributed at irregular intervals at the posterior portion of the body-chamber, appear to be somewhat more prominent than the rest. The serrations of the external periphery are very poorly developed indeed, and are limited to the pneumatic chambers. No trace of them is found on the body-chamber. The body-chamber takes up two-thirds of the ultimate whorl: the apertural margin, most of which is preserved, follows the same course as the costæ and the lines of growth. It possesses no auriculate appendages, and its ventral portion projects but slightly forward. That portion of the shell which lies behind the apertural margin is a little depressed or constricted, much as in *Opp. Griesbachi*. At the apertural margin the umbilical rim projects

most conspicuously forward, so that here the sides above the umbilical appear to be somewhat depressed.

The lobal line is, unfortunately, not well preserved. Nevertheless, the Tenuilobata type is unmistakably recognizable. The first lateral is characterized by an especially short and anteriorly broad stem, the external lateral rami of which approximate to the terminal ramus of the peripheral lobe without spreading out behind it. Three auxiliary lobes may be clearly traced, and a fourth very stunted one was probably devoloped at the umbilical wall. The first lateral saddle occupies a comparatively high position. The compressed form of the lobal line figured here may in part be explained by the restriction of the space assignable to this particular line, which is one of the last on the test.

The species just described differs from *Opp. Lymani*, Opp., chiefly in its narrower umbilicus, in the absence of tubercles on the external periphery of the body-chamber, in the want of a spiral inflation on the sides, in the more marked flattening of the last-named, somewhat feebler ornamentation, and lower lobes. Our species is still more closely allied to *Opp. punctatopicta*, although *Opp. sphenodoma* is easily distinguishable therefrom by the smooth external periphery of its body-chamber, the sharper umbilical rim, more prominent cuneiform tendency of the peripheral portion at the beginning of the body-chamber, and finer crescentic striations.

Opp. sphenodoma comes from Kibber in Spiti.

Oppelia (Streblites) punctatopicta, sp. nov.

(Plate VII, fig. 2 *a*, *b*; fig. 3 *a*, *b*.)

Dimensions :—

Diameter	43 mm.	52 mm.
Width of umbilicus	9·5 „	10 „
Height of the ultimate whorl (approximately)	19·5 „	24 „
Thickness of ultimate whorl (approximately)	11·8 „	14 „

The innermost whorls of this species are at the sides and peripherally rounded, and all but devoid of ornamentation. As the size increases, the sides flatten off, the external periphery tends to assume a wedge shape, and slight crescentic striations make their appearance. The body-chamber does not differ very markedly from the chambered portion which precedes it. The sides are still more conspicuously flattened off at the body-chamber, and are separated from the steep umbilical wall by a rounded umbilical rim. The external periphery is still more flattened off, and clearly demarcated from the sides. The cross-section, oval in the pneumatic chambers, assumes gradually in the body-chamber a rounded rectangular form, so that the greatest thickness is somewhere about the middle or a little above it. The length of the body-chamber is rather less than two-thirds of the ultimate whorl. In one specimen (Plate VII, figure 3) the inner portion of the apertural margin is preserved, and here, as in *Opp. sphenodoma*, the umbilical rim projects markedly forward. The ornamentation consists of fine, closely-set, crescentic striations, which become more distinct towards the external periphery, and give rise to small serrations along

the median line thereof. These serrations are observable on the body-chamber also, but become continuously feebler towards the oral aperture, so that in one specimen they can only be traced on the anterior-most portion of the body-chamber as excessively minute "points." The lobal line is recognizable in one specimen only, and even then is very small. On the sides are seen three auxiliary lobes, whereof the last is at the umbilical rim. The features of the lobal ramification are apparently similar to those observed in *Opp. sphenodoma*.

Four specimens of *Opp. punctatopicta* lie before us, whereof three are conspicuously concordant, while the fourth (Plate VII, figure 3) differs in its rather more cuneiform external periphery, and in its broader umbilicus.

The species just described is very nearly related to *Opp. Lymani*, especially to that form of the species which A. Oppel figured in the Palæontologische Mittheilungen. Even if we base the diagnosis of *Opp. Lymani* on the lost type-specimen of the Palæontologische Mittheilungen, and not on that figured here, it is impossible to unite *Opp. punctatopicta* with it, as the former species (*Opp. Lymani*) possesses a far broader umbilicus, more conspicuous ornamentation, and more prominent peripheral tubercles than the latter (*Opp. punctatopicta*). In *Opp. Lymani* certain crescentic costæ are conspicuously stronger than others, while in *Opp. punctatopicta* they are all equally faint. From *Opp. sphenodoma*, *Opp. punctatopicta* is differentiated by the presence of the row of tubercles on the external periphery of the body-chamber, by a less marked cuneiform tendency of the test before the beginning of the body-chamber, by its finer costation and blunter umbilical rim. *Opp. platydoma*, sp. nov., is smaller, more markedly flattened off at the external periphery, and somewhat more deeply striated than our species.

Opp. punctatopicta comes from the district that lies between Laptel and Chidamu (Hundes).

OPPELIA (STREBLITES) PLATYDOMA, sp. nov.

(Plate VII, fig. 4 *a*, *b*.)

Of this species only two imperfectly preserved specimens lie before us, the smaller of which measures but 37·3 mm. in diameter, although it is preserved up to the apertural margin. The larger specimen has at the diameter of 41 mm. an umbilical width of approximately 7·5 mm. The height of the ultimate whorl at the anterior extremity is 26·8 mm., and the breadth 10·2 mm.

Up to a diameter of about 6 mm. the whorls possess a rounded cross-section and are broader than they are high. At the diameter of about 9 mm. the height of the volution is equal to its breadth, and the height thenceforward increases so rapidly that it soon far outstrips the breadth. At this stage the whorls become flatter, and simultaneously the external periphery narrows, while the greatest breadth is shifted to the lower portion of the volution. As early as the diameter of 27 mm. the body-chamber makes its appearance, and at the very beginning of it the sides are markedly flattened off. This flattening both of the sides and the external periphery becomes still more conspicuous towards the apertural margin, in such wise that the

cross-section at that margin assumes a nearly rectangular form. The umbilical rim is rather prominent, and the umbilical wall dips vertically inward.

The innermost whorls appear to be all but bereft of ornamentation. The body-chamber is in the internal cast traversed by closely-set, fairly well-marked crescentic lines which also course over the external periphery and project but slightly forward. At the anterior extremity of the body-chamber the costæ course diagonally over the external periphery without any forward inclination (but this is in part to be attributed to damage suffered by the test, recognizable at this point). Some of the crescentic striations bifurcate on the inner, and others on the peripheral portion of the volution, but without any particular regularity. At the beginning of the body-chamber a fine striation courses over the "blunted" external periphery, swelling up into very minute tubercles at the points of intersection with the lines of growth and the costæ, and dying away gradually forward. The body-chamber takes up two-thirds of the ultimate whorl. In the smaller, worse preserved specimen, the attribution of which to the figured species is indeed not absolutely certain, the apertural margin is in part wanting. It is not expanded into auriculate appendages, but courses parallel to the lines of growth. Behind it is observable an extremely slight constriction, beyond which the shell projects a little outward, so that the cross-section broadens somewhat at the apertural margin. Of the lobal line the auxiliaries and the second lateral are unfortunately alone recognizable. The lobal line appears to be similar to that of *Opp. Lymani* and *sphenodoma*.

The flattening off of the external periphery is so conspicuous a feature of this species as to be unparalleled in the *Lymani* group. Superadded to this peculiarity are other characteristics, such as the small size, fairly prominent costation, marked flattening-off of the sides, and rectangular cross-section, taking all of which into account, the establishment of a new species for this form (so easily differentiated from all hitherto known types of the *Lymani* group) seemed inevitable. Of all the species of that group, *Opp. punctatopicta* is the most nearly related to the form just described: but the more conspicuous flattening of the external periphery and the sides, the stronger ornamentation, and the smaller size of *Opp. platydoma* make the specific differentiation a matter of absolute certainty.

The specimen figured here comes from Jandu, Sherik River, Hundes (Coll. Griesbach); the smaller specimen, with the apertural margin preserved, is from the Spiti Valley (Coll. Gerard).

OPPELIA (STREBLITES) LEPTODOMA, sp. nov.

(Plate VII, fig. 5 *a*, *b*.)

Dimensions of the figured specimen:—

Diameter	28·8 mm.
Width of umbilicus	5·8 „
Height of the ultimate whorl	14 „
Breadth of the ultimate whorl (approximately)	7 „

The species which we are about to consider is closely connected with the types

of the *Lamaed* group. Fine, closely-set crescentic striations cover the flat test, the whorls of which exhibit a fairly broad umbilicus. The sides are but slightly domed, nay, even flat, and are marked off by a rounded umbilical rim from the steep, low umbilical wall. The narrow external periphery is beset with a row of numerous fine serrations. In the chambered portion these serrations are recognizable only where some of the shell is adherent, the internal cast being perfectly smooth. The body-chamber, on the other hand, exhibits these serrations even on the internal cast: they become feebler towards the anterior extremity. On the broken specimen it may be noted that the innermost whorls are broader than high and all but entirely smooth. Gradually the whorls increase in height, and become marked by crescentic striations. The body-chamber does not appear to differ conspicuously in shape and ornamentation from the chambered portion. The lobal line is preserved in several specimens, and so one is enabled to conclude that not only are the lobes of this species clearly of the Tenuilobate type, but that despite the small size of the individuals the lobes are very considerably ramified. The external lateral rami of the first lateral lobe are rather widely separated from the terminal ramus of the external lobe, and the first lateral saddle lies comparatively high. Three small auxiliary lobes are recognizable, whereof the third forms merely a slight denticulation. Among the specimens of which the determination is somewhat doubtful, are four with a partly preserved apertural margin; in three of these impressions the inner portion of the apertural margin remains, and is characterized by a very marked forward inclination. In the fourth specimen the external portion of the apertural margin is seen, showing traces of the existence of small auriculate appendages, while the shell at the margin appears to be somewhat constricted. Although these badly preserved impressions, whereof indeed several yield evidence of peripheral tubercles, contribute but little to a detailed knowledge of the species, they at all events enable us to assert that we are not dealing here with the young or the spawn of a larger species, but with examples of an independent species, one of whose characteristics is its small size.

Opp. leptodoma approximates both in form and ornamentation to *Opp. punctatopicta*, but the much smaller size and the more conspicuous doming of the sides in the former species forbid its attribution to the latter. Among European forms we may more especially compare with our species *Opp. Pichleri*, *Opp. microdoma*, *Opp. fialar*, *Opp. lochensis*, and *Amm. flexuosus nudus*, Qu. *Opp. Pichleri* is differentiated from *Opp. leptodoma* by its narrower umbilicus and coarser ornamentation, which approaches more nearly to the ornamentation of the Flexuosi than it does to that of the Tenuilobati. *Opp. microdoma* has a much broader umbilicus and lower whorls, and *Opp. fialar* exhibits, besides, a spiral furrow. *Opp. lochensis* and *Amm. flexuosus nudus* appear to be more closely allied to *Opp. leptodoma* than the other species just enumerated. External shape and ornamentation give here but little ground for specific differentiation, the somewhat earlier disappearance of the peripheral tubercles in *Opp. lochensis* than in our species constituting a distinction of very inconsiderable significance. If we may judge,

however, from the existing figures, *Opp. lochensis* and *Amm. flexuosus nudus* have an altogether different lobal structure from that of *Opp. leptodoma*, and cannot therefore be brought into close association with it, any more than the other European species enumerated above, the lobal structure of which (according to Oppel's descriptions) exhibits no near relationship to the Tenuilobate type. The differences between *Opp. leptodoma* and *adunata* are enumerated in the description of the latter species.

Opp. leptodoma comes from Gieumal (one specimen, Plate VII, figure 5) and from Laptel (four specimens).

OPPELIA (STREBLITES) ADUNATA, sp. nov.

(Plate V, fig. 7 *a*—*c*.)

Only one specimen unfortunately is forthcoming whereupon to base this species: at the first glance it seems to be very closely allied to *Opp. leptodoma*, if not indeed identical with it. A closer inspection, however, reveals peculiarities which forbid its attribution to that species.

The diameter of the specimen, which is preserved up to the apertural margin, measures 30 mm., the breadth of the umbilicus 5·1 mm., the height of the ultimate whorl 15 mm., the breadth approximately 8·2 mm. On the whole, then, the dimensions approach those of *Opp. leptodoma*, with the difference that the species about to be described possesses a somewhat narrower umbilicus and greater thickness. This difference is enhanced by the circumstance that the sides are more conspicuously domed in *Opp. adunata* than in *Opp. leptodoma*. The serrations on the external periphery have much the same characteristics as in the last-mentioned species: they gradually become feebler towards the apertural margin, and immediately before the aperture they seem to disappear altogether. The ornamentation consists of slight crescentic striations, the lobal line is of the Tenuilobate type. We may recognize here auxiliary lobes, the third of which, lying close to the umbilical rim, possesses but two tiny lateral denticulations; while the fourth, at the umbilical wall, forms a mere plication, very small and barely recognizable, without any sign of a lateral denticulation. The body-chamber seems to be preserved entire, as the test is limited at the anterior margin by a crescentic line which has much the look of an apertural rim. (Compare text-figure 7.) If this be not a deceptive appearance, induced by the state of preservation of the fossil, the length of the body but little exceeds one-half of a whorl. Auriculate appendages were seemingly not developed at the apertural margin of this species, and the slight constriction, too, is wanting which in the allied species is the invariable accompaniment of the apertural margin. If it is with this margin that we are really dealing here, then we have another point of difference between *Opp. adunata* and *Opp. leptodoma*, the latter being provided with auriculate appendages, while the former is not so provided. But apart even from that, the greater thickness,

FIG. 7.—OPP. (STREBLITES) ADUNATA, n. sp. From Tandu, Sherif River, Hundes. Natural size. With the body-chamber and apertural margin.

more conspicuously domed whorls, and the narrower umbilicus form a combination of characteristics which allow us to separate *Opp. adunata* from *Opp. leptoloma*.

From *Opp. domocrenata* the species here described is differentiated by its broader umbilicus, more markedly domed sides, greater thickness, and feebler serrations on the external periphery. In outward shape and ornamentation our species approximates very closely also to *Opp. lochensis* (*Amm. flexuosus nudus*, Qu.). This European form is more conspicuously costate on the external portion of the sides than is *Opp. adunata*; but this difference would hardly justify a separation of the species, were not the lobal line of the Indian form characterized by its much more complex ramification, and its slenderer and longer lobal "bodies."

Another view of the sides of *Opp. adunata* showing the apertural margin has been intercalated in the text, as this margin, by an error of the draughtsman, has been omitted from the figure in Plate V.

Opp. adunata comes from Jandu, Sherik River, Hundes (Coll. Griesbach).

OPPELIA (STREBLITES) DOMOCRENATA, sp. nov.

(Plate V, fig. 5.)

This species is represented unfortunately by only one specimen, in which the greater portion of the body-chamber is preserved, and possessing a diameter of about 30 mm. At the diameter of 27 mm. the width of the umbilicus is 4·5 mm., and the greatest thickness 6·8 mm. The high-apertured, flat test has flattened-off sides clearly demarcated from the narrow external periphery. (Compare text-figure 8.) The umbilicus is very narrow, the umbilical wall low, dipping steeply inward, with a not very prominent, rounded umbilical rim. The ornamentation is extraordinarily indistinct, but the external periphery is beset with unusually conspicuous serrations which continue to be very prominent right up to the apertural margin. The body-chamber must have taken up two-thirds of the ultimate whorl. The apertural margin is unluckily not preserved.

FIG. 8.—OPP. (STREBLITES) DOMOCRENATA, n. sp. View of the external side. Natural size. From Chidamu.

The lobal line exhibits clearly the general characteristics of the Tenuilobate type, and, despite the small size of the specimen, its ramification is very complex. The outer pair of rami of the outer lateral approximates more closely than in *Opp. pygmæa* to the short external lobe. The first lateral saddle lies fairly high. Four auxiliary lobes may be traced, three of which are on the sides, while the fourth forms a simple digitation at the umbilical wall.

As the body-chamber is not preserved up to the apertural margin, and moreover fails to exhibit such characteristics as would justify us in regarding it as the ultimate body-chamber, the question arises whether we are dealing here with an independent species of small growth, or with the young of a larger species. To this question an absolutely unhesitating answer cannot be given; but it may be pointed out that among the hitherto known larger Oppelias of the Spiti Shales none has

been found possessing such flat sides as those which characterize the form now described. Wherefore we may infer that it is at least extremely probable that this specimen does represent the full-grown stage of an independent species.

On this assumption we should designate *Opp. leptodoma* and *Opp. adunata* as the most nearly allied species. *Opp. leptodoma* is distinguished from the form just described by its less prominent peripheral tubercles, much broader umbilicus, more distinct umbilical rim, and lower whorls. *Opp. adunata* is differentiated by its domed sides, feebler peripheral tubercles, somewhat narrower umbilicus, and rather more distinct ornamentation. Owing to the comparatively prominent development of its peripheral tubercles, *Opp. domocrenata* approaches more nearly than any of the other Oppelias of the Spiti Shales to the European types of the Dentati. Among these, the form which most resembles our species in outward shape and in the characters of the external periphery is *Opp. lophota*, Opp.[1] The lobal line figured by Quenstedt[2] diverges widely from the Tenuilobate type, and proves that there is in this case only a superficial similarity in the "direction of mutation," and no immediate close relationship.

One specimen is from Chidamu.

OPPELIA (STREBLITES) PYGMÆA, sp. nov.

(Plate VI, fig. 7; Plate VII, fig. 6.)

Dimensions :—

Diameter, with body-chamber	19·3 mm.;	16·3 mm.;	15·2 mm.;	14 mm.;	12 mm.
Width of umbilicus	4·3 „	4 „	4·1 „	3·3 „	2·8 „
Height of ultimate whorl	9·8 „	7·8 „	7 „	6·2 „	5·3 „
Thickness of ultimate whorl	5·6 „	4 „	——;	3·9 „	3·4 „

Of this small form several specimens lie before us, with the body-chamber and the constricted apertural margin preserved, thereby furnishing sufficient evidence to prove that we are not dealing here with the young stage of some larger form, but with a full-grown, independent species. The innermost whorls up to a diameter of between 5·5 and 6 mm. are broader than high; it is only later on that the height increases more rapidly than the breadth, in such wise that the cross-section gradually assumes an oval shape. Simultaneously, fine crescentic striations make their appearance on the sides. Over the rounded external periphery courses a string of very faintly prominent little tubercles, perceptible as such under a magnifying glass in a well-preserved specimen. Only on the biggest known individuals of this species, which with the body-chamber measure between 19 and 20 mm., do these peripheral tubercles assume somewhat more prominence, and are then recognizable by the unaided eye. The sides are slightly domed, the umbilical wall low, steep, but without any umbilical rim properly so-called.

The lobes, despite the small size of the test, exhibit fairly complex ramification. Their general conformity with the Tenuilobate type is unmistakable. The lateral ramuli have the same distribution and position as in the larger forms described in

[1] Palæontolog. Mittheil., I, page 201, plate LIII, fig. 3.
[2] "Ammoniten des schwäb. Jura," III, page 858, plate XCIII, figs. 20—23.

the foregoing pages, but they are somewhat simpler in structure. The external lobe is indeed small, and yet it is comparatively longer than in the larger species. The lateral rami of the first lateral do not extend so close up to the external lobe in *Opp. pygmæa* as in the larger Oppelias. Despite the small size of the whorls four auxiliary lobes may be clearly traced, whereof the third and fourth form merely a very small unbranched digitation.

Of the numerous specimens of this form, some measure, with the body-chamber, from 19 to 20 mm. in diameter, and others only from 12 to 15 mm. The larger specimens possess a somewhat narrower umbilicus than the smaller. The character of the apertural margin is also subject to variations: thus, in the best-preserved specimen (see text-figure 9), this margin protrudes at the suture very conspicuously forward, and just below the middle of the sides passes into a comparatively long auriculate appendage, curving then crescentically backward in such a manner as to form on the external periphery a small, forwardly protruding, ventral appendage. Throughout its whole extent the apertural margin is accompanied by a narrow and fairly deep constriction, which passes on to the auriculate appendage (unfortunately not preserved entire). At the external periphery this constriction recedes somewhat, and the ventral appendage here projects upward and outward. In the other specimens the apertural margin is unfortunately less perfectly preserved than in that just described, but one is able to ascertain that the constriction accompanying the apertural margin was shallower in the other specimens. The biggest available specimen among these has the apertural margin preserved only at the lower portion of the test: a distinct constriction is not present here, and the auriculate appendage appears to have formed a short, broad-based flap. Similar short, forwardly-convex, lateral flaps are observable at the apertural margin of a specimen which measures about 10 mm., and has been placed by Blanford under *Amm. acucinctus* in his "Palæontology of Niti." But the apertural margin of this specimen, whereof a plaster cast lies before me, is accompanied by a narrow, fairly distinct constriction. The body-chamber takes up but little more than half a whorl. It is covered with fine, crescentic striations, whereof a few (in some specimens) are rather more strongly developed than the others. There is as little trace of a bend in the body-chamber as of that broadening of the umbilicus which is distinctive of so many European dwarf forms of the genus *Oppelia*.

FIG. 9.—OPP. (STREBLITES) PYGMÆA, n. sp. Natural size.

In the introduction to the genus *Oppelia* the reader will have found some observations on the generic attribution of this species. For purposes of comparison only three of the Oppelias of the Spiti Shales need be considered here: *Opp. leptodoma*, *Opp. adunata*, and *Opp.* sp. nov. indet. The smaller specimens of the two first-named species are indeed very similar to *Opp. pygmæa*, especially to the larger and high-apertured variety of it, but they cannot be included in it. *Opp. adunata* in its full-grown stage is much larger, possesses a relatively narrower umbilicus, more prominent serrations, and more highly ramified lobes. *Opp. leptodoma* is differentiated from *Opp. pygmæa*

by its considerably larger size, more conspicuous serrations, flatter sides, and more distinct umbilical rim. *Oppelia* sp. nov. indet. approximates to *Opp. pygmæa* in respect of its broad umbilicus and low whorls, but is easily distinguishable therefrom by its much coarser peripheral tubercles and somewhat less highly ramified lobes.

Among European species one may especially compare with *Opp. pygmæa* the two forms *Opp. nimbata*, and *Opp. Bruckneri*. *Opp. nimbata*, Oppel sp., is distinguished from the form here described by the presence of a slight spiral furrow on the middle of the sides, by its narrower umbilicus, smooth external periphery, and extremely simple lobal line (which is evidence that it belongs to quite another branch of the Oppelias than our species). *Opp. Bruckneri* is chiefly differentiated by the slight contraction of the body-chamber.

Of *Opp. pygmæa* eleven specimens lie before us, from Gieumal and from the district north of Ting Jungta Pass (Hundes). The specimen examined by Blanford, and placed by him under *Amm. acucinctus*, comes from the Niti Pass.

Oppelia (Streblites), sp. nov. indet.

(Plate VI, fig. 9 *a—c*.)

A small, somewhat broadly umbilicate new species scarcely furnishes in the single available fragment, chambered up to the end, sufficient material for a complete diagnosis. At the broken off anterior extremity the height of the volution measures 8 mm., and the thickness 5·4 mm.; the cross-section here is approximately oval, the sides are somewhat flattened off, the external periphery is domed, the umbilical wall steep, with an indistinct umbilical rim. The innermost volutions have a rounded cross-section and are just as broad as they are high: it is only from the diameter of about 7 mm. onward that the height increases more rapidly than the breadth, and the cross-section becomes elliptical. The umbilicus takes up nearly a third of the diameter, the crescentic striations are very feebly developed but conspicuously undulating. The external periphery bears, even on the internal cast of the pneumatic chambers, comparatively coarse tubercles. The body-chamber has not been preserved.

Of the lobal line, the two lateral lobes and the external lobe are clearly recognizable. The first lateral is somewhat wide apart from the short external lobe, and is but moderately ramified: the first lateral saddle lies fairly high. The number of the auxiliary lobes cannot be determined with certainty: we may trace two auxiliaries of very simple structure, but it seems possible that there were also at the umbilical rim and umbilical wall one or two small unbranched lobal digitations, now covered over by shell and matrix. At the first lateral four small rami may be observed, grouped in two pairs, and it is for this reason chiefly that we assign this small form to the Tenuilobati or the sub-genus *Streblites*, Hyatt. It is true that the lobal ramification is somewhat less complex than in other dwarf species of the Tenuilobate group (such as *Opp. pygmæa* and *adunata*), but the development of the two pairs of rami of the first lateral is so characteristic that the complete separation of the form here described from the Tenuilobati would not be justified.

The external features of this species recall vividly the European group of the Dentati, for which Munier-Chalmas has established the designation *Creniceras*. If, however, the lobal structure of the European forms, such as *Opp. crenata*, *dentata*, *Renggeri*, *ophiota*, *microdoma*, etc., be compared with the lobes of our species, very marked differences are perceptible. For example, in the beautiful specimen of *Opp. crenata* described by G. von Bukowski, the first lateral possesses an unmistakable terminal ramus and two lateral rami, and its character is altogether unlike that of the corresponding lobe in our species. The nearer allies of the form here described should then be looked for, not among the European Dentati, but among the Indian Tenuilobati. Of the latter, *Opp. pygmæa*, on account of its small size, broad umbilicus, and the shape of its cross-section, comes nearest to our species: but is easily distinguished therefrom by its extremely feeble peripheral tubercles. From *Opp. adunata* and *leptodoma* the species here described is differentiated by its broader umbilicus, lower volutions, and more conspicuous peripheral tubercles, and additionally from *Opp. leptodoma* by its less flattened sides.

The species that we have been describing diverges somewhat more widely from the parent stem of the Tenuilobati than the other dwarf forms, such as *Opp. adunata*, *leptodoma*, and *pygmæa*. The lobal line diverges in the simplicity of its structure; and the serration of the external periphery is traceable on the chambered portion, not only in specimens which have the shell preserved (as in the true Tenuilobati), but also on the internal cast. These peculiarities lend a special interest to this form, and our regret, therefore, is all the keener that precisely of this remarkable type only a single small fragment is forthcoming which furnishes very inadequate material upon which to base our conception of the species.

Opp. (*Streblites*) sp. nov. indet. comes from Spiti Valley.

OPPELIA ACUCINCTA, Strachey sp.

(Plate IV, fig. 2 *a—d*; fig. 3 *a—c*; fig. 4 *a—c*.)

1863. *Amm. acucinctus*, Strachey, in Blanford, Journal Asiat. Soc., Calcutta, vol. XXXII, page 126, plate I, figs. 3, 3*a*.

1865. *Amm. acucinctus*, Blanford, "Palæontology of Niti," page 87, pl. XVIII, fig. 1 *b*, *c*, *non*; plate XVIII, fig. 1 *a*, fig. 2 *a*, *b*; plate XIX, fig. 4 *a—d*.

1866. *Amm. acucinctus*, Stoliczka, Mem. Geol. Surv. India, Calcutta, vol. V, page 72, *partim*.

Dimensions :—

Diameter	64	mm.	53	mm. (approximately).
Width of umbilicus	8·5	" (0,13)	6·8	" (0,12)
Height of ultimate whorl	35	" (0,54)	27	" (0,50)
Thickness of ultimate whorl	12·5	" (0,19)	9·9	" (0,18)

In the Introductory Remarks on the genus we have already drawn attention to the fact that Strachey's specific name of *Amm. acucinctus* was extended by Blanford and Stoliczka to forms which are indeed very similar to that species in shape and ornamentation, but on account of their completely divergent lobal structure are assignable to an independent group, strictly marked off from *Amm. acucinctus*. Most of the specimens assigned to *Amm. acucinctus* in reality do not belong to that species, but to the Tenuilobate group. Basing ourselves on the original specimen of Strachey,

reflgured here (Plate IV, fig. 3), and on some others which agree with it in every respect, we may give the following description of *Amm. acucinctus*:—

Test flatly discoidal, made up of high-apertured volutions, displaying a small umbilicus. The sides are at the median stage of growth almost completely even, a slight doming being just traceable towards the external periphery. At later stages, too, the sides remain comparatively flat, but become gradually domed (as may be seen in fig. 2 *d*). The narrow, low umbilical wall dips steeply inward, and is marked off from the sides by a slight yet fairly distinct umbilical rim. The ornamentation consists of extremely fine crescentic striations, which on the external periphery undulate markedly forward, showing, however, but little convexity on the sides. Some of these striations are especially conspicuous, while others are no more marked than mere lines of growth. At the external portion of the sides the crescentic costæ are increased in number by means of intercalary costæ. The extremely narrow external periphery bears a not very prominent keel, closely beset with small serrations. These serrations are especially well developed on the older part of the test, and there they are visible even on the internal cast. As the size increases the cuneiform tendency of the external periphery diminishes somewhat, and concurrently the serrations become less marked. Whether these latter disappear altogether on the body-chamber is not known, as the body-chamber is not preserved. The specimen represented in fig. 2 possesses a diameter of 64 mm., and is chambered up to the end. Another specimen, collected by A. von Krafft, which is unfortunately in a defective state of preservation, is chambered even up to a diameter of at least 95 mm. From this we gather that *Amm. acucinctus* could grow to a considerable size.

The lobal line is at least partly preserved in all the specimens. Both rami of the external lobe diverge so widely that they come to lie not upon the narrow external periphery, but entirely on the sides. The first lateral lobe extends but little deeper down than the external lobe; it passes an almost triangular stem (so much does this broaden out forward) which ends in a long, slender terminal ramus. On each side there spring from the stem of the first lateral three subsymmetrically placed, lateral rami, the branching of which is not very complex. The second lateral lobe extends almost as far down as the first, but, so far as can be ascertained, its structure is less symmetrical. The auxiliaries, which must have been five in number, decrease rapidly in size. The external saddle is very low, and is divided by a long, oblique secondary lobe into a lower external and a higher internal portion. The first lateral saddle projects very markedly forward, but in other respects its structure is similar to that of the external saddle. The saddle-folia are small and well rounded. The lobal extremities are frequently blunt-ended.

The specimens which are to be included in this species agree very well one with the other in regard to external shape, but in some details of the lobal line divergences of subsidiary importance are noticeable. For instance, in one specimen (fig. 3) the external saddle is somewhat narrower, the first lateral somewhat longer, and the lobal extremities more finely pointed than in another (fig. 2). If

better and more completely preserved specimens were available, certain other differences would probably be perceptible, and it does not seem to be altogether impossible that the discovery of more perfect material will at some future time impose upon the palæontologist the necessity of separating specifically the form represented in fig. 2 from the original type of *Amm. acucinctus* (fig. 3).

If we were to take no account of the lobes (which is unfortunately too often done), we might well confuse *Amm. acucinctus* with certain forms of the Tenuilobate group, and especially with *Opp. Griesbachi*. Careful examination, however, reveals sufficient difference, even in the external shape and ornamentation, to justify the separation of the species, for *Opp. acucincta* possesses rather flatter sides, a more oblique umbilical wall, a broader umbilicus, and lines of growth protruding more markedly forward at the external periphery, than *Opp. Griesbachi*. The peripheral tubercles, moreover, are visible on the chambered portion of *Opp. acucincta* even in the internal cast, while in *Opp. Griesbachi* they can only be discerned on the shell.

Opp. acucincta is an offshoot of the *Opp. subradiata* group of forms, for which Waagen in the first instance established the generic designation of *Oppelia*. Concerning the generic position and designation of *Opp. acucincta*, we may refer the reader to the Introductory Remarks on the genus.

Among the specimens described by Blanford in the "Palæontology of Niti" as *Amm. acucinctus*, one alone (Plate XVIII, fig. 1 *b—c*) really belongs to that species. Fig. 1 *a* in Plate XVIII, as Mr. G. C. Crick kindly informs me, is an erroneously combined figure. The view of the sides was drawn from *Amm. acucinctus*, fig. 1 *b*, but it was provided with an apertural margin taken from a small *Opp. pygmæa* (of which only a plaster cast is available). The variety of Blanford's *Amm. acucinctus*, which is called by him *Amm. mundus* (Plate XVIII, fig. 2), probably belongs to *Opp. Lymani*, and the specimen represented in Plate XIX, fig. 4, is clearly shown by the configuration of its lobes to be a small Tenuilobate form.

Four specimens of *Opp. acucincta* lie before us, to which may be added a fifth in the shape of the plaster cast of the specimen described in the "Palæontology of Niti." Out of these, four come from Spiti, and a large specimen collected by A. von Krafft is from the Upper and Middle Spiti Shales of Kuti.

OPPELIA (NEUMAYRIA) NIVALIS, Stoliczka sp.

(Plate VII, fig. 8 *a—d*.)

1866. *Ammonites nivalis*, Stoliczka, Mem. Geol. Surv., India, vol. V, page 106, plate X, fig. 1.

Dimensions :—

Diameter	48	mm.
Width of umbilicus	7	"
Height of volution	25·6	"
Thickness of volution	14·3	"

Of this species we possess only Stoliczka's original specimen, which has been refigured here. To Stoliczka's description very little remains to be added. The sides on first inspection appear to be absolutely smooth, but on closer examination one

may discern faint, crescentic costæ, so faint indeed as to be almost shadowy. In a better preserved specimen, however, they would certainly show much more distinctly. The costæ swell up at the dividing line between the sides and the external periphery into slight tubercles, and on the anterior portion of the test every third or fourth tubercle appears to be somewhat more strongly developed than the others. The rather blunt-edged external periphery is unhappily weathered to such an extent that at the median line the thick sipho is everywhere to be seen; and so we are unable to determine whether a median row of tubercles was present here, as in so many other forms of the genus *Oppelia*.

The septal line consists of the external lobe, the two lateral lobes, three distinct auxiliary lobes, and a small digitation lying close up to the umbilical wall. The external lobe is very short, the first lateral lobe is comparatively narrow and straight, ending up in a slender terminal ramus from either side of which three lateral rami branch off at parallel heights. In this fashion the first lateral lobe assumes a regular, sub-symmetrical form which contrasts strikingly with the crooked configuration of the second lateral lobe, this latter being provided only with external lateral rami. Of a structure similar to, but simpler than, that of the second lateral lobe, the auxiliary lobes diminish rapidly in size towards the suture. The fairly broad external saddle and the first lateral saddle are divided pairwise by secondary lobes; whereas, however, both portions of the external saddle are of about equal size, the outer moiety of the first lateral saddle is smaller than the inner and lies considerably higher up. The much deeper-lying second lateral saddle exhibits two small secondary lobes.

The specimen is an internal cast, chambered up to the end: the body-chamber is unknown.

Stoliczka appears to have regarded the species here described as related to the Dentati. If, however, we consider the flexuous striation, the tubercles on the external periphery, the configuration of the lobal line, and especially also the circumstance that some of the tubercles are rather more strongly developed than others, we shall feel impelled to designate the group of the Flexuose Oppelias, or the sub-genus *Neumayria*, as the one to which *Opp. nivalis* is most nearly allied. There is some difficulty, however, in determining this relationship in its more detailed aspects, as we are hardly in a position to diagnose sufficiently *Opp. nivalis*. Important characteristics, such as those of the external periphery and the body-chamber, are unknown; and these lacunæ in our knowledge are the more deplorable that precisely the Flexuosi, in the course of individual growth, undergo changes so far-reaching that the same individual presents an entirely different appearance, according as it is in the adolescent or in the adult stage.

With the foregoing reservations, I should be inclined to regard the group of *Opp. compsa*[1] as the most nearly allied. In it, for instance, *Opp. lithographica* shows considerable resemblance with *Opp. nivalis*, but the European species possesses a broader umbilicus, more markedly undulating costæ, and an unmistakable spiral band on

[1] To this group, established by Neumayr ("*Acanthicus* Schichten," pages 163 and 164) belong, among others, *Opp. compsa*, Opp., *pugilis*, Neumayr, *nobilis*, Neum., *Holbeini*, Opp., *lithographica*, Opp., *Thoro*, Opp., *Klettgoviana*, Württenb., *Erycina*, Gemm., *Greenackeri*, Mösch., *Franciscana*, Font., and *hemipleura*. Font.

the sides. Moreover, all the tubercles are equally prominent, while in *Opp. nivalis* some are more so than others. This last circumstance especially, and the feebler undulations of the costæ, impel us to look rather to species such as *Opp. compsa* and *pugilis*, which when full grown are beset with extremely prominent tubercles. Fontannes[1] figures a young form of *Opp. pugilis*. Neumayr, from Crussol, which is extraordinarily similar to *Opp. nivalis*. From this we may be permitted to infer, even if we cannot at present determine the exact position of this species, that perhaps *Opp. nivalis* also, when full grown, exhibits a more strongly developed ornamentation than in the young stage (the only stage in which it is so far known). As nearly related forms, we may further mention *Opp. franciscana* and *hemipleura*, Font., but these do not appear to stand so close to *nivalis* as *Opp. pugilis* does. Among the forms of the Indian Katrol Group the only one that could be compared with *Opp. nivalis* is *Opp. kachensis*, Waag.; and despite our insufficient knowledge of the species here described, which makes the determination of these relationships a matter of great difficulty, we have at any rate good grounds for asserting that *Opp. kachensis*, Waag., and *Opp. nivalis*, Stoliczka, are far from being one and the same species.

We have already observed that an exact diagnosis of *Opp. nivalis* is for the present impossible on account of the defective condition of the single specimen by which it is represented, and we must therefore content ourselves with the conclusion that the species evidently belongs to the group of *Opp. compsa*, postponing a more detailed diagnosis to a future occasion.

Opp. nivalis comes from Kibber in Spiti.

Oppelia (Œcotraustes) Adela, sp. nov.

(Plate XLIII, fig. 3 *a—d*.)

Of this species unfortunately but one internal cast, chambered up to the end, is forthcoming. It measures 29·5 mm. in diameter, the breadth of the umbilicus is 8·4 mm., the thickness of the ultimate whorl at the anterior extremity is 8·6 mm., and the height 12 mm. The flatly discoidal test exhibits a fairly blunt-edged carina, upon which traces of serration are discernible. The bad state of preservation of the fossil unhappily prevents us from determining exactly the number and size of the serrations or the tubercles on the external periphery, and it is more especially at the anterior extremity that we find it impossible to ascertain with certainty the characteristics of the keel, as here the shell is in certain parts weathered down to the sipho. On the older portion of the ultimate whorl, on the other hand, we may discern at one point the evident protuberance of the shell into conical tubercles, which correspond to very flat, longish inflations on the internal cast. Unfortunately the figure gives no true idea of these tubercles, as precisely those portions of the keel, which in the apertural and peripheral view are directed towards the onlooker, show such faint traces of the tubercles that they have been overlooked by the draughtsman.

[1] "Description des Amm. des Calcaires du Château de Crussol," page 45, plate VII, fig. 2.

The sides are slightly domed, and somewhat flattened off above. They pass gradually into the obliquely inward dipping umbilical wall. The greatest thickness is at the inner portion of the whorls, near the umbilical wall.

The ornamentation consists of crescentic costæ after the fashion of the Hecticl. On the inner portion of the whorls the costæ are inclined markedly forward; somewhere about the middle of the sides they bend round backward, and disappear somewhat suddenly at the external periphery, without actually giving rise to tubercles. At the point where they bend round, the costæ diminish in prominence. Their number cannot be stated with precision, but at the ultimate whorl about eighteen costæ must have radiated from the umbilicus, whereof some bifurcated and others did not do so.

The lobal line exhibits a remarkable and characteristic configuration. Both rami of the external lobe are widely divergent as in *Hecticoceras*, the first lateral saddle lies high, and the whole line ascends gently towards the suture. In all probability three auxiliary lobes existed, two of these being plainly visible, and the third being hidden by matrix. The lateral lobes possess comparatively long "bodies," from which more short, blunt digitations branch off in the guise of lateral rami. The first lateral lobe, curiously enough, does not end in a single terminal ramus, but in two short almost equally stout terminal rami. The second lateral lobe ends in a single extremity. The auxiliary lobes are small, with very narrow digitations, the saddles have short, broad "bodies" into which the short secondary lobes and the lateral denticulations of the lateral lobes do not penetrate very deeply. The consecutive septations follow one another at rather wide intervals.

The external outline does not describe a regular spiral, but seems at several points to break up into angles. Perhaps in the older portion of the shell this is merely a consequence of the bad state of preservation of the fossil; at the anterior portion, on the other hand, the so-called "constriction" of the whorl takes place precisely at the point where a slight tubercular thickening and heightening of the keel is observable. We may consequently infer that constriction really was simultaneous with the tuberculation of the keel.

The ornamentation and external shape of this remarkable species vividly recall *Hecticoceras*. The lobal line also, considering the breadth of the external lobe and the high position of the lateral saddle, is provocative of comparison with that group up to a certain point, although the characteristics of the first lateral lobe and the feeble development of the lateral rami constitute marked divergences.

Hecticoceras Guthei, Noetl. sp.,[1] from the Upper Jurassic of Mount Hermon in Syria, also *H. chatillonense*, de Lor., and *H. cœlatum*, Coq.,[2] in respect of their ornamentation and external shape, resemble our species so closely that at the first glance one is inclined to infer their near relationship. The differences in the lobal line and the character of the keel are, however, sufficient evidence that these forms are by no means closely allied. Moreover, it is impossible to associate our species

[1] "Der Jura am Hermon," Stuttgart, 1887, page 20, plate II, figs. 6—8.
[2] P. de Loriol, "Oxfordien inf. du Jura Bernois;" Mem. Soc. Pal. Suisse, vol. XXV, 1888, pages 34, 38.

with the Hecticei if only we take into account the existence of a tuberculated keel and the constriction of the ultimate whorl.

Amm. hispidus, Oppel,[1] shows a certain amount of resemblance to the species here described, on account of its crescentic costæ and the tuberculation of its keel. Its peripheral tubercles, however, are much more prominent, the sides bear a spiral furrow, and the configuration of the lobes is so widely divergent, that it is impossible that the two species can be nearly related.

The constriction of the test and the structure of the lobal line give evidence of the approximation of our species to the genus *Œcotraustes*, the so-called "crippled forms" of *Oppelia*.

Among these we discern in *Œco. Salvadorii*, Parona and Bonarelli,[2] a form which has some resemblance to ours, although certain divergences in the lobal line and the absence of carinal serrations in *Œco. Salvadorii*, forbid the inference of a very close relationship. Moreover, we must not overlook the circumstance that in *Œcotraustes* properly so-called (according to Waagen's diagnosis),[3] the constriction is observable on the body-chamber first of all, whereas here it is seen in the chambered portion.

According to all appearance, therefore, we are dealing here with a solitary representative of a hitherto unknown branch of the Ammonites, for which a new genus ought to be established. Unhappily some of the most important characteristics of this new type are unknown, and only a very incomplete diagnosis could be drawn up. Consequently we have refrained from establishing a new genus, preferring to assign this species to an already recognized genus.

Its inclusion in *Neumayria* is impossible on account of its broad umbilicus and its lobal structure, while the serration of the keel equally forbids its inclusion in *Hecticoceras*. If we choose temporarily to assign it to the sub-genus *Œcotraustes*, this at least has the advantage of giving due weight to the constriction of the test and the degenerate lobal structure. The definite classification of this interesting form must be postponed until fresh material is obtained. Some remarks on the generic attribution of this species will also be found in the Introductory Observations on the genus *Oppelia*.

The specimen here described was obtained by Dr. A. Krafft von Dellmensingen from the base of the Spiti Shales in Tera Gadh.

ASPIDOCERAS, Zittel.

In the year 1865 F. Stoliczka included among the fossils of the Spiti Shales *Amm. liparus*, Oppel, and gave a description of it, but omitted to supply any figure. Owing perhaps to this circumstance, Neumayr and Nikitin in discussing the geological age and provincial character of the Spiti fauna omitted to take this species into account, although it is of great importance in this connection. An examination of the specimen has now proved that Stoliczka's determination was correct in so far that we have here an *Aspidoceras* of the *Inflati* group, for which Hyatt has recently

[1] Palæontologische Mittheilungen, I, plate LII, fig. 2, page 193.
[2] "Sur la Faune du Callovien inf. de Savoie," Chambéry, 1895, page 96.
[3] Benecke's Geognost. Pal. Beiträge, vol. II, page 251.

established the generic designation *Physoderoceras*.[1] The relationship of the Spiti species to the European *Aspidoceras liparum* is indeed, as Stoliczka held, very close, although we cannot regard the two forms as specifically identical in the strict sense of the word. As only one specimen of this species is forthcoming, we may reasonably infer that the genus *Aspidoceras* hardly played so important a part in the Spiti fauna as it did in the Upper Jurassic of the Central European and Mediterranean region.

ASPIDOCERAS AVELLANOIDES, sp. nov.

(Plate III, fig. 1 *a—e*.)

Ammonites liparus, F. Stoliczka, Mem. Geol. Surv., India, 1866, vol. V, page 107.

One specimen alone is forthcoming, which, with a portion of the body-chamber preserved, attains a diameter of 67 mm. As it is, however, somewhat compressed at the anterior extremity, the measurements have been taken at the diameter of 63 mm. At this diameter the width of the umbilicus is 11 mm., the height of the ultimate whorl 31·5 mm., and the thickness of the same 36·2 mm. The test is narrowly umbilicate, spheroidally inflated, with stout, externally rounded, domed volutions. The flatly-domed sides pass gradually into the rounded external periphery; they dip vertically inward to the umbilicus with the intervention of a rounded umbilical rim. The greatest thickness lies near but not quite at this umbilical rim: it is a little above it, so that the narrowing of the cross-section only begins above the lower third of the height of the volution. The ultimate whorl is somewhat broader than it is high: the anterior portion of it belongs to the body-chamber.

The shell, only small fragments of which are preserved in a few places, exhibits strongly marked lines of growth. Shadowy traces of these may be seen on the internal cast. Otherwise the shell is smooth. The umbilical rim is beset with short spines, obliquely inclined towards the umbilicus: they arise from slight rounded tubercles. On the ultimate whorl they number from eight to nine. Two spines alone are really preserved, the remainder being broken off close to their tubercular bases. There is, however, no reason for assuming that the broken spines were larger than those which still adhere to the fossil, as the extremely feeble development of the just perceptible tubercles is an indication that the spines themselves can hardly have been very prominent.

The septal line in its main characteristics conforms to that of the so-called Inflati. But the lobal structure of the Indian form is specifically distinguished by the simultaneous occurrence of long and slender terminal and lateral rami with broad, low, and stout lobal "bodies." This may be clearly seen in the ultimate lobal line represented in fig. 1 *d*, although the finest digitations are not perfectly preserved here. To supplement this figure, two of the lines which lie farther back have been represented in fig. 1 *e*. It is true that here only a portion of the first lateral and the second lateral may be traced, but the fine denticulations are better shown than in the ultimate lobal line.

The species just described is founded on the same specimen as that assigned by Stoliczka in 1865 to *Amm. liparus*, Oppel. Regarding the species from a fairly

[1] "Text-book of Palæontology," by K. von Zittel, translated and edited by Ch. Eastman, London, 1900, page 582.

broad point of view, this determination was incontrovertible. If, however, we admit the utility of as close a specific definition as possible, this specimen cannot be retained under *Amm. liparus*. In that species the narrowing of the cross-section begins immediately above the sutural tubercle, and in the Indian form somewhat higher up. Further, *Amm. liparus*, both according to Oppel's first figure,[1] and according to the excellent figures of E. Favre[2] and P. de Loriol,[3] is a stout, full-grown form with extremely prominent spines, and it cannot therefore be put into the same species as the smaller Indian form, wherein the spines are not at all prominent.

Moreover, since the erection of *Amm. liparus* into a species, a form has been described to which the Indian specimen shows much closer affinities than it does to *Amm. liparus*. We refer to *Aspidoceras avellanum*, Zittel. In respect of the external shape and the weakness of the spines the concordance is so marked that one might almost infer complete identity, were it not for some striking divergences in the lobal structure. According to K. von Zittel's figures,[4] *Asp. avellanum* is characterized not only by stout lobal "bodies," but also by stout, rather short, blunt-ended rami, which contrast too markedly with the long, slender, finely-denticulated lateral rami of the Indian form, to permit of assigning both to the same species.

Asp. circumspinosum is also extremely similar in outward shape, but here again the difference in lobal structure forbids identification with our species: the lobal "bodies" in *Asp. circumspinosum* being much narrower and their denticulation more complex.[5] It may well be that the specimen described by Herbich[6] as *Asp. circumspinosum*, is very closely allied to our species: unfortunately the lobal line of the Transylvanian specimen has not been figured, so that detailed comparison is impossible.

All other European species are still more remote from the Indian form. Thus *Asp. Bathori*, Herbich,[7] is differentiated by its broader umbilicus and more markedly rounded whorls, and *Asp. altenense*, d'Orb., by its slender lobal bodies with highly complicated ramification.

Asp. Deaki, Herbich, possesses a much broader umbilicus, narrower and more highly ramified lobal "bodies," and lower whorls. A certain amount of resemblance may be traced also in Quenstedt's *Ammonites inflatus episus*[8] (*non Ammonites episus*, Oppel), but the number of weak tubercles in this species is much greater than in the Indian form, the test is not quite so stout, and flattish undulations characterize the external periphery: a close affinity cannot, therefore, be inferred.

Stoliczka gives the following account of the locality: "In the Spiti Shales near Kibber; rare."

[1] Paläontol. Mittheilungen, vol. I, page 220, plate LIX, fig. 1.

[2] "Fossiles jurassiques des Voirons," Mém. Soc. Paléontol. Suisse, vol. II, [illegible] plate VI, fig. 4.

[3] "Zone à *Amm. tenuilobatus* de Baden," Mém. Soc. Paléontol. Suisse, vol. V, page 114, plate XIX, fig. 1. F. Fontannes has also, it is true, attributed a small species possessing rather weak tubercles to *Aspidoceras liparum*, but this determination cannot be [illegible] authoritative [illegible] des Calcaires du Château de Crussol," page 94, plate XIII, fig. 1).

[4] "Faune des älteren Tithon," page 86, plate XXXI, figs. 2 and 3.

[5] Neumayr, "*Acanthicus* zeichner.," Abhandl. Geol. Reichs., vol. V, page 200.

[6] "Siebenbürgen," page 177, plate XX, fig. 1.

[7] "Siebenbürgen," page 170, plate XIX, fig. 4.

[8] "Ammoniten des Schwäbischen Jura," vol. III, plate CXVI, fig. 18, page 1021.

HOLCOSTEPHANUS, Neumayr.

Of the numerous groups of forms comprised within the genus *Holcostephanus*, only two are represented in the fauna of the Spiti Shales, namely, (1) the group of *Holcostephanus Schenki*, for which we shall use the subgeneric appellation *Astieria* Pavlow; and (2) the groups of *Holcostephanus spitiensis*, *Grotei*, *Stanleyi*, *Cautleyi*, etc.[1] While, however, the first-named group is confined to one single species, *H. Schenki*, Opp., the second group exhibits an unexampled variety of forms.

The available material reveals these two groups as self-contained, sharply distinguishable ramifications of the great Holcostephanine stem. This is all the more remarkable in that various forms of the *H. spitiensis* group had been hitherto unhesitatingly placed with species of the *H. Schenki* and *Astieri* group; while to others, such as *H. Cautleyi*, varying significance had been attached, some observers even placing them in *Hoplites*. We must, therefore, here first of all consider more closely the group of *H. spitiensis*, etc., for which we propose to establish the subgenus *Spiticeras*.

In the Spiti fauna, the subgenus *Spiticeras* is represented by the following species:

Holcostephanus (Spiticeras) Grotei, Oppel sp.
" " *spitiensis*, Blanf. sp.
" " *subspitiensis*, n. sp.
" " *bilobatus*, n. sp.
" " *subbilobatus*, n. sp.
" " *planus*, n. sp.
" " *binodiger*, n. sp.
" " *conservans*, n. sp.
" " *Stanleyi*, Opp. sp.
" " *Mojsvari*, n. sp.
" " *Griesbachi*, n. sp.
" " *Cautleyi*, Opp. sp.
" " *subcautleyi*, n. sp.
" " *bulliformis*, n. sp.
" " *guttatus*, Strach. sp.
" " *obliquelobatus*, n. sp.
" " *Oppeli*, n. sp.
" " *indicus*, n. sp.
" " n. sp. ind.
" " *eximius*, n. sp.
" " *speciosus*, n. sp.
" " n. sp. ind.
" " *scriptus*, Strach.

[1] It is probable that two or three species of the Spiti fauna, which are unfortunately in a defective state of preservation, are assignable to *Simbirskites*, a genus which some observers regard as identical with *Holcostephanus*, or at any rate a subgenus of it. As, however, the *Simbirskites* forms in their general habit differ considerably from the true Holcostephanine forms, it seems to us more suitable to assign to them an independent position in the sense of a distinct genus. We shall discuss these forms on a subsequent page.

The Spiticerata have generally a moderately evolute, more rarely a strongly evolute, shell, discoidal or thickly discoidal, the whorls being externally much rounded and possessing feebly developed sides with a rounded umbilical wall dipping steeply inward. At the point where the sides pass into the umbilical wall are rounded or elongate tubercles, from which start forwardly inclined groups of costæ. The whorls are thickest in the neighbourhood of the tubercles. It has long been known that the costal groups consist each of three to five costæ, some of which start from the tubercles, others starting higher up. Further, that the costæ run uninterruptedly over the periphery or shade off into an angle or curve directed forward; and, finally, that there are deep-cut forward-sloping constrictions.

On the other hand, the following modifications in ornamentation and form of the shell, which have taken place in the course of individual development, have received but scant attention hitherto, for which reason it is proposed to consider them here in some detail.

The innermost whorls are provided with forward-sloping fine costæ, which start from the suture, swell into a slight tubercle on the sides, and here undergo a bifurcation into secondary costæ. At this very early stage of the evolutional development, confined to the innermost core of the whorls, which we may call the "median tubercle stage," the whorls are depressed, much broader than high, and the greatest breadth occurs in the neighbourhood of the median tubercles. Unfortunately this "median tubercle stage" is clearly recognizable only in a very few examples, like those of *Sp. Mojsvari*, *Sp. speciosum* and *Sp. spitiense*.

On exceeding the diameter of 8 to 12 mm. the costæ swell gradually in a tubercular fashion at the suture itself, and thus for some distance two rows of tubercles are discernible: one row of elongate tubercles at the umbilical wall, and a second row of more rounded tubercles on the sides. From the upper tubercles start the bifurcating costæ. This well-marked evolutional stage, which has been hitherto completely overlooked, may well be termed the "double tubercle stage."

Concurrently with the increase in size of the individual, the sutural tubercles, which at the start were less prominent than the median tubercles, become more and more strongly marked; and at the same time the greatest thickness of the shell is shifted from the neighbourhood of the median tubercles to that of the sutural tubercles. The secondary costæ, which at first start from the median tubercles alone, become gradually independent of these, and at the same time lengthen out so as almost to reach the sutural tubercles.

At this stage the median tubercles disappear little by little, while the sutural tubercles, on the contrary, wax prominent, and the costæ now grouped together start from these alone. Therewith we reach the stage of "normal sculpture or ornamentation."

The transition from double-tubercular ornamentation to normal costation takes place in different species at very different stages of growth. Thus, *Sp. guttatum*, *Sp. indicum*, and *Sp. subcautleyi* lose their double tubercles on reaching a diameter of 12 to 15 mm.; other species, such as *Sp. spitiense*, at a diameter of about 25 mm.;

Sp. binodiger at 44 mm., on the very threshold of the body-chamber; and *Sp. Stanleyi* at a diameter varying from 45 to 50 mm. An extreme form, *Sp. conservans*, retains the primitive double-tubercular ornamentation up to the diameter of 67 mm., and in consequence assumes an appearance which differentiates it considerably from the ordinary type. Slight swellings, corresponding to the median tubercles, may, on attentive scrutiny, be traced right up to the body-chamber of one species, but in others every trace of the median tubercles is lost. In some species the median tubercles are very highly developed; while in others, as, for example, *Sp. guttatum*, they are barely indicated. Nevertheless, although it is evident from the foregoing remarks that the evolution of the double tubercle stage is subject to many vicissitudes, yet as regards the greater number of species of the subgenus *Spiticeras* (16 out of 22), it is plainly demonstrable that this is a regular evolutional stage, characteristic of the entire subgenus, at any rate in its Indian habitat, and that it must not be regarded as a more or less fortuitous variation.

In the normal stage the ornamentation consists of a varying number (16 to 27) of prominent, generally elongate, sutural tubercles, from each of which starts a group of costæ consisting of 3 to 5 ribs. The prominent but rounded costæ are inclined forward, sometimes straight, sometimes bent a little forward on the external periphery. The majority of the costæ in each group (2 or 3) start direct from the tubercles, the lesser number (1 or 2) arise higher up by bifurcation. The foremost costa of each group is the most strongly inclined forward; behind it arises invariably a small bifurcation rib. It is not always possible to distinguish clearly the group of costæ assignable to one tubercle from the neighbouring group, because occasionally a short intercalar costa thrusts its way in between every two groups of costæ. The costæ of one side unite on the external periphery with those of the other side, and describe here an angle or curve directed forward: in some cases this is very strongly marked, in others but feebly, but at the very least there is always an indication of it. In most species the costæ continue with undiminished prominence over the external periphery; but in some, as, for instance, in *Sp. Cautleyi*, there is a slight tendency to enfeeblement along the median line. In other species, again, the costæ on one side do not correspond exactly with those on the other, and in such cases the costæ break off abruptly at the median line and are "faulted" against each other around the intercostal area. This may be clearly seen, for instance, in *Sp. conservans* (Plate XIV, fig. 2) and in the young volutions of *Sp. Stanleyi* (Plate XVI, fig. 1 *c*). But there is never a real interruption of the costæ, as in *Hoplites* or in the Tithonian externally grooved Perisphinctidæ. On every whorl occur two or three strongly marked, deep constrictions, inclined forward. As a rule, these are bordered behind by a very prominent costa and in front by one which is but feebly marked. On account of the very much steeper forward inclination of the constrictional costæ the group of costæ next to the hinder constrictional costa occupies a broader area than the other groups of costæ. Wherefore this group consists of a larger number of ribs (6 or 7), whereof two, in the guise of very short intercalar ribs, are cut off in the angle by the constrictional costa.

As it has already been stated, the normal ornamentation described in the foregoing paragraph begins at varying stages of growth, and continues generally until very near the further end of the body-chamber. Then only do variations come in, and these of but slight consequence. In *Sp. Mojsvari* the tubercles lose in definition, passing into coarse or stout primary costæ (see Plate XVII, fig. 1). In *Sp. speciosum* (see Plate XI, fig. 2) the tubercles seem to vanish almost entirely. But in most species the change (as far as one knows) is limited to enfeeblement and multiplication of the costæ, elongation of the tubercles, and obliteration of the definite inter-dependence of tubercles and costæ.

In the course of individual evolution regular modifications take place in the cross-section of the whorl and the form of the test of Spiticerata. Concurrently with progressive growth the whorls increase more rapidly in height than in thickness. The inner whorls, broad and depressed, are gradually succeeded by whorls increasing in height, until they may finally become higher than broad. At all stages the greatest thickness is manifest in the neighbourhood of the umbilical tubercles, but the external side, originally somewhat broadly rotund, as growth progresses gradually narrows, until finally at the body-chamber it is more or less distinctly sphenoidal. The umbilicus itself broadens towards the body-chamber. The most extreme examples of this mode of development are the forms of smaller growth, such as *Sp. spitiense*, *Sp. subspitiense*, *Sp. planum*, and *Sp. speciosum*. In these, the variations, coincident with growth, of the body-chamber are not confined to angulation of the outer periphery, but the body-chamber is positively narrower at its frontal extremity than in the middle or at the hinder end, with the result that there is an actual and not unimportant constriction of the body-chamber. In forms of medium size (such as *Sp. Cautleyi*) and in those of large diameter (such as *Sp. Mojsvari* and *Sp. Stanleyi*) this change in the sectional area is less noticeable, but it takes place all the same. In *Sp. eximium* the outer periphery becomes sphenoidal at the penultimate whorl: in the frontal portion of the body-chamber the sectional area becomes rounded and almost ovoid (see Plate XVIII, figs. 3 *c*, 3 *d*). It is only in a very few species, such as *Sp. bilobatum* and *Sp. indicum*, nov., that the changes in sectional area appear to be insignificant. It is not yet possible to formulate a definite judgment in this matter: nevertheless, we must bear in mind its importance as regards the characterization of the subgenus *Spiticeras*.

The length of the body-chamber in *Sp. Stanleyi*, as Oppel has already remarked, is well-nigh that of a complete volution. *Sp. bulliforme* boasts the same length of body-chamber, and in fact similar relative dimensions of body-chamber may probably be assigned to most other forms. Unfortunately the bad condition of preservation is a bar to a definite pronouncement in this matter. It is true that in several species a portion of the body-chamber has been preserved; but the oral (or buccal) border is known only from three examples, in which, on the other hand, the last lobal line is not clearly recognizable. Thus much at all events may be safely inferred: the body-chamber takes up at least three-quarters of a volution, and to this rule even the forms of smaller growth, such as *Sp. spitiense* and *Sp. subspitiense*, constitute no exception.

The oral border is partly known only in *Sp. Cautleyi*, *Sp. subcautleyi*, and *Sp. eximium*. In these it is accompanied by a sharp constriction, and passes into an auricular prolongation. It is not at present possible to determine whether the forms of larger growth, such as *Sp. Stanleyi* and *Sp. Mojsvari*, were provided with an oral border having lateral auricles. This is a point of great interest, when one bears in mind that the nearly related *H. Astieri* exhibits a kind of dimorphism, as it includes large, slender forms unprovided with auricles, and smaller, stouter forms which are provided with auricles.

The lobal line consists of the peripheral lobe, the two lateral lobes, and the three auxiliary lobes which are joined to an obliquely pendent sutural lobe. The peripheral lobe is invariably longer than the first lateral lobe: the latter is of subsymmetrical form, and comprises a terminal ramus and at all times three large lateral rami. The second lateral lobe is conspicuous for its extreme variability: sometimes its lateral rami are but feebly developed and it ends off in a slender terminal ramus; in other cases the lateral rami extend to a considerable length and display complicated denticulation. In several species, indeed, one of the lateral rami extends to the length of the terminal ramus, giving to the second lateral lobe an unusual bifurcate form; of this *Sp. bilobatum* and *Sp. subbilobatum* may be cited as furnishing good examples. The first and second lateral saddles are separated by a secondary lobe; while in the external saddle two secondary lobes are intercalated, an outer short lobe and an inner long one. In many species the second lateral lobe already shows an oblique position, but much more is this observable in the pendent sutural lobe formed from the auxiliary lobes. The first auxiliary lobe is situated at the row of tubercles, but extends for varying distances over the sides of the shell. The "body" of the first auxiliary lobe forms an angle with the second lateral lobe, sometimes running down only as far as the apex of the second lateral lobe, sometimes going down very much lower. The second auxiliary lobe is very short, and but slightly denticulated; the third lies immediately next the suture, consisting, in the case of some species, such as *Sp. spitiense*, of only one small denticulation, while in others it consists of three denticulations. The inner lobe is known in one species alone (see plate XV, fig. 36).

The lobal line assumes extremely variable forms, and that even in species where the shape and ornamentation of the shell are very similar: this is a peculiarity to which Blanford has already drawn attention. For instance, while *Sp. spitiense* exhibits slender and long lobes with short lateral rami, *Sp. subspitiense* has short lobes with long lateral rami, and the second lateral lobe shows on the left side of the shell a bifurcate termination. The peripheral and second lateral saddles are very broad in many forms; while in others, owing to the penetration of greatly developed lateral rami and the marked prominence of auxiliary lobes, they assume a narrow and much indented outline. It has already been mentioned that the evolution of the second lateral lobe is very variable; and the auxiliary lobes are sometimes greatly developed and much pendent (as in *Sp. obliquelobatum* and *Sp. indicum*), while in other cases they are less prominent and do not extend so far

shown (see in *Sp. spitiense*, *Sp. Stanleyi*, etc.). In a somewhat abnormal form, namely, *Sp. indicum*, sp. nov., the first lateral lobe terminates, moreover, in two short bifurcate apices, and the auxiliary lobes are less obliquely placed and less intimately conjoined than is the case in other species (see plate XI, fig. 4 *c*). The lateral rami branch out sometimes at a right angle, sometimes at an acute angle, from the lobal "trunk." In most species the intervals between consecutive lobal lines are slight, in *Sp. conservans* alone are the septal walls far apart (see plate XIV, fig. 2 *d*). Finally, the lines on either side of the same shell exhibit certain differences, especially in the evolution of the second lateral lobe and of the auxiliary lobes. Nevertheless, there is no difficulty in tracing the fundamental type underlying these endless modifications.

The Spiticerata are remarkable for the wealth of individualization of types expressed in the circumstance that almost every specimen represents a distinct form of itself. But few species are known from several examples and even these do not always in all respects agree one with the other. Many species, such as *Sp. speciosum*, *Sp. eximium*, *Sp. abnormalobatum*, are completely isolated; and even among the remaining species it is difficult to establish natural groups based on mutually common characteristics. The character of the lobal line alone constitutes a possible standard. In quite a number of species the lobal line is characterized by broad saddles and feebly developed, barely pendent sutural lobes. In other species, however, the saddles are narrow and much "slashed" or indented, the auxiliary lobes are more distinctly pendent than the second lateral lobe, and are prominently developed. The first group possesses invariably a very broad peripheral saddle, while on the other hand in some species the first lateral saddle may be apparently compressed (or narrowed in) at the base. Although especially the group characterized by more simple lobal structure may include extremely various forms, the classification selected in the present instance appears to be the only one capable of facilitating a general view of these forms. It is proposed, therefore, to distinguish them as follows:—

I.—Forms with a broad saddle, and slightly pendent, feebly developed auxiliary lobes—

(*a*) Forms of larger growth—

Sp. Stanleyi (Oppel). M
Sp. Mojsvari, sp. nov. M

(*b*) Forms of medium and smaller growth—

Sp. spitiense (Blanf.).
Sp. subspitiense, sp. nov.
Sp. Grotei (Oppel).
Sp. bilobatum, sp. nov. M
Sp. subbilobatum, sp. nov.
Sp. binodiger, sp. nov. M
Sp. planum, sp. nov.
Sp. conservans, sp. nov.
Sp. Cautleyi (Oppel). M
Sp. subcautleyi, sp. nov. M
Sp. Griesbachi, sp. nov. M
Sp. scriptum (Strach.).
Sp. bulliforme, sp. nov. M

II.—Forms with narrow slashed saddles and deeply pendent, strongly developed auxiliary lobes—

Sp. obliquelobatum, sp. nov.
Sp. Oppeli, sp. nov.
Sp. indicum, sp. nov.
Sp. guttatum (Strach.).
Sp. sp. nov. indet.

III.—Isolated and extreme forms—

Sp. eximium, sp. nov.
Sp. speciosum, sp. nov.
Sp. nov. indet.

It is not proposed to lay great stress on the foregoing purely provisional classification, particularly when it is remembered that the occurrence of dissimilar lobal structure in forms which show great external resemblance, nay almost identity, such as *Sp. spitiense*, *Sp. subspitiense*, and *Sp. sp. n. indicum*, seems to prove that precisely in the Spiticerata the lobal line exhibits somewhat less uniformity than is the case with other groups of ammonites.

The isolation of several forms, and the difficulty experienced in grouping them more closely, contrasts markedly with the general "compactness" of the whole "stem" of the Spiticerata. The undoubtedly close relationship of these forms has been already rightly recognized by F. Stoliczka,[1] and his recognition of this fact was so uncompromisingly clear that he had no compunction in lumping together into one species all the then known species of these groups, such as *Amm. spitiensis*, *Amm. Grotei*, *Amm. guttatus*, *Amm. Stanleyi*, *Amm. Cautleyi*, *Amm. scriptus*—that is, in part forms of very different habit. Yet in its way Stoliczka's interpretation was thoroughly justified, for the recognition of close inter-relationship betwixt various forms must find its outward expression in a simplification of nomenclature. While, however, Stoliczka endeavoured to secure this simplification by bringing together many forms into one species, we think that the same ultimate goal is to be reached by establishing a subgenus. For the rest we think that it is imperatively necessary to describe and define each distinct form.

The second principal group of the genus *Holcostephanus* represented in the Spiti fauna, is, as has been remarked already, but scantily developed: indeed, it is represented there by one species alone, *H. Schenki* (Oppel). In areas foreign to India, the group is represented by *H. multiplicatus*, Roem., *H. psilostomus*, Neum. and Uhl., *H. Baini*, Sharpe, *H. Atherstoni*, sp., *H. Astieri*, Orb., *H. Sayni*, Kilian,[2] *H. Jeannoti*, Orb., *H. Douvillei*, Nickles, *H. sulcosus*, Pavl., *H. mittreanus*, Orb., and *H. perinflatus*, Math.

The relationship of this group with the Spiticerata finds its expression in several characteristics. In it also constrictions inclined forward and sutural tubercles are present, from which start groups of costæ. Here, too, the outer periphery is rounded, and the umbilical wall steep. On closer examination, however, many points of difference reveal themselves. If in the case of *H. Schenki* the umbilicus is narrower

[1] Mem. Geol. Surv. India, V, page 102.
[2] Bull., Soc. Geol. France, ser. 3, vol. XXIII (1896), p. 976.

and deeper, the shell still more swollen; if the costæ show a more gentle forward inclination, forming no angles on the periphery;—these may perchance be characteristics which will not hold good when a wider knowledge of the group in question is attained. On the other hand, three points of difference are noticeable, the significance of which is evidently far greater. In the individual evolution in *H. Schenki* not a trace of the double-tubercular stage is discernible; the body-chamber shows no sectional constriction; and the lobal line exhibits but few essential variations. The saddles, including the peripheral saddle, are very narrow, nor are they split up by secondary lobes; the auxiliary lobes are either not pendent at all, or much less so than in the Spiticerata, and they are not conjoined to a sutural lobe.[1]

In the median normal stage alone, which we have more numerous opportunities of observing than any other, does the ornamentation of the Spiticerata exhibit similarity to that in the *Astieri-Schenki* group. If, on the other hand, we follow attentively the costal evolution to the very innermost part of the shell, we shall find that the tubercles of the normal stage are, strictly speaking, not homologous in both groups, for in the *Astieri-Schenki* group they correspond to the median tubercles, while in the Spiticerata they correspond to the inner tubercles of the primary costæ.

Unfortunately the forms which belong to the group of *H. Schenki* are not very accurately known, although some of them, such as *H. Astieri*, are reckoned among the most frequently mentioned ammonites. In the case of several species the lobal line, for instance, is absolutely unknown. Here, if one is dependent solely on the literature, and is not in a position to make a complete monograph on the group, one is treading on rather unsafe ground. Nevertheless, certain particularities enable us to conclude with a fair degree of probability that the above-mentioned group is differentiated from the Spiticerata by sundry essential characteristics. *H. multiplicatus*, Roem.,[2] exhibits a lobal line typically similar to that of *H. Schenki*, with narrow lobes and narrow saddles, unaccompanied by the bifid separation by secondary lobes; while *H. Astieri* unites with similarity of shell-form and ornamentation the absence of a double-tubercular stage, and here, too, the lobal line is coincident with that of the *Schenki* type.

The severance of the *Spiticeras* ramification from the group of *H. Schenki* and *Astieri*, which is a natural outcome of the study of the Spiti fauna, in part overrides the views which have been hitherto held regarding these groups of forms. It is very generally considered that they are closely related, an opinion to which A. Pavlow has given formal expression by bringing together *H. spitiensis* and *Grotei* with *H. Astieri*, *Schenki*, *Atherstoni*, etc., into one group under the subgeneric designation of *Astieria*.[3] On examining more nearly the grounds for this classification, we soon find, however, that they are based exclusively on a certain amount of similarity of outward form and ornamentation in the normal stage. The evolution of the inner whorls, the characteristics of the body-chamber, the lobal line; in a

[1] The figure of the lobal line of *H. Schenki* in plate XVIII, fig. 2 *e*, shows the auxiliary lobes in a more inclined position than is the case in nature.

[2] *Cf.* Neumayr and Uhlig, "Hilsammonitiden," Palæontographica, vol. XXVII, p. 22, plate XXXIII, fig. *é*.

[3] "Argiles de Speeton," Bull. Soc. Imp. Nat. de Moscow, 1892, p. 183.

word, precisely those points which are genetically decisive have been in this case for the most part ignored. The similarity of ornamentation may be conditioned by adaptivity, and comes in as an indicator of convergence even in widely separated branches the Holcostephanine stock, nay, in far more remotely separated ammonites.

As no true passage from the *Astieri* to the *spitiensis* type has hitherto been proved, we see no reason to neglect the light which the wealth of material available from India throws upon the subject. The definite differentiation which we have been able to establish as between the Spiticerata on the one hand and the group of *H. Schenki* on the other, calls for recognition in the nomenclature. For this purpose we propose to found a particular subgenus, under the name of *Spiticeras* subgen. nov., embracing the group of *H. spitiensis*, *Grotei*, *Stanleyi*, etc., while we shall use for the group of *H. Astieri*, *Schenki*, *multiplicatus*, etc., the subgeneric name of *Astieria* already established by A. Pavlow. The mutual genetic relationship of these two subgenera cannot be determined more closely at present, as the material thus far available is insufficient. Later on it may prove possible to determine intermediate forms, exhibiting a combination of some of the characteristics of one group with some of those of the other: and thereby the genetic relationship of these subgenera would perhaps become more clearly apparent.

The diagnoses may be briefly summarized as follows:—

SPITICERAS, sub-genus nov.

Moderately evolute, seldom strongly evolute, discoidal and thickly discoidal shell, whose volutions are at first broadly compressed, but later on increase more markedly in height than in thickness and form a rounded or knife-edged periphery. Umbilical wall rounded, dipping steeply inward. Greatest thickness at the umbilical wall. The normal ornamentation consists of a varying number of sutural tubercles whence start groups of 3 to 4 generally straight secondary costæ rather strongly inclined forward. Of these ribs at least two or three start from the tubercles, the remainder starting higher up by bifurcation and intercalation. On the inner whorls the normal ornamentation is preceded by the double-tubercular ornamentation, and this again on the innermost whorls is preceded by the median tubercular ornamentation. The costæ form a more or less clearly marked angle on the periphery. On each whorl are two or three deep constrictions, strongly inclined forward. The body-chamber is longer than three-quarters and shorter than a whole whorl. At the periphery it inclines to a wedge shape, and is very markedly narrowed in several species. Ornamentation of the body-chamber but slightly altered. Buccal margin in three species shows deep constriction and an auricular extension.

The lobal line consists of the peripheral lobe, two lateral lobes, and three auxiliary lobes conjoined into a pendent sutural lobe. The peripheral lobe is longer than the first lateral lobe. The saddle is generally broad, divided pair-wise by secondary lobes. The second lateral lobe sometimes branches off into two bifurcating rami. Types: *Holcostephanus spitiensis*, *Stanleyi*, *Cautleyi*, *guttatum*.

ASTIERIA, Pavlow, emend. Uhlig and F. Suess.

Shell rather strongly evolute, discoidal or inflated. Umbilicus generally deep; umbilical wall rounded, somewhat steep or dipping very steeply inward. Periphery rounded, thickest at the umbilical wall. The ornamentation consists of a varying number of primary costæ which start from the suture, and at the passage from the umbilical wall into the sides swell up into tubercles. From these tubercles start groups of secondary ribs, which bifurcate higher up and admit of intercalary ribs. A double-tubercular stage is not present. On each whorl there are generally two or three deep constrictions strongly inclined forward. The costæ go right across the periphery without any diminution in prominence. The body-chamber exhibits no essential alteration of the cross-section. Oral margin with a deep constriction, probably dimorphous: in small forms provided with an auricular prolongation, in large forms without any.

The lobal line consists of the peripheral lobe, two lateral lobes and three auxiliary lobes, these latter being placed somewhat obliquely, independent, and not conjoined to an oblique sutural lobe. Saddle deeply crenulated, narrow, not divided up by secondary lobes. Types: *Holcostephanus Schenki*, Opp., *n. multiplicatus*, Roem., *Astieri*, Orb.

Both subgenera are remarkable for their wide geographical distribution. The sub-genus *Astieria* is known not only from India and Europe, but also from North and South Africa, and, according to A. Pavlow, it also occurs in the Shasta Group of California.[1] As far as present-day knowledge extends, the subgenus *Spiticeras* is most highly developed in the Himalayan region. Next in importance comes Argentina, from the Tithonian of which country A. Steuer has described five species apparently assignable to *Spiticeras*, namely: *H. fraternus*, Steuer, *H. Bodenbenderi*, Steuer, *H. depressus*, Steuer, *H. Damesi*, Steuer, and *H. Grotei*, Opp. The lobal lines of these forms, in so far as they have been figured, agree perfectly with those in the Indian type, and similarly the ornamentation shows a remarkable resemblance. Nor did this resemblance with our Himalayan forms escape Steuer's attention, for he made comparisons between *Amm. Cautleyi* and *Amm. Grotei*. Only one species was described by him as *Stephanoceras*, and that was *H. Damesi*, wherein the double-tubercular stage persists up to the diameter of 95 mm. or thereabouts. This species is of particular interest, because, like *Sp. conservans*, it illustrates the significance of the tubercular ornamentation in the diagnosis of the Spiticerata.

Apropos of the Argentine Spiticerata, the occurrence of this subgenus in Mexico is of considerable interest.[2] From that country Felix describes, in *H. Zirkeli*, a species similar to *Sp. Stanleyi*, in which also the double-tubercular stage plays for a long time a predominant part in the ornamentation of the shell.

In Europe we may link on to the Spiticeratan stem a long-known form from the Tithonian of the Crimea, whose near relationship to *Sp. spitiense* had already

[1] *Op. cit.*, p. 139.

[2] Palæontographica, vol. XXXVII (1891), plate XXIX, fig. 2, and page 182.

been rightly recognized by Stoliczka,[1] namely, *H. Theodosia*, Desh. Retowski[2] has recently described this form, and has added a second, nearly related species, *H. obliquenodosus*.[3]

Among the West European forms those which recall most vividly the normal stage of the Spiticerata are *H. Negreli*,[4] *H. ducalis* (Math.), *H. norbonensis*, Pictet, *H. Stenonis*, Gemm., and *H. polytroptychus*, Uhl.,[5] but neither the lobal line nor the individual evolution of these species is thoroughly known. *H. gratiopolitensis*, Kil.,[6] from the Valanginien of Fontanil, appears also to belong to this group as an independently specialized form.

Further, *H. pronus*, Opp., from the Stramberg limestone is unmistakably nearly related to the Indian Spiticerata.[7] In this species, above all, one would expect a similar course of evolution in the young individual to that which obtains among the Indian forms, but it so happens that an entirely different stage of young growth has been proved beyond a doubt in this species. According to K. von Zittel,[8] in *H. pronus* all the costæ on the first three volutions are simple, later on some bifurcate into two and then into three rami. Toucas[9] also designates the costæ of the inner whorls in this species as simple.

Finally, we must also mention here the various forms introduced into European literature as *Amm. Grotei* and *Amm. Cautleyi*, which will be referred to again in the detailed description. To K. von Zittel is due the credit of having first recognised the near relationship of the Indian *H. Grotei* to a Stramberg species and also to the forms from the Tithonian and lowermost Neocomian described by Pictet as *Amm. Astieri*. If we do not now consider the identity of these European forms with the Indian *Amm. Grotei* as complete, but prefer in the meanwhile to speak only of very near relationship, this does not imply so much the rejection of Zittel's view as a modification of it resulting from the greater perfection of the new finds. Thus, for example, the large Stramberg specimen figured by K. von Zittel as *Amm. Grotei* (*op. cit.*, plate XVI, fig. 1) is without a doubt specifically distinct from *Sp. Grotei* of the Spiti shales, as we shall show when describing the last-named form in detail. On the other hand, the first-named, which should be once more assigned to Oppel's *Amm. celsus*, shows a striking resemblance to the normal stage

[1] Mem. Geol. Surv. India, V, p. 105.

[2] Bull. Soc. Imp. Naturali, Moscow (1893), pp. 249-250.

[3] The lobes were not described by Retowski. Consequently we take this opportunity of pointing out that in a specimen in the State Collections at Munich an oblique, pendent, strongly developed auxiliary lobe may be observed, duly characteristic of the Spiticerata. The double-tubercular ornamentation has not been preserved in the fragment to which we refer, but from Retowski's figure it may be safely assumed that the normal ornamentation only begins at a diameter of about 35 mm., and that strong primary costæ are present on the innermost whorls, recalling vividly the double-tubercular stage.

[4] *Cf* W. Kilian, "Mission d' Andalousie," p. 646, plate XXVII, fig. 5 (*H. Negreli*, Math., *H. Barroisi*, Kilian); Toucas, Bull. Soc. Géol. France, ser. 3, vol. XVIII, p. 597, and plate XV, figs. 17-18.

[5] Jahrbuch der k. k. geol. Reichs-Anstalt, vol. XXXVII (1887), plate V, fig. 4 and p. 106.

[6] Bull. Soc. Statistique du Dept. del Isère, Grenoble, 1892, ser. 3, vol. XIV, plate II, and p. 4.

[7] *H. pronus*, according to W. Kilian, corresponds probably to the inner volution of *H. norbonensis*, Pict., Bull. Soc. Géol. France, ser. 3, vol. XXIII, p. 679.

[8] "Cephalopoden der Stramberger Schichten," p. 92.

[9] Bull. Soc. Géol. France, ser. 3, vol. XVIII, p. 596.

of the Indian Spiticerata. Then, too, the forms described by Pictet as *Amm. Astieri*, particularly that figured in plate XXXVIII, fig. 8, of the "Mélanges paléontologiques," recall vividly the normal stage of *Spiticeras*: unfortunately neither the lobes, nor the young volutions, nor the body-chamber of these forms are known.

Furthermore, the form from Fcverò di Velo in the Veronese, described by several authors as *Amm. Grotei*, is very closely related to the Indian Spiticerata. We possess in the Munich Palæontological Collections unfortunately only a few specimens, extremely defective for comparative purposes. Among the Indian forms *Sp. planus* especially shows a marked resemblance to the Veronese species, the specific distinction of which from *H. Grotei* has been duly recognized by E. Haug.[1]

There is then no doubt that in the Tithonian of Europe several forms occur which in the stage of normal ornamentation correspond remarkably well with the Indian Spiticerata. Unfortunately, however, the determination of the nearer relationship between these European and the Indian forms is at present a matter of no small difficulty on account of our defective knowledge of the first-named. The evolution in the young stage is known only in *H. pronus*, Opp., and it takes a notably different course from that which prevails in the case of the Indian Spiticerata. Whether all the above-mentioned European forms are innocent of the evolution in the young stage demonstrated in the case of the *pronus* type, or whether some of them go through a double-tubercular stage, after the fashion of the Himalayan forms, is a question to which at present we can give no answer.

A similar difficulty lies in our path if we attempt to lay the foundations for a scheme of the phylogeny of the Spiticerata and their relationship to the Astieriæ. If we apply in the usual way the fundamental phylogenetic law to the Spiticerata, and regard the double-tubercular ornamentation of the inner whorls as a palingenetic phenomenon, it will be necessary to assume that these forms arise from ancestors whose test-ornamentation corresponded to the double-tubercular stage of the Spiticerata. Such types, however, have not hitherto been recorded, so far as we know, from the Middle and Lower Malm. The *Anceps* group of the Kelloway stage is of no consequence here, on account of its entirely distinct lobal line and its deep peripheral groove. Greater probability of a long ancestry for the Spiticeratan branch is afforded by the examination of an off-shoot of that group which is so widely spread in the Oxfordian and Kimmeridgian, and comprises *Amm. involutus*, Quenst., *A. primerus*, Opp., *stephanoides*, Opp., *Strauchianus*., Opp., *Rolandi*, Opp. Neumayr originally assigned this group of forms to *Perisphinctes*, and later on to *Holcostephanus*, guided by the principle "that at the point where a new genus branches off, the line of demarcation must be so drawn that it begins where the generic characters first reveal themselves clearly if not very markedly."[2]

The forms just enumerated are not only characterized by a lobal structure typically corresponding to that of *Spiticeras*, and a similar external shape, but also by ornamentation very closely allied to the ornamentation of the Spiticerata.

[1] Jahrbuch der k. k. Geol. Reichs., vol. XXXVII (1887), p. 277.
[2] Palæontographica, vol. XXVI (1881), p. 20.

Supposing we regard the involutus group as the parent stem of the Indian Spiticerata, we shall certainly be obliged to consider the double-tubercular ornamentation as a caenogenetic, and not as a palingenetic, phenomenon; we shall have to look upon this ornamentation of the inner whorls as newly acquired—an acquisition, however, which was common to all the Spiticerata in the Indian-Tibetan region, and probably to those in the Pacific region. This view would considerably lighten the task of explanation of the position of the European Spiticerata: for if it be true that the double-tubercular ornamentation of the Indian Spiticerata is a caenogenetic phenomenon, the same statement must hold good for the differentiated ornamentation which demonstrably exists on the inner volutions of *H. pronus*. It may be that this *pronus* type of inner whorls is not peculiar to *H. pronus*, but will be found to occur in other European species, which would then possibly, as an European race of *Spiticeras*, constitute an off-shoot of the Indo-Pacific group. If this be so, the European and the Indo-Pacific species, despite the marked difference in youthful evolution, could all be grouped together into one genus. The diagnosis of the sub-genus *Spiticeras*, set out on an earlier page, would then have to be so modified that the young *pronus* ornamentation takes its place on the innermost whorls beside the double-tubercular ornamentation.

The questions which have been here discussed, as also the problems connected with the branching-off of the *Astieriæ* and their near relationship to the Spiticerata, can be settled only when minute and comprehensive investigations have been made at least as regards the European forms of these genera. It would seem that we are dealing here with one of those cases in which the difficult distinction, big with consequences, between inherited and newly acquired characteristics of the young stage, will be ultimately determined with satisfactory accuracy. The more fervently, then, must we wish that the present gap in our knowledge may soon be repaired.

1st GROUP.

Forms with broad saddles and slightly pendent feebly developed auxiliary lobes.

HOLCOSTEPHANUS (SPITICERAS) SPITIENSIS, Blanford sp.

(Plate VIII, figs. 1 *a—c*, 2 *a—c*, 3 *a—e*.)

1863. *Ammonites spitiensis*, Blanford. Journal of the Asiatic Society of Bengal, Calcutta, vol. XXXII, plate II, fig. 4, p. 131.
1866. *Ammonites spitiensis*, F. Stoliczka. Mem. Geol. Surv. India, Calcutta, vol. V. p. 102.

Dimensions :—

	Blanford's specimen, chambered.	Specimen of body-chamber from Lochambelkichak.
Diameter	56 mm.	95 mm.
Breadth of umbilicus	21·5 „	[illegible] „
Thickness of the last whorl, measured at the tubercles	25·5 „	—
Height of the last whorl measured over the suture	19·3 „	—

Besides Blanford's original specimen, chambered to the end, we may assign to this species two other examples wherein the body-chamber is preserved, and we are therefore in a position to give a more complete description than has hitherto been possible.

The volutions of the chambered portion of the shell are broader than high, enfolding one another for about half of their course, and show their greatest thickness in the neighbourhood of the sutural tubercles. The sides pass with a gradual decrease of thickness into the periphery. The umbilical wall is rounded, and dips rather steeply inward. The innermost whorls have a broad, compressed cross-section, but coincidently with progressive growth the cross-section gradually changes to the advantage of the height of the whorls, a change which becomes especially conspicuous from the diameter of about 48 mm. onward. This condition of growth is yet more strikingly expressed in the body-chamber which begins about the diameter of 58 mm. Here the increase of thickness not only lags relatively behind the general rate of growth, but in the foremost portion of the body-chamber is absolutely somewhat less than in the middle, so that an increase in height of the shell is concurrent with a narrowing of the body-chamber. Of the amount of this narrowing the figures give some idea, as also the following numerical details: the specimen from Lochambelkichak (plate VIII, fig. 1 *c*) shows in the median portion of the body-chamber, with a height of 24·6 mm., a thickness of 31·5 mm. (measured at the tubercles). In the foremost portion of the body-chamber the thickness decreases to about 25 mm., while the height increases to about 33 mm. A similar relationship is observable in the specimen from Spiti (plate VIII, figs. 2 *b* and 2 *c*).

Here the thickness of 27·3 mm. at the median portion of the body-chamber is reduced to 26·1 mm. in the foremost portion, while the height concurrently increases from 22·3 to 27 mm. In consequence of this alteration in cross-section, the body-chamber has well-developed sides, and the periphery gradually assumes a wedge shape. Furthermore, the umbilicus is slightly widened in the foremost portion of the body-chamber, and the umbilical wall here slopes much more gently to the suture than in the hinder portion of the body-chamber and in the air-chambers.

On the two last whorls there are 16 or 17 tubercles at the umbilical wall, from each of which starts a group of costæ numbering 4, or more rarely 5. The foremost costa of each group is generally somewhat more strongly inclined forward than the hinder costæ, and is also, as a rule, more clearly conjoined than the others with the tubercles. The hinder costæ of each group in part start higher up by bifurcation and intercalation, and in part from the sutural tubercles. Here and there, too, a short intercalary costa thrusts itself between the groups of costæ. The costæ are rounded but strongly marked, somewhat inclined forward, and at the peripheral extremity swing forward. At the periphery they encounter the costæ of the other side, forming with them a small angle. A fading-off of the costæ on the periphery appears to take place only at the body-chamber where, indeed, it is but slightly perceptible. In the foremost portion of the body-chamber the tubercles are elongated, drawn out, and, in the specimen from Spiti, markedly dwindling away.

The inner whorls exhibit that ornamentation which in our introductory descrip-

tion of the genus we have designated median and double-tubercular ornamentation. On the innermost whorls primary costulæ are developed which extend up to the suture, and then at the outer extremity at the point of costal bifurcation swell up into moderately prominent conical tubercles. With an increasing diameter these main costæ at their inner or sutural extremity gradually pass into elongated protuberances, so that with a diameter of about 15 mm. two rows of tubercles are evolved: the central one at the points of costal bifurcation and the inner in the neighbourhood of the suture. But at a diameter of 25 mm. the central row of tubercles of the points of costal bifurcation vanishes, giving place at first to a very slight protuberance, which in its turn disappears without leaving a trace behind. On the other hand, the sutural tubercles, less prominent at the start, become proportionately more marked, assuming a more rounded, conical form, thereby giving rise to the permanent ornamentation described above. On each whorl are two deep constrictions, strongly inclined forward, which are accompanied behind by a very strong costa and in front by a less marked one. Moreover, behind the strong constrictional costa the shell is rather more deeply depressed than elsewhere, and at this point a very short intercalary costa is observable.

The exact length of the body-chamber is not known, but it is at least three-quarters of a whorl. Oral margin unknown.

The lobal line is characterized by comparatively broad saddles, long, narrow lobes, and the poorly developed lateral rami of the lobes. Not only the peripheral saddle is broad here, but also the first and second lateral saddles, which in many forms are narrowed up by the lateral rami of the lobes. Such is not the case in *H. spitiensis*, where both terminal and lateral rami of both lateral lobes and of the first auxiliary lobe are widely separated. The second lateral lobe ends in a point, and its obliquity is but slight. The first auxiliary lobe is but poorly developed and does not advance far towards the second lateral lobe; moreover, it is so slightly pendent that its apex lies a little higher than that of the second lateral lobe. Three auxiliary lobes are present, conjoined into one pendent sutural lobe; the second of these is very small, and of simple structure; the third lies immediately at the suture, and forms a simple small denticulation.

Among the closely allied forms may be mentioned, first of all, *H. Grotei* (Opp.) and *H. subspitiensis*, sp. nov. This latter species is distinguished almost entirely by certain peculiarities of the lobal line: the former is perhaps identical with *H. spitiensis*. In order to avoid repetitions, it is sufficient to refer the reader as regards the nearer relationships of these species to the detailed description of *H. Grotei* and *H. subspitiensis*.

Some relationship with *H. spitiensis* is to be seen also in *H. bilobatus*, sp. nov. The resemblance is especially marked in the median stage of growth, but the tubercles of *H. bilobatus* are somewhat less prominent, the costæ rather more numerous, closer together, and swing less than in *H. spitiensis*. Moreover, the double-tubercular stage is less strongly marked in *H. bilobatus*. It is true that the body-chamber of that species is unfortunately not thoroughly known, but from the portion of it which has been preserved it is safe to infer that the body-chamber in *H. bilobatus*

was less constricted and less wedge shaped than that of *H. spitiensis*. Moreover, essential differences are observable in the lobal line, the first lateral saddle being much narrower than in *H. spitiensis*, while the second lateral lobe ends in two paired rami. *H. subbilobatus*, sp. nov., is in yet remoter relationship, for here, in addition to the paired symmetry of the second lateral lobe, we may observe the stouter form of the lobes, the slender lateral saddles, the greater breadth of the umbilicus, the flatter umbilical wall, the somewhat flatter discoidal shape, and the larger growth, as so many distinctive characteristics.

H. guttatus, Blanf., is distinguished from our species by closer costation, less pronounced tubercles, stronger involution, more numerous constrictions, and higher whorls. The lobal line is especially differentiated from that of *H. spitiensis* by the more oblique position of the second lateral lobe, the greater development of the first auxiliary lobe, and the narrow, more deeply crenulate form of the lateral saddles. Another distinctive characteristic, to which Blanford has already drawn attention, is the habit of the third auxiliary lobe; this forms in *H. spitiensis* a small, barely noticeable, simple denticle, while in *H. guttatus* the denticle is conspicuously larger and crenulate.

F. Stoliczka did not only place *Amm. spitiensis* with *Amm. Grotei*, Opp., in one species, but he also swept in *Amm. guttatus*, Blanf., *Cautleyi*, Opp., *Stanleyi*, Opp. and *scriptus*, Blanf., on the ground that a close study of these forms had convinced him of their intimate relationship. Though perhaps insufficient justice has been done to the high significance of Stoliczka's determination, the conviction that it is necessary to retain separate names for forms of varied evolution, despite their close kinship, is very generally gaining ground.

In his well-known monograph on the Speeton clay fauna A. Pavlow described a *H.* (*Astieria*) *spitiensis* from Speeton.[1] As, however, no figure of this ammonite is given, nor any description of the lobes, the body-chamber and the inner whorls, it is not possible to determine whether the form in question belongs to the group of the Spiticerata or to the Astieriæ, and whether it is really identical with the Indian species *spitiensis*. For this reason the quotation from Pavlow has not been included in the synonymy of *H. spitiensis*.

Blanford's original specimen, figured here once more in plate VIII, fig. 3, comes from the Spiti Valley (Gerard's collection). A second specimen was found in Spiti, and a third at Lochambelkichak, 3rd Stage.

Holcostephanus (Spiticeras) Grotei, Oppel sp.

(Plate IX, fig. 2 *a—c*; Plate VIII, fig. 6.)

1863. *Ammonites Groteanus*, Oppel. Palæontologische Mittheilungen, vol. I, plate LXXX, fig. 4, p. 283.

Non *Amm. Groteanus*, Zittel, non *Amm. Groteanus*, Gemmellaro, Nicolis and Parona.

As this species is unusually near to the foregoing, a detailed description may be here dispensed with, and it will be sufficient to enumerate the characteristics which mark off *Grotei* from *spitiensis*.

[1] Bull., Soc. Imp. Natural., Moscow (1891), p. 139.

Oppel's original specimen, which has been refigured here, is chambered to the end. It is 44 mm. in diameter, and the breadth of the umbilicus measures 17 mm. The last whorl at its foremost end has a thickness (measured at the tubercles) of 24·3 mm., and a height of 15·5 mm. On comparing these measurements with those of *H. spitiensis*, it is seen that *H. Grotei* at the same size is somewhat thicker at the anterior end and somewhat lower than *H. spitiensis*. This may be said to constitute the most important distinction between the two species, the other differences being very insignificant. If, for instance, in Oppel's example the costæ at the periphery are just a little less curved than is the case in *H. spitiensis*, this can hardly be of much consequence in view of the otherwise complete identity of ornamentation. Similarly, when we take into account the identity of the main characters of the lobal line, the circumstance that the lateral rami of the lobes are perhaps somewhat more strongly developed in Oppel's specimen than in Blanford's, does not carry much weight. In Oppel's *Amm. Grotei* the double-tubercular stage is as clearly exhibited as in Blanford's *Amm. spitiensis*.

In any case, the differences enumerated in the foregoing paragraph are relatively unimportant. Even the difference in thickness may, in accordance with the general tendency of growth in this group, diminish concurrently with increase in size, until it vanishes as the final stage of growth is reached. Consequently, if Oppel's original specimen of *Amm. Grotei* had come before us for the first time in conjunction with the other specimens, it is very probable that we should not have distinguished it specifically from *H. spitiensis*. Seeing, however, that it has received a name of its own, that a certain difference does undeniably exist, and that the smallness of the specimen leaves some doubt as to whether in the full-grown stage the species is in reality identical with *H. spitiensis*, we have resolved provisionally to retain Oppel's species. At the same time, it appears extremely probable that when more material becomes available, the abolition of *Amm. Grotei* as a separate species and its inclusion in *H. spitiensis*, already foreshadowed by Blanford,[1] will be recognized as unavoidable.

H. Grotei has been recorded by several authors, notably Nicolis and Parona,[2] Gemmellaro,[3] Kilian,[4] de Gregorio,[5] and Toucas,[6] from the Tithonian of the Mediterranean province. These determinations seem to be chiefly based on K. von Zittel's original view; that author, in his famous monograph on the Cephalopod Fauna of Stramberg, having identified several specimens from there with the Indian form. With wonderful insight, Zittel recognized the intimate relationship of forms hailing from widely separated tracts of the earth's surface, and he could not avoid setting them down as identical, as at that time neither the conditions of growth nor the body-chamber nor the ornamentation of the inner volutions of the Indian species were known. Zittel's view has now been superseded by the discovery

[1] Palæontology of Niti, p. 106.
[2] "Note stratigrafiche e paleontologiche Giura superiore," p. 74.
[3] "Studi paleontologici sulla Fauna del Calcare a Ter. Janitor," Palermo, 1868—1876, p. 41, pl. VII, figs. 4 and 5.
[4] Mission d'Andalousie, 1884, pp. 648, 697.
[5] "Annales de Géologie," publiées par A. de Gregorio, 3me. livr. Palerme, 1886, p. 5 and pl. I, fig. 14.
[6] Bull. Soc. Géol. France, ser. 3, vol. XVIII, p. 597.

of perfectly preserved specimens. The Stramberg specimens which he united into one species are probably assignable to two different species in accordance with the opinion expressed by A. Pavlow,[1] and neither of these species appears to be absolutely identical with *H. Grotei* or *H. spitiensis*. Specific identity is excluded, especially in the case of Zittel's largest example (plate XVI, fig. 1), for this, although it is already provided with the body-chamber, is nearly twice as thick at its anterior extremity as *Amm. spitiensis* at the thickest portion of its shell. Nor does the body-chamber of the Stramberg form show any such narrowing of the cross-section as may be observed in *H. spitiensis*, and *H. Grotei*, and its periphery is much broader and flatter than even in the chambered portion of *H. Grotei*. It is not possible to make certain whether the Stramberg form passes through a double-tubercular stage.

The foregoing distinctions do not permit of including the Stramberg species in *H. Grotei* or *H. spitiensis*, and they compel us to revive Oppel's original designation of *Amm. celsus* for the specimen figured by Zittel in his plate XVI, fig. 1. The smaller form which he figured in plate XVI, figs. 3 and 4, shows characters of the lobal line which bring it nearer to the true Astieriæ than to the Spiticerata.

The form described by G. Gemmellaro bears, it is true, much resemblance to the normal stage of *H. Grotei*, but is distinguished therefrom by its greater thickness. The details of the primitive stage and the lobes are unknown.

It has been already shown by E. Haug[2] that the form from Roverè di Velo recorded by Parona and Nicolis does not belong to *H. Grotei*. Moreover, in our introductory discussion of the genus we have pointed out that this occurrence in respect of its ornamentation recalls vividly the Indian Spiticerata, and especially *Sp. planum*. A young specimen from Roverè di Velo was figured by the Marquis de Gregorio, but as it measured only 10 mm. in diameter, no definite conclusions could be drawn as to the evolution of this form. So, too, the forms described by Pictet as *Amm. Astieri* from the Tithonian and lowermost Neocomian, which he, following in the footsteps of Zittel, identified with *H. Grotei*, are but imperfectly known.[3] If it is impossible to pronounce definitely regarding these figured specimens, because of the absence of the lobal line and the body-chamber, and because of their early stage of growth, still more is it impossible to base any conclusions on occurrences which are mere records unaccompanied by descriptions or figures.[4] We have therefore been unable to include these references in the synonymy of *H. Grotei*, though we think it quite possible that one or other of the forms so recorded does really belong to *H. Grotei* or *H. Spitiensis*. From certain observations of W. Kilian[5] it may be inferred that, especially in the Alps of Southern France, many hitherto unknown *Holcostephani* nearly related to *H. Grotei* have been found which still await description.

[1] "Argiles de Speeton," pp. 139-140.

[2] Jahrbuch d. k. k. geol. Reichs., vol. XXXVII (1887), p. 277.

[3] Pictet [illegible] remarks, with regard to the specimen figured in plate XXXVIII, fig. 8, of his "Mélanges paléontologiques," that it is identical neither with *H. Grotei* nor with *H. spitiensis*.

[4] Bull. Soc. Géol. France, ser. 3, vol. XVIII, p. 597, and vol. XXII, p. 679.

[5] Ibid., ser. 3, vol. XXIII (18), p. 710.

H. Grotei has not only been recorded from Europe, for A. Steuer cites it as occurring in Argentina. As in the deposit where it has been found—the Tithonian of Loconche—many true Spiticerata occur, it seems probable that the determination is correct. Steuer's description is, however, too short to permit of definite conclusions in regard to this form.

The exact locality of the original specimen of *H. Grotei* is unknown; according to the explanation of Oppel's plate, the specimen comes from the "province of Spiti."

HOLCOSTEPHANUS (SPITICERAS) SUBSPITIENSIS, sp. nov.

(Plate IX, fig. 4 *a—e*.)

In describing *H. spitiensis*, attention has already been drawn to the extraordinarily close kinship between it and *H. subspitiensis*.

With regard to the ornamentation no other difference can be mentioned than perhaps that the double-tubercular stage is less marked and ends sooner in the last-named species than in the former. As, however, even in several specimens of *H. spitiensis* the double tubercles vary in duration, and considering that *H. subspitiensis* is somewhat smaller than the other species, it is hardly possible to lay much stress on this difference. Perhaps the inner whorls are not quite so thick, and the umbilical wall is somewhat steeper than in *H. spitiensis*, but even these differences are far from striking.

The body-chamber shows exactly the same habit, the same characteristic narrowing of the cross-section, the same wedge-shaped periphery and flattened sides as *H. spitiensis*. The specimen figured here, measuring 82 mm. in diameter, exhibits a considerable portion of the body-chamber. The posterior part of the body-chamber has at the thickest point a breadth of 28 mm. (measured at the tubercles) and a height of 24 mm. A quarter of a volution farther forward, at the anterior extremity of that portion of the body-chamber which is preserved, the height increases to 27·5 mm., while the thickness concurrently decreases to 24·2 mm. A second specimen belonging to the State Collection at Munich, with a diameter of only 68 mm., already possesses the greater portion of the constricted body-chamber, and exhibits the double-tubercular stage clearly developed up to the diameter of 25 mm.

The "bodies" of the lobes are much lower and broader than in *H. spitiensis*, and the lateral rami of the lobes are more highly developed. The consequence of this is that, especially the first lateral saddle (which assumes in *H. spitiensis* a very broad shape) appears to be deeply indented and narrowed at the base. Moreover, this greater development of the lateral rami leads to a curious evolution of the second lateral lobe, which is, too, unsymmetrical on each side of the shell. On the right side the short and broad body of the second lateral lobe trifurcates into a terminal ramus and two equal lateral rami; on the left side it ends in two paired, equally prominent and equally long terminal rami, so that here comes in the paired division of the second lateral lobe which is peculiar to so many species of the sub genus

Spiticeras. The feeble development of the auxiliary lobes, whereof the third lying at the suture forms only one simple, small denticulation, is common to both *spitiensis* and *subspitiensis*.

Considering the lobal characters as a whole, they are so different in these two species that it is impossible to unite them into one, unless we are willing to admit a far greater range of variation of the lobal line than is the case in all other ammonites. Should a richer store of material become available, it is just possible that passage-forms would be found, and circumstances might then allow of the withdrawal of the specific name *subspitiensis*. Meanwhile, it appears to us advisable to lay stress on these remarkable characteristics of the lobes by specific separation of the forms which exhibit them.

In describing *H. spitiensis*, *H. bilobatus* was mentioned as an allied species; it is still nearer to *subspitiensis*, for it shows, in common with that form, the paired division of the second lateral lobe. This is in both species more conspicuous on the left side than on the right. In *H. bilobatus*, however, the lobal bodies are more slender and longer, and therefore the lobal line is not exactly identical with that of *subspitiensis*. The marked differences in shape and ornamentation were already referred to in the description of *H. spitiensis*, so, too, the differences in regard to *H. subbilobatus*.

One specimen of *H. subspitiensis* comes from Spiti Valley; another, collected by the brothers Schlagintweit, and in an excellent condition of preservation, is to be found in the State Palæontological Collection at Munich.

HOLCOSTEPHANUS (SPITICERAS) BILOBATUS, sp. nov.

(Plate X, fig. 1 *a—f*.)

Dimensions :—

Approximate diameter	72 mm.
Width of umbilicus	26 „
Thickness of ultimate whorl	29 „
Height of ultimate whorl	24 „

The shell consists of rounded whorls which are thicker than high and overlap each other for about a half. The greatest thickness is in the neighbourhood of the umbilical tubercles and directly above that. The sides pass insensibly into the much rounded periphery. The umbilical wall, too, is rounded and does not dip so steeply inward as in the case of the most nearly related species. The spiral of the sutural line appears in the umbilicus to be a little broken at the constrictions.

The ornamentation consists in rather widely separated tubercles, whence arise groups of simple or dichotomizing costæ. On the ultimate whorl are 17 tubercles; from each tubercle start 4 to 6 furcating costæ. Between the groups of these are a few short intercalary costæ, whose dependence on one or the other group is not very clearly manifest. The costæ are fairly prominent, and this prominence barely diminishes, if at all, on the periphery; the angle of the costæ in the median line of

the periphery is only just visible. On each whorl are three deep constrictions strongly inclined forward. Two specimens show a part of the body-chamber, the shape of which differs so little from that of the chambered portion of the ultimate whorl, that we may be allowed to infer the absence of any essential alteration in cross-section or height in the completely developed body-chamber. The body-chamber is so built that the umbilicus gains a little in width. The innermost whorls are not very clearly preserved, but it is apparent that the double-tubercular ornamentation lacks in prominence, and passes at a comparatively early stage of growth—say about the diameter of 13 mm.—into the normal ornamentation.

The lobal bodies are somewhat narrow, and the second lateral lobe is only slightly oblique. The saddles, particularly the peripheral and the second lateral saddle, have broad bodies. Especially characteristic of this species is the development of the second lateral lobe, which ends off in two nearly equal terminal rami and assumes, therefore, a paired division. The innermost of these terminal rami goes somewhat deeper down than the outermost, and one might be disposed to conclude that this peculiar habit of the second lateral lobe has arisen from stunting of the outer, and luxuriant growth of the inner lateral lobe. Moreover, the paired-divisional characteristic of the second lateral lobe is far more strongly marked on the left side than on the right, as may be seen on comparison of fig. 1 *d* (which shows the dextral lobal line) with figs. 1 *e* and 1 *f* (which show the sinistral lobal line). This development of symmetrically paired terminal rami of the second lateral lobe was the object of some comment in the Introductory Remarks on the genus; it is very striking in this species, and stamps it with a strong impress of individuality.

H. bilobatus is most nearly comparable to *H. subbilobatus*, *guttatus*, *indicus*, and *spitiensis*.

H. guttatus, despite a very considerable resemblance in general habit with the species just described, differs from it in its greater number of tubercles, its more markedly flattened and higher whorls, the steeper inclination of the umbilical wall, and the characters of the lobal line. The contrast in lobal structure is seen on mere inspection of the figures; it will be sufficient to add that besides the paired-divisional development of the second lateral lobe in *H. bilobatus*, the less marked prominence of the auxiliary lobes in this species should be noted.

One character which is common to *bilobatus* and *indicus* is the rounded form of the whorls. Besides an essential difference in the lobal line, *H. indicus* may be distinguished also by its somewhat more numerous tubercles, finer costæ, and inferior thickness.

H. subspitiensis and *spitiensis* may certainly be regarded as nearly allied forms, the first-named especially so, because the second lateral lobe exhibits paired terminal rami just as in *H. bilobatus*. On the other hand, the contrast in external ornamentation and in the habit of the body-chamber is very strongly marked. *H. spitiensis* and *subspitiensis* exhibit in the chambered portion of the shell a more steeply inclined umbilicus, somewhat more prominent tubercles, less numerous

secondary costæ, more clearly marked costal angles on the periphery, and very much more prominent double-tubercular ornamentation. While also in these two species the body-chamber undergoes considerable increase in height and decrease in breadth, *H. bilobatus* belongs to the forms wherein the body-chamber suffers but little alteration.

Among the European species, *H. celsus*, Opp. (see the description of *H. Grotei*), shows considerable resemblance to *H. bilobatus*, but the much greater thickness of the Stramberg species constitutes a useful distinguishing characteristic.

We have of *H. bilobatus* a specimen from Kibber; moreover, we were enabled to examine three specimens in the State Palæontological Collection at Munich, the exact locality where they were found being unknown.

HOLCOSTEPHANUS (SPITICERAS) SUBBILOBATUS, sp. nov.

(Plate X, figs. 2 *a—e*.)

Dimensions.—

Diameter	33 mm.
Breadth of umbilicus	33 ,,
Thickness	30·5 ,,
Height	26·5 ,,

It was only after long hesitation that we decided upon erecting a specimen which we had originally assigned to *H. bilobatus* into the type of a new species. Unfortunately the specimen is in bad preservation and has no body-chamber. As, however, it exhibits a whole series of well-marked characteristics which point to its specific distinctiveness, it seemed fitting to express these facts by means of a distinctive name. Bearing in mind the detailed description just given of *Sp. bilobatum*, we may restrict ourselves, as regards this nearly allied form, to an enumeration of the differences. The ornamentation agrees in its main features with that of *H. bilobatus*, showing, however, some divergences. For instance, the furcating costæ in *H. subbilobatus* form a much more acute angle on the periphery, and are, moreover, rather less numerous than in *H. bilobatus*. The shell is somewhat flatter, the umbilicus somewhat broader, the periphery more wedge shaped, and the inclination of the umbilical wall less steep than in *H. bilobatus*.

The lobal line of *H. subbilobatus* is also remarkable for the subsymmetrical paired-divisional evolution of the second lateral lobe, and we found upon it our view of the close relationship of these species. While, however, in *H. bilobatus* the lobal bodies are comparatively long and possess fairly long lateral rami, they have in *H. subbilobatus* a broad, stout shape and bear short, obliquely directed lateral rami. Especially remarkable in the second lateral lobe is the great breadth of the lobal body, to which are appended two long, almost symmetrical, terminal rami. The paired symmetrical evolution of the second lateral lobe is not quite equal on both sides of the shell; on the left side the two terminal rami are larger and more prominent, and the saddle which separates them cuts deeper into the lobe, than on

the right side, where the paired terminal rami of the second lateral lobe are shorter and more slenderly built.

The features of the body-chamber and of the inner whorls are unknown. As the specimen of *H. subbilobatus*, chambered up to the end, is decidedly larger than the specimen of *H. bilobatus*, although the latter is furnished with a portion of the body-chamber, the inference is allowable that *H. subbilobatus* was a form of larger growth than *H. bilobatus*.

H. subbilobatus is distinguished from *H. indicus* by its flatter shell, stronger ribs, less steeply inclined umbilical wall, and by the character of the lobal line; from *H. guttatus* by a broader umbilicus, flatter septation, less steeply inclined umbilical wall, and by the divergent course of the lobal line. *H. subbilobatus* shows at the stage of normal ornamentation a fairly close resemblance to *H. pronus*, Opp. (Zittel, Cephalop. d. Stramberger Sch., plate XV, figs. 8, 9, 11 *non* 10). The Moravian is distinguished from the Indian species by the interruption of the costæ on the periphery, coarse costæ and tubercles, and somewhat higher whorls. The mutual relationship in regard to the lobal line and the characteristics of the inner whorls remains uncertain, the inner whorls being unknown in the Indian species and the lobal line unknown in the Moravian.

From *H. Toucasi*, Ret. (compare *H. pronus*, Toucas), *H. subbilobatus* is distinguished by its more numerous costæ and the less acute costal angle on the periphery. The relations of the septal wall in *H. Toucasi* are not known. Finally, reference must be made to *H. Bodenbenderi*, Steuer, which also shows similarity to *H. subbilobatus*, but may be easily distinguished therefrom by its more prominent costation, more strongly curved sides, and by the course of the lobal line.

The species just described occurs as a specimen from Lochambelkichak (3rd Stage).

HOLCOSTEPHANUS (SPITICERAS) PLANUS, sp. nov.

(Plate XV, figs. 2 *a—d*.)

Dimensions :—

Diameter	78·5 mm.
Breadth of the umbilicus	29 "
Height of the ultimate whorl	28 "
Thickness of the ultimate whorl	25·5 "
At a diameter of 57 mm. the—	
Height of the whorl is	21·8 "
Thickness of the same	25·5 "

The species now to be described belongs to the relatively feebly costate types of the genus. The innermost whorls unfortunately are not to be seen at diameters ranging from 30 to 60 mm. The costation consists of fine ribs starting from clearly marked sutural tubercles, whose general plan and furcation are much the same as in the other forms. About five costæ may be reckoned to each tubercle. The costæ are not very strongly inclined forward; they run uninterruptedly over the periphery, where they form a distinct angle. On the ultimate whorl are twenty-three

tubercles and two constrictions much inclined forward, limited posteriorly by a more prominent costa. The foremost portion of the ultimate whorl belongs to the body-chamber, and upon it there appears to be a slight enfeeblement of the ornamentation,—the degree of which, however, cannot be determined very precisely as the body-chamber has lost some of its sharpness by weathering.

The shell is, on the whole, of a flat, discoidal shape, the whorls overlap one another by about a half, and in the inner portion of the shell are somewhat thicker than high. They are flattened off at the sides, and slightly wedge shaped towards the periphery. Simultaneously with the appearance of the body-chamber, a change becomes noticeable, the whorls become higher than broad,—as may be seen from the above table of dimensions. The sides seem to be better individualized, the periphery to thin down more decidedly to a wedge. Umbilical wall rounded, dipping somewhat steeply inward.

With regard to the lobal line, we may note as especially characteristic the slenderness and length of the lobe bodies and the breadth of the saddles. At the second lateral lobe obliquity is barely noticeable. From the lobal body of the second lateral lobe, which ends off in a main ramus, start an inner and an outer lateral ramus, whereof the last-named is somewhat more highly placed. The first auxiliary lobe lies rather deeper than the second lateral lobe.

The ornamentation of the species now being described recalls in many respects that of *H. guttatus*. The number of furcating costæ in *H. planus* is somewhat larger, the contact of the costæ at the periphery takes place at a more definite angle; furthermore, the whorls are somewhat higher, trending more to a wedge at the periphery, and the umbilicus is rather broader. Whether the body-chamber narrows down in *H. guttatus* in the same way as it does in *H. planus* is not known. The lobal line is distinguished especially by the divergent structure of the second lateral lobe, and of the first lateral saddle: the first-named being more obliquely placed in *H. guttatus*, and the second being much narrower than in *H. planus*. Finally, the first auxiliary lobe is more strongly developed in *H. guttatus*. The differences just enumerated make it impossible to unite these two species into one.

H. obliquelobatus approaches the species just described in the wedge-like thinning of the periphery, but diverges from it so widely in respect of its lobal line, that here again the two species must be recognized as distinct.

H. spitiensis and *H. subspitiensis* resemble *H. planus* in the narrowed form of their body-chamber and the simplicity of their lobal structure, but differ from it so greatly by their much more pronounced ornamentation that the specific distinction is not a matter of difficulty.

In the Tithonian of Roverè di Velo in the Veronese occurs a form, erroneously named *H. Grotei* by several authors, which bears some outward resemblance to *H. planus*. (Compare Introductory Remarks on the Genus and the description of *H. Grotei* in the text.) It is at present uncertain whether this Veronese form really belongs to the Spiticerata. The badly preserved specimens from Roverè di Velo which we have examined do not admit of complete determination of the lobal line:

the important auxiliary lobes in especial are wanting. The bodies of the lateral lobes are shorter and broader than in *H. planus*.

H. planus comes from Kibber.

HOLCOSTEPHANUS (SPITICERAS) BINODIGER, sp. nov.

(Plate XIV, figs. 1 *a—d*.)

Dimensions :—

Diameter	87 mm.
Umbilical breadth	35 "
Height of the ultimate whorl about the middle of the body-chamber	29·6 "
Thickness about the middle of the body-chamber	26·5 "
Thickness of the penultimate whorl	22 "
Height of the penultimate whorl	15·6 "

If one were to consider alone the body-chamber of this species, it would be possible on a cursory inspection to confound it with *H. spitiensis*. The inner whorls, however, show definitely the specific difference between the two forms. The complete evolution of the costæ in *H. binodiger* appears to be attained only at the body-chamber or a little before: the inner whorls show, up to diameters of 48 mm. and probably even more, the primitive ornamentation with two rows of tubercles. Unluckily the passage here cannot be traced with precision, as the critical portion of the shell has broken away. Nevertheless, a fairly prominent swelling up of the group of costæ immediately preceding the body-chamber, which corresponds to the lateral tubercle, shows that these lateral tubercles were still being developed a little while before—perhaps up to the time when the shell had attained a diameter of 58 mm. The primary costæ on the inner whorls are very strong, exhibiting, besides the lateral tubercles, elongate, lath-shaped protuberances at the umbilical wall. At the lateral tubercles, trifurcation takes place into three secondary costæ inclined markedly forward, and, in addition, an intercalary costa comes in. The spiral of the sutural line runs alongside the lateral tubercles, but as on one side in the specimen before us the sutural portion of the body-chamber has been weathered away, it is possible here to trace satisfactorily the lower part of the furcating costæ (fig. 1 *d*). The body-chamber is marked by the normal Spiticeratan ornamentation, but modified in such a way as to show that in this species the primitive ornamentation persists for a long period. The sutural tubercles, for instance, pass on the sides into broad, radial, flattish swellings, whence arise in the upper portion furcating costæ. These swellings are evidently neither more nor less than the flattened principal costæ of the inner whorls; moreover, in some costæ slight protuberances are observable which correspond to the median tubercles of the inner whorls. The furcating costæ are inclined rather markedly forward, and on the external periphery they form a very distinct angle; concurrently with this, as a consequence of the partial alternation of the furcating costæ, a slight enfeeblement of the costæ takes place at the median line. The constrictions are deep and broad, limited by strong costæ, whereof the posterior ones swell up considerably on the periphery.

As may be inferred from the sectional figure (fig. 1 *a*) and from the dimensions tabulated above, the inner whorls are low, much broader than high, possess a flat but slightly curved periphery, low, flat sides, and an oblique umbilical wall. The greatest breadth is at the sides in the neighbourhood of the median tubercles.

The form of the section assumes along the body-chamber an important and sudden modification. At the beginning of the body-chamber, or a little before, the greatest breadth is in the neighbourhood of the sutural tubercles. The section remains then broader than high, but appears to thin to a wedge shape towards the periphery; farther forward the body-chamber is decidedly higher than broad, and becomes almost ovoid in section.

The lobal line in the figured specimen is unknown. In the second specimen, to be mentioned below, one may observe at least traces of the lobal line which lead to the inference that it belongs to the simple type characterized by broad saddles and by feebly developed, slightly pendent auxiliary lobes.

The species here described differs from *H. spitiensis* notably in the long persistence of its primitive ornamentation, in the character of the body-chamber tubercles which pass into flattish blisters, in its greater thickness, and in the shape of the inner whorls. The differences between *H. binodiger* and *H. conservans* will be enumerated in dealing with the latter species.

Besides the figured specimen, another lies before us, but it is in such bad preservation that we cannot feel absolutely assured of its identity with the species just described. The whorls in this specimen are somewhat stouter, and the primitive double-tubercular ornamentation disappears at a somewhat earlier stage.

Both specimens come from Lochambelkichak (3rd Stage).

HOLCOSTEPHANUS (SPITICERAS) CONSERVANS, sp. nov.

(Plate XIV, figs. 2 *a*—*d*.)

Dimensions :—

Diameter	66·8 mm.
Width of umbilicus	32·8 „
Height of the ultimate whorl	19 „
Thickness of the ultimate whorl between the costæ	24 „
Thickness at the tubercles	26 „

We are unfortunately not in a position to give a complete description of this remarkable form, as the body-chamber is wanting and the innermost volutions are invisible. Nevertheless, the morphological relations of this species are so interesting that it appears preferable to remain content with an incomplete description rather than leave the form quite unnoticed.

Although the specimen before us, chambered up to the end, reaches a diameter of well nigh 67 mm., it shows to the very last the primitive double-tubercular ornamentation. On the ultimate whorl are twenty-three primary costæ, which swell

up into prominent pectinate tubercles at the suture, exhibiting on the middle of the sides more rounded, somewhat less prominent tubercles. Between the suture and the median tubercles, the primary costæ are much enfeebled or even sunk in. From the median tubercles arise by furcation three secondary costæ inclined forward. Moreover, in the space between every two primary costæ an intercalary costa comes in, somewhat below the row of median tubercles. In some groups of costæ this intercalary costa extends so far down that it all but unites with the sutural tubercle. In the foremost part of the ultimate whorl only two secondary costæ arise from the median tubercles, and two costæ are intercalated independently, a modification which appears to be a sign of the gradual passage into the definite ornamentation. The furcating costæ are rounded and comparatively coarse; on the periphery they assume partly an alternate position and form a very prominent angle. On the ultimate whorl are two deep constrictions, which at the sides run parallel to the primary costæ, but near the periphery they suddenly bend sharply forward.

Radial prolongations of the lath-shaped inner tubercles run along the steep umbilical wall almost as far as the suture.

The whorls of the discoidal, widely-umbilicate shell are much broader than high, compressed, with a flat-curved periphery, and flattened low sides. The whorls are broadest in the neighbourhood of the inner tubercles, although they seem but little narrower at the median tubercles. The umbilical wall is rounded, and dips rather steeply inward.

The lobal line is characterized by the breadth of the saddles and the wide intervals between every two consecutive septations. The second lateral saddle is conspicuous for its very slight obliquity. The auxiliary lobes are but feebly developed, slightly pendent. The body-chamber is unknown.

This species is very nearly related to *H. binodiger*. Indeed, there is a possible difficulty in distinguishing fragments of the inner whorls (with their primitive ornamentation) specifically one from the other. Nevertheless, specific identity of these two species is quite out of the question. *H. conservans* is much more widely umbilicate, possesses lower whorls and coarser furcating costæ, and the septations are much farther apart than in *H. binodiger*. The mutual relationships of the body-chambers of these two species are unfortunately not known, but from the differences in the inner whorls it may be assumed that they also do not agree entirely.

Steuer described under the name of *Stephanoceras Damesi* a species from the Argentine Jurassic which closely resembles *Sp. conservans*. In it the primitive ornamentation persists up to a diameter of about 95 mm. That this species, however, is not identical with that just described, may be inferred from the delicacy of the furcating costæ, the flatter inclination of the umbilical wall, and, especially, from the characters of the lobal line. This in *Sp. Damesi*, Steuer, exhibits a very narrow first lateral saddle, while *Sp. conservans* possesses a very broad first lateral saddle.

HOLCOSTEPHANUS (SPITICERAS) CAUTLEYI, Oppel sp.

(Plate XII, fig. 1.)

Oppel Palaontologische Mittheilungen, p. 279, plate LXXVIII, fig. 1 (*non* fig. 2).

Dimensions:—

Diameter	101 mm.
Width of umbilicus	10·4 ,,
Height of volution at the beginning of the body-chamber	21·4 ,,
Thickness at the beginning of the body-chamber, measured at the tubercle	25 ,,
Height of oral aperture at the anterior end of the body-chamber	3·34 ,,
Breadth	28 ,,

As Oppel's figure of this much-talked-of species is not absolutely accurate, we feel called upon to complete his description in some points, and to refigure the original specimen. The fossil is nothing like so well preserved as one might be led to suppose from Oppel's figure. It is so much weathered that the costæ appear to have vanished, but a better preserved portion on that side of the specimen which is not figured shows that fairly prominent, if not very stout, costæ were actually present. We reckon upon the ultimate whorl, which for the most part belongs to the body-chamber, five or six furcating costæ to every tubercle: some few of these may be regarded as intercalary costæ. The costæ meet on the periphery at a pretty sharp angle, and in the better preserved portions of the periphery it may be seen that, although a slight enfeeblement of the costæ takes place there, they do not disappear or die away. Finally, the costæ in this species are characterized by a peculiarity which does not seem to have been sufficiently noticed by Oppel. In the neighbourhood of the periphery they assume rather suddenly a strong forward trend. Much the same course as the costæ is run by the constrictions, which number four on the ultimate whorl. The ultimate whorl belongs for the most part to the body-chamber, whose oral aperture, accompanied by a deep constriction, extends into an auricular prolongation: this, however, is not so beautifully preserved as it is made out to be in the figure given in the "Palaontologische Mittheilungen." The anterior portion of the body-chamber has a wedge-shaped periphery, and the posterior portion a more rounded periphery. The height of the oral aperture is exaggerated and its breadth minimized in Oppel's figure. At the beginning of the body-chamber the height is almost equal to the thickness: at the oral margin, on the other hand, the height is greater than the thickness. The lobes are not visible.

The small fragment which Oppel figures as an inner volution of *A. Cautleyi* is neither more nor less than a *Hoplites*, which fact, rightly recognized by Neumayr [1] and Stoliczka,[2] has been wrongly contested by Nikitin.[3]

Although the lobes and the characters of the inner whorls are unfortunately not known, a comparison with other Spiticerata enables us to conclude beyond the possibility of doubt that *H. Cautleyi* belongs to a flat, widely umbilicate type of the

[1] "Geogr. Verbreitung der Tornform." Denksch. K. Akademie, Wien, 50 Bd., 1885, p. 92.
[2] Memoirs, Geol. Survey of India, vol. V (1865), p. 104, Calcutta.
[3] Neues Jahrbuch, 1869, vol. II, pp. 121, 130.

genus. In this respect *H. eximius* appears to occupy a still more extreme position, while *H. subcautleyi* forms the link with the narrower group of *Spiticeras spitiense*. *H. Cautleyi* is distinguished from *H. subcautleyi* by its narrower umbilicus, higher, more compressed whorls, steeper umbilical wall, and more numerous and closer-set costæ. As in *H. subcautleyi*, it is highly probable that in *H. Cautleyi* the inner whorls are relatively thicker and lower than the body-chambers. That Oppel's supposition of a relationship between *H. Cautleyi* and *A. Jason* is erroneous need hardly be emphasized. Nor is A. Pavlow's[1] assumption of an identity with his *Hoplites Syrti* correct. Nikitin also speaks of *H. Cautleyi* as a *Hoplites* characterized by constrictions, but not more nearly related to *H. Syrti* than to many other representatives of the genus. At a time when the group of the Spiticerata was but little known, it was very possible to imagine the existence of a near relationship between *H. Cautleyi* and the genus *Hoplites*. The rich material that now lies before us shows unmistakably that there is no close relationship between *Hoplites* and *Spiticeras*.

Retowski suggested the possible identity of *A. Cautleyi* with *A. Theodosia* (Desh). But the two species are easily distinguishable: *Sp. Cautleyi* has much higher whorls, less prominent tubercles and a less considerable thickness, so that its differentiation from *Sp. Theodosia* (Desh.) is based on plainly visible characteristics. In fact, the last-named species would be better compared with *H. Stanleyi* than with *H. Cautleyi*. On the other hand, a species recently described by Steuer[2] from the Tithonian of Argentina, *H. fraternus* (Steuer), appears to be very near *H. Cautleyi*, as indeed that author observes. The wider umbilicus and the much more numerous sutural tubercles of *H. fraternus* distinguish it specifically from *H. Cautleyi*.

J. von Semiradzki[3] quoted *A. Cautleyi* from the *Tenuilobatus* beds of Poland with the remark that this form possesses parabolic tubercles and a lobal line wherein the peripheral lobe is shorter than the first lateral. As in no single one of the numerous forms of *Spiticeras* which lie before us are such characteristics as these to be observed, it may be safely concluded that the Polish specimens are not assignable to *Sp. Cautleyi*.

Finally, our species has also been recorded by Nicolis and Parona[4] from the Veronese Tithonian. The very meagre description given by these authors does not enable us to conclude whether the Veronese species is really identical with the Indian or not.

Although recent collecting has made available a vast quantity of material belonging to the genus *Spiticeras*, none of these newly-found specimens have proved identical with *H. Cautleyi*, which is therefore known solely from Oppel's original specimen. This hails from Laptel in Gnari-Khorsum (Tibet).

[1] "Les Ammonites de la Zone à Amm. acanthicum de la Russie," Mém. du comité géologique, vol. II, No. 3 (1886), p. 81, St. Pétersbourg; and "Note sur l'Histoire de la Faune Kimméridgienne de la Russie," Bull. Soc. Imp. des Naturalistes de Moscow, 1886, No. 1, p. 11.

[2] "Argentinisch. Jura," Paläontol. Abhandl. von Dames und Kayser, vol. VII (1897), p. 66, pl. XV, figs. 1 and 2.

[3] Zeitschr. d. Deutsch. Geol. Gesellsch., vol. XLIV (1892), p. 482.

[4] "Note stratigrafiche e paleontologiche sul Giura superiore di Verona," Roma, 1885, p. 74.

HOLCOSTEPHANUS (SPITICERAS) SUBCAUTLEYI, sp. nov.

(Plate XII, figs. 2 *a*—2 *d*: Plate XIII, figs. 1 *a*, 1 *b*.)

Dimensions :—

	Specimen A.	Specimen B.
Diameter	86·5 mm.	98·5 mm.
Width of umbilicus	38·5 „	44 „
Height of the ultimate whorl, at the anterior extremity, approximately	27·5 „	33 „
Thickness of the ultimate whorl, measured at the tubercles, approximately	—	27 „

From the foregoing measurements it is plain that this species, like the nearly related *H. Cautleyi*, belongs to the most widely umbilicate and flattest-shelled types of the subgenus *Spiticeras*. The greatest thickness of the whorls lies in the neighbourhood of the umbilical tubercles. At the median stage of growth the thickness of the whorls is somewhat greater than their height, whereas at the ultimate whorl of the body-chamber the height is slightly superior to the thickness, as may be seen from the following measurements :—

		Specimen A.		Specimen B.	
Diameter	43 mm.	75 mm.	45 mm.	77 mm.	
Thickness	16·4 „	23 „	18 „	24 „	
Height	15·3 „	24 „	16 „	28 „	

In this species, too, then, we have those variations in section which are so characteristic of the Spiticerata, and are here only a little less conspicuous than in the majority of other forms. The sides are rather flat, the periphery of the inner whorls is rounded, that of the body-chamber angular. The body-chamber is equivalent to more than $\frac{3}{4}$ of a whorl. At the oral margin is a deep constriction; the lip itself has unfortunately not been preserved, but what does remain of it is indicative of the presence of auricular prolongations such as in *H. Cautleyi*. The umbilical wall is rounded, and dips obliquely to the suture.

Around the umbilicus upon the last whorl are 19 prominent tubercles, whence arise groups of costæ. To each tubercle correspond four costæ; a few secondary costæ come in as intercalary costæ, and may be reckoned as belonging indifferently to the anterior or posterior group of costæ. The costæ are not very conspicuous in the neighbourhood of the tubercles, but towards the periphery they are noticeably more prominent, appear to trend decidedly forward, and meet together on the periphery at a fairly acute angle. The ornamentation of the innermost whorls has not been clearly preserved, but the tubercles appear as early as the diameter of 12 mm. to be obliterated at the point of furcation of the costæ. A specimen shows on the ultimate whorl three deep constrictions. The lobal line is not thoroughly known; the second lateral lobe is placed obliquely and ends at about the same height as the inner lateral ramus of the first lateral lobe. The first auxiliary lobe is not strongly developed, but is somewhat markedly pendent.

To this species we assign two specimens, although we must expressly state that they do not completely tally one with the other. The specimen figured in plate XIII is perhaps somewhat thicker, the body-chamber has a somewhat

less angular periphery, the constrictions are deeper and more evident than in the specimen in plate XII. As, however, these divergences appear to be rather of a subordinate nature, we could the less easily incline to a specific separation of the two specimens, because their bad state of preservation hardly allows of an unmistakable determination of the differences. It is possible that fuller knowledge of the lobal line of these forms, based on better preserved material, may justify a separation which at present appears uncalled for.

H. subcautleyi is so nearly related to *H. Cautleyi* that we were originally disposed to refer it to Oppel's species. Minute comparison, however, convinced us of the existence of certain divergences which make it inadvisable to join the two species into one. Like *H. Cautleyi* and *H. eximius*, the form under description belongs to the most widely umbilicate and the flattest-shelled species of the genus. The number of the tubercles is the same in both species, the furcating ribs are strongly inclined forward, and the body-chamber is wedge shaped in section. The resemblances, therefore, are considerable. The differences are as follows. In *H. subcautleyi* the whorls are less wedge shaped and are notably lower, the umbilicus for the same size is still wider than in *H. Cautleyi*. The inclination of the umbilical wall is less steep, and the number of the furcating ribs is markedly smaller than in *H. Cautleyi*. Taken as a whole, these divergences give to the species just described an individuality of its own. *H. eximius* diverges from it still more widely along the same line as *H. Cautleyi*, and the risk of confusion is, therefore, still more remote. Among the other species occurring in the Spiti Shales, we might perhaps mention here *H. scriptus* as an allied form. This species is distinguished from *H. subcautleyi* by its narrower umbilicus, coarser tubercles, and thicker shell, in so marked a degree, that the separation of the two species should present no difficulties.

Among the species from other regions than India we must mention here *H. fraternus*, Steuer, from the Tithonian of Argentina. This form is still more closely allied to *H. subcautleyi* than to *H. Cautleyi*, but it differs sufficiently from the former, in the greater number of its sutural tubercles (31 on a single whorl), to ensure specific distinction.

The specimens described herein come from Lochambelkichak (3rd Stage).

Holcostephanus (Spiticeras) Stanleyi, Oppel sp.

(Plate XVI, figs. 1 *a—e*.)

1863. Paläontologische Mittheilungen, plate LXXIX, fig. 1, p. 282.

We base the description of this species on a specimen from Jandn, Hundes, and on Oppel's original specimen, which tally very satisfactorily one with the other. The first-named is on the whole not so well preserved, but it shows the innermost volutions more clearly than Oppel's specimen; this, on the other hand, shows in better preservation the median stage of growth and the body-chamber. In fact, the two specimens complete one another, and enable us to give a fuller description of the species than Oppel could possibly have done.

As his figure is a little reduced and diagrammatised, the number of the furcating ribs minimised, and the section drawn too round, refiguring would hardly be a matter of supererogation. Unfortunately the specimen is too large to refigure the whole of it, the anterior portion of the body-chamber has been left out, as in Oppel's figure, and the outline only has been dotted in.

On the innermost whorls are fine but sharply prominent costæ, arising from the suture and somewhat inclined forward. Precisely at the line of contact with the next whorl they swell up into spinose tubercles, which, judging from the analogy of other species, mark the point of furcation of the costæ. The evolution of the furcating costæ on the innermost whorls is unknown, but it is known at the diameter of about 35 mm. (see plate XVI, fig. 1 *c*. *d*). At that stage the costæ become stouter, diverge more widely one from the other, and, besides the spinose tubercle at the points of costal furcation, exhibit an elongate pectinate swelling at the suture. From each tubercle start three furcating costæ, whereof the foremost is in less evident relationship with the tubercles than the two hindermost. On the periphery the furcating costæ are so markedly enfeebled that, owing to incomplete coincidence of the costæ from either side, there appears to be practically an interruption. They form on the periphery an obtuse angle. The further modification of the ornamentation follows this course, that first of all the tubercles at the points of costal furcation disappear, while the elongate swellings at the suture increase in prominence, passing finally into elongate tubercles. As growth progresses these tubercles diminish in size: at the diameter of 135 mm. Oppel's specimen shows 19 tubercles on the ultimate whorl; at the diameter of 195 mm., 20 tubercles. To each tubercle correspond, on an average, four costæ, trending and dipping markedly forward.

Sp. Stanleyi may be reckoned among the species wherein the primitive costation with median tubercles and sutural protuberances continues up to a comparatively late stage of growth. Slight protuberances, corresponding to the median tubercles, may indeed be traced on careful inspection right up on to the body-chamber.

The variations in section of the whorls run a parallel course with the change in ornamentation. In so far as the available material enables us to judge, the innermost whorls are broadly trapezoidal in section, and their greatest thickness occurs in the neighbourhood of the furcation-tubercles. At a diameter of about 37 mm. (see plate XVI, fig. 1 *c*, *d*) the thickness of the whorls is about twice as great as their height, the periphery is feebly rounded, the sides are well rounded. As growth progresses, the height of the whorls increases faster than their thickness, the periphery becomes markedly rounded, and the greatest thickness occurs in the neighbourhood of the sutural tubercles. At the diameter of 160 mm. the extreme thickness, 56·4 mm., is attained; the anterior portion of the body-chamber retains this thickness while the height still further increases, as may be seen from the following measurements (which also include the values for the umbilical width):—

Diameter . . .	36	mm.	104	mm.	140	mm.	160	mm.	196	mm.
Height . . .	10	"	36	"	43·5	"	48	"	57	"
Thickness . . .	19	"	43	"	54	"	56·4	"	56·4	"
Width of umbilicus .	20	"	44	"	63	"	70·5	"	93	"

Oppel's measured specimen has evidently been broken off immediately short of the definitive oral margin. The predominance of height over thickness is here still more notable, and the section narrows still more to a wedge shape towards the periphery than at earlier stages of growth. On comparison of the figures for the umbilical width, it is seen that the umbilicus was very broad in the innermost volutions, later on it became comparatively narrower, and then, at the anterior end of the body-chamber (where this becomes higher than broad), the umbilicus widened out again considerably. So, then, in this species of a larger growth we may observe the same phenomenon of contraction of the body-chamber as in the smaller species of the same genus.

On each whorl are about three constrictions much inclined forward. The changes in ornamentation of the body-chamber do not appear to be very considerable so far as may be inferred from the somewhat defectively preserved material. On the inner portion of the body-chamber the costæ are somewhat stouter, the tubercles of medium size, but on the outer portion the tuberoles die down afresh, the costæ flatten out and are at the same time more markedly inclined forward. The body-chamber measures, as Oppel has already remarked, nearly a complete whorl, and is in perfect preservation, with the exception of the oral margin. So, too, the specimen from Jandu at a diameter of 160 mm. exhibits a portion of the body-chamber. The lobal line is characterized by elongate and rather narrow lobal bodies, the second lateral lobe shows only slight obliquity, if any, and is but little shorter than the first lateral lobe. The sutural lobe, consisting of the first and second auxiliary lobes, is, comparatively speaking, but feebly developed and does not reach noticeably deeper down than the termination of the first lateral lobe.

Oppel's specimen shows at one point traces of an injury which was subsequently healed up.

In the "Palæontology of Niti," under the name of *A. scriptus* (plate XVI, fig. 2), a small fragment was described of a species which possessed prominent tubercles and groups of costæ consisting of two or three furcating costæ, showing a certain amount of resemblance to *H. Stanleyi*. Blanford later on identified this species with *H. Stanleyi*, Opp. (page 106) : this identification, however, can hardly be correct, inasmuch as *H. scriptus* shows less numerous and stouter costæ and much more strongly denticulated lobes than *Stanleyi*.

It is permissible to regard *H. Theodosia* (Desh.) and *H. Zirkeli* (Felix) as species nearly allied to *H. Stanleyi*. These forms also possess a widely umbilicate shell marked by strong costæ, low, thick whorls, and, just as *H. Stanleyi*, they retain the primitive ornamentation with double tubercles up to a diameter of at least 35 mm. While, however, in *H. Stanleyi*, four costæ on an average correspond to each tubercle, in *H. Theodosia* there are five or six to each tubercle. The whorls of *H. Stanleyi* overlap one another almost for one half, those of *H. Theodosia*, according to Retowski, barely for a third. Finally, the costation of *H. Theodosia* is much finer, and the specific separation of this form from *H. Stanleyi* admits therefore of no doubt. The specific individuality of *H. Zirkeli* is not quite so certain. This form was

described by I. Felix from Cerro de la Virgen near Tlaxiaco in Mexico. All that he says about the Mexican species applies perfectly to *H. Stanleyi*, and the figure, too, agrees very well with it. One can hardly, therefore, go wrong in placing *H. Zirkeli* as very close to *H. Stanleyi*.

From all other species of the subgenus *Spiticeras*, *H. Stanleyi* is so easily distinguishable that it is hardly possible to enumerate all the points of difference. The second largest species of the Spiti shales, *H. Mojsvari*, shows, in regard to the breadth of the peripheral saddle, the advanced evolution of both secondary lobes of that saddle, and the other details of the lobal line, many concordant characteristics: a certain degree of relationship at least is implied thereby. But even within the limits of this resemblance the lobal lines show such divergences as the following:—The peripheral saddle of *H. Mojsvari* is still broader, the external secondary lobe of the peripheral saddle is more highly developed, and the lobal bodies have a shorter, more compressed form than in *H. Stanleyi*. The much feebler ornamentation and the less angular section of *H. Mojsvari* make the specific distinction an easy matter. For the sake of exhaustiveness we may mention also that *H. bulliforme* differs from *H. Stanleyi* by its much narrower umbilicus, finer and more closely-set costation, feebler development of the tubercles, and less marked forward inclination of the costæ.

The two specimens which we refer to *H. Stanleyi* agree very well, as already stated. The specimen from Jandu, Hundes, is perhaps somewhat more rounded in section. This hardly noticeable divergence is not of sufficient importance to warrant the attribution of the specimen to any other than Oppel's species.

Oppel's original figured specimen came from Laptel in Gnari-Khorsum.

HOLCOSTEPHANUS (SPITICERAS) MOJSVARI, sp. nov.

(Plate XVII, figs. 1 *a—d*.)

The innermost whorls of this species are much broader than high; at a diameter of about 12 mm. the height of the whorl measures 4·3 mm., and its breadth 6·3 mm. At this stage the whorls are furnished with costæ, exhibiting about the middle of the sides a slight tubercle, whence arises the furcation into secondary costæ. These last, so far as one can judge, are not very numerous, and they are somewhat sharply inclined forward. At this stage, too, the row of sutural tubercles is hardly indicated, the greatest thickness of the whorls is at the middle of the sides, perhaps inclining a little more towards the flattened periphery. The same sectional form may be observed at the diameter of 27 mm., but at the diameter of 34 mm. the greatest thickness has passed to the neighbourhood of the sutural tubercles, and the periphery is very much rounded. It is true that at this stage the breadth of the whorls is still markedly greater than their height; but as growth continues the breadth does not increase in the same ratio as the height, the result being that the ultimate whorl is scarcely broader than it is high. The section assumes here a trapezoidal shape, the sides are markedly flattened, the periphery is rounded, the dip of the umbilical wall rather steep. As in many other species of this group, the umbilical wall immediately at

the suture seems to be drawn inward, so that its steep declivity is somewhat modified. Naturally, this applies only to specimens wherein the shell is preserved.

Concurrently with the modification in sectional shape, changes in ornamentation take place. First of all, the row of sutural tubercles develops, besides which at the diameter of about 30 mm. tubercles may be still observed at the points of costal furcation. These last tubercles die away little by little, only the sutural row remains, and at the median stage of growth this consists of widely separated, blunt but prominent, stout tubercles. The furcating costæ are fairly numerous and sharply inclined forward. On the outer whorl the tubercles show signs of enfeeblement, lengthen out somewhat, and on the foremost portion of the body-chamber assume completely the aspect of flat costæ. The furcating costæ form on the periphery an unmistakable angle. At the stage of normal ornamentation about five furcating costæ would appear to correspond to every tubercle.

The lobal line is chiefly characterized by remarkably broad saddles and regular, almost subsymmetrical, rather short lobes; the second lateral lobe is somewhat obliquely placed, as in *Sp. scriptum*. The sutural lobe is not quite clearly recognizable, and appears to be but slightly pendent. The body-chamber is for the most part preserved, and embraces more than three-quarters of the ultimate whorl. Upon the body-chamber are three rather shallow constrictions, two of which are closely approximate. The foremost portion of the body-chamber is more elliptical in section, with a flatly dipping umbilical wall and feebly rounded sides. The greatest thickness passes here more towards the middle of the section. At the same time the umbilicus widens out considerably; the foremost portion of the body-chamber does not overlap the preceding whorl so much as the initial portion of the body-chamber does; this is clearly seen from the following measurements:—At a diameter of 114 mm., the width of the umbilicus measures 41 mm., the thickness 43 mm., and the height 39 mm. On the other hand, in the full-grown specimen of 154 mm. diameter, the umbilical width is 63 mm., the height of the foremost preserved portion of the body-chamber 47·5 mm., the thickness 53 mm. Thus, the width of the umbilicus, which at the diameter of 114 mm. is still midway between the thickness and the height, becomes in the full-grown specimen much greater than the thickness.

Of all the Spiticerata, *Sp. scriptum* seems to be the most closely allied to the species just described. It is not possible, however, to unite these two forms under the same name, as the number of costæ in *H. scriptum* is much smaller, and the periphery is much more wedge shaped than in *H. Mojsvari*. The innermost whorls of *H. scriptum* exhibit flattened sides, a rounded quadrate section, and are almost as high as they are thick. In *H. Mojsvari*, on the other hand, the inner whorls are much thicker than high.

From *H. Cautleyi* our species is distinguished chiefly by its greater thickness lower sectional area, and stouter tuberculation. *H. Stanleyi* has more strongly rounded whorls, fewer but stouter costæ, a wider umbilicus and divergent lobes.

The species just described occurs as a specimen from Lochambelkichak (3rd Stage).

HOLCOSTEPHANUS (SPITICERAS) SCRIPTUS, Strachey sp.

(Plate LVIII, fig. 2 *a—c*; Plate XV, fig. 1 *a—g*; Plate VIII, fig. 4 *a*, *b*; Plate XIV, fig. 3 *a—d*.)

Ammonites scriptus, Strachey, in Blanford's "Palæontology of Niti," 1865, page 81, plate XVI, fig. 2 *a—c*.

The above-mentioned species was founded by Strachey on a chambered fragment, so badly figured in the "Palæontology of Niti," that the species is unrecognizable from the figure and the accompanying description. Thanks, however, to an excellent plaster cast of the original specimen (which is in London), we are enabled to proceed to a more exact description of the species and to infer its probable identity with two specimens derived from the Collections of the Geological Survey of India.

In Strachey's original specimen not only two (as shown in the drawing in the "Palæontology of Niti") but four costæ correspond to each sutural tubercle. In each group of four costæ two arise direct from the sutural tubercle, and two arise from these by dichotomy or intercalation. The costæ are somewhat flat, wide apart, and forwardly inclined. They form an unmistakable angle on the external periphery, weaken here somewhat, and on the inner whorl are even interrupted (as may be seen from the impression of the external periphery). The tubercles are very prominent. At one point a non-tuberculate costa is intercalated, and this probably corresponds to a degenerate stage of constriction. The cross-section is rounded, a little broader than it is high. The sutural surface is fairly broad and slopes obliquely inward.

The lobes appear to present most resemblance to those of *Sp. Mojsvari* and *Stanleyi*. The external saddle is broad, the first lateral possesses a compressed "body," with a long terminal ramus and strong lateral rami. The second lateral lobe is set somewhat obliquely, and has a short, broad "body," with a long terminal ramus and two approximately equal lateral rami. The auxiliary lobes are set very obliquely, but do not hang downward. The first auxiliary lobe reaches almost up to the extremity of the lateral ramus of the second lateral lobe, and in that way causes a marked narrowing of the base of the second lateral saddle. The folia of the second lateral have full scope for free development. The inner whorls and the body-chamber are not to be found in Strachey's original specimen.

With the aid of the plaster cast of that specimen, however, we were enabled to ascertain that a fairly complete specimen from Lochambelkichak is either very closely allied to *Amm. scriptus* or else identical with it. It is true that the Lochambelkichak specimen appears to be somewhat more narrowly umbilicate than Strachey's, but the difference is so unimportant that it would not justify specific differentiation. Consequently we shall assign the form represented in plate XV, fig. 1 *a—g*, to *Amm. scriptus*, and now proceed to give a description of the specimen.

On the inner volutions the median tubercles disappear comparatively early; the

sutural tubercles, on the other hand, become prominent at an early stage. To each sutural tubercle there correspond on an average four costæ, sharply inclined forward. As early as the diameter of 15 mm. they make an unmistakable angle on the external periphery, and appear to suffer some interruption here. From each tubercle two costæ arise, dichotomizing higher up. Moreover, at some points an additional intercalary costa makes its appearance. Dichotomy does not take place in all the costæ at exactly the same height, but is observed to occur higher in some and lower in others. At the point where they start from the sutural tubercles some costæ are so feebly developed that their connexion with the tubercles is barely perceptible. The tubercles are set so wide apart that there could hardly have ever been more than eighteen on a whorl. Deep constrictions are apparent, but their number is not precisely determinable.

The cross-section assumes in the inner whorls a subquadrate shape which passes gradually into a rounded trapezoid. This modification of the cross-section is especially well seen in the body-chamber, partly preserved in this specimen. The tendency (observable in many Spiticerata) of the body-chamber to increase in height is here but feebly marked. At a diameter of 31 mm. the height is 11·2 mm., the girth measured over the tubercles 13·8 mm., the width of the umbilicus 10·6 mm. At a diameter of about 106 mm. the width of the umbilicus is 39 mm., the height of the ultimate whorl 39 mm., and its breadth 36·3 mm. That the whorls do increase gradually in height, however little, concurrently with general increase in size, is tolerably plain from the foregoing statistics. The lobal line of the specimen first described (wherein a portion of the body-chamber is preserved) is unfortunately not known.

The difficulty of a comparison of the original specimen of *Amm. scriptus* with that figured in plate XV, figs. 1 *a*—*g*, is much enhanced by the circumstance that in the latter the lobes are unknown, and in the former the body-chamber and the inner volutions. The concordance, however, of the very characteristic costation and of the cross-section is so complete, that we are fain to admit the very closest relationship between the two forms. It is true that Strachey's specimen exhibits a somewhat wider umbilicus, but the difference is so slight that it cannot furnish the basis of specific differentiation. If, however, divergences in lobal structure were demonstrable, we should feel obliged to assign these forms to different species. For the present, it seems advisable to apply the name *Amm. scriptus* to the specimen represented in plate XV, fig. 1.

H. scriptus approximates more especially to *H. subcautleyi*, *Mojsvari*, and *Stanleyi*. From *H. subcautleyi* our species is distinguished by its thicker test, narrower umbilicus, and more numerous costæ; from *H. Stanleyi* by its smaller size, feebler tuberculation, early disappearance of the median tubercles, and more quadrate cross-section. The lobal line of *Sp. Stanleyi* has simpler auxiliary lobes; moreover, the second lateral saddle in this species is much broader, and the second lateral lobe has two feeble terminal rami, while in our species one strong terminal ramus is developed. The differences between *Sp. scriptum* and *Sp. Mojsvari* are

enumerated under that species. *Sp. scriptum* also presents a certain resemblance with *H. Bodenbenderi*, Steuer.[1] The differentiation of these forms, however, is facilitated by the more rounded sides, the broader umbilicus, the feebler tuberculation, and the lower whorls of the Argentine species. Finally, we may allude to *H. narbonensi*, Pictet, a species which exhibits a certain similarity of habit to *H. scriptus*, but is easily distinguished by its much more prominent costæ, less prominent tubercles and far more numerous intercalary costæ.

The original specimen of *Amm. scriptus* came from Niti; that figured in plate XV, fig. 1, is from Lochambelkichak, 3rd Stage, Coll. Diener.

We must here associate with *Amm. scriptus* two specimens which are doubtless nearly related to it, but most probably not specifically identical with it. They are, at all events, so imperfectly preserved, that it would be impossible to found new species on them. The specimen represented in plate VIII, fig. 4 *a—b*, under the name of *Spiticeras* aff. *scriptum* has a more rounded cross-section and retains the traces of the median tubercles much later than the typical form of plate XV, fig. 1. So, too, the specimen represented in plate XIV, fig. 3 *a—d*, as *Spiticeras* aff. *scriptum*, exhibits, as late as the diameter of 50 mm., marked traces of the median tubercles. Further, the cross-section at the beginning of the body-chamber is somewhat broader, somewhat lower, and tending more to a wedge shape peripherally, than in the original specimen. But more especially do the lobes furnish evidence of divergences so considerable that we should hardly advise the direct attribution of this form to *Amm. scriptus*. Unfortunately, the imperfection of the specimen forbids precise determination. Both of the forms designated as *Spiticeras* aff. *scriptum* come from Lochambelkichak, 3rd Stage (Coll. Diener). Finally, we might place here yet another specimen from Lochambelkichak, 3rd Stage, but it is in so bad a state of preservation that it adds nothing to our knowledge of the species.

HOLCOSTEPHANUS (SPITICERAS) BULLIFORMIS, sp. nov.

(Plate XIII, fig. 2 *a—c*.)

Dimensions:—

Diameter	105 mm.
Width of umbilicus	36 „
Height of the ultimate whorl	35 „
Thickness of the ultimate whorl	50 „

The highly inflated shell consists of whorls which overlap one another for nearly two-thirds and are broadly surrounded in cross-section. The greatest thickness is in the neighbourhood of the sutural tubercles; the sides and periphery are curved; the declivity to the umbilicus is fairly steep, especially in the vicinity of the tubercles. Around the umbilicus on the ultimate whorl are eighteen large, strongly protuberant, sharp-pointed tubercles, which run out towards the suture into a slight costa or mere strip. From each tubercle start three or four costæ, which,

[1] "Argentinische Jura Ablagerungen," Palæont. Abhandlungen von Dames und Kayser, VII, 1897, plate IV, figs. 5—7, page 65.

on furcating higher up increase their number by two, the result being that at least five and frequently six costæ correspond to every tubercle. The costæ are somewhat sharply inclined forward, and form an angle on the periphery, which is conspicuous at the inner part of the ultimate whorl, but is somewhat more curvilinear at the outer part, though still recognizable. On the ultimate whorl there is only one constriction markedly inclined forward. On the next inner whorl are sixteen prominent tubercles, and also but one clearly-marked, deep-cut constriction. The innermost whorls are not to be seen. The lobal line is not accurately known; the first auxiliary lobe appears to be but slightly pendent.

The body-chamber, which takes up almost the whole of the ultimate whorl, shows no particular changes in ornamentation. Slight irregularities in the costæ are observable at some points, and appear to be due to injury or pathological conditions.

The form here described shows a considerable similarity of habit to *H. celsus*, Opp., from the Tithonian of Stramberg, but the Moravian species is somewhat more widely umbilicate, has a lower oral aperture, and is conspicuously smaller than the Indian species. From *H. Stanleyi* we may distinguish *H. bulliformis* by its stronger involution, more flattened periphery, greater breadth of whorls, and the character of its ornamentation. Moreover, the last-named species exhibits tubercles at a very early stage, and its costæ are about twice as fine as those of the other form.

H. spitiensis possesses identical ornamentation, but differs so markedly in the form of the shell and the character of the body-chamber, that any confusion with *H. bulliformis* is out of the question. So, too, the prominent tubercles of this species recall *H. scriptus*, from which it is again easily distinguishable by the different shape of the shell.

Although we are unfortunately not in a position to give a complete diagnosis of the species, the specimen which we have examined is, on the whole, in so excellent a state of preservation and exhibits so striking an individuality, that we could not pass it over without notice. The apparently slight inclination of the first auxiliary lobe would indicate that this form belongs to the group characterized by feebly developed, slightly pendent auxiliary lobes and broad saddles.

The specimen just described comes from Spiti Valley.

HOLCOSTEPHANUS (SPITICERAS) GRIESBACHI, sp. nov.

(Plate XI, fig. 3 *a—d*.)

Dimensions :—

Diameter	102 mm.
Width of umbilicus	39·2 "
Height of volution at the anterior extremity	34 "
Thickness measured at the tubercles	39 "
" measured in the intercostal space	36·6 "

The discoidal, rather widely umbilicate shell consists of whorls, whose sides, although they pass gradually into the curved periphery, are comparatively well developed. Umbilical wall rounded, sloping inward somewhat steeply, broadening

out a little at the suture and drawn inward. The whorls are thickest where the umbilical wall passes into the sides. The cross-section of the volutions assumes, especially at the anterior extremity, a rounded trapezoidal shape which is very characteristic of this species.

At the umbilical wall of each whorl are nineteen elongate tubercles terminating in a short point. From each tubercle starts a group of five, seldom six, secondary costæ not much inclined forward; they have, especially on the ultimate whorl a peculiarly irregular course. This irregularity of the costæ, which is very hard to describe in words and will be best understood from the figure, depends in part on the circumstance that secondary costæ may branch off from the same costæ forward and backward, and the intercalation or splitting-off of the secondary costæ takes place in some cases near the periphery. Further, the costæ, particularly on the ultimate whorl, are somewhat more delicate than in most species of the sub genus *Spiticeras*. The costæ pass uninterruptedly over the periphery and form here only a very inconspicuous angle. Upon each whorl are three constrictions, somewhat sharply inclined forward and feebly curved. The innermost whorls are not to be seen; it is probable that the double-tubercular stage gave place at a fairly early period to the normal ornamentation.

Unfortunately, the body-chamber is not known; the specimen is chambered up to the end, and must, therefore, when full grown, have attained a considerable size.

The lobal line shows relationship to the type of the second group in so far that the "body" of the second lateral saddle is very narrow, and the first auxiliary lobe is very obliquely placed. As, however, the peripheral saddle possesses a fairly broad "body," and the first auxiliary lobe, despite its obliquity, is but slightly pendent, lying markedly higher than the apex of the second lateral lobe, we considered it necessary to range this species also in the first group. The "body" of the first lateral lobe is broad and somewhat short, the lateral rami and the terminal ramus being, on the other hand, long and slender. All the branches of the lobal line are characterized by relatively prominent ramification, and are closely set with long denticulations. In many respects the species under description is very closely allied to *H. guttatus*, Blanf. When the fossils are in a defective state of preservation it is not easy to distinguish, say, the inner whorls of one form from those of the other. Nevertheless, we cannot subscribe to an identification of the two species. In *H. Griesbachi* the number of furcating costæ in a group is somewhat greater, while the number of tubercles is somewhat smaller than in *H. guttatus*. Further, the last named species fails to exhibit the peculiarly irregular costation so characteristic of *H. Griesbachi*. Then, too, *H. Griesbachi* attains a much larger size than *H. guttatus*; the former measuring at least 111 mm. at the beginning of the body-chamber, while the latter only measures 52 mm. To these differences we must add the divergence in lobal structure: in *H. guttatus* the "body" of the first lateral lobe is long and slender, with short lateral rami and a short terminal ramus. In *H. Griesbachi*, on the other hand, the "body" of the first lateral lobe is broad and short and the terminal ramus long; especially, however, are the lateral rami of the

first lateral lobe not only longer than in *H. guttatus* but also compressed together to such an extent that both the lower lateral rami are conjoined on either side each into one "split" lateral ramus. Finally, the peripheral saddle and the first lateral saddle in *H. Griesbachi* are somewhat broader than in *H. guttatus*, and the first auxiliary lobe is situated higher up than the terminal ramus of the second lateral lobe, whereas in *H. guttatus* the terminal ramus of the second lateral lies on the same line as the first auxiliary lobe.

A careful comparison of these two species shows, therefore, differences which it is impossible to pass over, denoting a distinct specific individuality for each form.

The rounded trapezoidal cross-section might perhaps give rise to confusion with young specimens of *H. Mojsvari*, but the much more prominent tubercles and the marked forward inclination of the costæ make it easy to distinguish between the two species.

H. scriptus has a narrower umbilicus, a more strongly curved and more angulate periphery, more prominent tubercles, and costæ much more sharply inclined forward. It also, therefore, is easily distinguishable from *H. Griesbachi*.

Finally, it is as well to mention that the peculiar irregularity in the course and furcation of the costæ is a feature which is common to *H. polytroptychus*, Uhlig.[1] This, however, is a form whose narrower umbilicus, extremely flat test, and small size differentiate it so markedly from our species, that it is hardly possible to postulate a relationship between the two.

H. Griesbachi, sp. nov., occurs as a specimen from Lochambelkichak (3rd Stage).

Holcostephanus (Spiticeras), sp. nov. ind.

(Plate IX, fig. 1 *a—c*, fig. 3 *a—d*; Plate VIII, fig. 5.)

Although this form cannot be identified with any of the hitherto known species, we have refrained from christening it with a new specific name, as we are, unfortunately, not in a position to give a complete diagnosis. The material consists of three externally very similar shells, whose lobal lines, however, exhibit considerable differences. The mutual relationships of these specimens cannot, at present, unfortunately, be established with certainty, and this is still another reason inducing us to abstain from the establishment of a new species.

The shell consists of almost circular whorls, overlapping one another for about a half, which are but little thicker than high, and give place to a broad umbilicus.

The sides are not markedly developed, and they pass gradually, on the one hand, into the curved, rather steep umbilical wall, on the other, into the rounded periphery. The cross-section undergoes no essential modification, as far as one can judge, up to the beginning of the body-chamber. Unfortunately, we cannot say what is the habit of the body-chamber in this respect, as it has not been preserved. Around the umbilicus are arranged about twenty-two tubercles, whence arise groups of costæ sharply inclined forward.

[1] Jahrbuch d. k. k. Geol. Reichs., vol. XXXVIII (1887), p. 107.

The costæ are rounded but strongly developed; they pass undiminished over the periphery, where they form a very inconspicuous, in fact barely noticeable, angle. Upon each whorl are three or four constrictions. In the smaller specimen (plate IX, fig. 1) the double-tubercular ornamentation, which, at a diameter of about 22 mm., passes into the normal ornamentation, is pretty clearly shown.

The lobal line of the larger specimen (plate IX, fig. 3 *d*) is characterized by very beautiful, elaborate denticulation; and, in view of the oblique, strongly pendent position and complete evolution of the sutural lobe, it approximates to the type of *H. indicus*. The lobal line of the species under description, however, differs from that of *H. indicus* chiefly by the greater breadth of the peripheral saddle, greater length of the second lateral lobe, and bifurcation of the terminal ramus of the second lateral lobe into two short paired rami. The evolution of the lobal line is not strictly symmetrical, as the median line of the peripheral lobes diverges a little to the right of that of the shell, and the right ramus of the peripheral lobe is longer than the left.[1]

The lobal line of the smaller specimen, on the other hand (plate VIII, fig. 5), recalls rather *H. guttatus*, Blanf., for the peripheral saddle is fairly broad, and the auxiliary lobes are more feebly developed and less markedly pendent. Here, too, the bifurcation of the terminal ramus of the second lateral lobe is indicated, and can be seen to originate in the somewhat more advanced development of an outer lateral branch of the second lateral lobe.

Whether these specimens, whose external form and costation are so similar, despite the not inconsiderable divergences in lobal structure, belong to one and the same species, cannot be determined with certainty from the scanty material which lies before us. Perhaps the differences in the lobal line do not stand alone; perhaps we ought to take into consideration the differences conditioned by the various sizes of the specimens. These are points which the future alone can settle, but we were loth to pass over these specimens without remark, as they do undoubtedly represent a divergent type, not found among the other Spiticerata. The numerous constrictions invest this species with a certain resemblance to many representatives of the genus *Holcodiscus*. Whereas in all other Spiticerata the greatest thickness of the shell occurs in the neighbourhood of the sutural tubercles, in the species just described the test curves up somewhat, even forward of the sutural tubercles, so that the cross-section assumes a more circular shape than in most other forms of the group. In this respect, also, *H. indicus* is perhaps the most closely related species of any to this one, but the much finer costation and smaller number of constrictions in *H. indicus* make it easy to differentiate between the two. From *H. guttatus* the species just described is distinguished by its wider umbilicus, lower whorls with a more circular cross-section, more numerous constrictions, and the peculiarities of lobal structure already mentioned.

Two of the specimens described come from Gieumal. The exact locality of the third, which was collected by the brothers Schlagintweit, is not known.

[1] Left and right of the oral aperture being understood.

2nd GROUP.

Forms with slender denticulated saddles and markedly pendent, highly developed auxiliary lobes.

HOLCOSTEPHANUS (SPITICERAS) GUTTATUS, Strachey sp.

(Plate XI, fig. 1 *a—c*.)

1863. *Ammonites guttatus*, Blanford. "On Gerard's Collection of Spiti Fossils." Journ. Asiat. Soc. Beng., vol. XXXII, p. 131, pl. IV, figs. 1 *a*, *c*.

1866. *Ammonites spitiensis*, Stoliczka, p. p., Mem. Geol. Surv. India, Calcutta, vol. V, p. 102.

Dimensions :—

Diameter	52 mm.
Width of umbilicus	17·3 „
Thickness of ultimate whorl	25·2 „
Height of ultimate whorl	20 „

The shell is discoidal, slightly evolute. The whorls of the chambered portion overlap one another for more than a half, and are somewhat thicker than high. The breadth of the whorls is greatest in the neighbourhood of the inner tubercles, and of the inner portion of the sides; thence it diminishes gradually towards the periphery. The sides are somewhat flattened on the inner portion only, the periphery is strongly curved, the umbilical wall rather high and dipping steeply towards the umbilicus. The spiral of the sutural line shows this peculiarity in the umbilicus, namely, where the constrictions come in the spiral appears to be slightly broken into angles—a phenomenon of growth which is perhaps in some way connected with the erstwhile sharper inclination of the costæ at the constrictions.

The ornamentation consists of "bidichotomous" costæ, which originate at the inner tubercles. It may be regarded as a general rule that to each tubercle correspond four costæ, one at least of which is a short intercalary costa. The first costa that starts from each tubercle is the most sharply inclined forward, behind it arises always a small furcating costa, and thereupon follow two simple costæ starting from tubercles, or else a bifurcated main costa. It is not always possible to distinguish clearly between the group of costæ corresponding to a particular tubercle, and the next preceding or next following. Upon each whorl are three deep constrictions markedly inclined forward, limited anteriorly by a smooth, or but slightly-swelling strip, or an inconspicuous costa, and bounded posteriorly by a very prominent costa. The anterior costa arises from a very feeble sutural tubercle, and the posterior from a very protuberant one. Owing to the marked forward inclination of the last-mentioned costa, a broad space appears to be left, admitting of the development of somewhat more numerous furcating ribs, so that the costal group at the constriction comprises altogether seven costæ. Next behind the constrictional costa come in two short furcating costæ, then follows a costa arising from the sutural tubercle and dichotomizing somewhere about the middle of the sides, the rear being brought up by a pair of costæ originating in the tubercle. The costæ course uninterruptedly over the periphery, undergoing there a very slight, barely noticeable decrescence. Consequent on the forward inclination of the costæ, they meet at the median line of the

periphery in an angle, which is specially inconspicuous in this species, and might indeed escape observation altogether, were it not that a similar angulation is much more clearly manifest in nearly related forms. This angle is best seen in the portions of the test that lie immediately behind the constriction. Finally, we may note that the costation on one side does not strictly correspond to that on the other.

The tubercles are twenty-one in number on the ultimate whorl; they are rather inflated, and run out towards the umbilicus, particularly on the inner whorls, into an inconspicuous costa. In this species the primitive costation does not appear to have endured beyond the diameter of 15 mm. The costæ at that stage were characteristic of the comparatively feeble ornamentation of the form, that is, somewhat delicate, and the little tubercles at the points of costal furcation were merely indicated faintly. Of the body-chamber only the initial portion has been preserved, upon which the ornamentation continues unaltered; nor does the ratio between height and breadth of the cross-section undergo any sensible change—there being at most a slight tendency to angulation at the periphery. The umbilicus widens out somewhat. Nothing, of course, can be said as to the features of the anterior part of the body-chamber and the oral margin, since the complete body-chamber is not available.

The lobal line is especially characterized by the presence of an obliquely pendent sutural lobe in the formation of which the second lateral lobe participates (as well as the three auxiliary lobes) in so far that it already occupies an oblique position. The first auxiliary lobe is elongate, and obliquely placed with regard to the second lateral lobe. The lobal "bodies" are comparatively slender, the lateral rami short and but little denticulated. The lobes of *H. guttatus* do not quite correspond to the typical lobal structure of the second group, showing, as they do, many points of agreement with the lobal structure of the first group. The peripheral saddle is somewhat broader than in *H. indicus* and *obliquelobatus*, but on the other hand somewhat narrower than in the several species of the first group. The predominance and markedly pendent position of the sutural lobe, so very characteristic of the second group, are not yet typically developed in this species, and yet they are far more clearly manifest than in the first group. Wherefore, from the point of view of lobal structure, *H. guttatus* constitutes a connecting link between the first and second groups, being, however, more closely allied to the second.

Among the forms of the first group, *H. Griesbachi* may be regarded as the most nearly related to the species just described. The points which differentiate it from *H. guttatus* were so fully dwelt upon in the description of *H. Griesbachi*, that we need here only refer the reader to that description. In the same way, with regard to the differences between *H. guttatus* and *H. indicus*, *H. bilobatus*, and *H. obliquelobatus*, we would refer the reader to our descriptions of the three last-named species.

Among European forms *H. Negreli*, Math., more especially recalls *H. guttatus*. The costæ and tubercles in the first named are still more delicate, the umbilicus is wider and the whorls overlap each other only for about a quarter of their height.

While in *H. guttatus* the breadth of the volutions is greater than the height, the contrary relation obtains in *H. Negreli*. The closely allied *H. obliquenodosus*, Ret., besides these differences, is distinguished from our species by its lower whorls.

In the "Palæontology of Niti," p. 79, pl. XIII, fig. 2, Blanford assigned to his *Amm. guttatus* a specimen collected by Colonel Strachey, but the figure is so bad that it is completely unrecognizable, and we are quite unable to realize the true characteristics of this form. We have, therefore, abstained from including it in the synonymy of *H. guttatus*, basing our description on Blanford's original specimen of *Amm. guttatus* which has been refigured here.

Next to this we place another specimen from Lochambelkichak (3rd Stage) which is indeed somewhat thicker than Blanford's original specimen; but the difference is so unimportant that it cannot for one moment interfere with the assignment of the two specimens to the same species. It is unfortunate that the lobes are only imperfectly preserved in this second specimen.

HOLCOSTEPHANUS (SPITICERAS) OPPELI, sp. nov.

(Plate LVIII, fig. 1 *a—c*.)

In the State Palæontological Collection at Munich is an ammonite from the Spiti Shales of Tibet, which has been determined as *H. spitiensis*, but undoubtedly belongs to another species, new indeed to us. The specimen is unfortunately bereft of body-chamber, but is otherwise so well preserved that we may unhesitatingly base upon it the establishment of a new species.

With a diameter of 75·5 mm., this form possesses an umbilical width of 22·5 mm. The ultimate whorl at the broken anterior extremity is 28·8 mm. high and 28·9 mm. broad; at the initial portion, on the other hand, the thickness measured over the tubercles is 19·8 mm., and the height 16·5 mm. Therefore in this species as growth progresses the height augments at a proportionately greater rate than the breadth.

The whorls of this thickly discoidal shell exhibit their greatest thickness in the neighbourhood of the sutural tubercles, whence also the thickness gradually diminishes towards the periphery. The periphery is strongly curved at the beginning of the ultimate whorl; at the extremity of this whorl, on the other hand, a slight tendency to converge into a wedge shape is noticeable. The umbilical wall is rounded, but dips steeply inward, the sides are rather flat, the cross-section at the anterior extremity of the ultimate whorl is curvitrapezoidal; the umbilicus is comparatively narrow, and the whorls overlap one another for about two-thirds.

At the umbilical wall there are upon the ultimate whorl twenty-seven elongate tubercles, from each of which starts a group consisting of three or four costæ. The costæ are rather sharply inclined forward, fairly straight, trending somewhat forward only at the peripheral extremities. Further, they are close set, but well-developed, and course undiminished over the periphery, where they meet the costæ of the opposite side at an unmistakable angle. Upon the ultimate whorl are three

constrictions whose forward inclination is especially well marked at the peripheral portion of the sides. Of the costæ which accompany the constrictions the rearmost is very fully developed, and here the costal group consists of five to six members. Of the innermost whorls only a small portion has been preserved, but enough to show very clearly the double-tubercular stage. This appears at a diameter of about 25 mm., to pass into the normal costation.

The lobal line is characterized by ramifying narrow lobal "bodies," and deeply denticulated narrow saddles; also by the obliquity of the second lateral lobe and the extraordinary marked development of the first auxiliary lobe. The latter has a very oblique position, is hardly smaller than the second lateral lobe, nor does it only reach up to the inner terminal ramus of that lobe, but is also very markedly pendent. It is especially worthy of note that two almost equally large, long, oblique secondary lobes cut deep into the second lateral saddle; while in most other forms, above all, in the closely allied *H. obliquelobatus* and *H. indicus*, only one secondary lobe is associated with the second lateral saddle. Finally, we may call attention to the remarkably high position of the first lateral saddle.

It is this very characteristic lobal line which enables us to fix upon *H. indicus* and *H. obliquelobatus* as the species most nearly allied to *H. Oppeli*. *H. indicus* has a wider umbilicus, lower, thicker, and more rounded whorls, finer costæ, and less numerous tubercles. The lobal line is differentiated mainly by the presence of only one secondary lobe in conjunction with the second lateral saddle, and by the lower position of the first lateral saddle. The differences from *H. obliquelobatus* will be dealt with when we come to describe that species.

At the first glance *H. planus* also reminds us of the form just described; especially do the great number of tubercles, the close conjunction of the costæ, and the height of the whorls incline us to infer a near relationship, which in reality does not exist. *H. Oppeli* possesses thicker whorls, a narrower umbilicus, somewhat coarser costæ, and more numerous tubercles than *H. planus*, but above all the completely divergent lobal structure makes it evident that the similarity between the two species is remote and purely external. From *H. guttatus* we distinguish *H. Oppeli* by its more numerous tubercles, more convergent periphery, and higher whorls; moreover, the lobal line of the latter differs very strikingly from that of the former, as a comparison of the figures will sufficiently show.

The exact locality where the specimen was found is not known: it does not appear upon the labels which lie before us.

X HOLCOSTEPHANUS (SPITICERAS) OBLIQUELOBATUS, sp. nov.

(Plate XV, fig. 3, 3 *a*; Plate XVIII, fig. 1 *a*—*c*.)

Dimensions:—

Approximate diameter	81 mm.
Approximate width of umbilicus	28·7 "
Approximate thickness of ultimate whorl	27·5 "
Height of ultimate whorl	30·5 "

The discoidal shell of this species consists of somewhat flattened whorls converging to a wedge shape towards the periphery, overlapping each other for about one half, and thickest in the neighbourhood of the sutural tubercles. While the inner whorls are thicker than high, in the outer still completely chambered whorls the height surpasses the thickness. The specimen happens to be so broken as to allow of the examination of the cross-section of the inner whorls: these are very thick, low, and rounded, while as growth progresses they become increasingly higher, flatter, and angulate (convergent). The umbilical wall is rounded but dips steeply inward to the suture. The external outline does not follow the course of a regular spiral, but shows slight protuberances at two points, independently of the constrictions. Whether this is a pathological phenomenon, concerning merely the individual, or whether it is a specific characteristic, is a point which we are unable to determine, in view of the circumstance that the species, at present, is represented by only one specimen. The body-chamber is not known.

The whorls are covered with costæ, fairly close-set, and sharply inclined forward, meeting in a very well-marked angle on the periphery, and, far from suffering there any enfeeblement, these costæ are, if anything, more prominent. To each of the somewhat blunt and small sutural tubercles correspond, as a rule, five furcating costæ. On the ultimate half-whorl is a shallow constriction which gradually flattens inward, in contrast with all the other Spiticerata, where the constrictions are precisely bounded inward by particularly strong costæ. The primitive ornamentation appears to give place to the fully developed costation as early on as the diameter of 10 mm.

In its main features the lobal line, with its narrow saddles, and large, markedly pendent umbilical lobe, resembles the lobal line of *H. indicus* and *H. Oppeli*. The "bodies" of the lobes and saddles are somewhat stouter, and the lateral denticulations less minute than in *H. indicus*. Furthermore, the two lateral rami following upon the terminal ramus, of the peripheral lobe, which in *H. indicus* are conjoined into a divided lateral ramus project in *H. obliquelobatus* as independent lateral rami from the "body" of the peripheral lobe. Finally, the secondary lobe which divides the first lateral saddle is in *H. obliquelobatus* very short and oblique,—in *H. indicus*, on the other hand, elongate and straight. In *H. obliquelobatus* the inner lobe is known to consist of a very narrow and long antisiphonal lobe, and, as it would appear, of three much smaller inner auxiliary lobes. The former ends in an unpaired termination, and bears numerous, small, unsymmetrically distributed lateral ramuli.

H. indicus and *H. Oppeli* may be regarded as the most closely allied species. *H. obliquelobatus* differs from *H. indicus* by the greater height of the volution, wedge-shaped convergence at the periphery, more numerous ribs (meeting at an angle on the periphery), and the characters of the constrictions. We have already discussed the differences in lobal structure. The species just described is even more nearly related to *H. Oppeli* than to *H. indicus*,—so closely indeed, that we should have been induced to regard it and *Oppeli* as one and the same form had not the remarkable peculiarities of lobal structure been superadded to certain slight divergences in shape

and costation. Among these peculiarities we may specially note two long secondary lobes associated with the second lateral saddle of *H. Oppeli*, which in *H. obliquelobatus* are represented by one secondary lobe only, and that a much shorter one.

In *H. obliquelobatus* with the extremely narrow first lateral saddle is associated only a very short oblique secondary lobe. In *H. Oppeli*, on the other hand, the first lateral saddle assumes a broad development as in *H. indicus*, and is divided by a long secondary lobe. Finally, at the peripheral lobe in *H. obliquelobatus*, a lateral ramus is more fully developed than in *H. Oppeli*.

Moreover, *H. obliquelobatus* is differentiated from that species by its rather wider umbilicus, less numerous tubercles, with equally close-set costation, and rather higher and more angulate whorls. Whether the protuberance of the external outline in *H. obliquelobatus* is to be regarded as of specific importance is doubtful. *H. Oppeli* and *H. obliquelobatus* afford an example of divergent lobal structure accompanied by fairly concordant external form, an example not unlike that already furnished by *H. spitiensis* and *H. subspitiensis*. If here the differences of lobal structure are less considerable, we are still of opinion that it is not permissible to assign both forms to the same species.

H. guttatus is distinguished from *H. obliquelobatus* by its broader peripheral saddle, much less marked development, and slighter inclination of the sutural lobe, curved, less angulate periphery, fewer costæ, much less prominent costal angle on the periphery, and deeper constrictions.

The resemblance with *H. planus* is superficial only, as may be inferred from the complete dissimilarity of lobal structure.

H. obliquelobatus occurs only as one specimen, chambered up to the end, from Gieumal.

HOLCOSTEPHANUS (SPITICERAS) INDICUS, sp. nov.

(Plate X, fig. 3 *a—d*.)

Dimensions :—

Diameter	68·7 mm.
Width of umbilicus	27 „
Height of whorl	25·4 „
Thickness of whorl	29·5 „

This species is strikingly characterized by its costation and the course of its lobal line.

The costæ have an almost radial position, being but slightly inclined forward; they are finer, and more closely set than in the majority of Spiticerata. Despite the slight inclination of the costæ they meet on the periphery at a fairly well-marked angle. Upon the ultimate whorl are twenty-three lath-shaped tubercles, to each of which correspond on an average five furcating ribs. The tubercles lengthen out upon the umbilical wall to feeble costæ, which die away only at the suture. Upon the ultimate whorl are two constrictions. The primitive costation with median tubercles appears to give place to the fully developed ornamentation as early on as the diameter of 14 mm.

The whorls are somewhat thicker than high, overlapping (each other) for rather less than one half. The greatest thickness is in the neighbourhood of the sutural tubercles; thence the breadth diminishes gradually towards the convex periphery. The umbilical wall is rounded, but dips rather steeply inward. The lobes and saddles are more slender and more abundantly ramified with intricate denticulations than in any other species of the genus *Spiticeras*. The slender lateral rami of the peripheral and first lateral lobe approximate so as almost to touch one another, and consequently in this species too the peripheral saddle is remarkably narrow and constricted at the base. The second lateral lobe and both the auxiliary lobes unite, as in other species of the second group, to form a pendent sutural lobe. While in the Spiticerata of the first group the extremity of the second lateral lobe is more markedly pendent than in *H. guttatus*, at least as much so as the first auxiliary lobe, here the second lateral lobe is much more highly placed, and the first auxiliary lobe trends so far towards the first lateral lobe, that thereby the second lateral lobe is to some extent narrowed in, and terminates higher up. The body-chamber has not been preserved.

In view of the structure of the lobal line, *H. Oppeli* and *H. obliquelobatus* may be considered the most nearly related species, as their lobal "bodies" too are fairly slender, and, moreover, the second lateral lobe takes up the same position as in our species. The whorls of *H. obliquelobatus* are much flatter, higher, and more convergent towards the periphery, the costæ are somewhat more fully developed and more sharply inclined forward, and therefore the angle formed by the costæ on the periphery is much more marked than in *H. indicus*. The differences in the lobal line have been discussed when dealing with *H. obliquelobatus*. As regards the distinction between *H. indicus* and *H. Oppeli*, we may refer to the description of the last-named species. From *H. guttatus* the form now described may be differentiated by its finer and more closely-set costation, more curved and less overlapping whorls, its somewhat wider umbilicus, and, most of all, by the evolution of the lobal line. The curvation of the whorls recalls *H. bilobatus*, a species which, however, differs so markedly from *H. indicus* by its prominent costæ, fewer tubercles, more flatly sloping umbilical wall, and especially by the characters of its lobal line, that the separation of the two is a very easy matter. Much the same divergence exists between *H. indicus* and *H. subbilobatus*, but in the case of the latter we may also add the lesser thickness of the whorls and the angulate periphery.

Among the European species so far described, those especially comparable with *H. indicus* are *H. pronus*, *H. Negreli* and *H. polytroptychus*. *H. pronus*, as understood by Zittel, exhibits more widely separated costæ, fewer tubercles, and rather more flattened sides. Perhaps the most nearly allied to *H. indicus* is the species described by Toucas under the name of *H. Negreli*. The points of resemblance are the wide umbilicus, the close-set costation, the rather inflated whorls, and the presence of only two constrictions on the whorl; the only points of difference are the somewhat smaller number of tubercles and the finer and more sharply inclined costation of the French species. As, however, the lobal

line of that form is unknown, we are unfortunately unable to determine its exact degree of relationship to *H. indicus*. The form described by W. Kilian as *H. Negreli* from Andalusia differs so widely from *H. indicus* by its narrow whorls that any confusion between the two is impossible. The same remark holds good of *H. polytropichus*, Uhl., which, moreover, possesses a narrower umbilicus, and more unsymmetrically furcated costæ. Unluckily, in none of the European forms mentioned is the lobal line known, and the difficulty of determining them is therefore greatly enhanced, as was already observed in the Introductory Remarks on the genus.

The species just described occurs as a specimen from Spiti.

3rd GROUP.

Isolated Types.

HOLCOSTEPHANUS (SPITICERAS) EXIMIUS, sp. nov.

(Plate XVIII, fig. 3 *a—d*.)

Dimensions :—

Diameter of specimen preserved with the entire body-chamber	100	mm.
Width of umbilicus	22	"
Height of oral aperture	30	"
Breadth of oral aperture	20·5	"

Although only an incompletely preserved specimen of this form lies before us, we feel impelled to give it a specific name of its own, as it exhibits very well-marked characteristics, and appears to constitute in every respect an extreme type of the subgenus *Spiticeras*.

The shell is flatly discoidal, very evolute, the whorls are much higher than broad, and overlap each other hardly for more than one-fourth. The sides are much flattened, the umbilicus rounded, sloping flatly inward. The periphery converges in the chambered portion at the beginning of the ultimate whorl to a wedge shape, but is rounded at the body-chamber. The greatest thickness lies in the neighbourhood of the sutural tubercles, in the intercostal spaces somewhat above the sutural tubercles.

The ornamentation consists of numerous elongate tubercles extending toward the umbilicus; from these arise numerous costæ, at first almost radial, but suddenly near the periphery trending sharply forward. Upon the ultimate whorl are thirty-one tubercles, and to each tubercle correspond four costæ. Upon the periphery the costæ meet at an acute angle. It is seen at the beginning of the ultimate volution that these costæ have arisen by furcation from the tubercles in just the same way as in other species of the genus. Upon the body-chamber the inter-relationship of the tubercles and the furcating ribs is not quite so evident, but is nevertheless recognizable. Only one constriction is observed. The ornamentation of the inner whorls is not known, and the lobal line also is wanting.

The body-chamber in its initial portion is still pretty clearly angulate toward the periphery; in the anterior portion, on the other hand, the periphery becomes increasingly curved, and the cross-section assumes almost an oval shape. Despite this,

however, the greatest thickness is still in the inner part of the whorls (see figs. 3 *c* and 3 *d*). In this species, too, variations in the form of the body-chamber come in, but while in all the other species the chambered whorls are mostly broader than high, here the penultimate whorl already exhibits an angulate periphery and is markedly higher than broad; the body-chamber assumes gradually an almost oval cross-section. The features of the innermost whorls are unknown; probably they were comparatively thicker. The changes in ornamentation on the body-chamber are merely insignificant, as the foregoing remarks have shown. Immediately before the oral aperture the costation is greatly enfeebled, and next to the oral margin is a constriction which is limited only at the umbilical wall and on the periphery by more conspicuous costæ. The lip is prolonged into an auricular extension, the whole of which, however, has unfortunately not been preserved.

Whether the heightening or lengthening of the oral aperture at the periphery exhibited by this specimen is really a specific characteristic, or whether it has something to do with the state of preservation of the fossil, is a point that cannot be determined with certainty. The first hypothesis, however, is the most probable.

H. eximius may be ranked among the flat-shelled widely umbilicate forms of the genus with but slightly overlapping whorls. In this respect, the only species that we can place beside it is *H. subcautleyi*.

Furthermore, of all the Spiticerata from the Spiti Shales, *H. eximius* has the flattest whorls and the most closely-set tubercles, which latter also are more elongate than in other species. Then, too, the costæ curve around almost like a sickle, to a degree unknown elsewhere, and as a result they meet on the periphery at an extremely acute angle. We need not apprehend, therefore, a possible confusion of this species with any other. In regard to flatness and wide umbilication of the shell, *H. subcautleyi*, as we observed before, is near to it, but *H. subcautleyi* has thicker and lower walls, fewer but more prominent and more rounded tubercles, less strongly curved but much wider-spaced and stouter costæ. Finally, the cross-section of the body-chamber, almost oval in *H. eximius*, is angulate in *H. subcautleyi*.

The species here described occurs as a specimen from Lochambelkichak (3rd Stage).

HOLCOSTEPHANUS (SPITICERAS) SPECIOSUS, sp. nov.

(Plate XI, fig. 2 *a*, *b*.)

The most specialized of all the forms of Spiticeras is unfortunately available only as a small fragment. Nevertheless, we think it desirable to give this form a particular name, as it possesses characteristics so well marked as to make the species easily recognizable.

At a diameter of about 8 mm. the whorls are much broader than high, flattened outwardly, with sides inclining obliquely towards the umbilicus. The ornamentation consists of fine costæ which bear small sharp spines at the points of furcation. The spiral of involution takes its course over this row of spines, at which the innermost whorls attain their greatest breadth. As growth progresses the costæ swell

to a lath shape at the umbilical wall, in such wise that only two rows of tubercles remain. The median tubercles are still clearly visible at a diameter of 16 mm., and even at that of 23 mm. they are recognizable. Only when that stage is passed do the median tubercles gradually die away, and therewith the form passes into the phase of normal ornamentation. The number of furcating costæ cannot be determined precisely, but is probably about five. The constrictions are extraordinarily deep, sharply inclined forward, and accompanied by prominent protuberances. At a diameter of about 30 mm. the breadth is 21 mm. and the height 10 mm., the whorl being, therefore, nearly twice as broad as high. The greatest breadth lies at this stage in the neighbourhood of the sutural tubercles; the very low sides pass by gradual curvation into the broad, flat periphery. The inclination of the umbilical wall is somewhat steep.

At the next following whorl, which, in the specimen before us, already belongs to the body-chamber, the same modification of the cross-section takes place as in other Spiticerata. The breadth of the body-chamber is the same as that of the preceding whorl, that is, also about 21 mm., but the height is 16 mm., there being consequently a considerable relative narrowing. On examining the specimen from the periphery of the body-chamber the tubercles of the preceding whorl are seen to project a little above the outline of the body-chamber (fig. 2 *b*). The sectional figure inserted here in the text also gives some idea of the peculiar conditions of growth of this species. The periphery of the body-chamber is strongly curved, the sides pass gradually into the periphery and slope very flatly towards the umbilicus. The ornamentation becomes much fainter on the body-chamber, but this enfeeblement is probably somewhat exaggerated in the specimen before us by the partial absence of the fairly thick test.

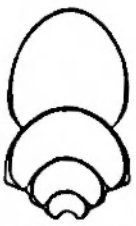


FIG. 10.—HOLCOSTEPHANUS (SPITICERAS) SPECIOSUS, n. sp. Cross-section of the specimen figured on pl. XI. fig. 2, from Kibber in Spiti.

Around the umbilicus may be seen faint, nodular swellings, whence arise rather feeble costæ. On the periphery the costæ are uninterrupted and form there a not very prominent yet unmistakable angle. In none of the species hitherto described does the narrowing of the body-chamber, with the consequent changes in ornamentation, take place so early as in *H. speciosus*. Indeed, this form differs in so marked a degree from all other Spiticerata that it can not possibly be confounded with any of them. In respect of the small size of shell and the method of evolution, we might perhaps place near it *H. depressus*, Steuer, from Argentina. In that form, also, the passage from extraordinarily broad inner whorls with a double row of tubercles into the comparatively much higher and feebly costate body-chamber is direct and sudden. It will suffice to point out, however, that the inner whorls of *H. depressus* are three times as broad as high, and that the primary costæ are very stout and massively developed, in order to demonstrate its entire specific independence of *H. speciosus*.

The specimen just described comes from Kibber in Spiti.

HOLCOSTEPHANUS (SPITICERAS), sp. nov. ind.

(Plate XI, fig. 4 *a—e*.)

It was impossible to pass over without notice a fragment (unfortunately in a bad state of preservation) characterized by a very peculiar development of the lobal line; its existence widens considerably the range of evolution of the subgenus *Spiticeras*. The defective condition of this unique specimen rendering a complete diagnosis impracticable, we have thought it advisable to refrain from giving any definite name to the form.

The whorls are broader than high, the rounded umbilical wall slopes obliquely inward to the umbilicus, the sides pass gradually into the convex periphery. The greatest breadth of the cross-section is at the row of tubercles. Thence the breadth diminishes gradually towards the periphery. The height of the ultimate whorl amounts at the beginning of the body-chamber to 29·5 mm., and the breadth measured over the tubercles to 32 mm. The ornamentation consists of fairly prominent rounded tubercles, whence rise furcating costæ inclined forward. To each tubercle correspond five or six furcating costæ, which form on the periphery a not very prominent yet unmistakable angle, and here suffer no enfeeblement. The constrictions are deep, limited posteriorly by a very prominent costa. The primitive ornamentation seems to disappear very early, perchance already at the diameter of 15 mm.

The lobal line, which may be regarded as the most characteristic feature of this species, shows long, slender lobal "bodies," which bear rather short, but slightly ramifying, lateral branches. The secondary lobes cut extraordinarily deep into the saddles. The first lateral lobe which in all other Spiticerata ends in a simple terminal ramus, dichotomizes here into two almost equally long terminal rami, or we may perhaps regard these as a split terminal ramus. The second lateral lobe, which in many Spiticerata participates in the formation of the pendent sutural lobe, or at the very least is obliquely placed, far from showing any obliquity here is rigidly parallel to the first lateral lobe; and the same statement applies to the first auxiliary lobe.

A slight deviation begins only with the second and third auxiliary lobes, but neither do they form, properly speaking, a sutural lobe, as in the case of all the other species. Whereas in all these the first auxiliary lobe makes an angle with the second lateral lobe, and the former has an oblique, nay, almost prostrate, position, the above-mentioned lobes in the species under description are all but parallel. Moreover, the evolution of the auxiliary lobes on each side of the shell does not quite coincide. The parallelism of the auxiliary lobes with the second lateral lobe is less manifest on the right side (fig. 4 *d*) than it is on the left (fig. 4 *c*); so, too, the saddle between the first and second auxiliary lobes is fairly broad on the right side, but very narrow on the left. The peripheral lobe has not a strictly median position, but lies a little to the right.

The unusual features of the lobes in this species give rise to the supposition that we are perhaps dealing here with a purely pathological phenomenon. This is a

point which can only be decided after the examination of more abundant and less defective material. The ornamentation and external form of the specimen remind one especially of *H. scriptus*; the latter, however, is differentiated by its coarser tubercles, more definitely curved costæ, somewhat narrower umbilicus, and whorls rather more angulate at the periphery.

Another species, *H. bilobatus*, differs not only in the characters of the lobal line, but also in its somewhat lower whorls, narrower umbilicus, and more delicate tubercles. *H. Beulenbenderi*, Steuer, is distinguished from our species by fewer but more prominent secondary costæ, more definitely curved sides, and the course followed by the lobal line.

The specimen described comes from Spiti.

Holcostephanus (Astieria) Schenki, Oppel sp.

(Plate XVIII, fig. 2 *a—c*; Plate XLII, fig. 1 *a—c*.)

1863. *Ammonites Schenki*, Oppel. Paleontologische Mittheilungen, vol. I, p. 286, and Pl. LXXXI, fig. 4 *a—c*.

As Oppel's figure of this important and oft-quoted species constitutes a considerable restoration, it appeared to us advisable to give a new and more exact figure, accompanying it by a description. Besides Oppel's original specimen we have seen only one fragment, and even this we cannot with absolute certainty assign to *H. Schenki*. This fragment, however (figured in plate XLII, figs. 1 *a—c*), belongs unquestionably to a very closely allied species, and forms an important contribution to our knowledge inasmuch as it furnishes a clue to the characteristics of the body-chamber, not preserved in Oppel's original specimen. Although Oppel's specimen at the anterior end is broken in and compressed at the periphery, the most salient features can be determined without difficulty.

The shell is much inflated, the whorls are low and outwardly strongly curved. The greatest breadth is in the neighbourhood of the umbilical tubercles, thence it diminishes towards the periphery, slowly at first, then very rapidly. The umbilical wall is high, rounded, sloping very steeply on the ultimate whorl, somewhat more flatly on the inner volutions. Umbilicus spindle-shaped, periphery broad, rather flatly curved, and passing gradually into the sides. Oral aperture almost semicircular.

At the suture arise fine, straight or rather slightly arcuate primary costæ, inclined backward; they become rapidly more prominent at the umbilical wall, and swell up into large tubercles at the passage of the umbilical wall into the sides. From these tubercles, numbering twenty or twenty-one upon each whorl, arise groups of straight secondary costæ inclined forward. To each tubercle correspond on an average three secondary costæ, of which two at least clearly start from the tubercle, while the third, though it often assumes the appearance of an intercalary costa, reaches close up to the tubercles. The group of costæ associated with the constriction consists of five costæ.

The costæ pass uninterruptedly and undiminished across the periphery. In the surface of the volutions are deep-cut constrictions, somewhat more sharply inclined forward than the costæ, and limited, in especial posteriorly, by a particularly prominent costa; they appear to number two to each whorl.

The lobal line is characterized by long and narrow lobes and saddles. A feature of the peripheral and first lateral saddles is the absence of a secondary lobe. On the other hand, the second lateral saddle is divided by a rather long secondary lobe. The first lateral lobe is as conspicuously pendent as the peripheral, but the second lateral is somewhat shorter. The first auxiliary lobe is at the umbilical wall; it borders on the inner side of the tubercles, and is very slightly oblique. It is succeeded by the two feeble rami, lying at the suture, of a lobe whose third ramus is already situated at the *inner side* of the whorl. If the terminations of the saddles be joined by an imaginary line, that line will coincide almost exactly with the radius. In the otherwise correct reproduction of the lobal line drawn in plate XVIII, fig. 2 *e*, the first auxiliary lobe appears more oblique than it is in nature. The peripheral lobe does not occupy an exactly median position, but lies a little to the left of that.

Oppel's specimen being so compressed, exact dimensions cannot be tabulated. At an approximate diameter of 50·8 mm. the umbilical width amounts to 15·5 mm., the breadth at the anterior extremity measured over the tubercles to 36 mm., and the height 23 mm. The specimen described is chambered up to the end. Supposing that we supplement it by the other fragment of shell, a diameter of at least 70 mm. is obtained. *H. Schenki*, then, with its body-chamber, must have attained a fairly considerable size.

Oppel's original specimen came from Shangra, east of Puling in Gnari-Khorsum (Tibet). The second specimen, found at Lochambelkichak, (plate XLII, fig. 1 *a—c*) is a fragment of body-chamber whose outward form agrees well with *H. Schenki*, only the umbilicus appears to be somewhat narrower. In regard to the ornamentation the only difference is that the costæ in each group (four or five) are somewhat finer and more numerous, and the protuberances at the umbilical wall have more the appearance of reinforced costæ than tubercles. The greater delicacy of the costæ is perhaps chiefly assignable to the very evident weathering of the fragment which has been preserved in the form of a cast. With regard, however, to the somewhat narrower umbilicus and the greater number of the secondary costæ, these are not reliable specific characteristics, for we know that, with inflated peripheries, the umbilicus becomes relatively narrower as growth progresses, and so, too, the greater number of the costæ might be fairly attributed to the considerably larger size of the specimen.

The figure of *H. Atherstoni*, which is nearly related to *H. Schenki*, shows upon an inner whorl groups of costæ, each consisting of three costæ; upon the next whorl but one, however, five costæ correspond to each tubercle. It is possible that the same relation obtains with *H. Schenki*. Finally, the prominence of the sutural tubercles in that species undergoes considerable variations.

These considerations impel us to assign the specimen from Lochambelkichak,

provisionally to *H. Schenki*. As, however, possibility of specific distinction is not excluded, we designate it as *H.* cf. *Schenki*. The diameter of this specimen measures about 94 mm., the umbilical width 19·5 mm., the height of the volutions at the anterior extremity 35 mm., the breadth at the same point 53 mm., and the diameter at the beginning of the body-chamber 64 mm.

In one respect this specimen is of great interest; it proves that the body-chamber at least in its first half, exhibits the same form and the same cross-section as the chambered volutions. As in the Spiticerata, the change in cross-section mostly takes place in an unmistakable fashion in the first half of the body-chamber, while in this species at the same stage no such change is observable, we are free to infer that the body-chamber in *H. Schenki* never does undergo that modification:—a negative characteristic which has been also demonstrated in the case of certain allied forms, such as *H. Astieri* and *H. psilostomus*.

H. Schenki is in especial nearly related to *H. multiplicatus*, Roemer, and *H. psilostomus*, Neum. and Uhl., from the Hils beds of Northern Germany, and to *H. Atherstoni* from South Africa. *H. multiplicatus* [1] is easily differentiated from *H. Schenki* by its much greater whorl-height and very dissimilar oral cross-section. Moreover, the lobes of the North German species possess much slenderer "bodies" with delicate, more pendent lateral rami. *H. psilostomus* [2] is also distinguished by the greater height of its whorls and a dissimilar cross-section, but more especially by its much inferior breadth, and its flatter, better developed sides, to such an extent that its differentiation from *H. Schenki* offers no difficulty.

H. Atherstoni in respect of its outward form certainly does agree very well with *H. Schenki*, but is distinguished therefrom by its much more numerous costæ. In regard to the number of these, the Indian species occupies a position midway between *H. Atherstoni* and *H. Baini*. Unfortunately, the lobal structure of these South African species is not known. According to A. Pavlow,[3] besides these two, there occurs in South Africa a form corresponding to *H. Schenki*. Among the forms designated as *Ammonites Astieri*, we know that there are comprised very different types; some of them may be closely allied to, or may even accord with, the Indian *H. Schenki*; but the typical Alpine species *Astieri*, with its slender shape and its delicate, close-set costation, is easily distinguishable from *H. Schenki*.

Neocomil

[1] Neumayr and Uhlig, "Hilsammonitiden," p. 22, and pl. XXXIII, fig. 2.

[2] Neumayr and Uhlig, "Hilsammonitiden," p. 21, and pl. XXXII, fig. 2. Prof. Pavlow erroneously identifies this species with *H. Atherstoni*: the almost semicircular cross-section of the South African species and its considerable breadth do not admit of its assignment to *H. psilostomus*. On the other hand, it is quite true that Neumayr and Uhlig have attributed far too much importance to the bidichotomy of the costæ in *H. psilostomus*. ("Argiles de Speeton.")

[3] "Argiles de Speeton," p. 135.

PLATE I.

Fig. 1 *a—c*. PHYLLOCERAS STRIGILE, Strach. sp.

Page 6. Specimen with the body-chamber preserved, but for the most part without adherent shelly substance. Natural size. 1*a*, Lateral view. The lobal line figured is the ultimate one. 1*b*, Apertural view. 1*c*, View of the external periphery. The lobal line is represented in plate III, fig. 6. From the Spiti Valley. (Coll. Gerard.)

Fig. 2 *a*, *b*. PHYLLOCERAS STRIGILE, Strach. sp.

Page 6. Internal cast, with the body-chamber preserved. Natural size. The specimen is cut through the middle, and the second half is preserved in the British Museum (Natural History). (Strachey's original specimen figured in Journ. Asiatic Soc., 1863, plate III, fig. 1.) 2*a*, Lateral view. The lobal line figured is the ultimate one. The weakening of the ornamentation at the anterior extremity points to the immediate proximity of the ultimate apertural margin. 2*b*, View of the external periphery. Spiti Valley. (Coll. Gerard.)

Fig. 3 *a—d*. LYTOCERAS EXOTICUM, Opp. (=*L. alatum*, Blanf.)

Page 14. Specimen mostly preserved as an internal cast, possessing the body-chamber and the ultimate apertural margin. Natural size. 3*a*, View of the sides; the body-chamber alone is actually preserved (there being merely an impression of the pneumatic chambers) and upon this impression the more prominent "crinkly" costæ and finer intercalary striations may be clearly traced. The "ridges" of the more prominent costæ continue into the surrounding matrix as thin, leaf-like hollows. Of the apertural margin only the lower portion remains. 3*b*, View of the sides. Impression of the specimen after ablation of the body-chamber. 3*c*, View of the external periphery, in order to show a costal ridge with the shelly matter preserved. 3*d*, View of the internal periphery, so as to exhibit the cross-section. From Chidamu. (Coll. Diener.)

Fig. 4 *a—c*. LYTOCERAS EXOTICUM, Opp. sp. (=*L. alatum*, Blanf.)

Page 14. Specimen partly retaining the shell. Natural size. 4*a*, View of the sides. The fragment of the ultimate whorl belongs to the body-chamber. The ridges of the "crinkled" primary costæ of the ultimate whorl are in part traceable in the hollows of the surrounding matrix. 4*b*, Apertural view. 4*c*, Lobal line. From Chidamu. (Coll. Diener.)

JURASSIC FOSSILS (HIMALAYA).

R. Mayer del. et lith.

Albert Berger print.

PLATE II.

Fig. 1 *a—d*. OPPELIA (STREBLITES) ADOLPHI, Opp. sp. (Oppel's original specimen, Paläontolog. Mittheilungen I, page 270, plate LXXV, fig. 1 *a*, *b*.)

Page 42. Internal cast chambered up to the end. Natural size. 1*a*, Lateral view. 1*b*, Apertural view. The position and size of the keel on the inner volution are clearly shown at the internal lobe of the anterior-most, ultimate septation. The ramifications of the internal lobe beset the keel, itself absent from the specimen, but indicated by a hollow between the rami of the internal lobe. 1*c*, View of the external periphery. 1*d*, Lobes. The specimen was found in Raj Hoti, on the road from Selchel to Badrinath (Gnari Khorsum). (State Palæontological Collection, Munich.)

Fig. 2 *a—e*. OPPELIA (STREBLITES) LYMANI, Opp. sp.

Page 56. Internal cast, exhibiting a portion of the body-chamber. Natural size. 2*a*, View of the sides. The lobal line figured is the ultimate one. 2*b*, Apertural view. 2*c*, View of the external periphery, with the external tubercles on the body-chamber. 2*d*, View from above, in order to show the increase in thickness of the body-chamber. 2*e*, Lobal line. From Gieumal in Spiti. (State Palæontological Collection in Munich.)

Fig. 3 *a—c*. OPPELIA (STREBLITES) SUBSTRIATA, Opp. sp.

Page 54. (Oppel's original specimen, Paläontol. Mittheilung., plate LXXV, fig. 2 *a*, *b*.) An internal cast, chambered up to end, with only scanty remnants of the shell still adherent. Natural size. 3*a*, View of the sides. 3*b*, Apertural view. 3*c*, View of the external periphery. From Shangra in Gnari Khorsum. (State Palæontological Collection in Munich.)

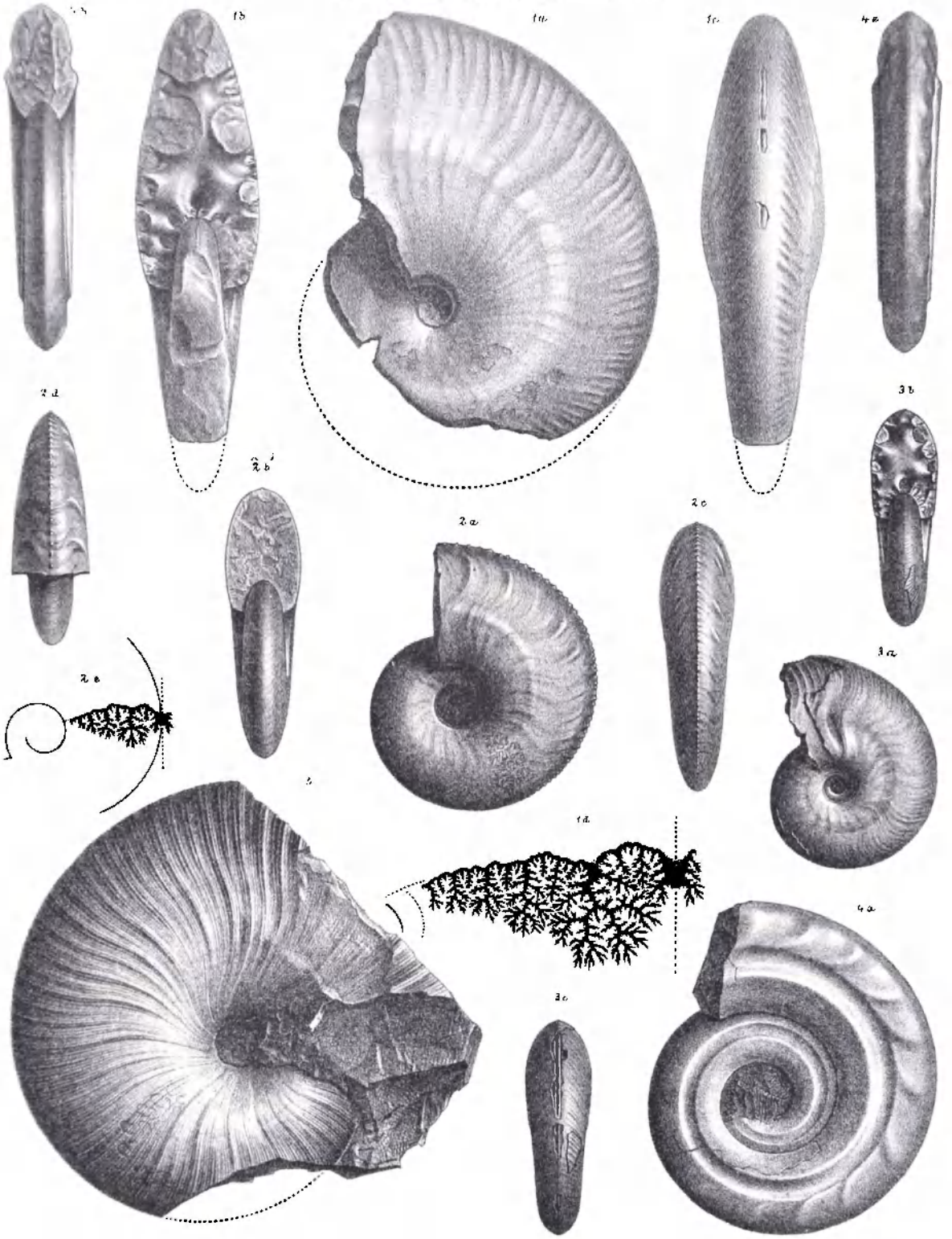
Fig. 4 *a—e*. HECTICOCERAS LATISTRIGATUM, sp. nov.

Page 27. A specimen, chambered up to the end, preserved for the most part as an internal cast. Natural size. 4*a*, View of the sides. 4*b*, Apertural view. 4*e*, View of the external periphery. The lobal line is represented in plate III, fig. 5. From the middle horizon of the Spiti Shales of Chidamu. (Coll. Diener.)

Fig. 5. PHYLLOCERAS PLICATIUS, sp. nov.

Page 4. Specimen for the most part retaining the shell, and exhibiting the body-chamber. Natural size. The external periphery is much weathered. The ultimate lobal line is indistinctly traceable. From the middle horizon of the Spiti Shales of Shalshal. (Coll. Diener.)

JURASSIC FOSSILS (HIMALAYA).



R. Mayer del. et lith.

Albert Berger print.

PLATE III.

Fig. 1 *a—e*. ASPIDOCERAS AVELLANOIDES, sp. nov.

Page 75. Internal cast, natural size. 1*a*, View of the sides. The lobal line figured is the ultimate one. The anterior portion of the ultimate whorl belongs to the body-chamber. On the opposite side, two weak spines are preserved around the umbilicus. 1*b*, Apertural view. 1*c*, View of the external periphery. 1*d*, Ultimate lobal line. 1*e*, Parts of two more posteriorly situated and better preserved lobal lines. (Second lateral with a portion of the first lateral and the first auxiliary.) From the neighbourhood of Kibber. (Original type of Stoliczka's *Amm. liparus*.)

Fig. 2 *a—d*. HAPLOCERAS INDICUM, sp. nov.

Page 21. Internal cast, natural size. 2*a*, View of the sides. Half of the ultimate whorl belongs to the body-chamber. 2*b*, Cross-section. 2*c*, External periphery. 2*d*, Lobal line, made up from three consecutive lines. From the middle Spiti shales of Chojan. (Coll. Diener.)

Fig. 3 *a—c*. OPPELIA (STREBLITES) INDOPICTA, sp. nov.

Page 52. A specimen preserved for the most part as an internal cast, retaining a portion of the body-chamber. Natural size. 3*a*, View of the sides. The ultimate lobal line is inserted. The anterior portion of the ultimate whorl belongs to the body-chamber. 3*b*, View of the external periphery of the chambered part. The serrated keel is mostly not preserved. 3*c*, Lobal line. From Jandu, Hundes.

Fig. 4 *a—d*. OPPELIA (STREBLITES) PLANOPICTA, sp. nov.

Page 47. Specimen for the most part preserved as an internal cast, and chambered up to the end. On the external periphery both shell and keel are adherent. 4*a*, Lateral view. The umbilicus is drawn too broad by about 1·6 mm. 4*b*, View of the external periphery. 4*c*, Section along the fracture observable in the lateral view. 4*d*, Lobal line. From Sirkia, South Hundes.

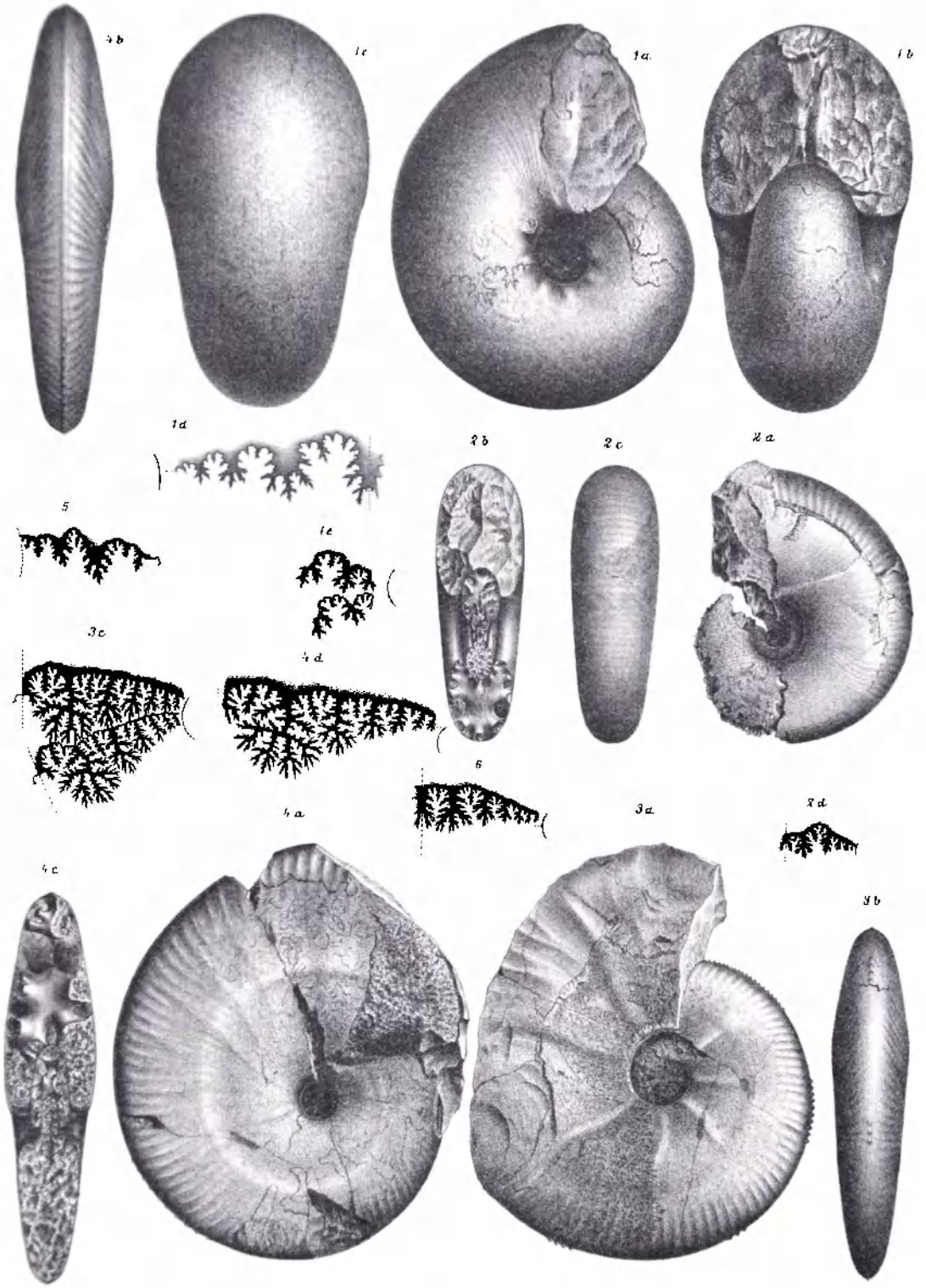
Fig. 5. HECTICOCERAS LATISTRIGATUM, sp. nov.

Page 27. Lobal line of the specimen represented in plate II, fig. 4. From Chidamu, middle horizon of the Spiti shales. (Coll. Diener.)

Fig. 6. PHYLLOCERAS STRIGILE, Strach. sp.

Page 6. Lobal line of the specimen represented in plate I, fig. 1. From the Spiti Valley.

JURASSIC FOSSILS (HIMALAYA).



R. Meyer del. et lith.

Albert Berger print.

PLATE IV.

Fig. 1 *a—d*. OPPELIA (STREBLITES) KRAFFTI, nov. sp.

Page 44. Specimen chambered up to the end, with the shell partly adherent. Natural size. 1*a*, Lateral view. 1*b*, Apertural view. 1*c*, View of the external periphery. 1*d*, Lobes. From Chidamu. (Coll. Diener.) See plate XLIII, fig. 1, and plate V, fig. 1 *a—d*.

Fig. 2 *a—d*. OPPELIA ACUCINCTA, Strach. sp.

Page 68. Internal cast, chambered nearly up to the end. Natural size. 2*a*, View of the sides. 2*b*, Apertural view. 2*c*, View of the external periphery. 2*d*, Lobal line. A somewhat more complete representation of the lobal line is figured in the text, page 33. From the Spiti Valley.

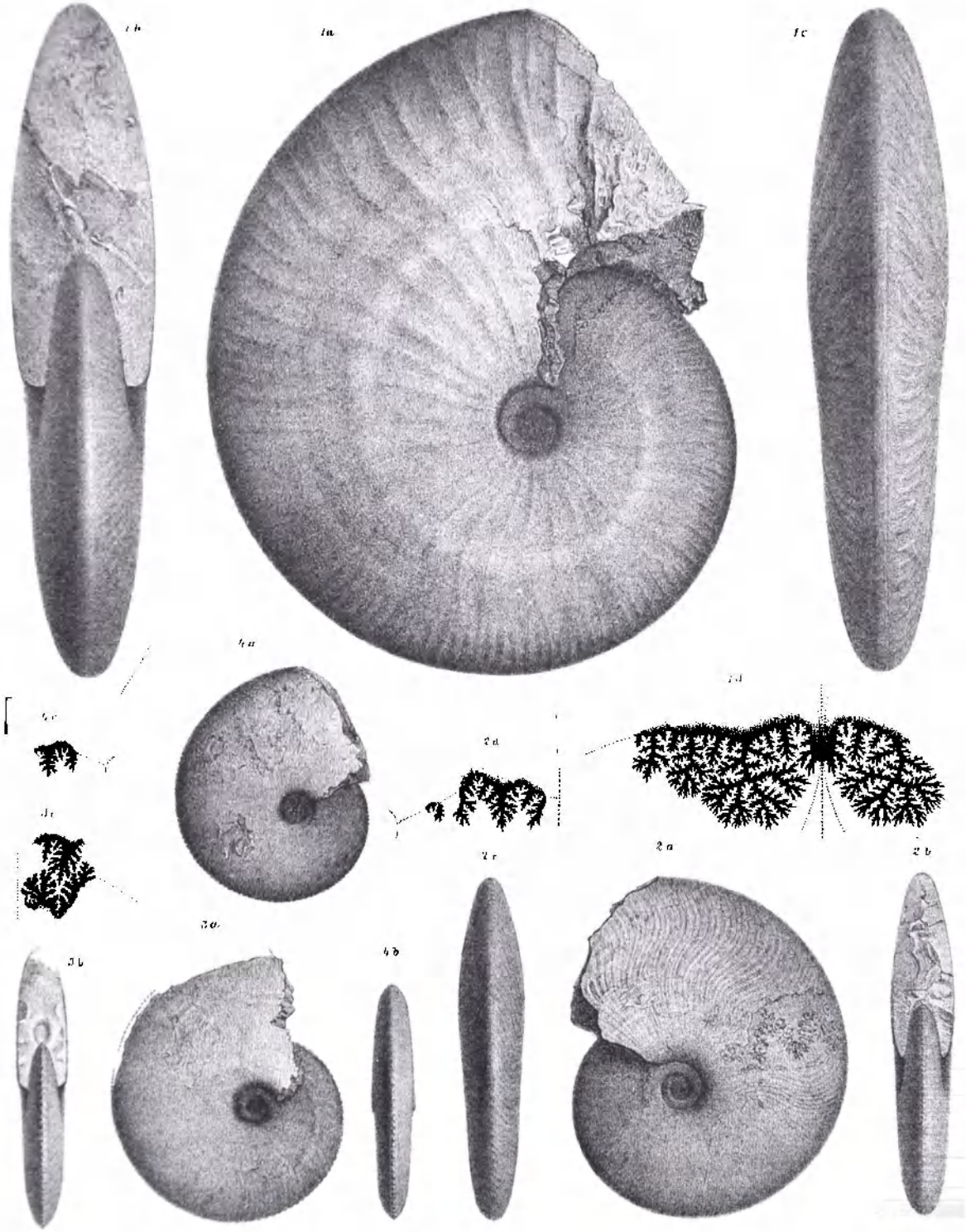
Fig. 3 *a—c*. OPPELIA ACUCINCTA, Strach. sp.

Page 68. Internal cast, chambered up to the end. Natural size. (Strachey's type-specimen, figured in Journ. Asiat. Soc., 1863, vol. XXXII, plate I, fig. 3.) 3*a*, View of the sides. 3*b*, Apertural view. 3*c*, Lobes. From the Spiti Valley.

Fig. 4 *a—c*. OPPELIA ACUCINCTA, Strach. sp.

Page 68. Specimen chambered up to the end, somewhat compressed, bereft of shell. Natural size. 4*a*, View of the sides. 4*b*, Apertural view. 4*c*, Lobes (first and second lateral). From the Spiti Valley.

JURASSIC FOSSILS (HIMALAYA).



N. Liepoldt del. et. lith.

Albert Berger print.

PLATE V.

Fig. 1 *a—d*. OPPELIA (STREBLITES) KRAFFTI, sp. nov.

Page 44. Internal cast, chambered up to the end. Natural size. 1*a*, View of the sides. 1*b*, Apertural view. 1*c*, View of the external periphery. 1*d*. Lobes. (See plate XLIII, fig. 1, and plate IV, fig. 1 *a—d*.)

Fig. 2 *a—c*. OPPELIA (STREBLITES) GRIESBACHI, sp. nov.

Page 47. Compare plate VI, figs. 1, 2, 4, 5. Specimen with most of the body-chamber preserved and the greater part of the shell adherent. Natural size. 2*a*, Lateral view. The umbilicus is drawn 1 mm. too broad. 2*b*, Apertural view. 2*c*, View of the external periphery. From Chidamu.

Fig. 3 *a—c*. OPPELIA (STREBLITES) GRIESBACHI, sp. nov.

Page 47. Specimen with most of the body-chamber and part of the shell preserved. Natural size. 3*a*, View of the sides. 3*b*, Apertural view. 3*c*, View of the external periphery. From Chidamu.

Fig. 4 *a*, *b*. OPPELIA (STREBLITES) GRIESBACHI, sp. nov.

Page 47. Internal cast, with the body-chamber and apertural margin preserved entire. Natural size. 4*a*, View of the sides. The indistinct lobal line figured here is the ultimate one. 4*b*, View of the external periphery. From between Chidamu and the Chiangur Pass.

Fig. 5. OPPELIA (STREBLITES) DOMOCRENATA, sp. nov.

Page 64. Internal cast, natural size. More than half of the ultimate whorl belongs to the body-chamber. From Chidamu.

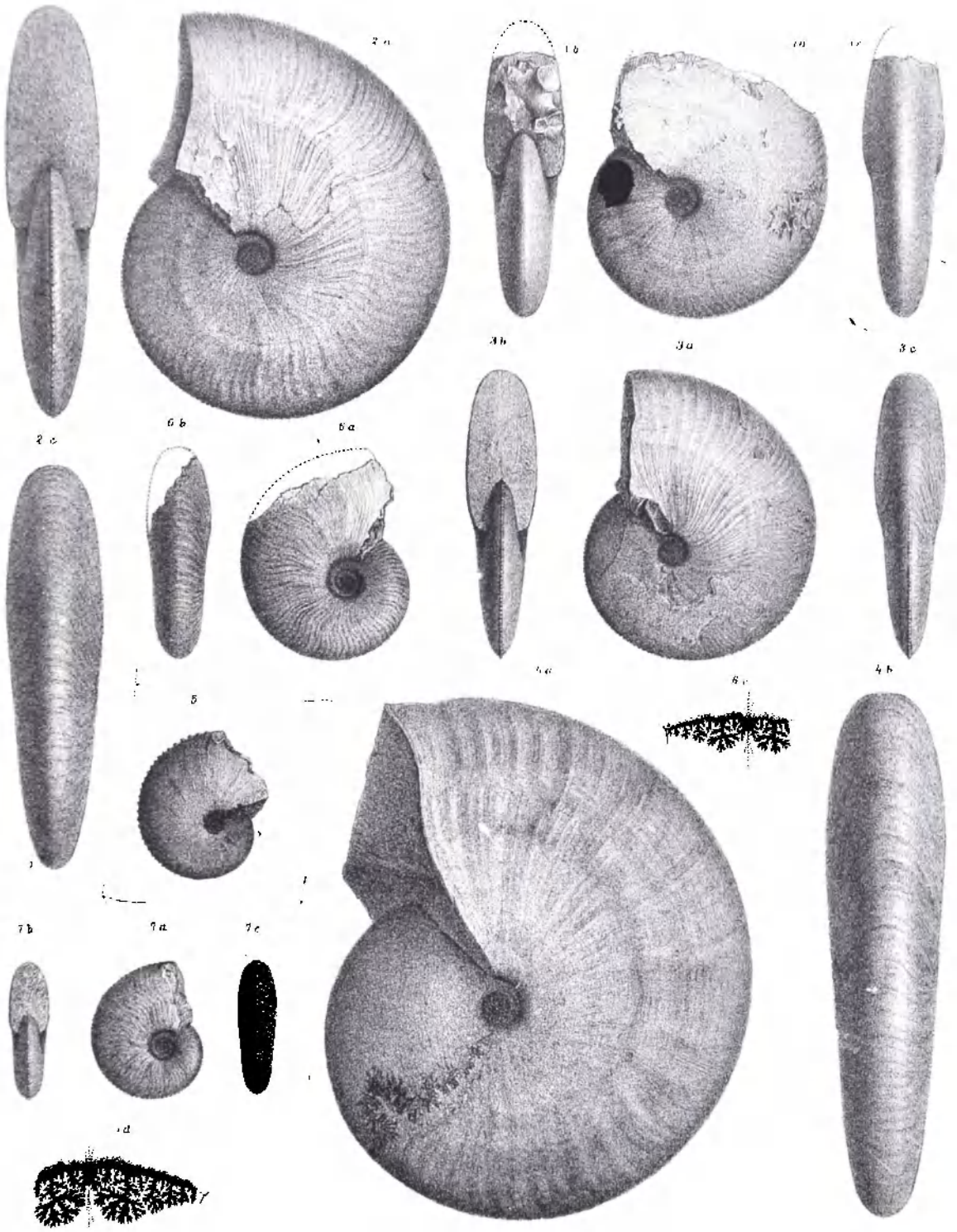
Fig. 6 *a—c*. OPPELIA (STREBLITES) aff. SUBSTRIATA, Opp. sp.

Page 55. Internal cast, chambered up to the end. Natural size. 6*a*, View of the sides. 6*b*, View of the external periphery. From Spiti Valley.

Fig. 7 *a—c*. OPPELIA (STREBLITES) ADUNATA, sp. nov.

Page 63. Specimen with the body-chamber preserved. Natural size. 7*a*, View of the sides. 7*b*, Apertural view. 7*c*, View of the external periphery. Half of the ultimate whorl goes to make up the body-chamber. The anterior-most portion of the body-chamber, with the apertural margin, is broken off, but preserved in the broken fragment. This unfortunately was overlooked by the draughtsman, and in order to supplement the plate-figure, another figure showing the apertural margin has been inserted in the text. From Jandu, Sherik River, Hundes. (Coll. Griesbach.)

JURASSIC FOSSILS (HIMALAYA).



W. Liepoldt del. et. lith.

Albert Berger print.

PLATE VI.

Fig. 1 *a—c*. OPPELIA (STREBLITES) GRIESBACHI, sp. nov.

Compare plate V, figs. 2—4. Strongly costate variety.

Page 47. Specimen with the shell partly adherent and the body-chamber preserved. Natural size. 1*a*, Lateral view. The remnants of the auxiliary lobes figured here indicate the position of the ultimate septal wall. 1*b*, View of the external periphery. 1*c*, Lobal line. From Jandu, Sherik River, Hundes.

Fig. 2 *a—d*. OPPELIA (STREBLITES) GRIESBACHI, sp. nov.

Narrowly umbilicate variety. Specimen mostly preserved as an internal cast, and exhibiting the greater portion of the body-chamber. Natural size. 2*a*, Lateral view. The lobes figured here indicate the position of the ultimate septal wall. 2*b*, Apertural view. 2*c*, View of the external periphery. 2*d*, Lobal line. From south of Shalshal, Hundes.

Fig. 3 *a—d*. OPPELIA (STREBLITES) SPHENODOMA, sp. nov.

Page 58. Specimen preserved for the most part as an internal cast, exhibiting the apertural margin and the body-chamber entire. Natural size. 3*a*, Lateral view. The remnants of lobes figured here indicate the position of the ultimate septal wall. 3*b*, Apertural view. 3*c*, View of the external periphery. 3*d*, Lobal line of the antepenultimate septal wall. From Kibber in Spiti.

Fig. 4 *a—d*. OPPELIA (STREBLITES) GRIESBACHI, sp. nov.

Page 47. Specimen for the most part preserved as an internal cast, chambered up to the end. Natural size. 4*a*, Lateral view. 4*b*, View of the external periphery. 4*c*, and *d*, Lobal lines. From Sirkia, South Hundes. (Coll. Griesbach.)

Fig. 5 *a*, *b*. OPPELIA (STREBLITES) GRIESBACHI, sp. nov.

Rather widely umbilicate and strongly costate form. Specimen with the shell partly adherent and part of the body-chamber preserved. Natural size. Body-chamber shattered and displaced. 5*a*, Lateral view. 5*b*, Lobes. From Jandu, Sherik River, Hundes.

Fig. 6 *a—c*. OPPELIA (STREBLITES), sp. nov. indet.

Page 50. Specimen chambered up to the end, for the most part preserved as an internal cast. Natural size. 6*a*, Lateral view. 6*b*, Apertural view. 6*c*, View of the external periphery. From Spiti Valley.

Fig. 7. OPPELIA (STREBLITES) PYGMÆA, sp. nov.

Page 65. Internal cast, with the shell partly adherent, exhibiting the body-chamber. Natural size. (Compare plate VII, fig. 6, and text-figure, page 66.) From Gieumal.

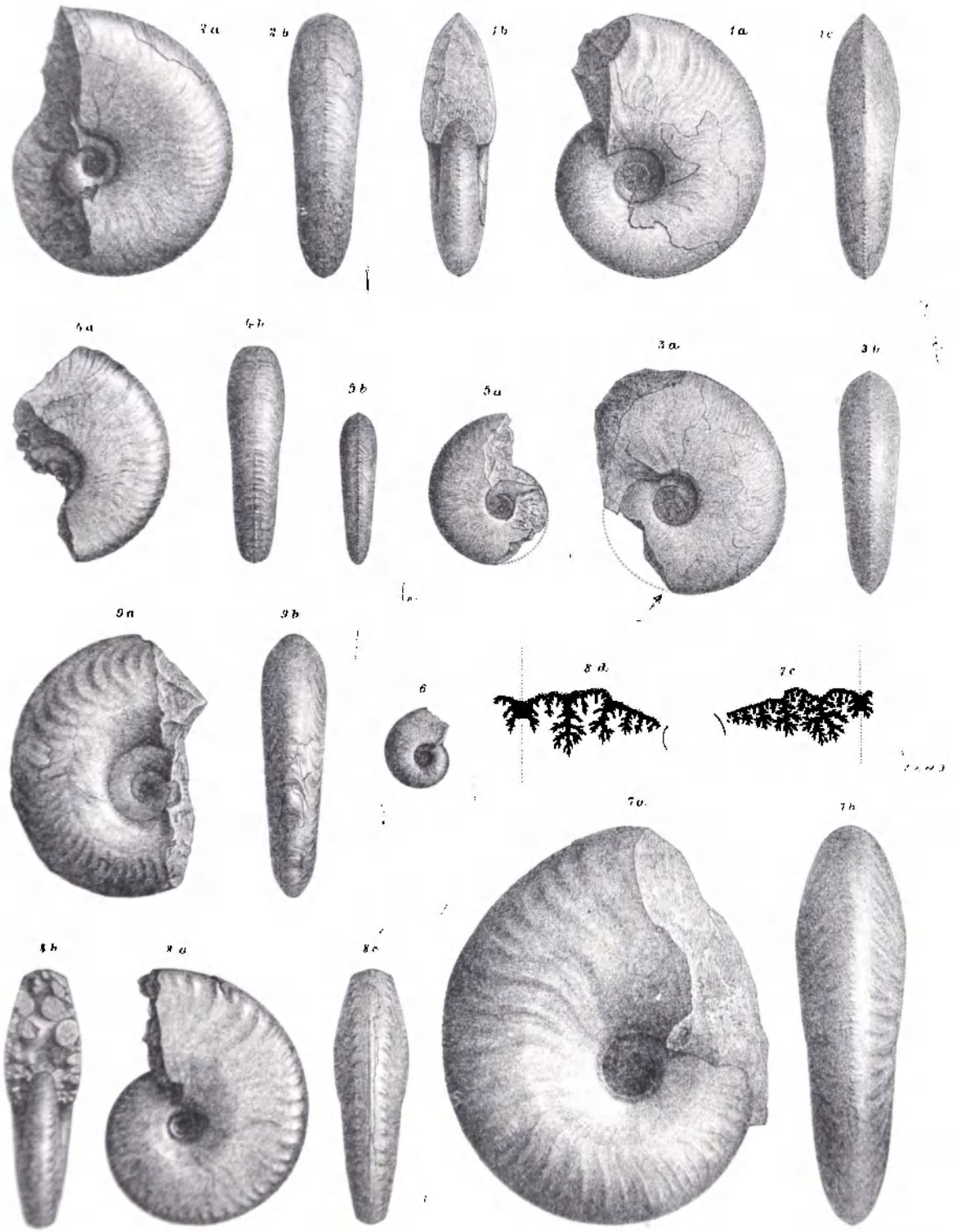
Fig. 8 *a—c*. OPPELIA (STREBLITES) sp. nov. indet. aff. LYMANI, Opp.

Page 57. Chambered internal cast. Natural size. 8*a*, Lateral view. 8*b*, View of the external periphery. 8*c*, Lobes. From Niti.

Fig. 9 *a—c*. OPPELIA (STREBLITES), sp. nov. indet.

Page 67. Fragment chambered up to the end, for the most part preserved as an internal cast. Natural size. 9*a*, View of the sides. 9*b*, View of the external periphery. 9*c*, Lobes. From Spiti Valley.

JURASSIC FOSSILS (HIMALAYA).



Albert Berger print

PLATE VII.

Fig. 1 *a—c*. OPPELIA (STREBLITES) LYMANI, Opp. sp.

Page 56. Specimen exhibiting part of the body-chamber, with shell partly adherent. Natural size. The anterior quarter of the ultimate whorl belongs to the body-chamber, which is much compressed. 1*a*, View of the sides. 1*b*, Apertural view. 1*c*, View of the external periphery. On account of the compression which it has suffered, the test simulates a more marked cuneiform tendency at the external periphery than is really the case. (Coll. Griesbach.) From Jandu, Hundes

Fig. 2 *a*, *b*. OPPELIA (STREBLITES) PUNCTATOPICTA, sp. nov.

Page 59. Specimen with the shell partly adherent, and the body-chamber preserved almost entire. Natural size. 2*a*, View of the sides. The portion of the ultimate whorl which is preserved belongs in its entirety to the body-chamber. 2*b*, View of the external periphery. From the district between Laptel and Chidamu. (Coll. Griesbach.)

Fig. 3 *a*, *b*. OPPELIA (STREBLITES) PUNCTATOPICTA, sp. nov.

Page 59. Specimen with the body-chamber preserved and shell partly adherent. Natural size. Broadly umbilicate variety, with somewhat more markedly cuneiform external periphery. The body-chamber begins at the point where the ultimate whorl is broken. The inner part of the apertural margin is preserved. 3*a*, View of the sides. 3*b*, View of the external periphery. From the district between Laptel and Chidamu. (Coll. Griesbach.)

Fig. 4 *a*, *b*. OPPELIA (STREBLITES) PLATYDOMA, sp. nov.

Page 60. Internal cast, with the body-chamber preserved. Natural size. 4*a*, Lateral view. The portion of the ultimate whorl that is preserved forms the body-chamber. 4*b*, View of the external periphery. From Jandu, Sherik River, Hundes. (Coll. Griesbach.)

Fig. 5 *a*, *b*. OPPELIA (STREBLITES) LEPTODOMA, sp. nov.

Page 61. Internal cast, with the greater part of the body-chamber preserved. Natural size. 5*a*, View of the sides. The well-preserved portion of the ultimate whorl belongs to the body-chamber. 5*b*, View of the external periphery. From Gieumal. (Coll. Gerard.)

Fig. 6. OPPELIA (STREBLITES) PYGMÆA, sp. nov.

Page 65. Specimen with a portion of the body-chamber preserved, and the shell partly adherent. Natural size. (Compare plate VI, fig. 7, and text-figure on page 66.) From Gieumal.

Fig. 7 *a—c*. OPPELIA (STREBLITES) HIMALAYANA, sp. nov.

Page 51. Specimen chambered up to the end, for the most part preserved as an internal cast. Natural size. 7*a*, Lateral view. 7*b*, View of the external periphery. 7*c*, Lobes. From Spiti Valley.

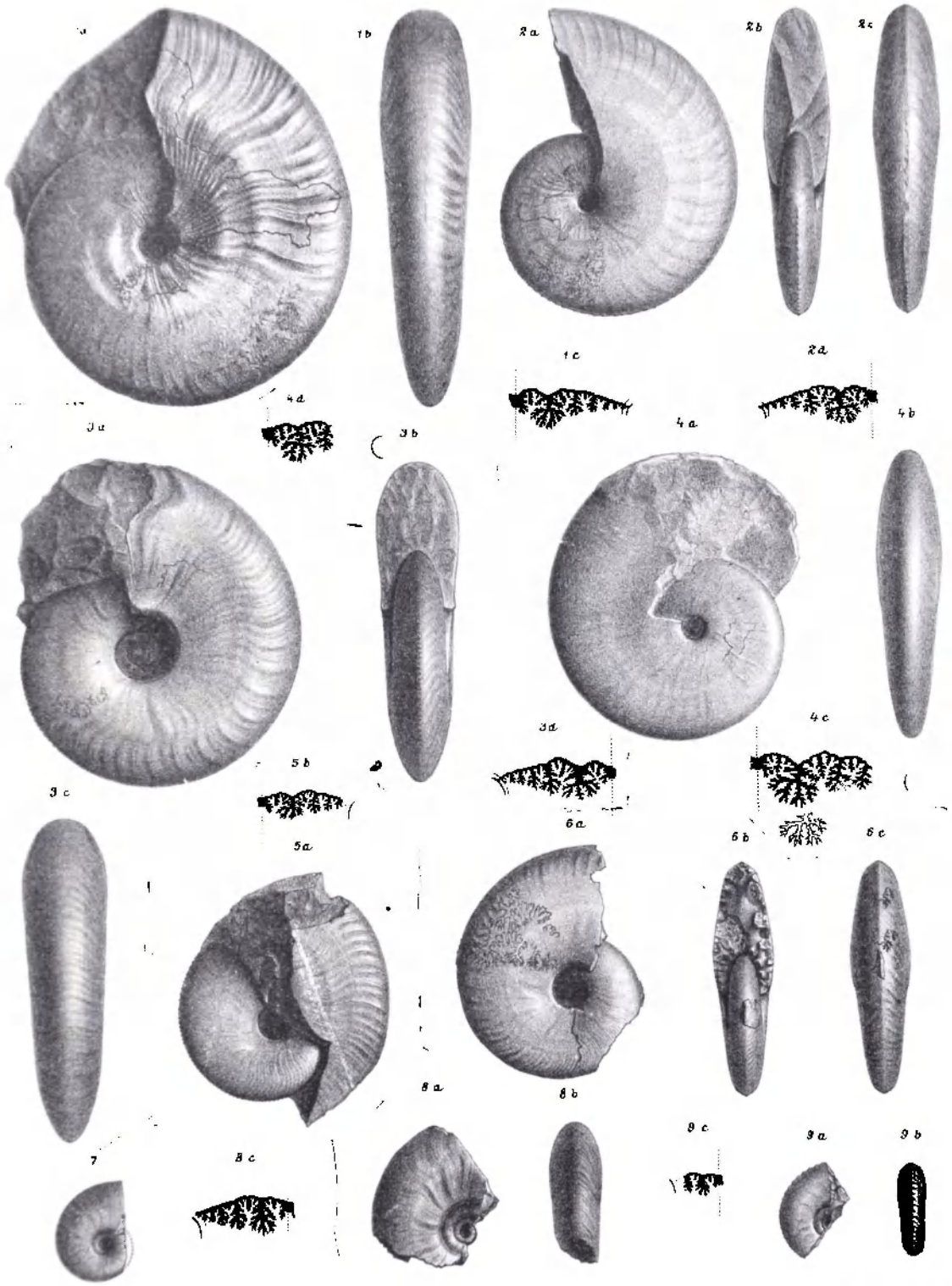
Fig. 8 *a—d*. OPPELIA (NEUMAYRIA) NIVALIS, Stoliczka.

Page 70. Internal cast, chambered up to the end. Natural size. 8*a*, Lateral view. 8*b*, Apertural view. 8*c*, View of the external periphery. 8*d*, Lobes. (Stoliczka's original specimen.) From Kibber in Spiti.

Fig. 9 *a*, *b*. HAPLOCERAS DIENERI, sp. nov.

Page 19. Specimen with the greater portion of the body-chamber preserved, shell only partly adherent. Natural size. 9*a*, View of the sides. The ultimate whorl, so much of it as is preserved, belongs mostly to the body-chamber. 9*b*, View of the external periphery. The lobal line is figured in the text. From Chidamu. (Coll. Diener.)

JURASSIC FOSSILS (HIMALAYA).



R. Mayer del. et lith.

Albert Barger print.

PLATE VIII.

Fig. 1*a*—*c*. HOLCOSTEPHANUS (SPITICERAS) SPITIENSIS, Blanf. sp.

Page 89. Specimen with most part of the body-chamber preserved, and the shell partly adherent. Natural size. 1*a*, Lateral view. The ultimate whorl belongs almost entirely to the body-chamber. The ultimate lobal line is drawn in the figure, but the course which it follows is in reality traceable only in a very general way. 1*b*, Apertural view. 1*c*, View of the external periphery. The outer portion at the anterior extremity of the body-chamber is restored. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

Fig. 2 *a*—*c*. HOLCOSTEPHANUS (SPITICERAS) SPITIENSIS, Blanf.

Page 89. Internal cast, with part of the body-chamber preserved. Natural size. 2*a*, View of the sides. The portion of the ultimate whorl that is preserved belongs to the body-chamber. 2*b*, Transverse section. 2*c*, View of the external periphery. (Coll. Gerard.) From Spiti.

Fig. 3 *a*—*e*. HOLCOSTEPHANUS (SPITICERAS) SPITIENSIS, Blanf.

(Strachey's original specimen.) Page 89. Internal cast, chambered up to the end. Natural size. 3*a*, View of the sides. 3*b*, Apertural view. 3*c*, View of the external periphery. 3*d* and *e*, Lobes. From the Spiti Valley. (Coll. Gerard.)

Fig. 4 *a*, *b*. HOLCOSTEPHANUS (SPITICERAS) aff. SCRIPTUS, Strach.

Page 112. Young specimen. Natural size. 4*a*, View of the sides. 4*b*, Apertural view. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

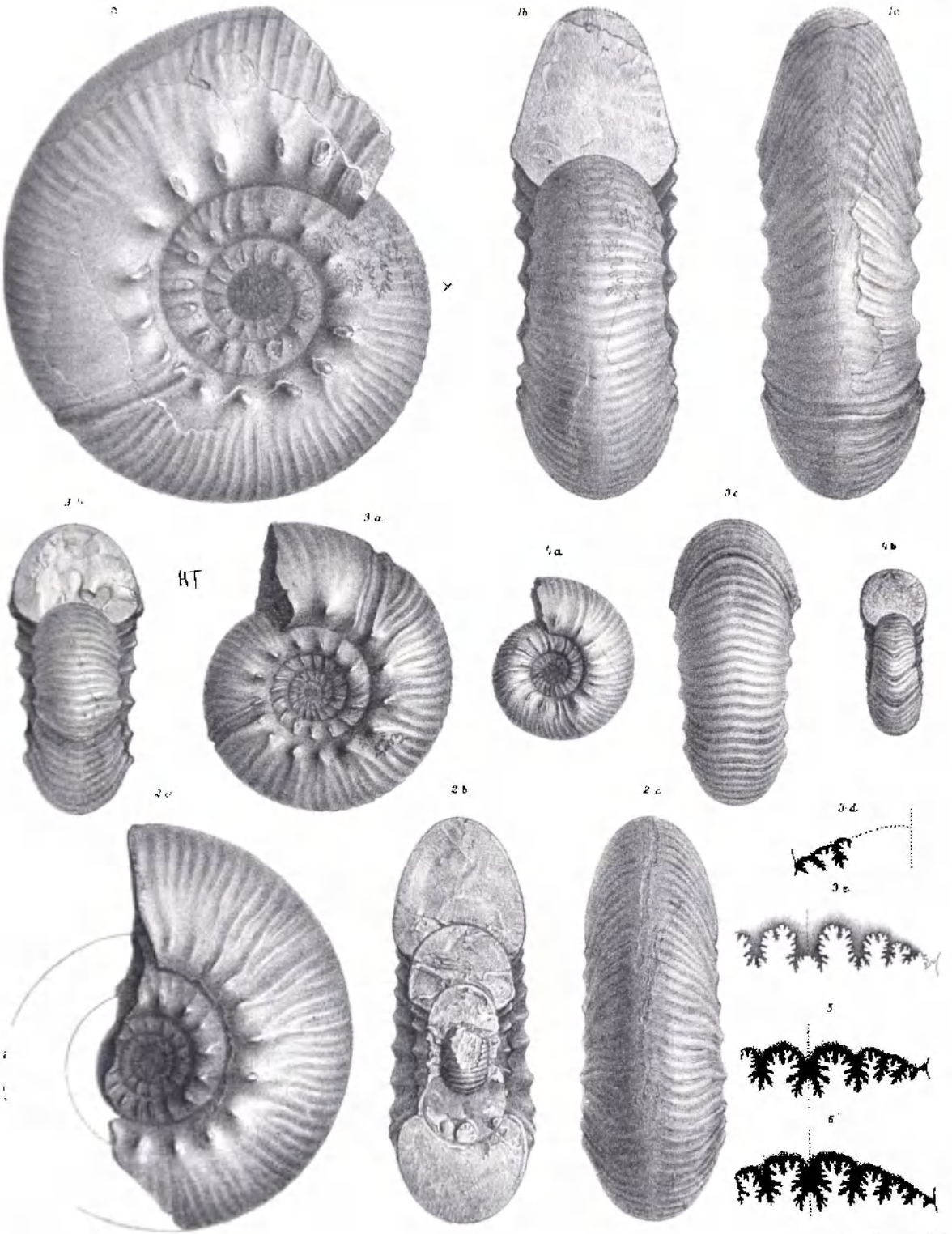
Fig. 5. HOLCOSTEPHANUS (SPITICERAS), sp. nov. indet.

Page 117. Lobal line of the specimen represented in plate IX, fig. 1 *a*—*c*. Natural size. From Gieumal. (Coll. Gerard.)

Fig. 6. HOLCOSTEPHANUS (SPITICERAS) GROTEI, Opp. sp.

Page 92. Lobal line of Oppel's original specimen represented in plate IX, fig. 2 *a*—*c*. Natural size. From Spiti. (State Palæontological Collection in Munich.)

JURASSIC FOSSILS (HIMALAYA).



W. Liepold del. et lith.

Albert Berger print.

PLATE IX.

Fig. 1 *a—c*. HOLCOSTEPHANUS (SPITICERAS), sp. nov. indet.

Page 117. Internal cast chambered up to the end. Natural size. 1*a*, View of the sides. 1*b*, Apertural view. 1*c*, View of the external periphery. This specimen is somewhat compressed below. Lobes represented in plate VIII, fig. 5. From Gieumal.

Fig. 2 *a—c*. HOLCOSTEPHANUS (SPITICERAS) GROTEANUS, Opp. sp.

Page 92. Internal cast, chambered up to the end. Natural size. The internal inner tubercles of the primary costæ of the volution are shown somewhat too weak in the figure. The lobes are represented in plate VIII, fig. 6. This is Oppel's original specimen from the Schlagintweit Collection. (See Paläont. Mittheil., pl. LXXX, fig. 4.) Locality, Spiti. (State Palæontological Collection in Munich.)

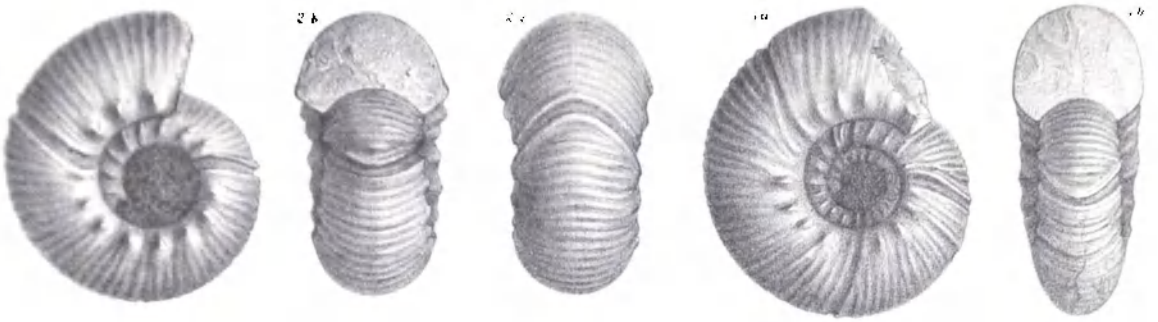
Fig. 3 *a—d*. HOLCOSTEPHANUS (SPITICERAS), sp. nov. indet.

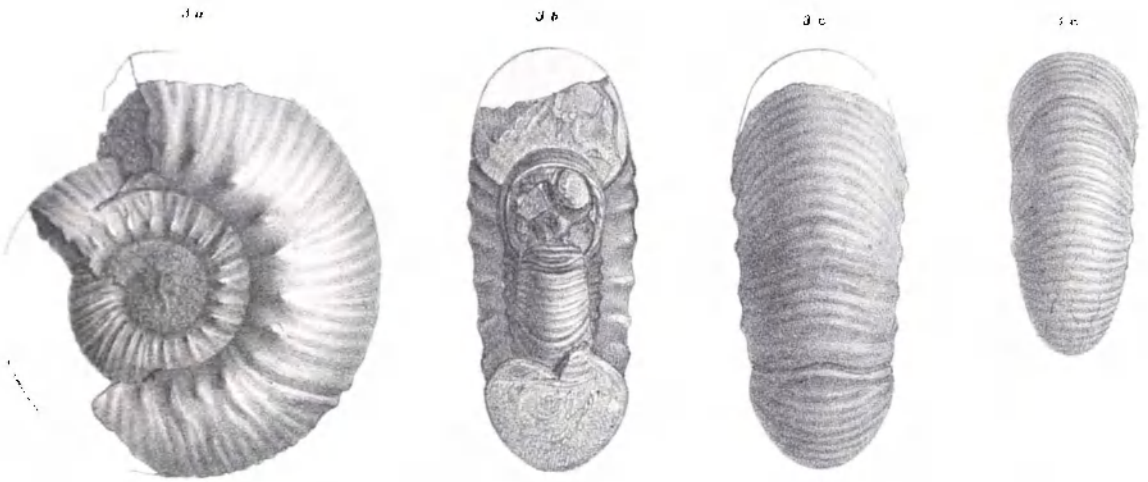
Page 117. Chambered internal cast. Natural size. 3*a*, View of the sides. 3*b*, Apertural view and cross-section. 3*c*, View of the external periphery. 3*d*, Lobal line. Compare fig. 1. From Gieumal. (Coll. Gerard.)

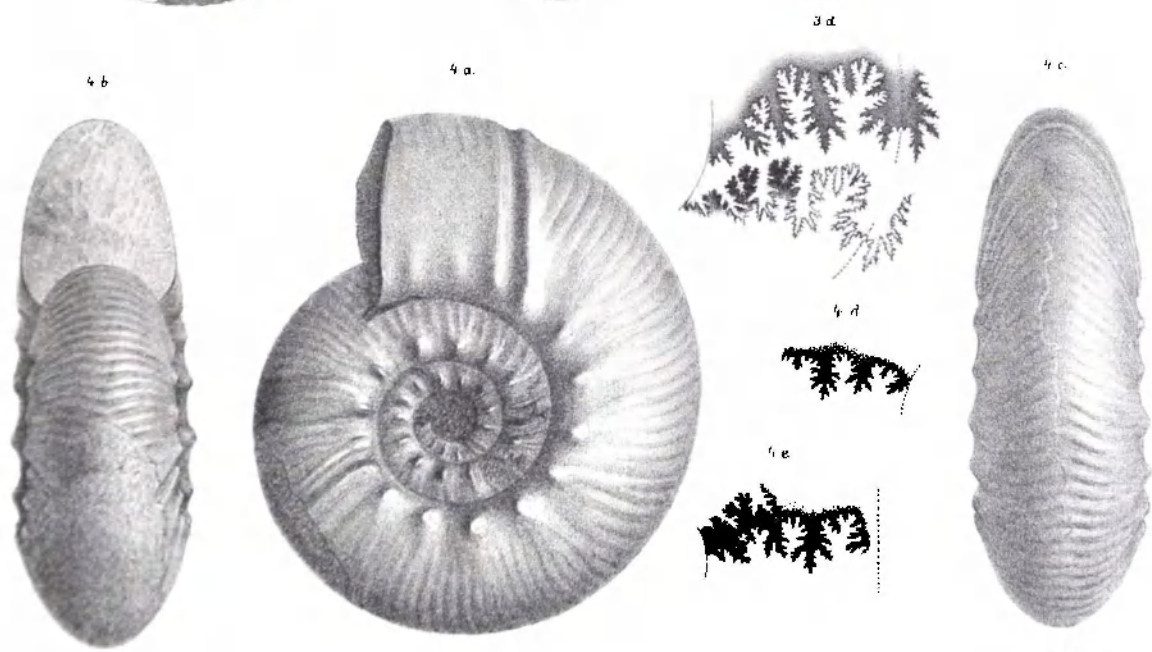
Fig. 4 *a—e*. HOLCOSTEPHANUS (SPITICERAS) SUBSPITIENSIS, sp. nov.

Page 95. Internal cast, with the greater part of the body-chamber preserved. Natural size. 4*a*, View of the sides. Somewhat more than a half of the ultimate whorl belongs to the body-chamber. 4*b*, Apertural view. 4*c*, View of the external periphery. 4*d*, Lobal line, right-hand side, second lateral with unpaired terminal ramus. 4*e*, Lobal line, left-hand side, with second lateral divided pairwise. From the Spiti Valley. (Coll. Gerard.)

JURASSIC FOSSILS (HIMALAYA).







W. Leopold del et lith

Albert Berger print.

PLATE X.

Fig. 1 *a—f*. HOLCOSTEPHANUS (SPITICERAS) BILOBATUS, sp. nov.

Page 96. Internal cast, with part of the body-chamber preserved. Natural size. 1*a*, Lateral view. The body-chamber begins at the lobal line drawn in the figure. 1*b*, Apertural view. 1*c*, View of the external periphery. 1*d*, Two consecutive lobal lines, right-hand side. 1*e* and *f*, Lobal lines of the left-hand side, showing clearly the division pairwise of the second lateral lobe. From Kibber. (Coll. Gerard.)

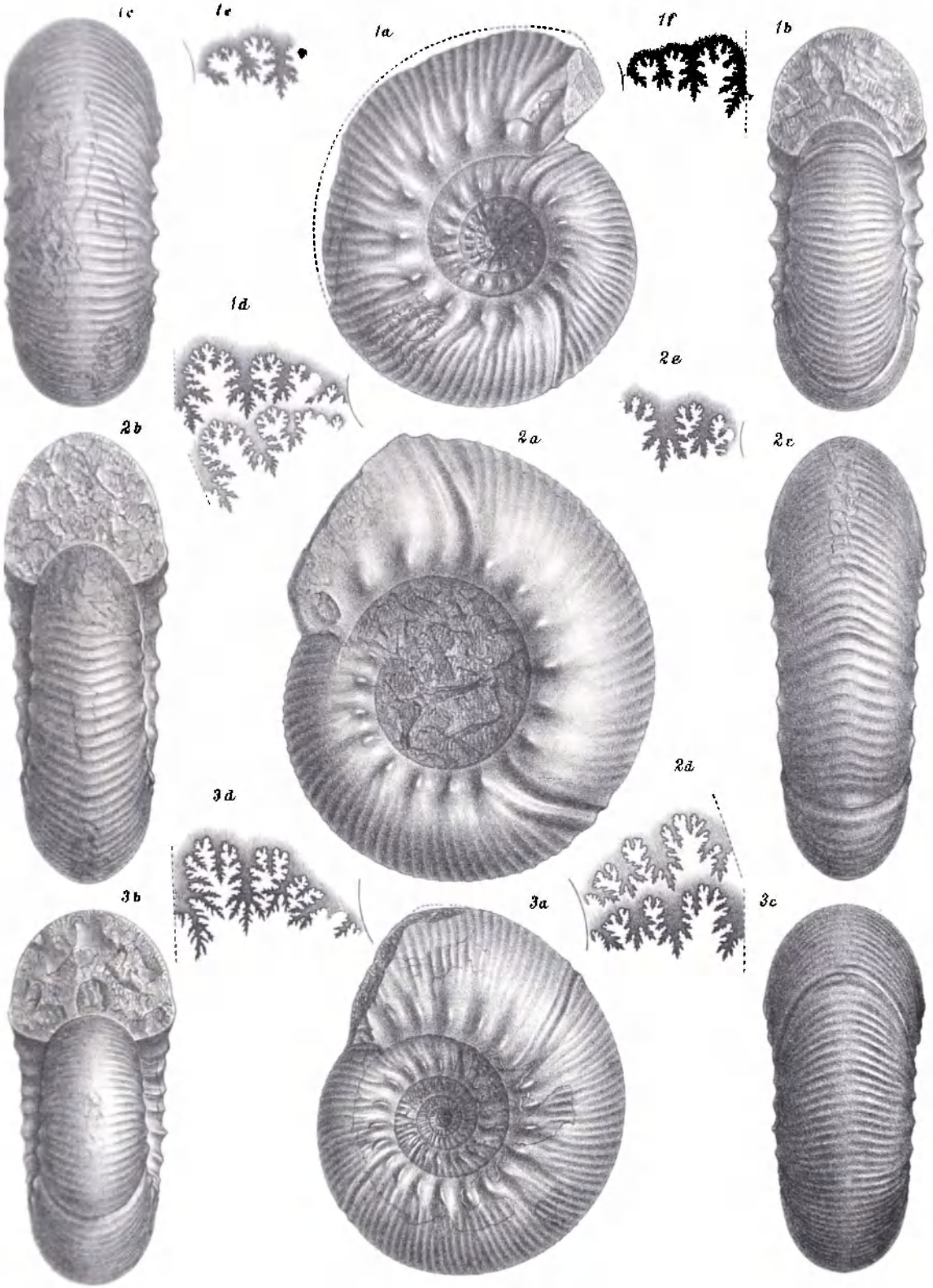
Fig. 2 *a—e*. HOLCOSTEPHANUS (SPITICERAS) SUBBILOBATUS, sp. nov.

Page 98. Internal cast, chambered up to the end. Natural size. 2*a*, Lateral view. 2*b*, Apertural view. 2*c*, View of the external periphery. 2*d*, Two consecutive lobal lines of the left-hand side. 2*e*, Lobal line, right-hand side. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

Fig. 3 *a—d*. HOLCOSTEPHANUS (SPITICERAS) INDICUS, sp. nov.

Page 124. Internal cast, chambered up to the end. Natural size. 3*a*, View of the sides. 3*b*, Apertural view. 3*c*, View of the external periphery. 3*d*, Lobal line. From Spiti. (Coll. Gerard.)

JURASSIC FOSSILS (HIMALAYA).



Albert Berger print.

PLATE XI.

Fig. 1 *a—c*. HOLCOSTEPHANUS (SPITICERAS) GUTTATUS, Strachey sp.

Page 119. Internal cast, chambered almost up to the end. Natural size. This is Strachey's original specimen, figured in Journ. Asiat. Soc., vol. XXXII, plate IV, fig. 1, 1863. 1*a*, Lateral view. The body-chamber begins at the tubercle behind ultimate constriction. 1*b*, View of the external periphery. 1*c*, Lobal line. From Spiti. (Coll. Gerard.)

Fig. 2 *a, b*. HOLCOSTEPHANUS (SPITICERAS) SPECIOSUS, sp. nov.

Page 127. Internal cast. Natural size. 2*a*, View of the sides. The penultimate whorl is chambered; the ultimate whorl, so much of it as is preserved, belongs to the body-chamber. 2*b*, View of the external periphery. A drawing of the cross-section is inserted in the text. From Kibber in Spiti. (Coll. Gerard.)

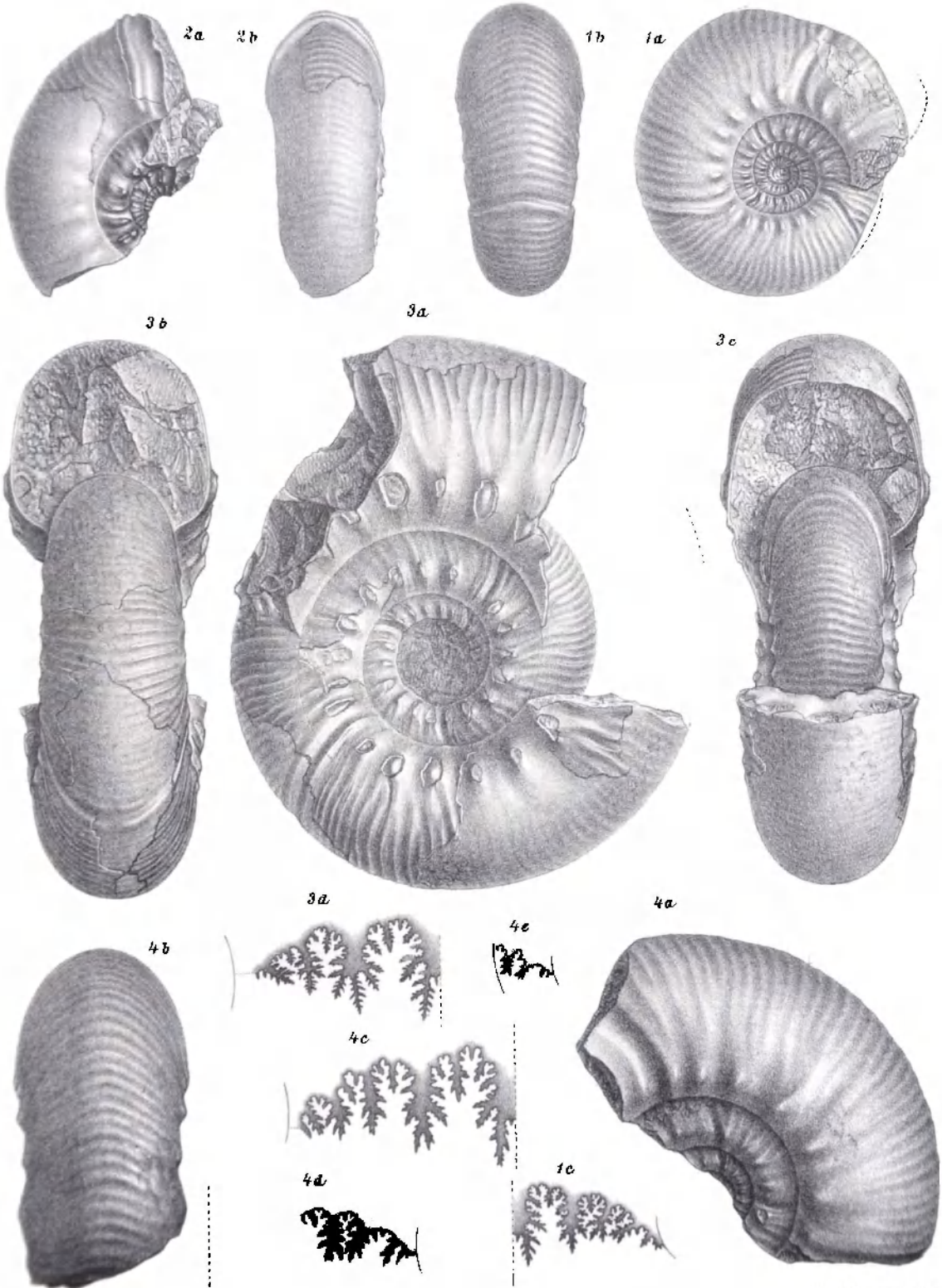
Fig. 3 *a—d*. HOLCOSTEPHANUS (SPITICERAS) GRIESBACHI, sp. nov.

Page 115. Specimen with shell partly adherent, chambered up to the end. Natural size. 3*a*, View of the sides. 3*b*, Apertural view. 3*c*, View of the external periphery. 3*d*, Lobal line. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

Fig. 4 *a—e*. HOLCOSTEPHANUS (SPITICERAS), sp. nov. indet.

Page 129. Internal cast, chambered almost up to the end, considerably weathered. Natural size. 4*a*, Lateral view. The body-chamber begins at the foremost constriction. 4*b*, View of the external periphery. 4*c*, Lobal line. 4*d*, Second lateral lobe and auxiliary lobes of the other side, in order to show a slight difference in the lobal structure, conditioned by the position of the tubercle between the first and the second auxiliary lobe. 4*e*, Auxiliary lobes of the next preceding whorl. From Spiti. (Coll. Gerard.)

JURASSIC FOSSILS (HIMALAYA).



R. Mayer del. et lith.

Albert Berger print.

PLATE XII.

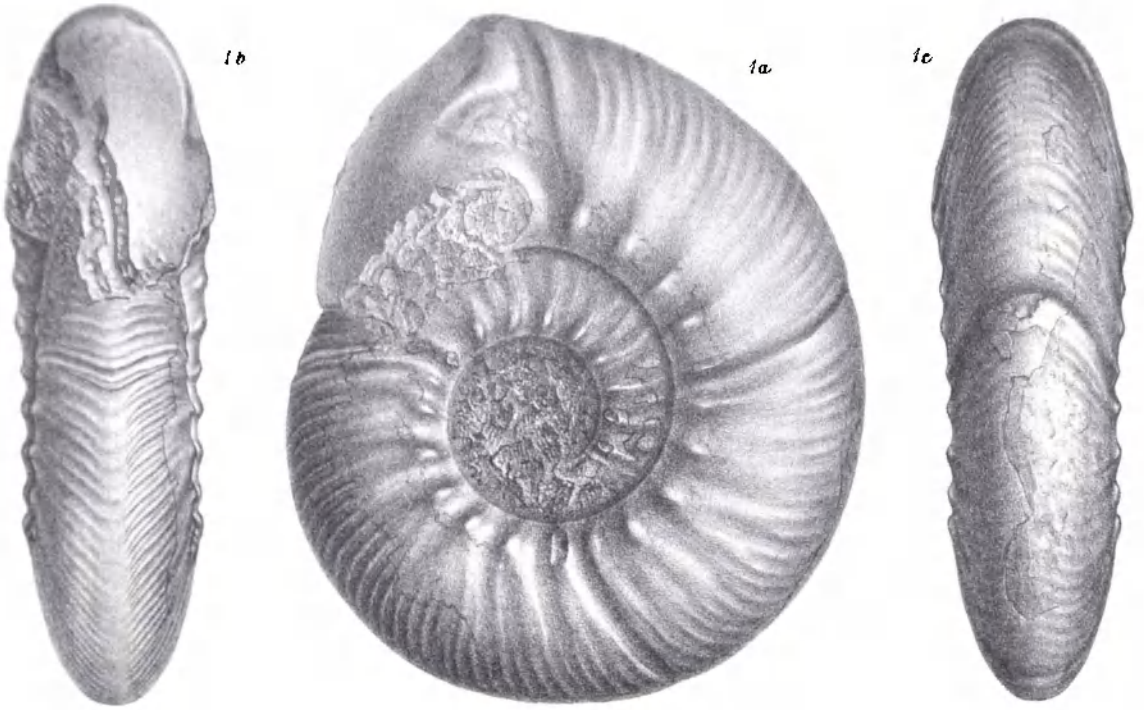
Fig. 1 *a—c*. HOLCOSTEPHANUS (SPITICERAS) CAUTLEYI, Oppel sp.

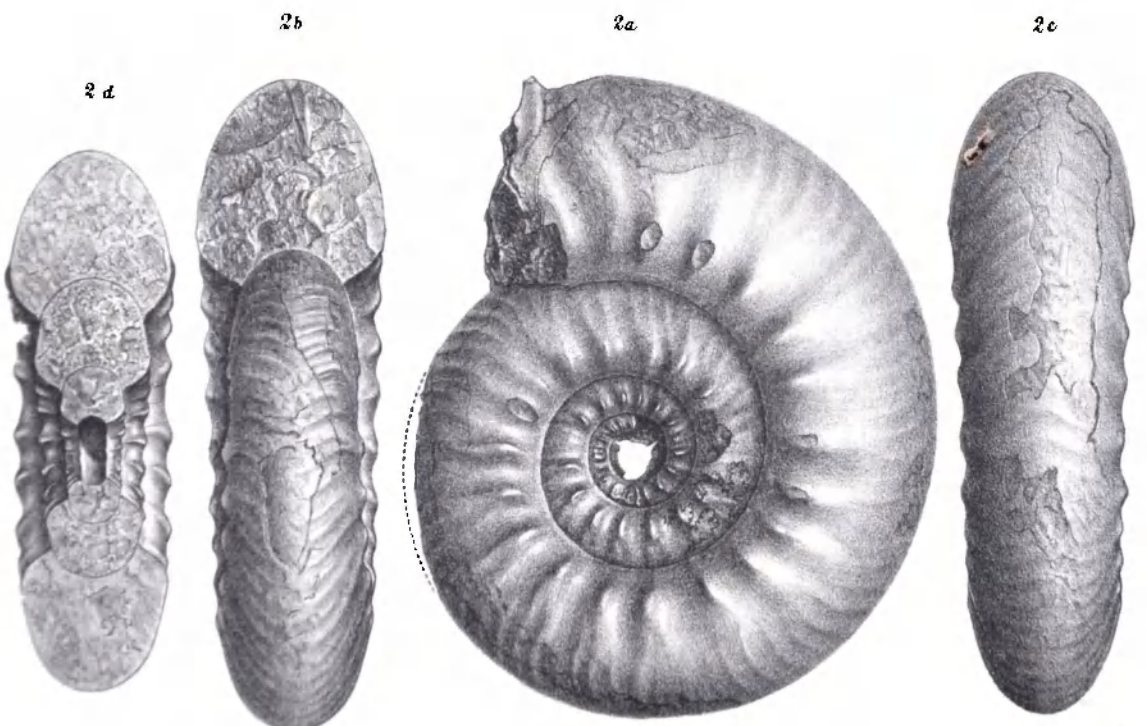
Page 104. (Oppel's original specimen from the Schlagintweit Collection.) Internal cast, with the body-chamber and apertural margin preserved. Natural size. The specimen is considerably weathered, so that the nicer details of the ornamentation are only visible in a few places, as, for example, in the apertural view. (State Palæontological Collection in Munich.) Locality, Laptel (Gnari Khorsum).

Fig. 2 *a—d*. HOLCOSTEPHANUS (SPITICERAS) SUBCAUTLEYI, sp. nov.

Page 106. Internal cast. Natural size. The body-chamber is preserved up to the constriction at the apertural margin. 2*a*, View of the sides. The body-chamber takes up nearly the whole of the ultimate whorl. 2*b*, Apertural view. 2*c*, View of the external periphery. 2*d*, Section along a fortuitously fractured surface. From Lochambelkichak, 3rd Stage. (Coll. Diener.) (Compare plate XIII, fig. 1.)

JURASSIC FOSSILS (HIMALAYA).





R Mayer del et lith

Albert Berger print.

PLATE XIII.

Fig. 1 *a*, *b*. HOLCOSTEPHANUS (SPITICERAS) SUBCAUTLEYI, sp. nov.

Page 106. Internal cast, with the body-chamber preserved. Natural size. 1*a*, Lateral view. So much of the ultimate whorl as is preserved belongs to the body-chamber. 1*b*, View of the cross-section. From Lochambelkichak, 3rd Stage. Upper Spiti shales. (Coll. Diener.) (Compare plate XII, fig. 2 *a*—*d*.)

Fig. 2 *a*—*c*. HOLCOSTEPHANUS (SPITICERAS) BULLIFORMIS, sp. nov.

Page 114. Internal cast, with the body-chamber preserved. Natural size. 2*a*, Lateral view. The paired lobes drawn in the figure indicate the position of the ultimate septation. 2*b*, Apertural view. 2*c*, View of the external periphery. From Spiti Valley.

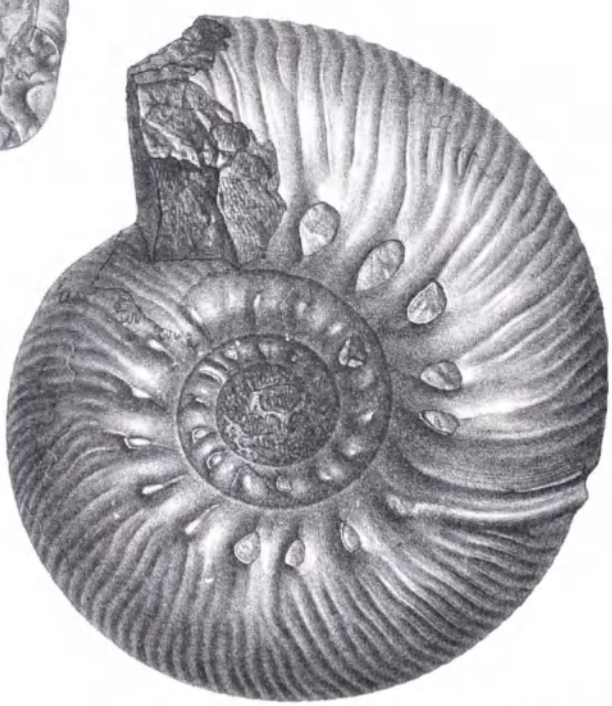
2c

1a

1b

2b

2a



R. Meyer del. et lith.

Albert Berger print

PLATE XIV.

Fig. 1 *a—d*. HOLCOSTEPHANUS (SPITICERAS) BINODIGER, sp. nov.

Page 101. Specimen with a part of the body-chamber preserved. Natural size. 1*a*, View of the sides. So much of the ultimate whorl as is preserved belongs almost entirely to the body-chamber. 1*b*, Cross-section taken through a fortuitous fracture in the specimen. 1*c*, View of the external periphery. 1*d*, View of the penultimate whorl, weathered out pretty completely on one side of the specimen. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

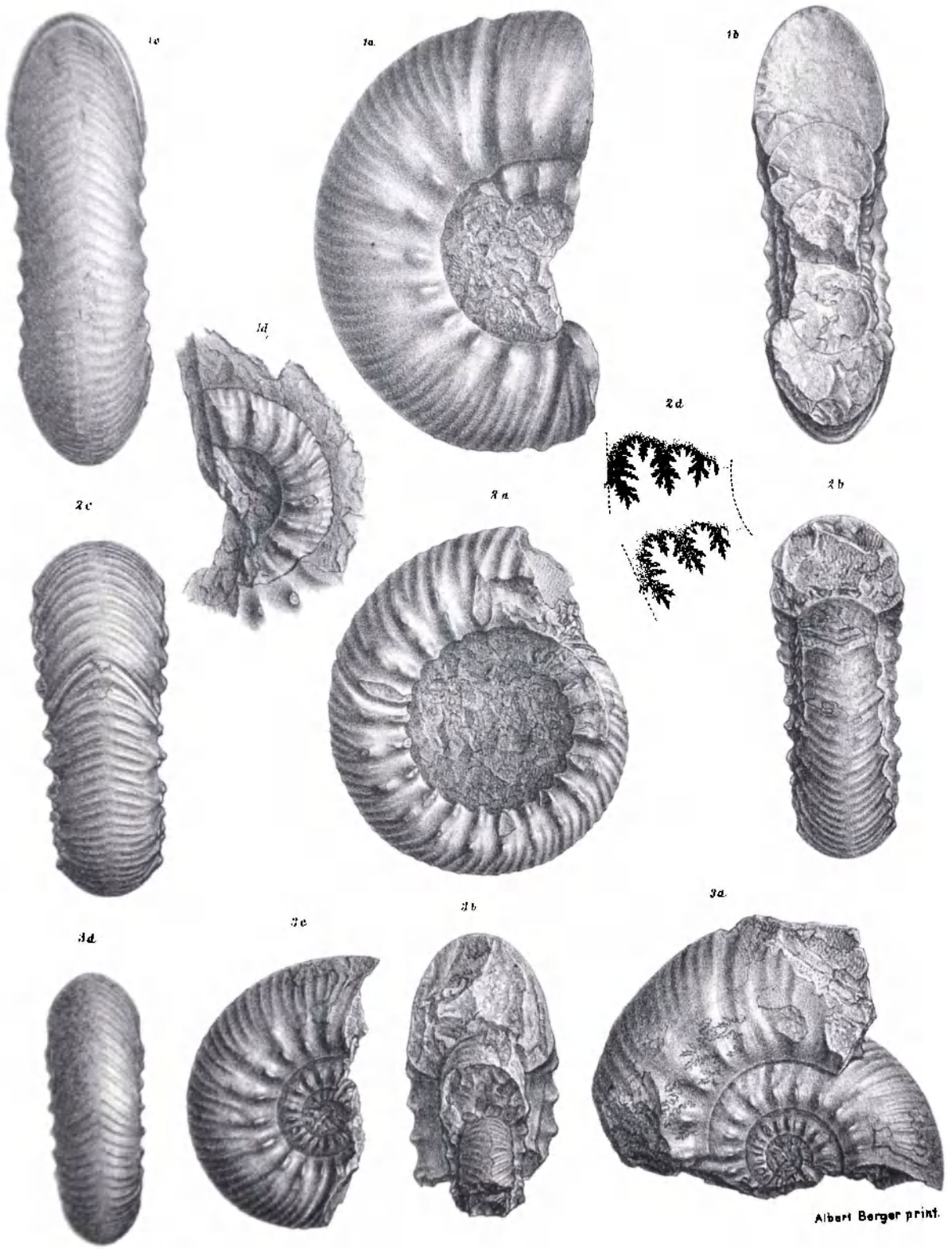
Fig. 2 *a—d*. HOLCOSTEPHANUS (SPITICERAS) CONSERVANS, sp. nov.

Page 102. Internal cast, chambered up to the end. Natural size. 2*a*, View of the sides. 2*b*, Apertural view. 2*c*, View of the external periphery. 2*d*, Two consecutive lobal lines. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

Fig. 3 *a—d*. HOLCOSTEPHANUS (SPITICERAS) aff. SCRIPTUS, Strach.

Page 112. Internal cast, chambered up to the end. Natural size. 3*a*, View of the sides. 3*b*, Apertural view. 3*c*, View of the internal volution, after ablation of the fragmentary remnant of the ultimate volution. 3*d*, View of the external periphery of the penultimate volution. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

JURASSIC FOSSILS (HIMALAYA).



Albert Berger print.

R. Mayer del et lith.

PLATE XV.

Fig. 1 *a—g*. HOLCOSTEPHANUS (SPITICERAS) SCRIPTUS, Strach. sp.

Page 112. Internal cast. Natural size. 1*a*, View of the sides. 1*b*, View of the external periphery. 1*c*, View of the inner whorls, enveloped by a portion of the ultimate volution. 1*d*, Apertural cross-section, forming part of what is shown in fig. 1*c*. 1*e*. View of the sides, internal volution. 1*f*, Apertural view, internal volution. 1*g*, Peripheral view, internal volution. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

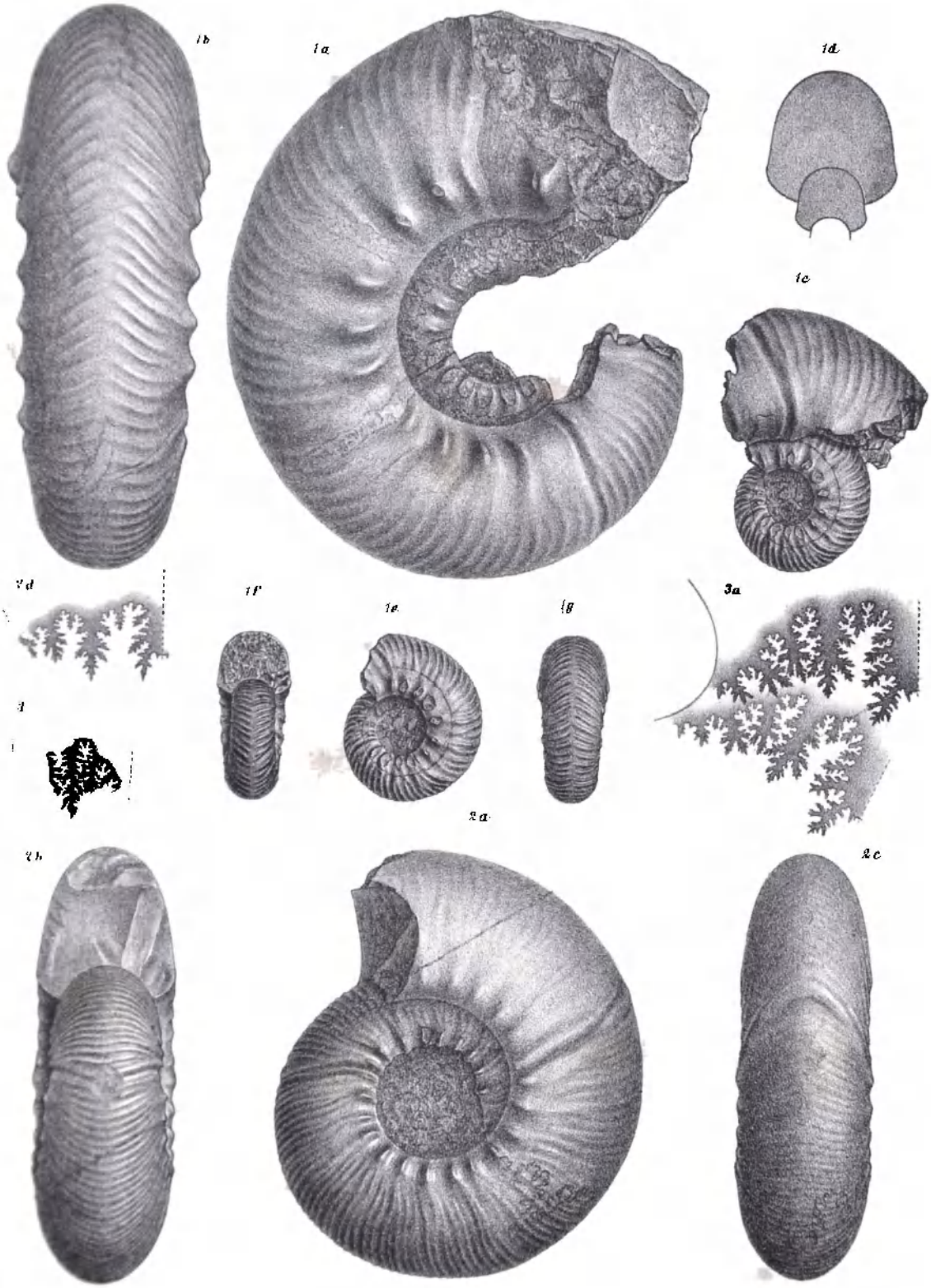
Fig. 2 *a—d*. HOLCOSTEPHANUS (SPITICERAS) PLANUS, sp. nov.

Page 99. Internal cast, with part of the body-chamber preserved. Natural size. 2*a*, View of the sides. The lobal line figured here is the ultimate one. 2*b*, Apertural view. 2*c*, View of the external periphery. 2*d*, Lobal line. From Kibber. (Coll. Gerard.)

Fig. 3, 3 *a*. HOLCOSTEPHANUS (SPITICERAS) OBLIQUELOBATUS, sp. nov.

Page 122. Lobes of the specimen represented in plate XVIII, fig. 1. 3, Two consecutive lobal lines, natural size. 3*a*, Internal lobe. From Gieumal. (Coll. Gerard.)

JURASSIC FOSSILS (HIMALAYA).



R. Mayer del et lith.

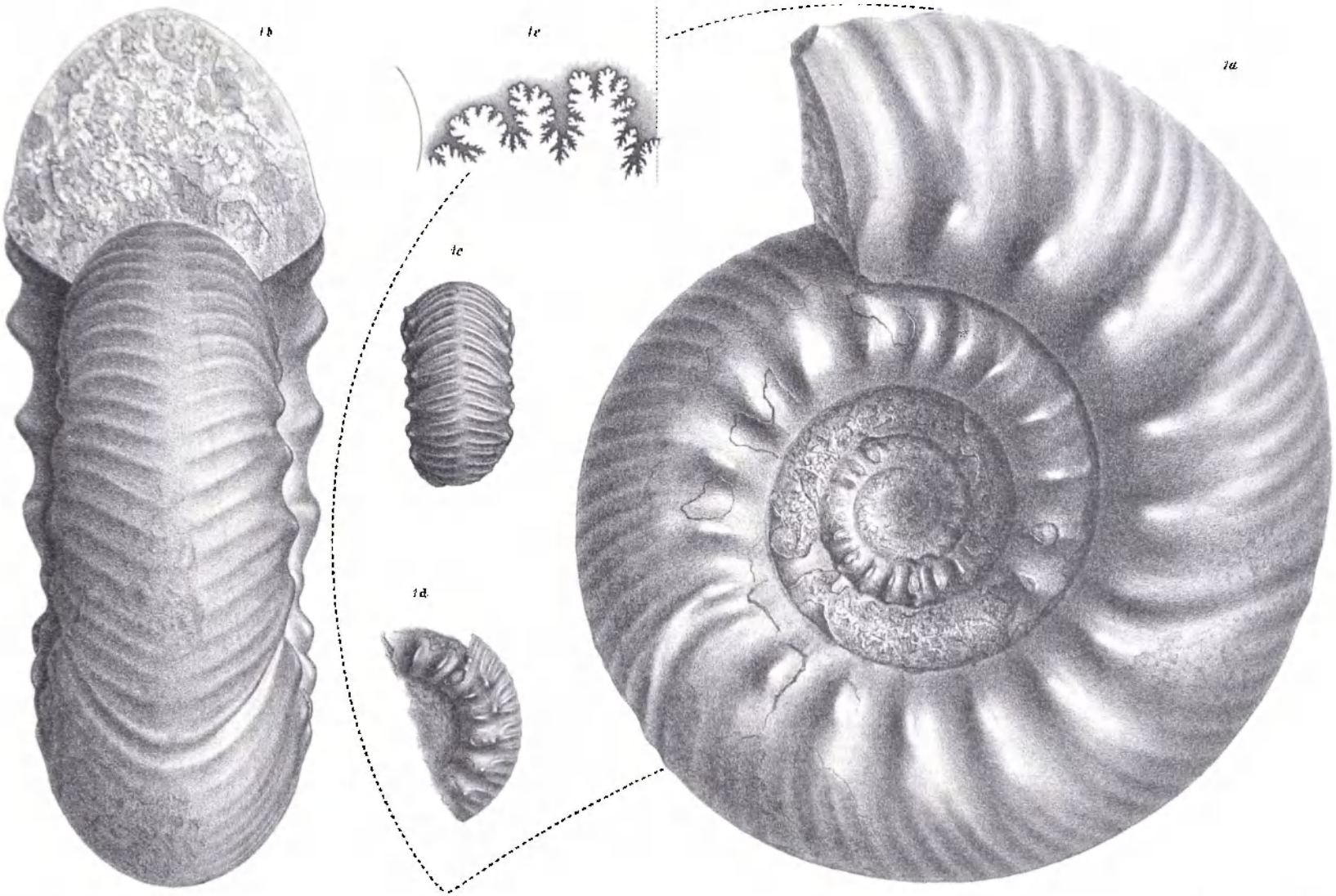
Albert Berger print.

PLATE XVI.

Fig. 1 *a—e*. HOLCOSTEPHANUS (SPITICERAS) STANLEYI, Oppel sp.

(Oppel's original specimen; see Paläont. Mittheil., plate LXXIX, fig. 1, page 282.) Internal cast. Natural size. The anterior portion of the body-chamber has been omitted, and only indicated by a dotted line. More than three-quarters of the ultimate whorl belongs to the body-chamber. Figs. 1*c* and 1*d* show views of the external periphery and the sides of an inner whorl, natural size. They show also the double-tubercular stage. (State Palæontological Collection in Munich.) Locality, Laptel in Gnari Khorsum. Page 107.

JURASSIC FOSSILS (HIMALAYA).



R. Meyer del. et. lith.

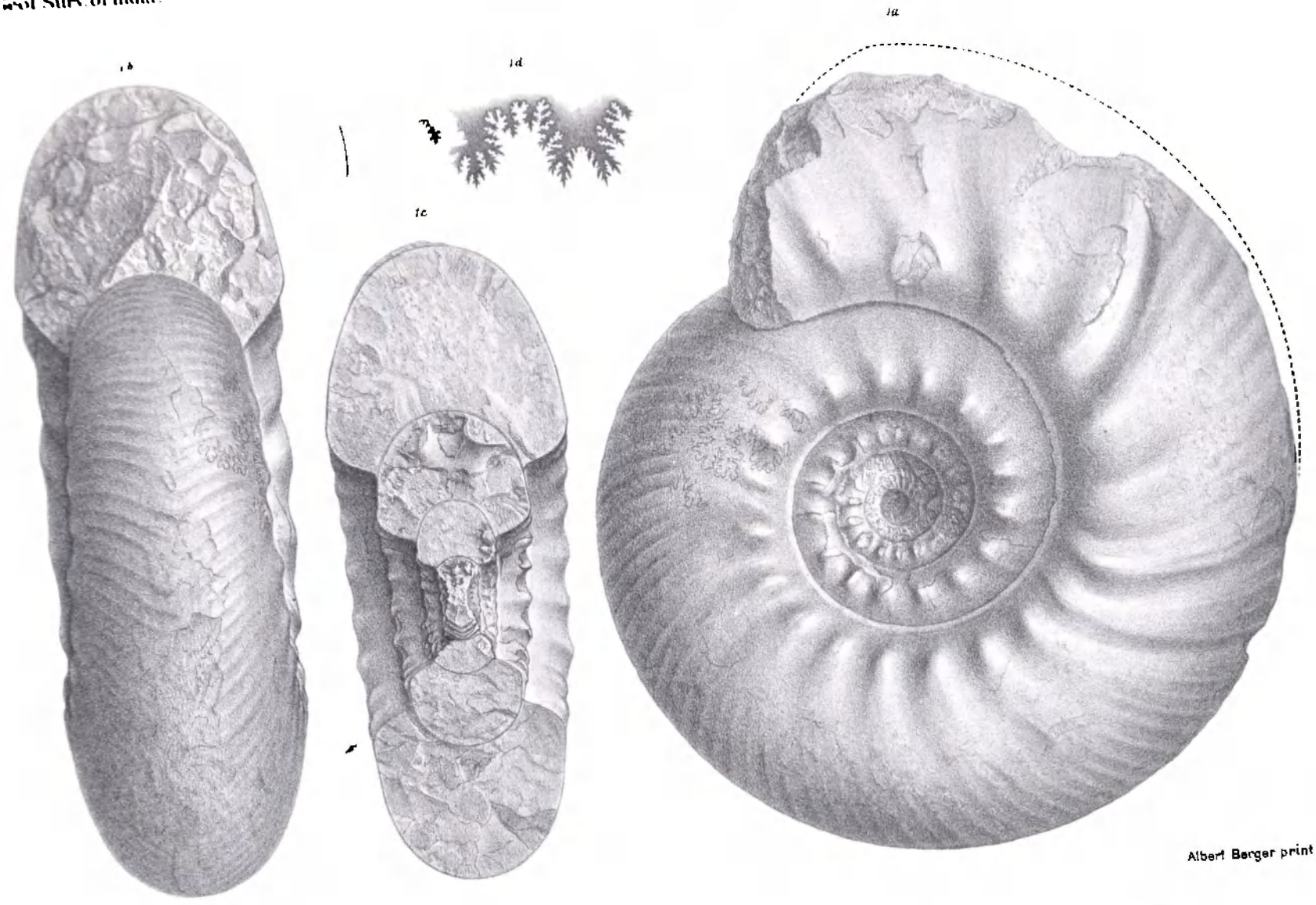
Albert Berger print.

PLATE XVII.

Fig. 1 *a—d*. HOLCOSTEPHANUS (SPITICERAS) MOJSVARI, sp. nov.

Page 110. Specimen with a part of the body-chamber preserved. The shell is in places adherent to the inner whorls, but the outer whorls are rather badly weathered. Natural size. 1*a*, View of the sides. Three-quarters of the ultimate whorl belong to the body-chamber. 1*b*, Apertural view. 1*c*, Cross-section, taken along a fortuitously fractured surface. 1*d*, Lobes. The configuration of the second lateral lobe may be seen in the view of the sides. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

JURASSIC FOSSILS (HIMALAYA).



R. Mayer del. et lith.

Albert Berger print

PLATE XVIII.

Fig. 1 *a—c*. HOLCOSTEPHANUS (SPITICERAS) OBLIQUELOBATUS, sp. nov.

Page 122. Internal cast, chambered up to the end and somewhat weathered. Natural size. 1*a*, View of the sides. 1*b*, Cross-section. 1*c*, View of the external periphery. The lobes are represented in plate XV, fig. 3, 3*a*. From Gieumal. (Coll. Gerard.)

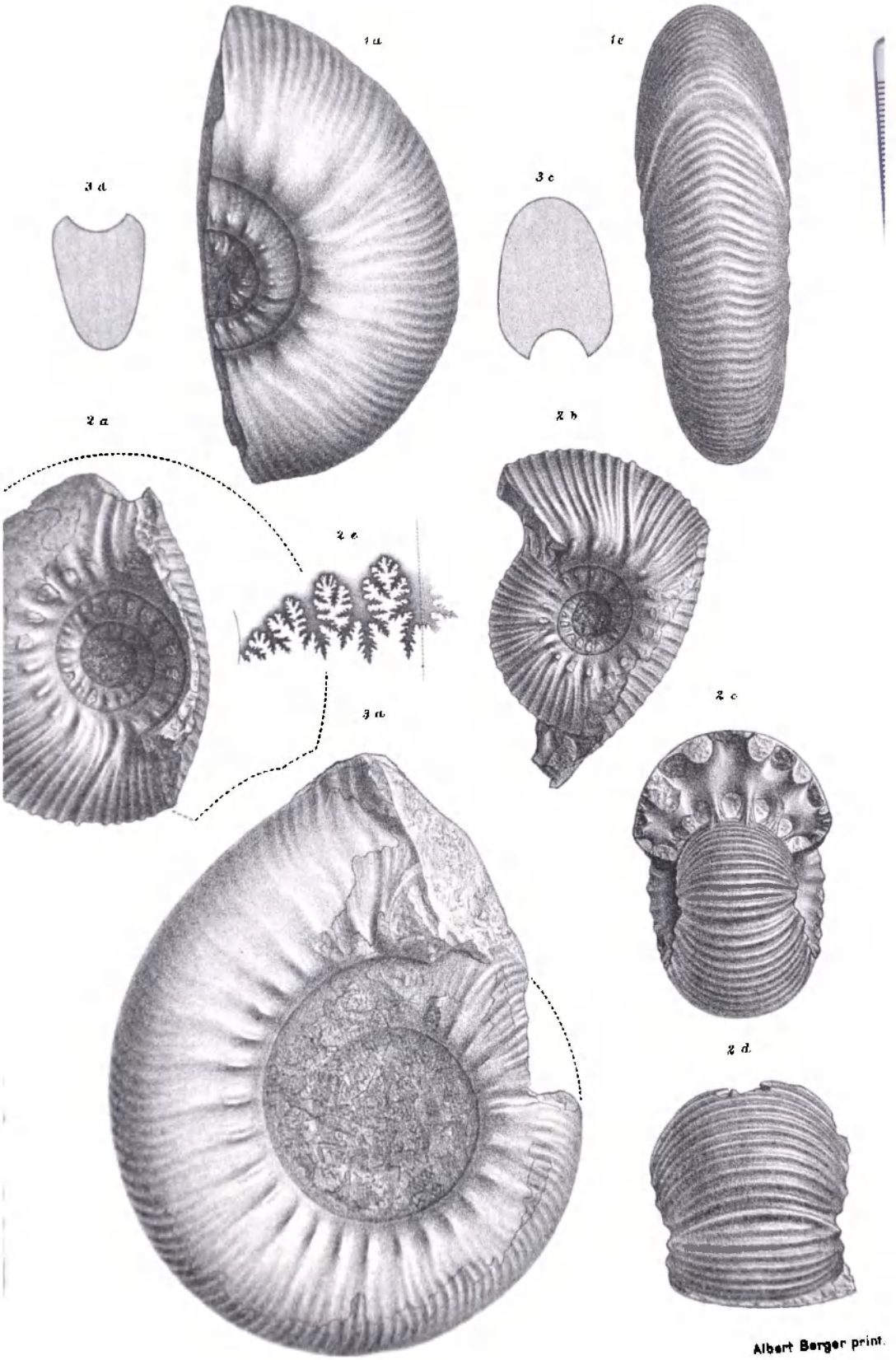
Fig. 2 *a—e*. HOLCOSTEPHANUS (ASTIERIA) SCHENKI, Oppel sp.

Oppel's original specimen has been refigured here, as that author's figure is largely a restoration (compare Paläont. Mittheil., plate LXXXI, fig. 4, page 286). The specimen is compressed to such an extent that the external portion of the ultimate whorl appears to be thrust over (or squeezed on to) the external portion of the next preceding whorl. In fig. 2*c* the compressed ultimate whorl is omitted. At the extremity of this whorl lobes are still recognizable. The auxiliary lobes of the lobal line in fig. 2*e* are drawn too oblique: in reality the stem of the first auxiliary lobe is parallel to the second lateral lobe, and it is only the second auxiliary lobe that shows a slight divergence. That the auxiliary lobes are not pendent (do not hang downward) is shown in the correctly drawn view of the septal wall in fig. 2*c*. Natural size. Locality, Shangra, east of Puling in Gnari Khorsum (Tibet). (State Palæontological Collection in Munich.) Page 130.

Fig. 3 *a—d*. HOLCOSTEPHANUS (SPITICERAS) EXIMIUS, sp. nov.

Page 126. Specimen with the body-chamber and apertural margin preserved and the shell partly adherent. Natural size. 3*a*, Lateral view. 3*b*, View of the external periphery. 3*c*, Cross-section of the anterior portion of the body-chamber. 3*d*, Cross-section at the beginning of the body-chamber. From Lochambelkichak, 3rd Stage. (Coll. Diener.)

JURASSIC FOSSILS (HIMALAYA).



Albert Berger print.