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VOL. IV.

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THE CAVE FAUNA OF NORTH AMERICA, WITH REMARKS ON THE ANATOMY OF THE BRAIN AND ORIGIN OF THE BLIND SPECIES.

By A. S. PACKARD.*

CONTENTS.

PREFACE.

Most of the materials on which this essay is based were obtained while connected temporarily with the geological survey of Kentucky, in charge of Prof. N. S. Shaler.

During portions of the months of April and May, 1874, I examined Mammoth Cave and several adjoining, *i. e.*, White's Cave, Dixon's Cave, Diamond Cave, and Proctor's Cave, in company with Professor Shaler and Mr. F. G. Sanborn, assistant on the survey, and subsequently Mr. Sanborn explored these, Carter, and many smaller caves. In company with Professor Shaler, I also made a slight examination of the four Carter caves. Fully appreciating the importance of the subject of cavern life and of comparing the fauna of different caves, Professor Shaler invited me to visit Wyandotte Cave, and the Bradford caves in Indiana. The Bradford caves I visited in company with Dr. John Sloan, of New Albany, Indiana, who had already examined with much success many of the small caverns in southern Indiana. The collections made by him, and contained in the Museum of Natural History of New Albany, were also examined, and he has kindly sent me other material. I have also received specimens and notes from Dr. Moses N. Elrod of Orleans, Orange County, Indiana, a region abounding in small caves. On my return I examined Weyer's Cave and adjoining Madison's Cave near Staunton, Virginia, and discovered about twelve forms, where before none were known to inhabit those caves. In the autumn Professor Putnam made a thorough exploration of Mammoth Cave. This paper is accordingly based on material collected by Mr. Sanborn, Professor Shaler, Mr. Cooke, Professor Putnam, Dr. Sloan, and myself.

Mr. Emerton kindly identified and described the spiders of the caves, and his descriptions and drawings accompany this article. The Coleoptera have been identified by Dr. Le Conte, the Dip-

* Read November 9, 1886.

tera by Baron Osten Sacken, and the only Psocidæ found have been described, so far as they could be, by Dr. Hagen.

In 1880 I visited the New Market and Luray caverns. Mr. H. G. Hubbard has kindly loaned me many of the specimens which he collected in Mammoth Cave. The entire collection of cave insects, excepting some of the duplicates, embracing the types obtained by Mr. Sanborn and myself while attached to the Kentucky geological survey, have been placed in the Museum of Comparative Zoology at Cambridge, Massachusetts.

I. DESCRIPTION OF THE BETTER-KNOWN CAVES.

MAMMOTH CAVE.

As Mammoth Cave is the largest and most frequented, and was the first known to contain eyeless animals, we will first briefly describe this great cavern, simply dwelling on those points which are of interest from a biological point of view. One can form little idea of the general geological relations of this cave from a few visits, especially when busied with the search for cave animals; and we are indebted to the Kentucky geological reports, containing accounts by Professors Owen and Shaler, also to an excellent paper by Mr. W. Le Conte-Stevens,[1] and the carefully-prepared work of Rev. H. C. Hovey on "Celebrated American Caverns," who has given the results of much time spent in exploration, and has taken, with more care than any one else, the temperatures of this[1] and other caves. By consulting Mr. Hovey's map of the cave[2] and reading Mr. Stevens's condensed account, aided by his sketches, we can obtain a fair idea of the topography of the cave, embracing the dry and damp portions; *i. e.*, those portions not deserted, and those most frequented by the animals of the caves.

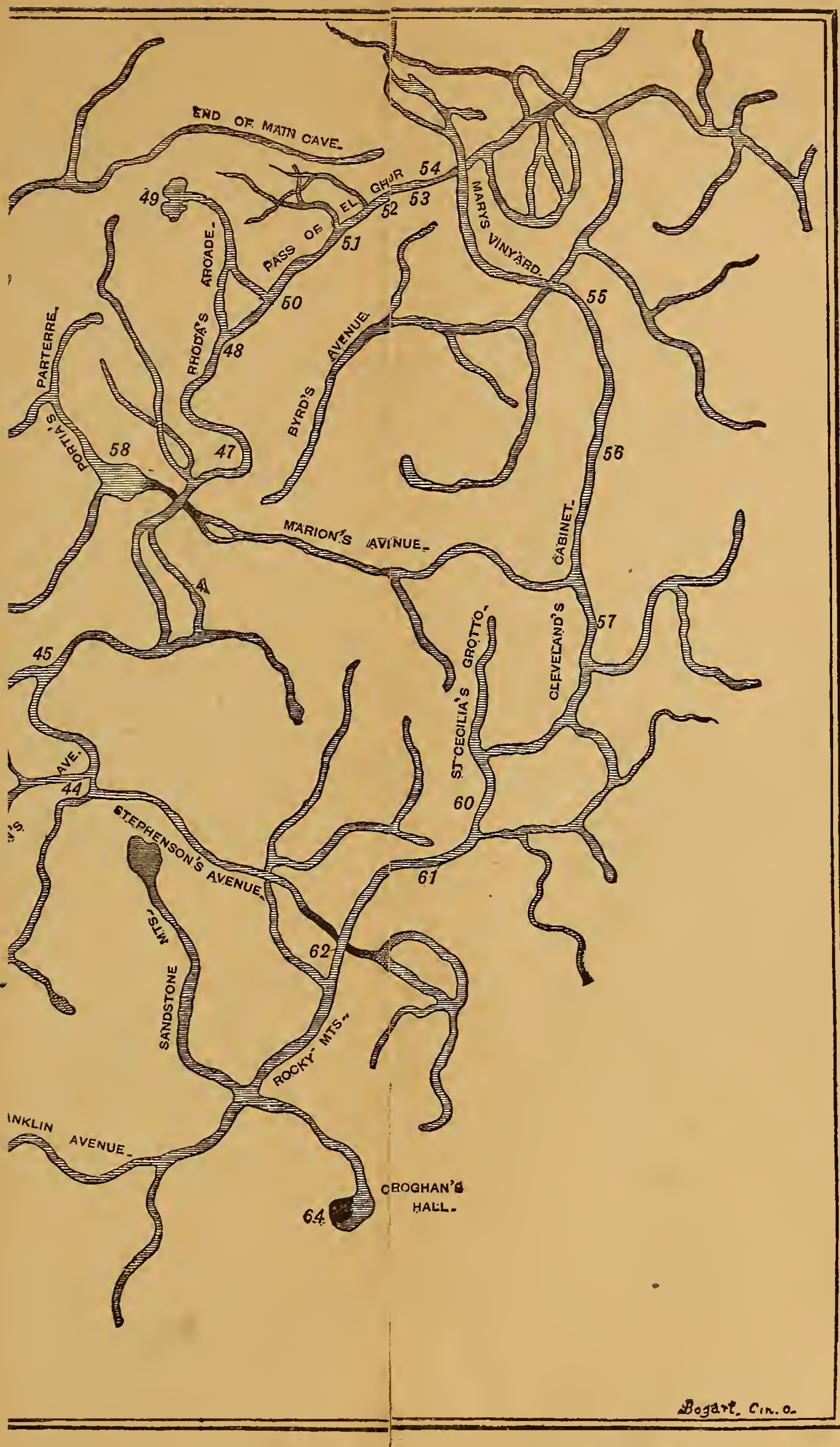
Mammoth Cave is situated in latitude 37° 14′ N., and longitude 86° 12′ W., in Edmondson county, Kentucky. It is the largest out of five hundred caverns estimated to exist in this county. These caves are excavated in the subcarboniferous limestone, covering a more or less elevated area, estimated to be 8,000 square miles in extent, and varying in thickness from 10 to 300 or 400 feet. This plateau is so honey-combed, that the drainage is almost entirely subterranean. The general features of this limestone table-land are paralleled by those of the less extensive Carniolan caves, described as follows, in Geikie's Elementary Lessons in Physical Geography (p. 246-247).

One of the most remarkable examples of this kind of scenery is that of the Karst, in Carniola, on the flanks of the Julian Alps. It is a table-land of limestone, so full of holes as to resemble a sponge. All the rain which falls upon it is at once swallowed up and disappears in underground channels, where, as it rushes among the rocks, it can be heard even from the surface. Some of the holes which open upon the surface lead downward for several hundred feet. Some turn aside and pass into tunnels, in which the collected waters move along as large and rapid subterranean rivers, either gushing out like the Timao at the outer edge of the table-land, or actually passing for some distance beyond the shore, and finding an outlet below the sea. Here and there the labyrinths of the honey-combed rock expand into a vast chamber with stalactites of snowy crystalline lime hanging from the roof or connecting it by massive pillars and partitions with the floor. Such is the famous grotto of Adelsberg near Trieste—a series of caverns and passages with a river running across them."

Stevens states that the subcarboniferous limestone in which the Mammoth Cave is situated is overlaid with a thin stratum, mostly of sandstone, which is pierced by thousands of sink-holes, through which the surface drainage is carried down into limestone fissures and thus to the general drainage level of the Green River. "This stream passes at the distance of less than a mile from the Cave Hotel, the floor of the latter being 312 feet above the water and 118 feet above the mouth of the cave." He adds: "The rate of erosion in the Mammoth Cave has been variable. The older parts are perfectly dry, and entirely free from stalagmitic deposits, indicating rapid erosion, followed by elevation, so as to deviate the water completely into other channels. In the newer parts the water is still dripping from the surface above, and depositing stalactites and stalagmites." It is in the newer damper parts, as well as in or near the subterranean streams and pools of this and most if not all the other caves that the animal life mostly congregates. It will be seen that the caves have frequent passages communicating with the upper world, and it will also be seen how

[1] For the titles of these articles see Chapter X, Bibliography.

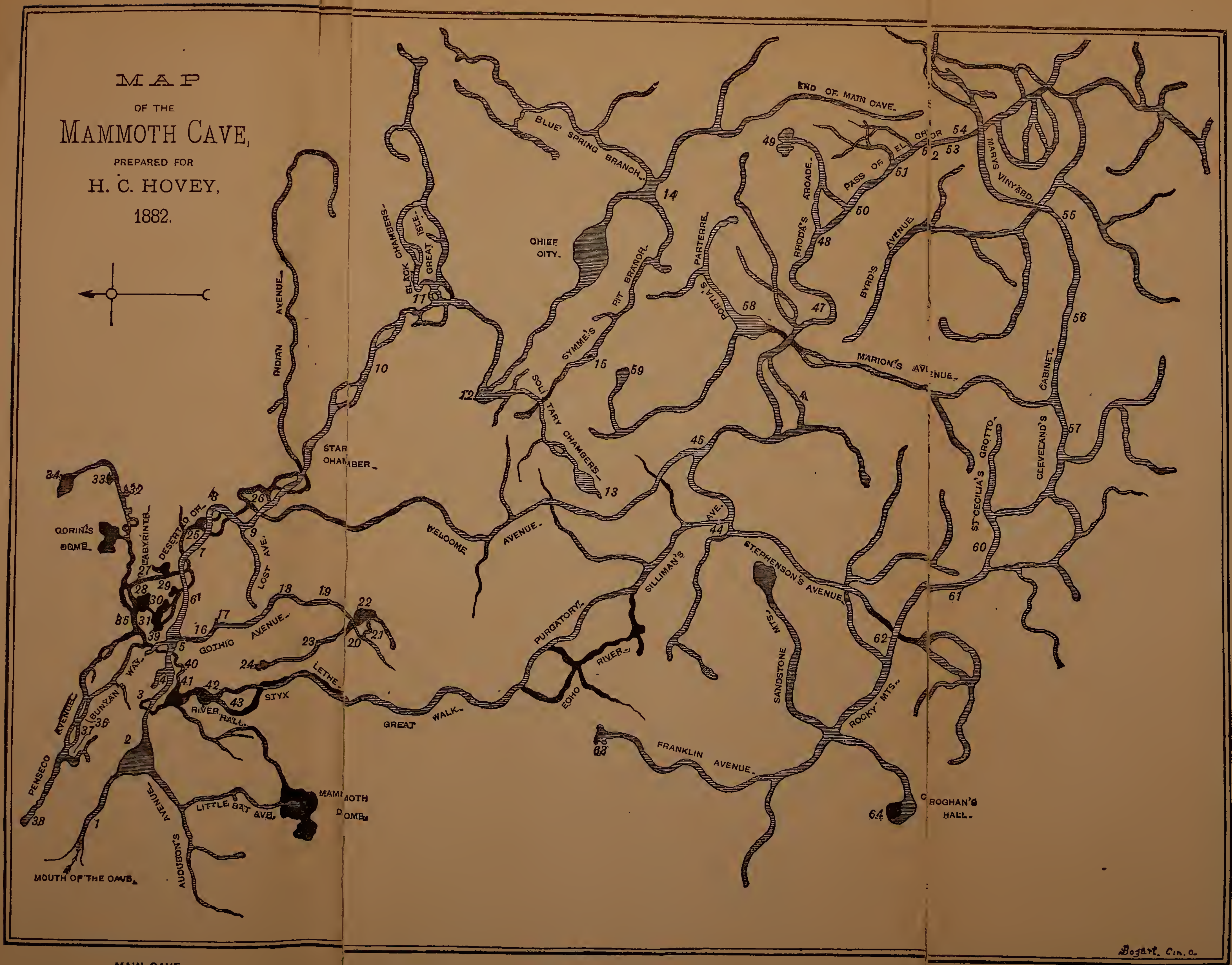
[2] Kindly loaned by the publishers, Robert Clarke & Co., Cincinnati.



UE.

ON THE LONG ROUTE.

39. Scotchman's Trap.
40. Fat Man's Misery.
41. Great Relief.
42. The Dead Sea.
43. Cascade at the Styx.
44. Cascade Hall.
45. Serpent Hall.
46. Valley-Way Side-Cut.
47. Great Western.
48. Valley of Flowers.
49. Lucy's Dome.
50. Ole Bull's Concert Hall.
51. Fly Chamber.
52. Sheep Shelter.
53. Corinna's Dome.
54. Black Hole of Calcutta.
55. Washington Hall.
56. Snow Ball Room.
57. Floral Cross and Last Rose of Summer.
58. Paradise.
59. Zoe's Grotto.
60. Flora's Garden.
61. Vale of Diamonds.
62. Charlotte's Grotto.
63. Serena's Arbor.
64. The Maelstrom.



MAIN CAVE.

1. The Iron Gate.
2. The Rotunda.
3. Kentucky Cliffs and the Corkscrew.
4. The Methodist Church.
5. Gothic Galleries.
6. Standing Rocks.
7. Grand Arch.
8. Giant's Coffin.
9. Acute Angle, and Cottages.
10. Proctor's Arcade.
11. Wright's Rotunda.
12. The Cataracts.
13. Fairy Grotto.
14. St. Catherine's City.
15. Symmes' Pit.

GOTHIC AVENUE.

16. Seat c f the Mummy.
17. Regis ter Hall.
18. Gothi c Chapel.
19. The A rm Chair.
20. Lover 's Leap.
21. Elbow Crevice.
22. Napol eon's Dome.
23. Lake Purity.
24. Anne tte's Dome.

DESERTED CHAMBERS.

25. Wood en Bowl Room.
26. Black Snake Avenue.
27. Side-S addle Pit.
28. Bottomless Pit.
29. Covered Pit.
30. Scylla.
31. Charybdis.

LABYRINTH.

32. Putnam's Cabinet.
33. Hovey's Cabinet.
34. Ariadne's Grotto.

PENSICO AVENUE.

35. Revelers' Hall.
36. Grand Crossing.
37. Pineapple Bush.
38. Angelica's Grotto.

ON THE LONG ROUTE.

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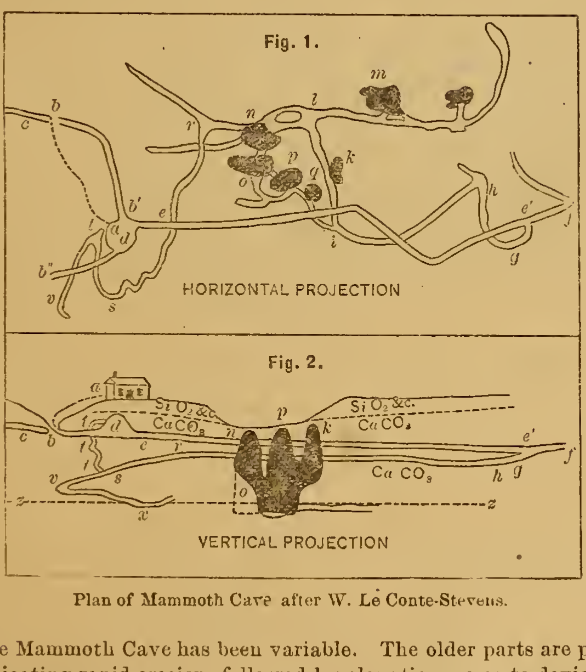
easy it is for small animals such as crustacea and insects to be carried through these sink-holes from the surface of the soil above into these caves. These sink-holes are said to average 100 to the square mile, and Shaler claims that "there are at least 100,000 miles of open caverns beneath the surface of the carboniferous limestone in Kentucky." He also (Antiquity of the Caverns, etc.) claims that "there are at least 1,000 miles of open water channel beneath the surface of the carboniferous limestone belt in Kentucky."

Owen says:

The known avenues of Mammoth Cave amount to 223, and the united length of the whole equals 150 miles. The average width is 7 yards, and the height the same. About 12,000,000 cubic yards of cavernous space have here been excavated by calcareous waters and atmospheric vicissitudes. (Geol. Surv. of Kentucky, i. p. 81.)

We will now avail ourselves of Mr. Stevens's description of Mammoth Cave, read at a meeting of the Academy of Sciences, New York, adding some comments by Prof. J. S. Newberry:

Mr. Stevens exhibited a geological map of Kentucky, showing the area of subcarboniferous limestone in which the Mammoth Cave is situated. This is overlaid with a thin stratum, mostly of sandstone, that is pierced by thousands of sink-holes, through which the surface drainage is carried down into limestone fissures and thus to the general drainage level of the Green River. This stream passes at the distance of less than a mile from the Cave Hotel, the floor of the latter being 312 feet above the water and 118 feet above the mouth of the cave. He briefly explained, with a diagram, the general mode of cave production in limestone strata, showing that subterranean tunnels must be started by the solvent action of slightly acidulated rain-water, and subsequently enlarged by erosion, along the fissures in the limestone. These agencies are still at work in portions of the cave, and the whole of this limestone country is thus honey-combed with caverns. No tunnel can thus be formed at any point lower than the general drainage level, since there must be an exit for the saturated water. The production of the fissures is referable to the general upheaval of this area at the close of the coal period; but that there has been subsidence since the completion of much of the Mammoth Cave is indicated by the fact that at its lowest parts to-day the floor is covered with water to the depth of 30 feet or more, having subterranean connection with Green River. The fissures intersect at various angles, but many of them are nearly or quite coincident with the dip of the strata, which is very gentle. Water passing through these forms the tunnels, while that passing through the vertical fissures scores out the pits which pierce them. The same pit, starting from a sink-hole at the surface, may have successively lower tunnels as exit passages. If the visitor encounters it while walking through the higher, and therefore older, tunnel, the upper part appears to him as a dome, the lower as a pit.



Plan of Mammoth Cave after W. Le Conte-Stevens.

The rate of erosion in the Mammoth Cave has been variable. The older parts are perfectly dry and entirely free from stalagmitic deposits, indicating rapid erosion, followed by elevation, so as to deviate the water completely into other channels. In the newer parts the water is still dripping from the surface above and depositing stalactites and stalagmites; but as a whole the cave is by no means remarkable for these formations, being much surpassed in this respect by the neighboring White's Cave, of more recent origin. Those which do occur are moreover deeply colored with iron, which exists in the soil in the form of both oxide and sulphide. In the dry parts, the ceiling of the cave is more or less covered with efflorescent calcic, magnesic, and sodic sulphates, which contrast with the iron-stained limestone, giving rise to the beautiful effects that have conferred celebrity on the opening known as the Star Chamber, and the myriad rock-flowers of Cleveland's Cabinet.

The structure of the pits and domes was then illustrated, with the aid of the accompanying map, by describing a journey through the cave. From the hotel (*a*, Figs. 1 and 2) the visitor walks to its mouth (*b*) by the side of a shallow ravine, terminating in what was formerly a large sink-hole. The door of this fell through about seventy years ago, producing the present mouth of the cave, and cutting off part of the gallery now known as Dixon's Cave (*c*), which opens out near the Green River, a half mile distant. A walk of 1,000 yards brings him to the Great Rotunda (*d*), about 170 feet in diameter and 100 feet high. It is immediately under the hotel, its roof being not more than 40 or 50 feet from the surface. Besides the gallery called the Narrows (*b*′), by which access has just been obtained, another tunnel from the farther side terminates in the Rotunda, to which the name of Audubon's Avenue (*b*″) has been given. The large, almost hemispherical, opening seems to have been cut out by the meeting of nearly opposite streams of water, which found exit, probably, through the main cave (*e*). At some distance within Audubon's Avenue a small opening in the floor is found, connecting it with the roof of the Mammoth Dome, a vast cavern 400 feet long, 100 feet wide, and 250 feet high. These figures are of course only approximate, but it is believed that they are not exaggerated. Into this cavern the water is still trickling, and stalagmites are forming with sufficient rapidity to have cemented firmly to the floor a lamp dropped in 1812 and found in 1843. Returning to the Rotunda and passing through a half mile or more of the main cave, the visitor reaches at (*e*′) a large fallen slab of limestone, to which has been assigned the title of the Giant's Coffin. This makes the entrance to a side passage (*g*), which leads off to the lowest part of the present cave. The main cave forms an acute angle (*f*), and may be followed for several miles, terminating abruptly in a pile of rocks, where the roof has fallen in the same manner as at the terminus of Dixon's Cave. Many of its side passages and avenues are yet unexplored.

Returning and entering the side passage near the Giant's Coffin, the visitor passes obliquely beneath the main cave, starting upon what is known distinctively as the Long Route. At an expansion (*h*) are successive deposits of gravel, sand, and clay, indicating the downward course of the water, which was here partially arrested. Some distance farther on the passage forks (*i*). Keeping to the right, the dangerous Side-Saddle Pit (*k*) is encountered, which measures 65 feet in depth and 20 feet across. It is surmounted by Minerva's Dome, 35 feet high. The pit yawns across the right half of the floor of the tunnel, leaving a narrow path on the left. A short distance beyond (*l*) the tunnel again forks. Keeping to the right, as before, Gorin's Dome (*m*) is reached, and may be viewed with the aid of magnesium lights from a small opening on the side 10 feet above the pathway. The abyss extends 117 feet downward, 100 feet upward, and 60 feet across. Leaving this and passing the fork (*l*), the tunnel is completely interrupted by the so-called Bottomless Pit (*n*), across which a bridge has been laid, resting upon a ledge. Despite its ominous name it does not defy measurement, having been found to be 95 feet deep on one side of the ledge and 105 feet on the other. Almost immediately overhead is Shelby's Dome, 60 feet high. Between the Bottomless Pit and the Side-Saddle Pit are a pair of very large pits, discovered not a year ago by one of the guides (William Garvin), and examined for the first time last August by Mr. Hovey, who gave to them the names Scylla (*p*) and Charybdis (*o*) on account of the narrow rugged passage which separates them and the great difficulty and danger of access. By timing the fall of pebbles into the water at the bottom the depth of each was ascertained to be about 200 feet. Charybdis was seen to be directly connected with the Bottomless Pit. Indeed the latter may be regarded as only a part of Charybdis, its depth (105 feet) being that of a jutting ledge or the floor, upon which water ceased to fall after being slightly deviated into Charybdis, where the sound of its trickling is still audible. Shelby's Dome is simply the upward continuation of this combined pit. So narrow, moreover, are the ridges separating Scylla from Charybdis on the one side and from the Covered Pit (*q*) on the other, and so small is the distance to the Side-Saddle Pit (*k*), that it seems in the highest degree probable that the group of pits compose merely the upper branches of a single large pit into which they are all united, or at least directly connected, before the bottom is reached, and the small relative depth of the Side-Saddle Pit is explicable in the same manner as that of the Bottomless Pit. Such an extraordinary group of pits, forming an apparent nucleus of cave drainage, might be expected to have its counterpart in an unusually large depression or group of sink-holes at the surface. Impressed with this idea, Mr. Hovey found in the woods scarcely half a mile from the hotel, in the known direction of these pits, a depression (*p* Fig. 2) many acres in extent, and so deep that from its edge he could overlook the tops of the pine trees that rose from the middle.

Leaving this region of pits and domes, the route leads still downward, passing again under the main cave through the narrow tortuous channel known as Fat Man's Misery (*s*), where the distance from floor to roof is in many places not more than 3 feet. Through the floor a winding passage has been worn away, varying in width and depth from 1 to 3 feet. This terminates in a chamber, which has received the appropriate name of Great Relief, where the succession of pebbles, gravel, sand, and fine clay again records the work of erosion and deposit. This bed is not more than 50 or 60 feet above the drainage level, and from here down to the River Styx the ground becomes more or less damp. A succession of bodies of water are then encountered, including the tubular Echo River, which s navigated in boats. It is a part of the tunnel, which has subsided below the water level, and is in connection with Green River, being filled to within a few feet of the roof in summer, and completely closed in winter when the Green River rises. The column of air between the water and the impervious roof, closed everywhere except at the two ends, which are three-fourths of a mile apart, serves as a resonator for any note within the range of the human voice, and multiple echoes gliding imperceptibly into each other continue to be returned for many seconds after the voice has been hushed.

Beyond Echo River the cave may be followed with continual ascent through Silliman's Avenue, the Pass of El Ghor, and Cleveland's Cabinet for about 5½ miles. A pile of jagged rocks 100 feet high, is then surmounted, and the wearied climber is confronted with a large cavern 100 feet wide and 70 feet deep, where three short branches have united in one tunnel. Following the left branch for a few yards a hall is found, in the floor of which is a pit 175 feet deep. The corresponding dome overhead is scarcely noticeable as such, for the surface of the ground is not more than 30 or 40 feet distant. The end of the Long Route has been reached.

In returning the passage through Fat Man's Misery is avoided, and nearly 2 miles of walking are saved by climbing through a very steep, narrow, winding Corkscrew pass (*t*, Fig. 2), starting from the neighborhood of Great Relief and terminating at the side of the Great Rotunda. The vertical ascent is about 140 feet. To even stout-hearted mountaineers, if stout-bodied also, this Corkscrew is an intensified Fat Man's Misery, and upon them it rarely fails to leave strong and deep impressions, which may be of more kinds than one.

Dr. Newberry remarked on the geology of the region adjacent to the Mammoth Cave:

"The limestone beds of this high table-land are jointed in the manner common to rocks, apparently by some sort of polarization, producing fissures which run in a north and south and an east and west direction. The plateau is about 500 feet above the drainage, part of the drainage passing into the Green River and part into the Ohio. No streams occur on the surface, and the drainage is quite gradual. At the angle between these two rivers several streams are seen bursting out of the cliffs at various heights above the Ohio; they are, so to speak, subterranean sewers, representing the underground drainage of the country; at one point three such streams pouring out of the rock form very beautiful cascades; and near Sandusky a full-grown river flows out of the cliff of cavernous limestone. The beds consist of Lower Carboniferous limestone, with sandy layers beneath. In the vicinity occur portions of the great 'blue-grass region,' one of the oldest parts of the continent, once an extensive highland, forming an island in the sea. Around this rims of sediment were deposited, consisting of sandstones and limestones; while, on the other hand, the continuous process of erosion during the lapse of a vast period removed the material of the table-land within, and converted it into a broad depression or basin, the 'blue grass region,' above which the present plateau of the encircling sediments now rises to a height of 500 feet.

"The erosion of the joints in this plateau has resulted in the formation of the pits described by Mr. Stevens, but it is probable that some of these may reach 200 or 300 feet below the Ohio and Green rivers. There is evidence, from borings in the Delta of the Mississippi, etc., that the continent was formerly more elevated, standing 500 to 600 feet higher at New Orleans than at present; the drainage was much freer, the Mississippi being a free-flowing stream as well as the Ohio and other tributaries. Borings have been sunk in the present trough of the Ohio River to a depth of over 100 feet below its present bottom without reaching the true bottom of the trough, the ancient bed of the river, which is perhaps 100 to 200 feet farther down."

The hydrography of Mammoth Cave may be understood by reference to the shaded portion of the passages in the cave now filled with water or containing pools.

Soon after entering the main cave one passes on the left a miniature cascade, which runs or drips down into a basin called Wandering Willie's Spring, situated between the Standing Rocks and the Grand Arch. This rill probably comes more or less directly from the surface of the soil above; and from the rill, as well as the pool, I took the water containing several species of infusoria, while the pool was tenanted by the Crangonyx. It is possible, however, that the rill arises from the collection of pools in the Labyrinth. Still farther on is Richardson's Spring, not mentioned in Mr. Hovey's book; it is situated near Star Chamber, and in the pool, under stones, lives the white eyeless Planarian worm, *Dendrocœlum percœcum*, while in the damp soil around and under the stones were found beetles, Podurids, mites, and Myriopods.

Another locality where the animals are in greatest abundance is the Labyrinth, in which is a pool 12 feet deep. Near this is a brook, which we have called Shaler's Brook. It abounds in the white eyeless Planarian worms, usually occurring on the under side of the pebbles in the bottom, while a species of Chironomus and Crangonyx live in its waters. Near by is the Devil's Cooling Tub. It was noticed here, as well as in other wet or watered localities, that no animals occurred in the dry portions of the cave. Dampness or some degree of moisture is essential to their existence. The cray fish and blind fish for the most part, if not exclusively so, live in the River Styx and the Dead Sea. The most accurate account of this region of the cave is that given by Mr. Hovey:

On entering River Hall we followed a path skirting the edge of cliffs 60 feet high and 100 feet long, embracing the sullen waters to which the name of Dead Sea is given. Descending a flight of steps we came to a cascade, but a little farther on, by some conjectured to be a re-appearance of the waterfall at the entrance of the cave, it precipitates itself into a funnel-shaped hollow in a massive mud-bank. On another visit, in 1881, we found a natural bed of mushrooms growing here, a species of Agaricus, that has suggested the idea of a mushroom farm, similar to those at Frépilon and Méry, in France, whence many thousands of bushels are sent to market annually.

The estimated length of the Styx is 400 feet and its breadth about 40 feet. It was formerly crossed by boat before the discovery of the Natural Bridge, whence Mat's party are hailing us with invitations to join their number and go on.

Lake Lethe comes next; a body of water about as large as the Styx, and, like it, once crossed only by boat. It is now lower than formerly, being slowly filled with mud, and a narrow path runs along its margin, at the foot of cliffs 90 feet high, leading to a pontoon at the neck of the lake. Crossing this, we step upon a beach of the finest yellow sand. This is the Great Walk, extending to Echo River, a distance of 500 yards, under a lofty ceiling mottled with white and black limestones, like snow-clouds drifting in a wintery sky. A rise of only 5 feet would completely cover this sandy walk, and this is its condition for from four to eight months in every year. The streams are usually low in summer, when there are also the most visitors; a fortunate coincidence.

The connection of the cave rivers with Green River has been demonstrated by the simple experiment of throwing chaff upon them, which comes to the surface in the upper and lower big springs—deep, bubbling pools, lying half a mile apart, under cliffs bristling with hemlock and pine. When these pools are submerged by a freshet in Green River the streams in the cave are united into a continuous body of water. The rise is augmented by the torrents emptied down through the sink-holes, and sometimes is so great as to touch the iron railing above the Dead Sea.

The subsidence of so vast a body of water, although for some reason less rapid than of streams without, must be with powerful suction, causing eddies and whirlpools. In order to save from destruction at such times the uncouth little fleet, built of planks and timbers, every piece of which was brought in through passes we had traversed with difficulty empty-handed, the boats are securely fastened, when not in use, by long ropes of twisted grape-vines, that let them swim with the flood.

A further account of the water-system and its inhabitants by Mr. H. G. Hubbard is copied from the American Entomologist, iii., 1880.

With this avenue the water system of the cave communicates at several points, forming pools known as Lake Lethe, the River Styx, and similar plutonic appellations. The floor of the avenue is of fine sand, and at high tide the water rises from 40 to 50 feet, filling it nearly to the roof. When the Green River rises above a certain height a submarine connection is established between its waters and those of the so-called river of the cave, which then rises and falls with the water outside. At the time of our visit the flood was at its usual summer ebb, and these Stygian pools lay in motionless tranquillity, their crystal depths undimmed and their glassy surfaces unruffled by current or eddy.

Arrived at the point where the River Styx crosses the gallery, we found Charon's boat drawn up upon the sand, and, depositing our burdens, we began a search alongshore for blind fish and crawfish. The forms of several were soon seen floating like white phantoms in the almost invisible water, and we captured with an insect-net several small specimens of both species of blind-fish, Amblyopsis and Typhlichthys, which resemble each other closely, but want the ventral fin in the latter genus. We took also good specimens of the cave crawfish (*Cambarus pellucidus*, Tellk.), and, in addition, a gigantic female of *Cambarus bartoni*, the common crawfish of the Green River, but which has quite often been found in the cave waters. A very unexpected find however was a common frog. He was resting upon the sand, not far from the water, and was somewhat emaciated and apparently much discouraged. A fish with large and perfect eyes, probably a darter, showed itself in one of the large pools. It remained for some time motionless at the surface of the water within easy reach, but "Pete" missed it with the net, and it vanished in a twinkling, not to appear again. A single Anophthalmus, found running on the sand, was the only insect, except crickets, seen here. When, therefore, the party arrived we decided to accompany them farther. We embarked with them in one of the boats, and leaving the gallery on our left, pushed under a low, wide arch, and floated for half a mile in an aqueduct, like a mammoth sewer, over water 30 or 40 feet deep. The guides, standing up in the bows, propelled the boats by pushing with their paddles against the low roof. At its end the river sinks beneath the wall of rock, but another great gallery opens here at the side, and another system of halls and avenues begins, the farthest point of which, and the end of the Long Route, is still a walk of 6 miles from the river.

An avenue extends from Cascade Hall to Roaring River; a succession of shallow ripples and deep basins, navigated by a canoe.

During the time I was at Mammoth Cave, the last of April, 1874, the water was very high, and it was impossible to collect either crayfish or blind-fish. It had been above the stairs leading down to the Dead Sea. The water here rises 70 feet. Above the highest water-mark near the Dead Sea, and again in River Hall, I found three species of Helix; the shells were dead, and of course must have been brought in from out of doors. On the damp sand banks above the water were the little holes or burrows of Anophthalmus, showing that they had retained the burrowing habits of their ancestors of the upper world of light. The Adelops was also frequent. Anthrobia and its egg-sacks or cocoons, *Phalangodes armata*, *Chthonius packardii*, *Campodea cookei* lived under stones in the drier places, and *Hadenœcus subterraneus*, or the cave cricket, clung to the walls. In the mud were the larvæ of Chironomus and Sciara.

That there is a free communication between the River Styx and the Green River, or streams outside of the cave, is proved by the presence of large snail shells, besides the occurrence of specimens of *Cambarus bartoni*, and of a frog, as well as eyed fishes said to be common in the waters of the region overhead.

Temperature of Mammoth Cave.—This has been elaborated by Mr. Hovey more completely than by any one else. The mean temperature of the Carniolan caves is said by Dr. Joseph* to be

* Dr. Joseph remarks that the temperature of the Carniolan caves depends on the equal pressure of the air, equal elevation above the sea-level, and equal distance from the entrance. The air in those outer chambers which are reached by daylight is somewhat lower in summer and higher in winter than the inner chambers. The air in the

7° Réaumur or 47°.8 Fahr. That of Mammoth Cave is a little higher; whether the mean temperature of Carniola is a little lower than that of Kentucky, we have not the means of stating.

"Before proceeding further, it may be well to speak of the temperature of Mammoth Cave. It has been roughly estimated that 12,000,000 cubic yards of limestone have been displaced by this immense excavation; and the importance occurred to me of ascertaining *exactly* the temperature of such a body of subterraneous air. On inquiry I learned that this had never been accurately done. Hence I made a series of observations in 1878, that satisfied me of the need of still more careful work. Accordingly, in 1881, armed with two standard thermometers, one a Casella from the Kew Observatory, England, and the other a Green from the Winchester Observatory at New Haven, Connecticut, I took a number of observations with the utmost care. Among my conclusions were the following: That the highest degree reached at any time in any part of Mammoth Cave is 56° Fahr., and the lowest 52½° Fahr.; the mean for summer being 54°, and for winter 53°. The latter is probably the temperature of the earth's crust in the region where this cave is located.

"The above conclusions are confirmed by the readings of an ordinary thermometer placed by Mr. Klett in the Rotunda, and left there till it was, so to speak, acclimated. This gentleman reports, as the result of almost daily inspection by himself or the guides, that during the period of six months the mercury did not rise above 54° nor fall below 53° Fahr., the fair inference being that there was not at any time a variation of more than one degree!"*

FAUNA OF MAMMOTH CAVE.

INFUSORIA:

Vibrio and still more minute bacterium-like organisms in tightly-corked water from Mammoth Cave, opened at Salem, Massachusetts, 1874.
Chilomonas emarginata Ehr. River Styx (Tellkampf).
Chilodon cucullus Ehr. ?
Syneda ulva Ehr.
Monas 2 sp. Serena's Bower (Tellkampf).
Colpoda? . Wandering Willie's Spring.
Nassula? or *Prorodon?* . Wandering Willie's Spring.
Bodo. Serena's Bower (Tellkampf).

VERMES:

Dendrocœlum percœcum Pack. In Shaler's Brook, Richardson's Spring, and other pools.
A nematoid worm, parasitic in the larva of *Adelops hirtus*. (Hubbard.)

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chambers very far removed from the entrance, where thick darkness reigns throughout the day, winter and summer alike, averages 47°.8 F., and is influenced neither by the time of year nor the time of day. To this is due the fact that in the deepest caves the small number of Arthropods inhabiting them do not hibernate, and that many species belonging to the middle cave regions are found in the innermost parts of the caves (Anophthalmus, Adelops, Thysanura, etc.). The Arthropods native to the outer regions of the caves (such as species of Sphodrus, Homalota, Quedius, Thysanura, Scolopendræ, etc.), like their out-of-door relatives, hibernate at the beginning of cold weather under sticks and stones, in moss, etc.

*As this is a matter that has been under dispute, former observations by scientific observers having agreed on 59° Fahr. as the correct temperature, I give below a table of my main observations, which were most carefully made with practically perfect instruments on the 13th and 15th days of August, 1881:

	Deg. Fahr.
At the hotel on the hill the mercury indicated	92
At the mouth of the cave (at noon)	65½
At the mouth of the cave (7 p. m.)	60
At the Iron Gate, 100 yards within, where the current is strongest	52½
In the Rotunda (1,000 yards within)	53
In Audubon's Avenue	54
In Little Bat Avenue	54
In the Gothic Avenue (oldest and driest portion)	56
In Richardson's Spring (in the water)	54
In the Arched Way	54½

	Deg. Fahr
At the Bottomless Pit:	
Top	54
Midway	56
At the bottom	53
In the Mammoth Dome:	
Top, 250 feet above bottom	54
Midway	53½
Bottom	53
At the Echo River:	
In the water	55
In the air	56
Where it empties into Green River	58

CRUSTACEA:

Lumbricus sp. Dead Sea.
Canthocamptus cavernarum Pack.
Cæcidotæa stygia Pack. Shaler's Brook; River Styx.
Crangonyx vitreus (Cope). Wandering Willie's Spring and Labyrinth.
Cambarus pellucidus (Tellkf.). River Styx.

ARACHNIDA:

Acarus ? cavernarum Pack. River Hall, and one at Richardson's Spring.
Gamasus ? cavernicola Pack. Labyrinth.
Chthonius packardii Hagen. River Hall.
Oribates bulbipedata Pack. Richardson's Spring.
Phalangodes armata Tellkf. River Hall.
Anthrobia mammouthia (Tellkf.). Labyrinth.
Cœlotes juvenalis Keys.
Liocranoides unicolor Keys. "Elyhöhle, einer der Mammuthöhlen in Kentucky" (Keyserling).

MYRIOPODA:

Scoterpes copei (Pack.). Richardson's Spring and Labyrinth.

INSECTA:

Lipeura sp. Richardson's Spring.
Isotoma ? sp. River Hall, under stones.
Degeeria sp. Devil's Cooling Tub.
Smynthurus, a white species. Labyrinth.
Campodea cookei Pack. River Hall, Labyrinth, Richardson's Spring.
Machilis cavernicola (Tellkf.). Wandering Willie's Spring.
Hadenœcus subterraneus Scudder. River Hall.
Atropos divinatoria Muell. Rotunda (Hubbard).
Hyperetes tessulatus Hagen.
Adelops hirtus Tellkf. Richardson's Spring, River Hall, Labyrinth (larvæ and beetles).
Anophthalmus tellkampfii Erichson. Labyrinth, Richardson's Spring, River Hall.
Anophthalmus menetriesii Motsch. Richardson's Spring.
Anophthalmus interstitialis Hubbard. Washington's Hall (Hubbard).
Blepharoptera defessa Osten Sacken. Near the entrance.

VERTEBRATA:

Typhlichthys subterraneus Girard. River Styx (Putnam, Hubbard).
Amblyopsis spelæus De Kay. River Styx (Tellkampf, Putnam, Hubbard, and others).

ANIMALS LIVING TEMPORARILY IN THE CAVE:

Lumbricus, sp.
Helix, 3 sp. Dead Sea.
Cambarus bartoni. River Styx (Putnam, Hubbard).
Phora, sp. Hubbard.
Borborus, sp. River Styx.
Sciara, sp. River Styx.
Mycetophila, sp. River Styx.
Corticaria sp. (Hubbard) Amer. Ent., iii, 37.
Chironomus sp. River Styx and Shaler's Brook.
"Mud-fish" (Tellkampf), perhaps Melanura (Putnam).
Fish with eyes, "probably a darter." River Styx (Hubbard).
Amiurus catus. River Styx (Putnam).
Uranidea, sp. River Styx (Putnam).
Cyprinoids, 2 sp. River Styx (Putnam).
Spelerpes, "a white salamander" at end of the Long Route (the guide William).
Rana, sp. River Styx (Hubbard).
Blind rat. *Neotoma*.*

* We find the fullest account of this rodent in Darwin's Origin of Species, where he refers to it in the following words: "In one of the blind animals, namely, the cave-rat (Neotoma), two of which were captured by Professor Silliman at above half a mile distance from the mouth of the cave, and therefore not in the profoundest depths, the eyes were lustrous and of large size; and these animals, as I am informed by Professor Silliman, after having been exposed for about a month to a graduated light, acquired a dim perception of objects." (Page 142, Amer. edit., 1871.

DIXON'S CAVE.

This is supposed to be the former outlet of Mammoth Cave. It is a chasm 50 feet wide, and by a fall of the entrance to a sink-hole it became cut off from Mammoth Cave. The entrance to the cave is half a mile distant from that of Mammoth Cave. In this cave Mr. Sanborn found two species of mites, and I detected species of other groups. The end is wet, with dripping walls.

FAUNA OF DIXON'S CAVE.

Acari, 2 sp. (Sanborn).
Oribates longisetosa Pack. End of the cave.
Chthonius packardi Hag.
Isotoma ?. (Lead-colored.)
Smynthurus sp. (Sanborn.)
Hadenœcus subterraneus Scudd.
Ceuthophilus stygius Scudder. Near the mouth in twilight.
Adelops hirtus Tellkf.

TEMPORARY RESIDENTS AT OR NEAR THE MOUTH.

Helix sp. With eyes normal.
Meta menardi. Also found in shady places in Massachusetts and New Hampshire.
Epeira cavatica Keys. From caves in Kentucky (Keys iii, 4); which cave is not stated.
Batrisus spretus Lec. Of a reddish color. Two females occurred at the end of the cave.
Quedius fulgidus. (Fabr.)

WHITE'S CAVE.

This cave is 500 yards in length, is wet, dripping in many parts, and is said to be a section of Mammoth Cave. "The exact point of communication is supposed to be with the extremity of Little Bat Avenue and Mammoth Dome, though no one has as yet made his way through." (Hovey). Within the mouth of the cave, 10 feet from the actual entrance, I found four species of Podurids, a common Tettigonia, and two kinds of flies, as well as *Ceuthophilus stygius*, Lumbricus, and Spelerpes of a deep flesh color. These are evidently temporary residents near the entrance and living in partial daylight.

FAUNA OF WHITE'S CAVE.

Cæcidotæa stygia Pack. In pools.
Acarus. ? sp.
Phalangodes armata Tellkf.
Anophthalmus tellkampfii Erich.
Campodea cookei Pack.
Hadenœcus subterraneus Scudd.
Ceuthophilus stygius Scudd.

SALT CAVE.

This is a large cave, the entrance of which is situated about 2 miles northeast of that of Mammoth Cave. We found it rather difficult to enter on account of the blocks of stone which have fallen from the roof at the mouth. It was in this cave that on May 1, 1874, Mr. Sanborn found the pupa, while I was fortunate enough to find the larva of Anophthalmus, and the freshly-evolved beetles. About 100 feet from the mouth, in partial daylight, occurred the cave-cricket (*Hadenœcus subterraneus*) and *Anophthalmus tellkampfii* as well as *Campodea cookei.*

On the same day Mr. Sanborn and myself explored a short cave about 80 feet in extent and situated near Ice Cave. It is partially lighted by day, and the animals in it constitute a twilight fauna; these were *Hadenœcus subterraneus*, which is a twilight as well as true cave species; the only other animals found was a Phalangium and a Tipulid fly. About 50 feet within the cave from the mouth I found a snail (*Helix* sp.) with eyes; all these three forms were migrants from out-of-doors.

PROCTOR'S CAVE.

This cave was visited in company with Professor Shaler and Messrs. Proctor and Sanborn. It is 3 miles from Mammoth Cave; 3 miles of avenues are open to the public. We did not find so rich and interesting a fauna as in Diamond Cave. It is a wet cave. The following species occurred: *Anthrobia mammouthia, Anophthalmus tellkampfii, A. menetriesii.*

DIAMOND CAVE.

The entrance is about five miles from Mammoth Cave Hotel. The chambers are smaller, but more beautiful and damper than those of Mammoth Cave. The stalactites are still dripping and in course of development. A brook flows through it, containing *Cambarus pellucidus*, *Cæcidotæa stygia*, and the eyeless transparent flat worm (*D. percæcum*). Though the darkness is total, there is more or less free communication with the upper world, as leaves were found on the floor, and three species of living normal snails, evidently belonging to out-of-door species of Helix; small earthworms (Lumbricus) were frequent in muddy places, and a species of Phora and a Dipterous larva (Sciara?) were obtained, with a single Staphylinid beetle. Near the steps into the cave and in almost total darkness I observed a hard-wood tree growing with living but bleached shoots six inches long.

FAUNA OF DIAMOND CAVE.

Dendrocœlum percæcum Pack.
Cecidotæa stygia Pack. In the brook and pools. Common.
Cambarus pellucidus Tellkf. In the brook and pools. Common.
Anthrobia mammouthia (Tellkf.). In the brook and pools. Frequent.
Lepidocyrtus atropurpureus Pack.
Degeeria cavernarum Pack.
Campodea cookei Pack.
Adelops hirtus (Tellkf.).
Anophthalmus tellkampfii Erichs.
Anophthalmus menetriesii Motsch.

CAVES NEAR CAVE CITY.

Several caves near Cave City, situated on the railroad 10 miles from Mammoth Cave, were explored by Mr. Sanborn. Of these caves the Grand Crystal is said by Hovey to be 3 miles long. Others were Hundred Dome Cave and Long Cave. Near Glasgow Junction are Walnut Hill Spring Cave and a cave under Gardner's Knob.

No new forms were discovered in these caverns, and the species found in them are mentioned in the descriptive or zoological part of this essay.

WYANDOTTE CAVE.

The following account and map of the cave are taken from the facts stated by Mr. John Collett in the eighth, ninth, and tenth annual reports of the "Geological Survey of Indiana," 1878; also from Hovey's "Celebrated American Caves:"

This and adjoining caves are also, like the Mammoth Cave group, excavated from a table-land of subcarboniferous limestone, and are situated south of the southern limit of the drift. Wyandotte Cave is situated 5 miles northeast of Leavenworth, the county seat of Crawford county, Indiana, which is 50 miles below Louisville, Kentucky, and 126 miles south of Indianapolis. The avenues and rooms are estimated to be, in all, 23 miles in extent. The Cave House is "situated on a commanding eminence, 573 feet above tide-water, 270 above low water in the Ohio River, and 220 above Blue River." Across the narrow valley of Blue River is Greenbrier Mountain, which is capped with Chester rocks, "and in the background knobs are seen reaching from 200 to 250 feet higher than the hotel."

Section of Wyandotte Cave.

	Feet.
Slope and loess	20
Buff sandstone, with fossil plants	75
Gray limestone, with Archimedes, etc	6
Brown limestone and shale	40
Gray limestone and shale	50
Lithographic bands	34
White oölitic Saint Louis limestone	4
Gray, cherty, encrinital limestone	220
Blue River	
Total	449

The cave is drier, not so well watered, as Mammoth. The temperature of the cave is 54°. "A series of careful observations was made, showing that, while in a few localities the mercury rose to higher markings, the temperature of all the large rooms, without exception, was uniformly 54°; thus being identical with that of Mammoth and Luray. Rothrock informs me that the temperature is the same in winter as in summer, and that the breeze is into instead of out of the cave when the outer air is colder than that within." (Hovey.)

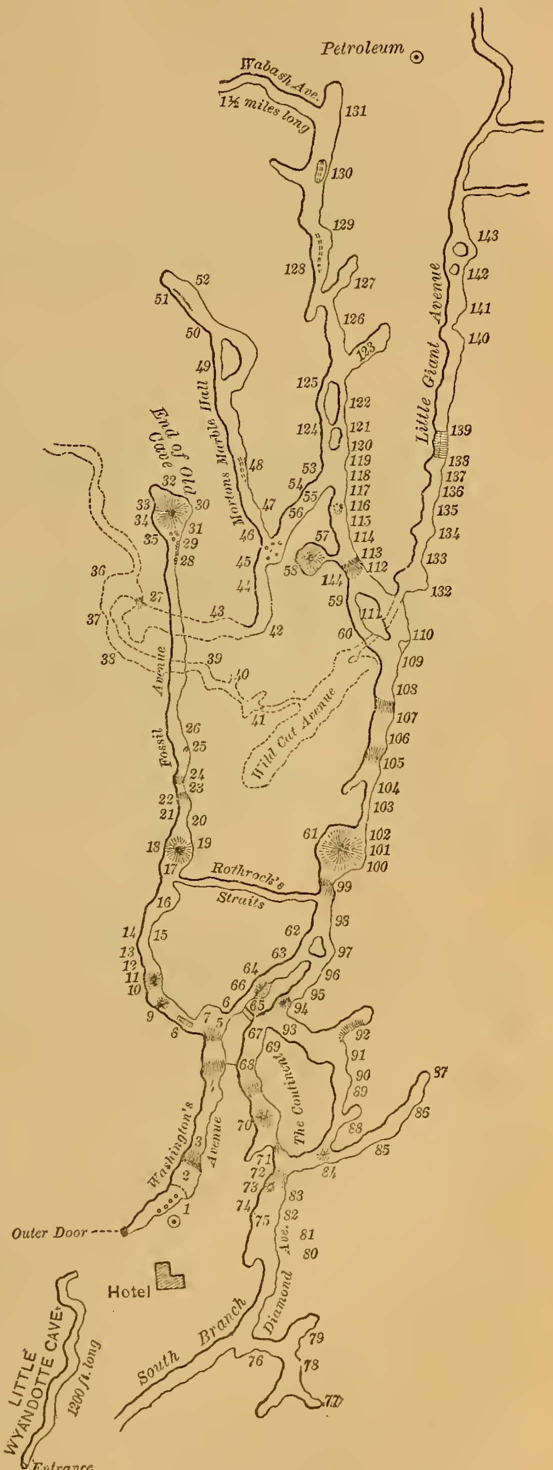
TABLE OF DISTANCES IN WYANDOTTE CAVE.

[Measured and estimated by Wash. Rothrock, a guide of twenty-eight years' experience.]

	Miles.	Miles.
Outer door to Bandits' Hall	.25	
Bandits' Hall to Pillar of Constitution	1.75	
		2.00 1st route.
Outer door to Auger Hole	1.25	
Auger Hole to Junction Room	1.25	
Junction Room to Crawfish Spring	1.00	
Crawfish Spring to end of Wabash Avenue	1.50	
		5.00 2d route.
Junction Room to Fairy Palace		.50
Outer door to Delta Island	.50	
Delta Island to the Throne	1.00	
Throne to South Branch	1.00	
		2.50 3d route.
Lower division, partly explored, 10 to 7 miles		7.00 3d route.
Smaller avenues		6.50
Total		23.50

REFERENCES.

0 Salt-peter Hoppers.
1 Arched Entrance.
2 Faneuil Hall.
3 Columbian Arch.
4 Falling Rock.
5 Bats' Lodge.
6 Entrance to New Cave and Fat Man's Misery.
7 Bandits' Hall.
8 Jacob's Ladder.
9 Pigmy Dome.
10 Débris Dome.
11 Continued Arch.
12 The Canopy.
13 Lucifer's Gorge.
14 Natural Bridge.
15 The Stoop.
16 Temple of Honor.
17 Secret entrance to Rothrock's Straits.
18 Odd Fellows' Hall.
19 Phantom ship "Millie."
20 Pharaoh's Stairway.
21 Conrad's Hall.
22 The Cliffs.
23 The Pit.
24 Falls of Minnehaha.
25 Dead Fall.
26 Cyclops' Chasm.
27 Dead Sea.
28 Screw Hole.
29 Polished Bowlders, Indian.
30 Senate Chamber.
31 Chair of State.
32 Pluto Ravine.
33 Stallasso Monument.
34 Stillo Mountain.
35 Pillar of the Constitution.
36 Hymen's Bower.
37 Hine Cliffs.
38 Lonigan's Pass.
39 Diamond Labyrinth.
40 Emmonecy Arcade.
41 Rode Rock No. 1.
42 Queen Mab's Retreat.
43 Snow Banks.
44 Zoe Grotto.
45 Ice House.
46 Frosted Rock.
47 Snowy Cliffs.
48 Indian Foot-prints.
49 Beauty's Bower.
50 Queen Mab's Marble Garden.
51 Fairy Palace.
52 Wyandotte Potatoes (pebbles).
53 The Arm Chair.
54 Lovers' Retreat.
55 Ewing Hall.
56 Frost King's Palace.
57 Bowlder Flints.
58 Milroy Temple.
59 Penelope Grotto.
60 Ulysses' Straits.
61 Rothrock Cathedral.
62 Coons' Council Chamber.
63 The Rotunda.
64 Rugged Mountain.
65 Cut-off.
66 Counterfeiters' Trench.
67 Starry Hall.
68 Wyandotte Grand Council Cham.
69 The Card Table.
70 Hall of Representatives.
71 Hill of Science.
72 The Alligator.
73 The Mound.
74 The Throne.
75 Gen'l Scott's Reception Room
76 Ante-Room.
77 Hovey Point.
78 The Pit and Sieve.
79 The Amphitheater.
80 Rocky Hill.
81 Muddy Fork.
82 Lost Rivulet.
83 Frozen Cascades or Curtains.
84 The Hippopotamus.
85 Fairy Grotto.
86 Neptune Retreat.
87 Hermit Cell.
88 The Sepulcher.
89 Purgatory.
90 Calliope Bower.
91 Palace of the Genii.
92 Pillared Palace.
93 Creeping Avenue.
94 Junction Room.
95 Drawing Room.
96 Dining Room.
97 Delta Island.
98 Sandy Plain, 300 feet long.
99 Hill of Difficulty.
100 Monument Mountain, 135 feet high, over which is Wallace's Grand Dome, 50 feet above top of mountain, and 185 feet above base of the hill.
101 Sulphur Spring.
102 The Auger Hole.
103 Lilliputian Hall.
104 Spade's Grotto.
105 Slippery Hill.
106 Hall of Ruins.
107 White Cloud Room.
108 Sentinel Office.
109 Bishop's Rostrum or Pulpit.
110 Journal Office.
111 Calypso's, or Island No. 2.
112 Cerulean Vault.
113 Rugged Pass.
114 Chapel.
115 Vestry.
116 Josephine's Arcade.
117 The Parsonage.
117 The Junction.
119 The Lone Chamber or Ball Room.
120 Dry Branch.
121 Island of Confusion, or No. 3.
122 Grand View Island, or No. 4.
123 Sandy Branch and Air Torrent.
124 Newhall's Forum.
125 Grosvenor's Avenue.
126 Gothic Chapel.
127 The Gallery.
128 Indian Foot-prints.
129 The Den.
130 Ship on the Stocks.
131 Crawfish Spring.
132 Maggie's Grotto.
133 Joseph's Pit.
134 Lama's Bower.
135 Marble Rivulet.
136 Marble Hall.
137 Miller's Reach.



138 Andrew's Retreat.
139 Rode Rock No. 2.
140 The Devil's Elbow.
141 The Pit.
142 Langsdale's Basin.
143 Wash. Rothrock's Island.
144 Bourbonoi.

The topography of the cave and the different halls and avenues are sufficiently indicated for our purpose by the map on p. 13. It should be noticed that stalactites and stalagmites are much more numerous than in Mammoth Cave, showing that it is in portions perhaps of more recent origin than that cave.

As regards the hydrography: Two miles from the entrance in the Senate Chamber, which contains the Pillar of the Constitution, near an enormous stalactitic pillar, there is a small spring, and this region is damp; hence cave animals, especially the myriopod *Pseudotremia cavernarum* abound here, although I found it more or less common nearly everywhere in the Short Route. Another pool of water containing blind crayfish is called Crawfish Spring. I have been unable to learn that there is a brook in the cave, or that any blind-fish have been found in the cave. *Cœcidotœa stygia* was obtained by Professor Cope from the water in a cave adjoining Wyandotte, and the blind-fish and crayfish he obtained from one of four wells in the neighborhood.

LITTLE WYANDOTTE CAVE AND OTHER CAVES IN CRAWFORD AND LAWRENCE COUNTIES, INDIANA.

As seen on the map, Little Wyandotte, or Sibert's Cave, as it is often called, is near the larger cave. It is damper than Wyandotte, being muddy in places in May, the month we visited the cave; and Mr. Hovey states there are in it "two pits, flooded, it is said, in the winter, and about 60 feet deep."

Here should also be noticed, in order to understand the connection evidently existing between caves and subterranean streams and the wells containing blind animals, the subterranean streams and smaller caves in the cave region of southern Indiana, of which Mr. Hovey gives us an account:

For 20 miles north of Madison nearly every ravine has its rock houses and water-swept chasms. Occasionally true caverns are found whose roof is the solid limestone of the Upper Silurian, while the excavation itself is in the softer rocks ot the Lower. One of these is estimated to be a mile and a half long, though at a point about 1,000 yards from its entrance the roof has fallen in, and the obscure opening, by which access is gained to the ample chambers and winding passages beyond, might readily escape notice. The stream flowing out of this cave runs through the village of Hanover, and then turns capriciously towards the Wabash from the very banks of the Ohio. Some of the streams of the region, after receiving tributaries and increasing in volume, suddenly sink into the sand or leap down a gorge and disappear, as

"Alph, the sacred river, ran
Through caverns measureless to man,
Down to a sunless sea.

One such stream is significantly named the Lost River. It is in Orange county, where it sinks and rises five times before finally emerging a mile below Orangeville. These rises are generally marked by gulfs, denoting the fall of superincumbent rocks; and at one of them a small boat has been put upon the stream, it having been found to be navigable for a long distance under ground. It is certainly remarkable to see a stream 45 feet wide rise quietly, as if from a great depth, at the bottom of a wild forest ravine. Should Lost River ever find another channel, the cave that would remain might equal in size any hitherto discovered. The stream flowing from Hamer's Cave, in Lawrence county, turns a mill-wheel 22 feet in diameter. The water fills the floor of the archway so that a boat is needed to make an exploration. After proceeding thus for perhaps three-quarters of a mile we reach a place where the whole body of water rushes violently down a passage only 3 feet wide and with a noisy uproar. Carrying the boat around this fall, we can go on 300 feet farther to the Grand Cascade, beyond which progress is difficult.

Donelson's Cave, in the same county, also disharges a large mill-stream from its wide and lofty mouth. A light canoe is of service in making explorations, although in may places the stream is shallow enough to be waded easily. "Within is a magnificent cascade, where the stream rushes and leaps down a narrow passage with such violence that the rumbling noise is heard at the entrance. This passage is known to extend through Dalton's Spring three-fourths of a mile to E. S. E. Near the entrance a dry cave is seen opening to the east, directly opposite a lofty corrider leads to the west, and in less than 100 feet enters a grand hall 12 feet high, 300 feet long, and 40 feet wide. The upper chambers are frequented by bats, and the soil is rich in niter, which supplied a powder mill that formerly stood in the vicinity. Both these caves contain eyeless fish, crawfish, and insects.

Other caverns in Lawrence county are: Connelly's, Grinstaff's, Campbell's, Dry, Buzzard, Shiloh, and Blue Spring (see Geol. Survey of Indiana, 1873, pp. 280–310). Nearly all of them contain blind animals, niter-beds, bats, and Indian relics. Of Shiloh Cave Professor Collett gives a glowing description, mentioning lofty halls and black depths; "a natural fountain, which pours three jets of pure silvery water, from which a cloud of spray arises;" festoons of stalactitic drapery "giant corrugations," and many varieties of pure and beautiful ornamentation, leading him to say in his enthusiasm, "This cavern far exceeds Mammoth Cave in beauty and rivals any that I have ever seen, though only 1 mile has yet been explored." It should be added that the entrance is through a sink-hole, and the tunnel may be followed through to its exit near Salt Creek.

I had the pleasure of exploring several of these caves myself a few years ago, and was especially interested in one that did not seem to have been named, but that certainly deserved it, as well as others that have been admired in print. From a great gateway, perhaps 80 feet wide, the passage dwindled to a point where we could barely stand erect. This colossal trumpet magnifies the human voice to a deafening volume; and the name of the Trumpet Cave would not be inappropriate. A large swift stream issues from Blue Spring Cave near Mitchell, whose current at high water is said to sweep completely across the White River, into which it empties. It has been explored for about 3 miles, and contains great basins cut down 100 feet into the rock and overflowing with limpid water. (Pp. 123–125.)

Dr. John Sloan also wrote us in 1873 as follows regarding this river:

Did you ever hear of Lost River? It is a stream of considerable magnitude which formerly ran upon the surface of the ground, and at spring floods still fills the upper as well as lower channel. It sinks into the ground at various points and again rises to the surface seven miles below, as is proved by sawdust from the mills upon it above. It has crayfish above the sink with eyes; within the subterranean passage without and with eyes, pellucid. I intend soon to explore it below, as I have recently above. There is too much water to get to its under-ground channel before June. The bullheads are found mostly in cave streams.

Dr. Sloan again visited Lost River in July of the same year, and under date July 22, 1873, wrote me as follows:

I went in the interior 60 miles on the 10th instant, for the purpose of procuring some eyeless fishes before their spawning season. I crawled a long distance into a muddy cave until I reached the under-ground channel of Lost River, which I found very high and as thick as gruel with mud; of course, I could see no fishes. I caught some eyeless beetles and some with eyes, which I send you for names. Next day I went into another cave, where I secured three Amblyopses and five crayfishes, *C. pellucidus*. It has been too wet during the spring and summer to do anything in wet caves.

The specimens of beetles came during my absence from Salem, and in some way were overlooked or mislaid and not named, with the exception of a large *Asellus communis*, which was bleached nearly white, though with distinct eyes. It is broad, the telson broad, and the antennæ are unusually stout, but it has preserved the exact shape and sculpturing of specimens of the normal form and size received from Indiana.

LIST OF THE ANIMALS OF THE WYANDOTTE CAVES.

CRUSTACEA:

Cauloxenus stygius Cope. Parasite on blind-fish from a well near Wyandotte Cave.
Cæcidotæa stygia Pack.
Cambarus pellucidus (Tellkf.).

MYRIOPODA:

Pseudotremia cavernarum Cope. Also a single specimen of var. *Carterensis* Pack.

ARACHNIDA:

Oribates ? lucifugus Pack. Little Wyandotte Cave.
Phalangodes flavescens (Cope).
Linyphia subterranea Emerton.

INSECTA:

Degeeria cavernarum Pack.
Campodea cookei Pack.
Machilis sp. (Cope.)
Ceuthophilus stygius Scudd.
Ceuthophilus sloanii Pack. Little Wyandotte Cave.
Myopsocus or *Elipsocus* sp. (Pack.)
Anophthalmus tenuis Horn. (Cope.) Little Wyandotte (Pack.).
Anophthalmus eremita Horn. (Cope.) Little Wyandotte (Pack.).

FISHES:

Amblyopsis spelæus Tellkf. Wells near Wyandotte Cave.

Besides these there occur the following twilight species: *Quedius spelæus* Horn; *Lesteva* n. sp. Horn; *Phora* sp.; *Blepharoptera defessa*, Osten Sacken (the Anthomyia of Cope's lists); *Catops* n. sp. ?, and an Aleocharid allied to Tachusa (Cope, Amer. Nat., vi., 413). *Porcellio* sp. blind.

It will be seen that Wyandotte Cave has about one-third as many species as Mammoth, while the Myriopod (*Pseudotremia cavernarum*) and the Phalangid (*Phalangodes flavescens*) are much more numerous in individuals than any terrestrial Arthropods occurring in Mammoth Cave.

A "cave rat" was described to me by Mr. Rothrock as having been seen in the main Wyandotte Cave. It was said to be of the same color as the domestic rat, but with the body longer, somewhat like a weasel's; the whiskers are longer than those of a rat, and "the ears are nearly twice as large." It is probably a Neotoma.

BRADFORD CAVE.

[16 miles from New Albany.]

This is a type of many caves in southern Indiana. A brook (temperature 55°) flows through it, and after leaving the mouth of the cave is tenanted by *Cambarus rusticus* and "possibly *Putnami*" (Faxon, Revision, 114, 119.) Near it is Loughmiller's Cave. Both of these caves I visited in company with Dr. John Sloan, who kindly devoted a day to their exploration.

The following species inhabit it:

Cecidotœa stygia. Pack.
Cambarus pellucidus. (Tellkf.) Abundant in the stream in the cave.
Degeeria cavernarum Pack.
Ceuthophilus sloanii Pack.
Anophthalmus tenuis Horn. More abundant than I have ever seen other species elsewhere.

CAVES AT CLIFTY, BARTHOLOMEW COUNTY, INDIANA.

For the following account of these caves I am indebted to Dr. John Sloan:

Since I wrote you I have visited the caves at Clifty. The mouths of the caves are about 200 yards apart, each with a small stream of water running through. The larger cave is easy of access, containing very little insect life, but some very fine blind-fishes and some blind crayfish. The former presented a rotundity which encouraged me to expect an increase from them, which has not happened yet. Temperature of the water, 56°. The smaller cave supplies a mill and has deep water at the mouth. It occupies a higher level than its neighbor and is less capacious. I went up about 200 yards on a raft of timber, where I came to rapids with still water above; being unable to lift our raft over, and the water above being too deep to wade, we were obliged to return. I saw no blind-fishes, but caught three eyeless crayfishes in the edge of the upper pool. Temperature of water, 60°. About 40 feet within the larger cave I found, under stones, some little leeches ? with parasites upon them.

MAYFIELD'S CAVE.

This cave has been visited by Mr. C. H. Bollman, of Bloomington, Indiana, and it is situated near that town. It contains *Cambarus pellucidus* (Tellkf.), *Cœcidotœa stygia* Pack., *Crangonyx* sp. A Machilis occurred within a few rods from the entrance.

CARTER CAVES.

These are situated in the hilly portion of northeastern Kentucky, in Carter county, not far from Cincinnati. They are in limestone and are comparatively small grottoes, without fine stalactites, and have not been very fully explored. There are three caves, visited by Professor Shaler and myself—Zwingle's, Bat, and X Cave—and a small cave used as a pantry by the proprietor of the hotel. They are well watered, having streams passing through them. Professor Shaler found the temperature of the water (May 15) both of Zwingle's Cave and Bat Cave to be 48° Fahr.

FAUNA OF THE CARTER CAVES.

VERMES:

Vortex ? cavicolens Pack.

MYRIOPODA:

Pseudotremia cavernarum Cope, var. *carterensis* Pack.

ARACHNIDA:

Phalangodes flavescens Cope, var. *cœcum* Pack.
Phlegmacera cavicolens Pack.
Nemastoma inops Pack.
Nesticus carteri Emerton.
Linyphia subterranea Emerton.
Linyphia incerta Emerton.

INSECTA:

Tomocerus plumbeus var. *pallida* Pack.
Degeeria cavernarum Pack.
Hadenœcus subterraneus Scudd.
Ceuthophilus stygius Scudd.
Undetermined eyeless coleopterous larva. Bat cave.

WEYER'S CAVE.

As stated by Mr. Hovey, the caves of the Shenandoah Valley are smaller than those of Kentucky and Indiana, owing to the fact that the Lower Silurian (probably Trenton) limestones out of which they are excavated are much thinner than the subcarboniferous rocks westward.

Weyer's Cave is situated in Augusta county, Virginia, 17 miles north of Staunton, and its entrance is on "the eastern side of a ridge running parallel to the Blue Ridge, from which it is distant 4 miles." The cave is said to be 1,650 feet in length. It is a wet cave, the water percolating from the red sandstone above, forming pools with muddy edges, but containing no Crustacea or Planarians. According to Hovey the temperature is uniformly 54° Fahr. (The temperature of the water and air taken by us were 55° and 56° Fahr.) An adjoining cave situated farther on from the hotel is called by the proprietor "Cave of Fountains." This is probably Madison's Cave, first described by President Jefferson, and we will consider the one we entered as that. Within the entrance, near the steps, were detected two species of flies, and a few Helices occurred, but no cave crickets or beetles.

FAUNA OF WEYER'S CAVE.

VERMES:

Lumbricus sp. Frequent under every board.

MYRIOPODA:

Zygonopus whitei Ryder.

ARACHNIDA:

Acarus ? weyerensis Pack.
Chthonius cæcus Pack.
Phalangodes flavescens (Cope) var. *weyerensis* Pack.
Linyphia weyeri Emerton.

INSECTA:

Tomocerus plumbeus var. *pallida* Pack.
Smynthurus ferrugineus Pack.

FAUNA OF MADISON'S CAVE.

Nesticus pallidus Emerton.
Linyphia incerta Emerton.
Dorypteryx pallida Aaron. (Near the old mouth.)

THE NEW MARKET CAVES.

These caverns are situated about 6 miles southeast from the railroad station of New Market. Zirkle's Cave is about a mile in extent. It contains a flowing stream 6 feet wide, besides pools and miniature cataracts. We visited this cave in 1879 on our way to Luray Cave. The temperature of the cave is said to be 56° Fahr.

FAUNA OF NEW MARKET CAVE.

Zygonopus whitei Ryder.
Acarus ? sp.
Obisium cavicola Pack.
Linyphia ? sp.
Tomocerus plumbeus, var. *pallida* Pack.
Smynthurus ferrugineus Pack.
Blepharoptera defessa Osten Sacken.

LURAY CAVE.

This well-known cave we visited in June, 1880, a year after the cave had been discovered and before the present hotel had been built. It had, however, been opened, and the plank walks and fresh stair-ways, with other improvements, and the beaten tracks, made it unfavorable for collecting cave life, which is much less abundant than in Weyer's Cave. It contains pools of water * and numerous dripping stalactites. The temperature of Diana's Bath is 52° Fahr.; that of the air is 54° Fahr.

FAUNA OF LURAY CAVE.

Zygonopus whitei Ryder. Not infrequent.
Cambala annulata (Say). Found dead and encrusted with lime.
Linyphia weyeri Emerton. Differed only from the type specimens in having rather smaller eyes.
Anophthalmus tenuis Horn. (Hubbard.)

NICKAJACK CAVE.

This cave is situated near that point of the southern boundary of Tennessee where it is joined by the line which separates the States of Georgia and Alabama. In dimensions it ranges with the Mammoth and Wyandotte Caves of Kentucky and Indiana. Many miles of galleries have been explored, and no end has yet been reached. The entrance is in the northern side of a hill, not far from the road that passes on the south side of the "bottom" of the Tennessee River. It is of much more imposing proportions than that of either of the caves already mentioned. The visitor climbs the hill from the road, following a path which leads along the high bank of a considerable creek. The entrance has a wide floor, which is cut by a gorge at one side, through which the stream just mentioned issues. The roof is flat, and is overhung by vegetation. The following pages record the results of two collecting expeditions made there by Professor Cope.

Near the mouth of the cave a salamander of the genus Plethodon was found, which is very peculiar. Instead of the black color, with or without pale bluish dots of the *P. glutinosus*, the sides and back are thickly spotted with large, yellowish-green blotches of irregular form, producing an effect something like the coloration of the Mexican *Spelerpes leprosus.* The dorsal spots are much larger than the lateral, and are often confluent. On the head they almost exclude the ground color. In addition to this color peculiarity, the feet differ from those of the *P. glutinosus* in the rudimental character of the inner digit both anteriorly and posteriorly. It is represented by metapodial bones only, having no phalanges. There are thirteen costal folds, one less than in *P. glutinosus*, and the vomerine teeth do not extend beyond, or even to, the internal nares. The tail is round and rather slender. Length to axilla, .020; to groin, .051; to end of tail, .122^{m}. This species is about the size of the *P. glutinosus*, and, as it is distinct from it, we propose that it be called *Plethodon æneus* Cope.

In company with it was found the smaller *P. cinereus.* Then there was a small scorpion; a Polydesmus, and some other centipedes, and a beetle like Scarites, but larger than the common northern species. Snails, as in other limestone regions, are abundant.

On entering the mouth of the cave abundant traces of former human habitation are found. These consist principally of charcoal and remains of shells—as Ios and Unios, from the Tennessee River, brought there by the Indians as food. The creek was formerly dammed at this point and supplied water to a mill at the mouth of the cave. This was grinding the grain of the neighborhood at the time of the first visit, but had disappeared by the second. Fishing was attempted from this point far into the depths of the cave. The results were chiefly Crustacea, which are described below. No blind fishes were seen or taken, but some fishes of the outer world were caught at a point where a very little light from the mouth was distinguishable. These were the common blob (*Potamocottus meridionalis*) and sucker (*Catostomus teres*).

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* One of the distinguishing peculiarities of Luray Cavern is the existence of these limpid pools, hundreds of them, varying in size from a diameter of 6 inches to one of 50 feet (Hovey, p. 182). They seem to be wholly uninhabited. (Page 184.)

At a distance of a mile from the mouth the blind crayfish, *Orconectes hamulatus* Cope, began to be abundant; their snowy-white forms being readily distinguished by candle light in the clear water.

On the land the *Pseudotremia cavernarum* proved to be common in some places, especially near to bat excrement, where were also found a number of Pselaphid beetles.*

On examination of the aquatic cave life it appears that of the five kinds of animals found living in the waters of the cave all but one differ decidedly from those of the caves of Kentucky, Indiana, or Virginia. This is a matter of considerable interest from an evolutional point of view, as it shows that these cave forms are the descendants of different out-of-door species from those of the caves to the northward. The Nickajack Cave may be in a different faunal region from the Mammoth or Wyandotte Caves, and thus the blind crayfish has evidently originated from a different species of Cambarus than that which gave origin to *Cambarus pellucidus*. Thus, while the conditions, such as dryness and temperature, of cave life are much the same throughout the United States, the ancestors of the different cave animals were in many cases of distinct species, since they belonged to somewhat different zoogeographical areas.

The first animal to notice, and one not uncommon in the waters of the cave, is a little Isopod crustacean (*Cecidotæa nickajackensis* Packard), which is evidently a modified Asellus, or water wood-louse, of the same genus as that so abundant in the caves, subterranean streams, and wells of Indiana and Kentucky.

This species forms, in the antennæ and slightly purplish color and the proportions of the leg-joints, perhaps a nearer approach to the genus Asellus than that of Mammoth and Wyandotte caves; on the other hand, *C. stygia* approaches Asellus more in its shorter, broader body, with the shorter, broader abdomen. It seems quite evident that the two species must have descended from different species of Asellus. Thus far we know of but one widespread species of Asellus (*A. communis* of Say) from the middle and northern States. Whether there is an additional species in the Gulf States, from which the present species may have been derived, remains to be seen.

The genus Cecidotæa differs from Asellus in the larger and much longer head, the longer claw of the first pair of feet, the much longer telson, and in the rami of the caudal appendages being of nearly equal size, while in Asellus one is minute; it is also eyeless.

The second crustacean discovered swimming about in the subterranean stream was a species of Amphipod, belonging to the genus Crangonyx, and has been described as *Crangonyx antennatus* Packard. It is a large purplish species, with very long antennæ, and distinct, well-developed black eyes. This genus occurs in caves and subterranean wells in Europe and this country.

The form of most decided interest, however, is the blind crayfish (*Orconectes hamulatus* Cope). It is quite different from *C. pellucidus* of Mammoth and Wyandotte caves, in the rostrum, the slender hands, the much broader antennal scale, and in the form of the gonopods, while the whole creature is slightly slenderer than *C. pellucidus*, though the rudimentary eyes are of the same proportion to the neighboring parts as in the other species.

Of the two crickets found in Nickajack Cave, there were three small specimens of *Hadenœcus subterraneus* Scudder, which only differed from Mammoth Cave individuals in having rather shorter, thicker maxillary palpi; but this is not even a varietal difference, as the antennæ and legs have the same proportions. The other cricket is a new species of Ceuthophilus, and has been called *Ceuthophilus ensifer* Packard. It is very nearly allied to *C. stygius* of Mammoth Cave, but may be distinguished by the characters given elsewhere.

CLINTON'S CAVE, UTAH.

While attached to the United States Geological and Geographical Survey of the Territories in the summer of 1875, during a visit to Great Salt Lake, my attention was called by Jeter Clinton, esq., to a curious cave on his estate, about half a mile east of his hotel at Lake Point. It is, at a rough guess, about 200 feet above the level of the lake, and the mouth faces the northeast. It was evidently due to wave action, being situated on an ancient beach-line, while the top and bottom of the cave were formed by a breccia. As my examination of it was a hasty one, no

* The five foregoing paragraphs were written by Professor Cope. (See Amer. Naturalist, xv, 877, 1881.)

measurements having been taken, I quote the following account of it by Mr. G. K. Gilbert, in his report "On the Geology of Portions of our Western Territory," visited in the years 1871, 1872, and 1873:*

Along many of the beaches, and especially at points where they are carved in solid rock, the beach or terrace below the water-line is composed of calcareous tufa, usually full of small Gasteropod shells, and often involving so many fragments of the contiguous rock as to constitute a breccia. In the localities where I found it best exhibited the beach was carved in limestone, but the deposit is probably independent of the character of the adjacent formation. Mr. Howell observed it upon Granite Mountain, coating granite, and remote from limestone exposures; and a similar association was seen by Prof. W. P. Blake on the Colorado Desert. Down some steep slopes it stretches as an apron for several rods, and, when it rests on soft materials, the waves of the retiring lake have undermined it and formed caves. Several of these are to be seen on the north end of the Oquirrh range, and the largest, which is popularly reputed to have been excavated by Spaniards years ago as a mine, is remarkable as a specimen of purgatorial wave-work. The Carboniferous strata have a local northward dip of 80°, and trend parallel to the face of the declivity. Two beds of limestone, which constitute the walls of the cavern, are separated 12 feet at the entrance and evenly converge to the rear end, where they are 4 feet apart. At the end a shale, in place, fills the interval, but I was unable to determine whether this had once occupied the entire excavated space. The roof is built entirely of recent calcareous breccia, and the floor is evenly spread with earthy débris. The height of the gallery is uneven, ranging from 2 to 25 feet, and the length is 275 feet. The breccia of the roof pertains to one beach of the great series, and the floor is near the level of another. The wonderful depth of the excavation in a direction nearly parallel to the shore is explained by the convergence of the straight walls, between which the waves gained in their progress, on the principle of the hydraulic ram, enough velocity to compensate for the loss by friction.

In order to feel entirely certain that the cave I examined was the same as the one thus described, I wrote Mr. Gilbert, and received such information from him as placed the matter beyond a doubt.

The specimens occurred entirely under stones, none upon the walls, as the cave is perfectly dry, a very slight degree of moisture gathering under the flat pieces of brecciated limestone, which had fallen from the roof above. The darkness was not quite total, a faint glimmer of light appearing, although it was necessary to use candles in exploring the cave as well as in searching for specimens. Having previously examined a much larger cave in the Carboniferous formation in Williams Cañon at Manitou, Colorado, without finding any signs of indigenous life except *Diclidia lætula* and its larva, which occurred on the steps near the entrance, and which had been evidently a recent introduction, I was much interested to find in this small isolated cave in Utah a well-marked cave fauna, although not as characteristic as that inhabiting the caverns of Kentucky, Indiana, or Virginia. Four forms occurred, of each of which several individuals were found in a few minutes' search.

The spider-like form, *Nemastoma troglodytes*, belonging to the group of "harvestmen," was perhaps more abundant than the others. It belongs to a group not before known to inhabit North or South America, none of the family occurring in caverns east of the Mississippi River. Species of the genus occur, however, in Europe. It had well-marked eyes. The Myriopod belongs to a widely-distributed genus (Polydesmus), but which in this country has not been hitherto known to be a true troglodyte. Like all the species of the genus, which as a rule live in the twilight under stones and leaves, etc., it is eyeless. Its entirely white color, when all the other known species are highly colored, shows that it is also a true cave-dweller. The Poduran (*Tomocerus plumbeus*) is found abundantly in Europe, Greenland, and North America. It occurred of very large size under stones at an elevation of 11,000 feet on Gray's Peak. It will probably be found on the Pacific coast. The individuals, however, discovered in Clinton's Cave, Utah, represented a white variety peculiar to caverns, and which differed in no respect from bleached individuals found in the Carter caves of Grayson County, Kentucky. A small Zonites was discovered, which was white. Its occurrence was of a good deal of interest, from the fact that of the numerous Helices which occurred in the caves of Kentucky none were bleached or differed notably from those found in their usual habitats, though I am told by Prof. E. S. Morse that adult white individuals do occur in ordinary habitats.

A high degree of interest attaches to this cave fauna, because we are able to determine with much precision the period when the cave was made and the time of its subsequent colonization by the ancestors of the present inhabitants. On turning up the loose material constituting the bottom of the cave I found that it was largely composed of a shell-marl, in which occurred in abundance little fresh-water shells, which the late Mr. G. W. Tryon determined as *Amnicola decisa*

* Extracted from volume iii. of the United States Engineer Reports of Explorations and Surveys West of the 100th Meridian, Lieut. G. M. Wheeler in charge.

Hald., *A. cincinnatiensis* Anthony, and *Pomatiopsis lapidaria* Say. It is plain that this marl is from the Bonneville beds of Mr. Gilbert, containing shells which lived in the lake when the waters were at the level of the mouth of the cave. Prof. F. V. Hayden, in 1870, found in these beds *Fluminicola fusca* Hald., *Valvata sincera* Say, *Limnæa catascopium* Say, *L. desidiosa* Say, *Amnicola limosa* Say, *Pomatiopsis cincinnatiensis*. Afterward Mr. Gilbert found the following additional species: *Pomatiopsis lustrica* Say, *Succinea lineata* Binn., and a Cypris (?). This formation was regarded as Quaternary by Dr. Hayden. Mr. Gilbert regards the deposit as a Lacustrian one, thrown down during the glacial epoch, when "the great climatal revolution which covered our northeastern States with ice was competent to flood the dry basin of Utah." The cave, then, is of very recent origin, and as it is only perhaps 200 feet above the present level of the lake, the highest terrace or raised beach being 1,000 feet above the present level, Clinton's Cave was not excavated until the latter half or last third of the Quaternary epoch, and it was not until some time after then that the ancestors of the present inhabitants obtained a foothold, and that nearly the present relations of the existing fauna of Utah were established. That this was the case is further supported by the fact that the species of animals found in the cave are such as may have been descendants of an assemblage which flourished when the country was more humid than now.

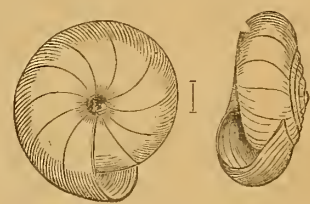

FIG. 3.—*Zonites subrupicola.*

FAUNA OF CLINTON'S CAVE.

Zonites subrupicola Dall. (Since found under stones above ground in California.—DALL.)
Polydesmus cavicola Pack.
Nemastoma troglodytes Pack.
Tomocerus plumbeus, var. *alba* Pack.

NOTE ON THE FAUNA OF A CAVE AT MANITOU, COLORADO.

I made a brief examination of a large but very dry cave, about 600 feet long, opened to travelers in 1874, in the Carboniferous limestone in Williams Cañon, at Manitou, Colorado. The only life found in the cave was a beetle, identified by Dr. Horn as *Diclidia lætula* Le Conte, two flies, and three Coleopterous larvæ. The beetle occurred near the entrance, and did not differ materially from other specimens which I collected under stones in the cañon near the entrance to the cave. A species of Mycetophilid fly also occurred near the door, as well as a specimen of *Blepharoptera defessa* Osten Sacken, not differing from specimens which occur in various caves in Indiana (Wyandotte), Mammoth Cave, and adjoining caverns. The occurrence of this species in caves so remote is interesting. No Diptera, I am informed by Baron Osten Sacken, are peculiar to caves, though this species is common in most of our caves, especially near the entrance, and has not been found elsewhere. Associated with the beetle were three larvæ, which I am inclined, with some doubt, to regard as the young of *Diclidia lætula* Le Conte. It seems to agree with the family characters of the larvæ of the Mordellidæ, as laid down by Chapuis and Candèze; but of course, until some one rears it, the identification will be uncertain. I give meanwhile a brief description of it.

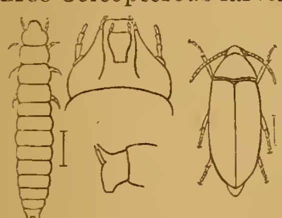

FIG. 9.—*Diclidia lætula* and larva.

In general form it is like the larva of Anaspis, the body being rather long and narrow, the head nearly as wide as the prothoracic segment, the body a little wider than the head, thickest in the middle, and gradually tapering toward the end; head as long as broad, subtrapezoidal, somewhat square, the sides not very convex, the surface depressed, with a few scattered hairs. Antennæ as long as from the base of the head to their insertion; four-jointed; second joint a little wider and one-third as long as the third joint; the fourth joint as long as the third is thick, ending in three or four hairs. Mandibles acute, not very long. Maxillary palpi one-third as long as the entire maxilla, being small and short, appressed to the head; three-jointed, the joints subequal; second joint short, the third nearly twice as long as the second. Labium small; palpi feeble, short, and small; two-jointed, the joints subequal. No eyes can be detected. Prothoracic segments well rounded in front, nearly as long as broad; second abdominal segment not much longer than the third; the terminal segment narrows rapidly behind, ending in a pair of upcurved spines, which are rather long and slender, acute, tipped with brown, with the anal proleg rather large Legs rather long and slender; tarsi ending in a single claw. Color whitish; head and prothoracic segment slightly tinged with honey-yellow. Length, 5^{mm}. Three specimens, apparently not fully grown, as they were small in comparison with the beetle. They were found on boards forming the steps in the entrance of the cave, in perpetual darkness however, and had evidently been artificially introduced.

This genus belongs to an interesting family, as the larvæ of Metoecus, Rhipiphorus, Symbius, and Horia, live in wasps' nests, and Rhipidius is a parasite on *Blatta germanica.* The young of Mordella and Anaspis, however, burrow in the stems of herbaceous plants, while the larvæ of *Mordella fasciata* Fabr. in Europe live in the "dead wood of the poplar."

From Alabaster Cave, California, situated in El Dorado County, Dr. Horn has described an eyeless beetle, *Anillus explanatus.* (Trans. Amer. Ent. Soc., XV, 26, 1888.) The name of the collector is not given, but on July 6, 1886, Mr. E. A. Schwarz wrote me as follows regarding an alleged Anophthalmus from a cave in California:*

I have examined the Californian specimen collected by Mr. Koebele near Sacramento and find that it is no Anophthalmus at all, but a large Anillus, which is possibly different from *A. debilis* Lec.

THE MODE OF COLONIZATION OF CAVES.

Not only have the Indians in prehistoric times, as is well known, frequented some of the larger caves (*e. g.*, Mammoth, Salt, Wyandotte, and Luray caves), but tracks of bears, wolves, and the smaller mammals occur in most of the caves. In Luray Cave tracks and other marks of wild beasts, now exterminated from the region of the cave, occur. As remarked by Mr. Hovey:

We saw likewise, in 1878, thousands of tracks of different kinds of animals, some of which we recognized as those of raccoons, rabbits, rats, and smaller creatures, while some larger tracks seemed to have been made by wolves or panthers. * * * We found also the bones of mice, rats, bats, a squirrel, and a raccoon.

Mammoth, Wyandotte, Luray, and other caves are frequented by multitudes of bats, and though several species and genera of Arthropod parasites are found on those which take up their abode in caves in Europe, thus far no parasites have been discovered on our native specimens. The wood-rat (Neotoma) also occurs in caves in Indiana, Kentucky, and Virginia. In fact, as is well known, nearly all caverns accessible from without are more or less inhabited by wild beasts, and in this way, either by clinging to their bodies, or by adhering to the substance they may drag or carry into the cave, some of the mites, false scorpions, and harvestmen may have been introduced from the outer world. Moreover, the species of three groups of insects which are known to live a more or less subterranean life in twilight, under stones or buried in the earth, may enter the fissures, chasms, or sink holes, and thus colonize the caverns. The genus Trechus is a subterranean one, its species burrowing under stones; so with the European hypogean harvestmen, Phalangodes, etc., and the Myriopods. The wonder is not so much that many animals should fall or be carried into or voluntarily take up their abode in caves, as that they should be able to survive a life in total darkness; a condition so fatal to even the lowest plant life. The fact that the number of cave species of animals is so small, both in Europe and America, as compared with the fauna of the upper world, shows how adverse are the conditions of life in such situations. This condition, *i. e.*, total darkness, is the barrier that forbids a number of twilight species, such as *Chelifer cancroides*, the cricket (*Ceuthophilus stygius*), *Blepharoptera defessa* and other flies, Quedius, Polydesmus, and *Lysiopetalum lactarium*, *Cambala annulata*, and others, from becoming acclimated to the darkness.

The agency of torrents passing through the sink-holes and in spring and autumn flowing through the lower channels, as is the case in Mammoth Cave, is clearly sufficient to account for the presence in the River Styx, of Mammoth Cave, of the eyed fishes which inhabit Green River, and of *Cambarus bartoni.* In this way, without doubt, individuals of *Asellus communis* and other out-of-door species of Asellus, as well as the ancestors of *Dendrocœlum percœcum*, were transported into subterranean streams, pools, and wells, since they abound in the pools, ditches, and streams throughout the country.

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* Dr. G. Marx writes me, as these pages are passing through the press, that Count Keyserling has described from this cave a spider under the the name *Usofila gracilis*, but that the description has not yet been published by him.

On the other hand, from the facts presented in regard to the intercommunication of subterranean streams, caverns, and wells, it may be inferred that all in Grayson county, Kentucky, for example, or in the Wyandotte Cave region, belong to one and the same system of subterranean drainage. That the Mammoth Cave system of caverns is connected with the Wyandotte system on the north side of the Ohio may well be doubted, since there are such radical differences in the faunæ of the two systems of caves. But the blind fish and crayfish found in wells without doubt enter such places from dark, subterranean streams, and sometimes it may happen, as in the case mentioned by Mr. Putnam,* that these creatures may occasionally go very near the entrance into partial daylight. On all these points, however, much is to be learned by future exploration.

THE GEOLOGICAL AGE OF THE CAVES AND THEIR PRESENT INHABITANTS.

This topic we have formerly discussed in the American Naturalist (December, 1871,) and we then coincided with Professor Cope, "that our true subterranean fauna probably does not date farther back than the beginning of the Quaternary, or Post-Pliocene period." All geological authors agree that these caverns have been made by running water.

It is evident from Wheatley and Cope's account of the Port Kennedy Cave that there are in the Central and Atlantic States two classes of caves; an older or preglacial and a much more recent class, and hence we can be more specific in assigning an age to the caves as we now find them.

It seems quite evident that the fauna represented by the Port Kennedy collection, with its remains of the tapir, peccary, and the bones of the Megatherium, Megalonyx, and Mylodon in the caves of Virginia, was rendered extinct by the proximity of that region to the glaciers, which extended during the height of the glacial epoch into northern New Jersey, Pennsylvania, and southern Ohio, Indiana, and Illinois.

The present caves, whether in existence before the glacial epoch or not, were with little doubt reëxcavated, enlarged, and assumed their present proportions synchronously with the formation of the Niagara gorge, the gorge of the Mississippi, and other river valleys throughout the Northern States. The Mammoth and the numerous other caves in Grayson county, Kentucky, must, for example, have been excavated by the confluents of the Green River in the higher levels during the River Terrace epoch, and long after the melting and disappearance of the ice. After the then great rivers had shrivelled to nearly their present size the deeper abysses or pits and channels were cut, while the subterranean passages were drained dry simultaneously with the general desiccation of the country, until the autumnal, winter, and spring freshets alone sufficed to flood certain of the lower passages and galleries which were and now are dry in the summer time.

It seems, then, fair to assume that the final completion of the caverns, when they became ready for occupancy by their present fauna, may not date back more than—to put it into concrete figures—from 7,000 to 10,000 years, the time generally held by geologists to be sufficient for the cutting of the present river gorge of the Niagara and the Falls of St. Anthony. We may, then, put the age of our cave fauna as not much over from 5,000 to 10,000 years before the dawn of history, which itself extends back some 5,000 to 6,000 years.

We think we have given sufficient proof that the greater part of the cave fauna of this country was directly derived from the present fauna, with nearly, if not quite, the same limits as it had at the time of the Columbian discovery of the country. Before the present cave fauna could have been established the late Pliocene or preglacial fauna, with the Megatherium and other gigantic sloths, the tapir and peccary, was swept away by the incoming Glacial epoch; then the present fauna was established, and, as emigration from the south went on, and the emigrants intermingled with boreal and antarctic forms, and the cavernous regions became drained and dry—not until then (which was obviously but a few thousand years ago) were opportunities offered for the establishment of the existing cave assemblage. The biologist, in seeking an explanation of the origin of

* Mr. Putnam alluded briefly to the other forms of animal and vegetable life in the caves of Kentucky, and specially mentioned a cave on the opposite side of the Green River, several miles below the Mammoth Cave, where blind fishes and blind crayfishes were obtained very near the entrance by himself, and previously by others, so near the entrance that artificial light was not required to see the specimens. (*Proc. Bost. Soc. Nat. Hist.*, xvii., 223.)

this peculiar troglodyte assemblage, need not demand the "numberless generations" insisted on by Mr. Darwin in his Origin of Species. The time since the present climatic relations and the present fauna came into existence may, it seems to us, be estimated by a few thousands rather than by hundreds of thousands of years.

It should be borne in mind that early in the River Terrace epoch, when the cavernous region was flooded, no life could have existed in these caves. Even now that extensive cavern, Howe's Cave, excavated from the Silurian limestone in Schoharie county, New York, is said to have no life in it except a few common crickets (*Ceuthophilus maculatus*), found everywhere in New York and New England under stones and logs. In his excellent account of Howe's Cave, through which a stream runs, Rev. Mr. Hovey remarks:

But the guide assured me that during a rainy season * * * there were times when the whole cavern would be filled and, as he said, "pour forth a mighty flood."

Again, on page 195, he says:

The swiftness of the cave stream and its liability to sudden overflow have prevented the aborigines from making this cavern a place either of residence or sepulture. It may be doubted, indeed, if they knew of its existence. Few animal remains have been found here. Large numbers of bats, however, hibernate in its chambers, clinging in clusters, like swarms of bees. No fish inhabit the lake or the stream, except such as have been put there by the hand of man, and even these forsake these subterranean waters when the spring freshets give them the opportunity to do so.

It is noteworthy that in glaciated regions the few caves in existence, of which Howe's Cave is the largest known to us, do not support a true cave fauna. In Europe the Carniolan and Pyrenean region may have been glaciated, but we infer not. In the United States, at all events, the cavernous regions of southern Indiana, Kentucky, Tennessee, and Virginia lie south of the great moraine. It is plain enough that the caves of Carniola and other portions of Austria and of Illyria, as well as the caves of Basse-Pyrenees in France and the caves of Spain, have been colonized from members of the existing fauna, which was derived mainly from the shores of the Mediterranean, and are warm, temperate in their complexion, belonging to the Mediterranean sub region.

THE SOURCE OF THE FOOD SUPPLY OF CAVE ANIMALS.

So far as observed cave animals, even the carnivorous species, take remarkably little food, and the source of the food supply in caverns is naturally a question of much interest. As regards the voracity of the blind-fish (*Amblyopsis spelæus*), several of which I had the pleasure of seeing in Dr. John Sloan's aquarium, he wrote me as follows, under date of May 9, 1875:

I have some large blind-fishes which I put in my aquarium in August, 1873. They have taken no food, except what has grown up in the water and on the sand in their tank. Are they nourished by the confervoid and animalculæ growth?

This quotation will also give proofs that this blind-fish may be readily kept for over a year in a large aquarium, the one in question having stood in a well-lighted room in Dr. Sloan's house.

It is, however, known that an Amblyopsis, in one case at least, swallowed a fish with eyes, as Dr. Wyman found in 1856, in the stomach of an Amblyopsis he was dissecting, a small fish figured by Professor Putnam (Amer. Naturalist, Jan. 1872, Pl. I, fig. 13).

Without much doubt the natural food of the blind-fish, besides an occasional young fish of its own or some other species, is the blind crayfish, as well as Crangonyx, and perhaps the Cæcidotæa, though the latter usually lives concealed under stones.

The food of the blind crayfish appears to consist of living Cæcidotæa. Mr. Moses N. Elrod, of Orleans, Orange county, Indiana, writes me as follows regarding this point under date of June 4, 1873:

Since writing the above I have collected over a hundred Cæcidotæa and a number of other forms (Crangonyx) from a well in town. They were in and on the bucket, that had been in the bottom of the well for several days. I also have a live eyeless crayfish taken from one of our own wells yesterday, and have fed the Cæcidotæa to it. If the Cæcidotæa are put near, in its claw, it eats them almost instantly. I am trying the blind-fish to see if they will eat them. I have three live blind-fish in my cellar, one as large as they ever grow, and I think it a female.

The blind crayfish, then, appears to prefer living small crustacea, and is not omnivorous in its appetite. Regarding this point Mr. Putnam remarks as follows:

Many of the specimens [of *O. pellucidus*] were brought alive to Massachusetts, and several still continue in good condition, though they have eaten very little since their capture. I have several times offered them food in the shape of small bits of cooked meat and raw liver, crumbs of bread, etc., but, though they have generally carried the morsels to their jaws, after long deliberation they have, apparently, taken but a few mouthfuls, and, discarding the substances, have not touched them again. The specimens of *Cambarus bartoni*, the eyed crawfish collected in the cave at the same time, on the contrary, are quite ready to eat and at once seize any food offered to them. The difference in the actions of the two species at such times is quite striking. The moment the water in its jar is disturbed the eyed species rears itself up on its tail, throws out its large claws, seizes the piece of meat or bread, and, hastily conveying it to its mouth, generally holds on to the morsel until it is all eaten, though sometimes this species will take but a bite or two and then drop the food, and I do not think it will touch the same piece again.*

The nature of the food of the carnivorous blind beetles (Anophthalmus) is unknown. They are found running over damp sand-banks, sometimes hiding in little pits excavated under stones. Having retained the general habits of their out-of-door allies, it is presumed that they attack and devour other living Arthropods, such as their own larvæ, and those of Adelops, besides spiders, harvestmen, and mites. At all events the food supply is scanty. As stated elsewhere, the tendency to variation in the Anophthalmi is to diminution in size, and this depauperation is generally, among insects, due to lack of sufficient food.

The only other truly carnivorous cave animals are the harvestmen (Phalangodes) and the spiders. What the food of these animals can be, unless the young of their own kind or order, must remain a matter of conjecture until further observation. But, whatever their food, it must be very scanty.

The scavengers constitute a large proportion of the cave population. *Adelops hirtus*, the scavenger beetle of Mammoth Cave, is allied to Choleva and Catops, the species of which live in fungi, carrion, or in ants' nests—*i. e.*, in dark places. At present Adelops is most abundant under loose stones at Richardson's Spring, where parties have for many years taken their lunch, the remains of which (bread, eggs, chicken, etc.) form a perennial pasturage for these beetles. Here also congregate Podurans and mites, as well as an occasional Scoterpes.

The Myriopods of caverns are not members of the carnivorous groups, but belong to those families which in the upper world devour fragments of dead leaves and other vegetable débris, or sometimes growing plants. In the caves they probably sustain life by feeding on decayed wood, what little fungous growth there is to be found, and similar objects, as well as bats' dung. Whatever be their food, the Pseudotremia, which is perhaps the most abundant of cave animals, is especially common in Wyandotte Cave. When kneeling in the beaten path one can see numbers of these creatures gathered around the hardened drops of tallow which drip from the candles of tourists. The food of the Hadenœcus is probably like that of Ceuthophilus, which lives under stones, and the nature of whose food is not well known, unless it be decayed vegetable matter. As to the food of the aquatic Crangonyx and Cæcidotæa, one would suppose it would be almost wholly animal, but unless they devour their own young it is a matter of conjecture how they can maintain an existence. Still more difficult is it to conjecture what forms the food of the young of these Crustacea, since infusoria, rotifers, and copepods are so very scarce. It goes without saying that there are no truly vegetable-eating animals living permanently in caves; no plant life exists (except in rare cases a very few fungi, and most of those probably carried in by man) in the caves on account of the total lack of light. It would seem as if the lack of food, as well as the absence of light, was one of the factors concerned in the diminution in size and in the slenderness of blind cave animals as compared with their lucicolous allies.

II.—THE VEGETABLE LIFE OF THE CAVES.

The extreme dryness, as well as absence of light, is especially unfavorable to the growth of plants in caves. On this point the following remarks by Mr. Hubbard are in place:

The common fungus found in Mammoth Cave has been identified by Professor Farlow as the old *Byssus aurantiaca*, now known under the name of *Ozonium auricomum* Link. Professor Farlow, who kindly identified the cave plants, says that it is "found in caves on wood in Great Britain, Germany, etc., and has been found in Michigan and elsewhere by Schweinitz. As far as I know it is simply the mycelium of some unknown fungus."

I observed, in all, four or five species of fungi in Mammoth Cave; besides the Ozonium, a reddish button-shaped fungus, a green mold, a long white mold, and a fungus (Plate XVII, fig. 3)

* Proc. Bost. Soc. Nat. Hist., xviii, 16, 1875.

growing from the hind body of a cave cricket (*Hadenœcus subterraneus*). A young Peziza (identified by Professor Farlow) occurred in Weyer's Cave; it was not in fruit, was colorless, and impossible to determine specifically. A colorless agaric also occurred in Weyer's Cave.

Mr. Hovey notices the occurrence of agarics in River Hall, Mammoth Cave: "In 1881 we found a natural bed of mushrooms growing here, a species of Agaricus."

Mr. Hovey discovered two species of fungi in Luray Cave; one was a long white mold hanging in festoons, the other supposed to be a new species which he described under the name of *Mucor stalactitis* in the Scientific American for March, 1879.

Washington's Hall is a chamber of the largest size, and for many years the lunching place of tourists. "The floor of the hall is of white gypsum sand strewed with fragments of the same material. The larger masses of gypsum afford convenient seats and tables for picnickers, and are strewn about with chicken bones and bits of food. The accumulation of such rejectamenta is very great, to be reckoned perhaps by the cart-load; yet, notwithstanding the presence of so much offal, kept perpetually moist by contact with the gypsum sand, not the slightest taint is perceptible in the air of the chamber; only at close quarters the recently-deposited morsels give off a peculiarly rancid odor. As before, in the Rotunda, I was struck with the conviction that decay in the cave is an exceedingly slow process, accomplished mainly through the agency of a few fungi.* Professor Tyndall has shown that in the pure atmosphere of the Alps perishable infusions of meat and vegetables remain unchanged for an indefinite length of time.† May it not be that the equally pure and bracing air of these caverns is likewise comparatively free f om the germs of Bacteria, Vibrios, and other agents of putrefaction and fermentation? It has been asserted by the guides that meat hung up "at the mouth of the cave" will keep fresh a long time.‡ But if Bacteria are absent, other scavengers in abundance attack this food material. I found it swarming with the larvæ of Adelops and the maggots of a small fly (Phora). The imagos of the beetle and puparia of the fly were also present in countless numbers." (Hubbard, Amer. Ent., iii., 38.)

III.—SYSTEMATIC DESCRIPTION OF THE INVERTEBRATE ANIMALS.

INFUSORIA.

Four species of Infusoria appear to have been discovered by Dr. Tellkampf in Mammoth Cave, and I quote the following remarks on these forms from his essay in the New York Journal of Medicine for July, 1845, page 86: "I have examined the water of the cavern for animalculæ, and have shown some hasty sketches of them to Professor Ehrenberg, of Berlin, Germany, who has furnished me with some remarks concerning them.

"In the farthest grotto, 'Serena's Bower,' 9 miles from the entrance of the cave, are found some animalculæ resembling *Monas kolpoda*, *Monas socialis*, and a new species similar in external form to the Bodo.

"The water of the 'Styx' contains a Chilomonas, which also appears to be new. *Ch. emarginata*, elliptic, irregularly sinuated, with a projecting lip; and, besides, another species resembling the *Kolpoda cucullus;* possibly it might have been the *Chilodon cucullus*, which is very common in mines."§

* The fungi of our caves have not, as far as I know, been studied. Two species have been identified by Dr. Farlow from the Mammoth Cave, *Ozonium auricomum* Link, the mycelium of an unknown fungus, and *Stemonitis ferruginea*, also immature. A list by Pokorny of fungi from the Adelsberg and Luege caverns (Germany), extracted from Dr. Ad. Schmidt's Die Grotten und Hoehlen von Adolsberg, Wien, 1854, and kindly sent me by Dr. Hagen, enumerates nineteen species, all found above ground, and originating, as Pokorny thinks, from spores introduced from without on wood. (Hubbard, *l. c.*)

† For an accurate account of these experiments, see Popular Science Monthly for February, 1878. (Hubbard, *l. c.*)

‡ During the summer months, when the temperature outside is higher than that of the cave (59° Fahr.), a strong current of air flows out of its mouth. The incoming supply is said to be by filtration through the rocks, in which case it would be very probably freed of floating germs. (Hubbard, *l. c.*)

§ In addition, Ehrenberg (Microgeologie, 1856) gives a list of eight Polygastric Infusoria (*Biddulphia?*, *fossil?*, *Bodo?*, *Chilomonas*, *Gallionella?*, *Kolpoda*, *Monas?*, *Synedra ulva*); one fossil Polythalamian (infusorian;) five Phytolitharia; and plant forms (microscopic fungi)." (Hubbard, in Amer. Ent., iii, 79.)

It is probable that the list of Infusoria will eventually be considerably enlarged when special attention is given to the subject. Our own examinations of water from Wandering Willie's Spring, Mammoth Cave, taken May 3, 1874, and at once examined, revealed three forms of holotrichous Infusoria, which, however, we were unable to identify even generically.

No. 1. *Vibrio.* Observed in the water taken from Wandering Willie's Spring.

No. 2. *Colpoda ?* . It was a ciliate infusorian, rounded oval, with well-marked cilia all over the surface. This was the largest form observed.

No. 3. *Nassula ?* , or *Prorodon ?* . Was common in the water, and about half as large as No. 2. It is regularly oval-cylindrical, rounded at each end; the cilia are short and very minute, scattered over the body. There are two round contractile vesicles and a long rod-like nucleus.

No. 4. This form is longer than any of the others; long, oval-cylindrical, with long sparse cilia, and a distinct mouth-opening; it is more like Paramecium than any of the other forms.

VERMES.

VORTEX ? CAVICOLENS Pack.

Vortex cavicolens Pack., Amer. Naturalist, xvii, 89, January, 1883.

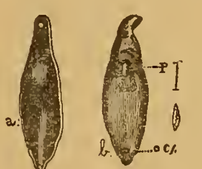

FIG. 5. Planarian Worm, Carter caves: *a*, dorsal; *b*, ventral, 6 × magnified; *c* natural size, ventral; *p*, proboscis. (Gissler del.)

This Rhabdocœlous worm was found in a brook in X Cave, one of the Carter caves, Kentucky. It belongs near Vortex, and it may provisionally be called *Vortex cavicolens.* The body is flat, elongated, narrow, lanceolate-oval, contracting in width much more than is usual in Vortex. The pharynx is situated much farther back from the anterior end of the body than usual in Vortex, being placed a little in front of the middle of the body; it is moderately long, being oval in outline. The body behind suddenly contracts just before the somewhat pointed end. The genital outlet is about one-half as wide as the pharynx and orbicular in outline. Though described from two alcoholic specimens, I can discover no eyes, nor do I remember seeing any when it was living; it was when alive white, and apparently eyeless. Length, 4^{mm}; breadth, 1.5^{mm}. Found by us in X Cave, one of the Carter caves, eastern Kentucky.

This worm may not prove to be a genuine Vortex, the species of which are broad and blunt in front, with the pharynx much nearer the front end than in the present species, which is therefore only provisionally placed in the genus Vortex. In *Vortex cœcus* Œrsted, the eyes, as the specific name implies, are wanting, but most of the species have eyes. As our species occurred in a brook in a dark cave, it would naturally, as in the case of the Mammoth Cave eyeless white Planarian, be eyeless, and as a consequence of losing its eyes become white. Schultze, in his Naturgeschichte der Turbellarien, states that *Vortex viridis* in winter was generally without chlorophyl bodies and wholly white, but that in April the white individuals are rare. He then adds: "Kept for a considerable time in darkness, the green animals become, through bleaching and the disappearance of the chlorophyl, almost colorless."

Upon sending the above description of the single alcoholic specimen to Professor von Graff, of Aschaffenburg, he very kindly replied as follows:

> As to the systematic position of the doubtful Turbellarian, I can, unfortunately, not form a precise opinion. According to your short description it may be a Vorticide or Mesostomide, and it would seem to correspond to the last family in the flatness of the body and the size, since there are few Vorticidæ so flat and large.

DENDROCŒLUM PERCŒCUM Pack.

Dendrocœlum percœcum Pack., Zoology, 142, 1879.

FIG. 6.

A cave Planarian. *Dendrocœlum percœcum* Pack.

This interesting form was first observed at different points in Mammoth Cave. It is entirely white, and after repeated examinations of living specimens we could see no eye-specks, the creatures being totally blind. In form it is oval-lanceolate, the head end at times scarcely more pointed than the posterior end, though it is sometimes angular in front, a lobe-like process extending out on each side of the head, as observed in other species of the genus. It extrudes a large square-tipped proboscis, the end being orbicular, and then suddenly withdraws it. Length, 5^{mm}.

This was not uncommonly found under stones in a stream we have called Shaler's Brook, in the water in Gothic Avenue, in Richardson's Spring, Mammoth Cave, and also in water in Diamond Cave. It is quite active in its habits, moving freely about like an ordinary *Dendrocœlum lacteum.*

LUMBRICUS sp.

Earth-worms were not uncommon, though of small size, in Mammoth, Diamond, and other caves; living especially in the damper situations.

MOLLUSCA.

Numerous Helices were found in all the smaller caverns, but as none seemed to be specially bleached or to differ from out-of-door forms, no attention has been given to them. Still, it would be desirable to pay an attentive examination to those living in caves, as there may be found, as have occurred in European caves, some individuals whose eyes have been modified by a cave life.

CRUSTACEA.

CAULOXENUS STYGIUS Cope. Pl. I, figs. 1, 1*a*, 1*b*.

Cauloxenus stygius Cope, Amer. Naturalist, vi., 412, July, 1882, figs.

This Lernæan is said by Cope to be a parasite of the blind-fish, and to live attached by the disc to the inner edge of the upper lip. "This position being maintained, it becomes a favorable one for the sustenance of the parasite, which is not a sucker or devourer of its host, but must feed on the substances which are caught by the blind-fish and crushed between its teeth. The fragments and juices expressed into the water must suffice for the small wants of this Crustacean." Cope describes and figures the two egg-pouches, but these were not present in the specimen we had for examination. Whether Mr. Cope's genus Cauloxenus really differs from Achtheres or not, we are not prepared to say. "The character," he remarks, "which distinguishes it from its allies is one which especially adapts it for maintaining a firm hold on its host, *i. e.*, the fusion of its jaw-arms into a single stem." In the specimen we figure, however, the arms are much as in *Achtheres carpenteri*, separate for a part of the way, but not so widely so as in *A. carpenteri.* The body is short and thick, the head oval-rounded, the "arms" short and thick, and of the same length as the head. The shape of the rest of the body in my specimen is irregular. The reader is, for further details, referred to our camera figures.

COPEPODA.

CANTHOCAMPTUS CAVERNARUM Pack. Pl. I, figs. 2, 2*a*, 2*b*.

Canthocamptus cavernarum Pack., Zoology, 297, Fig. 238, 1879.

Body slender, cylindrical, tapering slowly to the end of the body. Carapace not wider than the segment next behind it, but about three and a half times longer, and equal to the combined length of the succeeding five segments; sixth and seventh segments of the body the longest, the eighth being but little shorter than the seventh. The hinder edge of each segment except the last is serrate, the teeth being like those of a saw, conical, with the bases approximate. Eyes distinct, broader than long, blackish, situated directly in front of the stomach; the latter being short, pyriform. The intestine, as usual, long and straight.

The first antennæ of the male composed of eight very unequal joints, the two basal shorter than thick, the second with three spines; third joint very short, less than half as long as the first, and with the distal end oblique, and with a stout spine; fourth joint large, much swollen, as long as the second and third together, and with a row of slender setæ on the inner side; fifth joint small, two-thirds as thick and as long as the fourth; sixth long and slender, one-half as thick as the fourth; the seventh and eighth much slenderer than the sixth; the eighth (terminal one) considerably shorter than the seventh, and tipped with three hairs. Second antennæ three-jointed, basal joint short, no longer than broad; second and third joints subequal, of about the same length and thickness; from the base of the second a slender curved joint arises, which is about one-third as thick as the second joint, and gives origin to four large setæ; third joint subclavate, with about six hairs, besides four long terminal setæ, which are flattened and bent in the middle, with the ends hair-like.

In the first pair of feet the outer branch consists of rather short joints, shorter than those of the inner ramus, which is 3-jointed and nearly twice as long as the outer.

The feet in general are rather long, with large, long spines. The fourth arthromere behind the carapace bears a pair of tapering triarticulate rudimentary feet as long as the segment itself, and ending in hooks. The succeeding segment only bears a pair of two unequal stout setæ. Caudal setæ not more than one-third longer than the appendages themselves, which are conical and of the usual form; the inner pair are twice as long as the outer; the setæ are stiff and stout, simple, with no hairs. No spines on the terminal segment between the caudal appendages; only a few fine minute hairs. Color of the body and appendages, snow white.

Length, $.03^{mm}$ (or $\frac{1}{33}$ inch.)

This species differs from *C. cryptorum* and *C. staphylinus*, *minutus*, and *rostratus* of Europe in the simple caudal setæ and the large coarse spines on the edges of the arthromeres.

In its general appearance, and especially the form of the male antennæ, the present species is much nearer allied to *C. cryptorum* Brady than to the other European species figured.

Several specimens occurred in water taken from Wandering Willie's Spring. The intestines were filled with a dark mass of food, and the dejections were elongated pyriform. This spring is probably fed from pools above, or the water percolates from above down into the spring. Whether this species of Copepod is peculiar to the cave or carried down into the cavern each year from out-of-doors remains to be seen when the Copepod fauna of the water in the neighborhood of Mammoth Cave has been thoroughly investigated.

Family ASELLIDÆ.

CÆCIDOTÆA STYGIA Packard. Pl. III, IV, figs. 1, 1*a*–1*m*.

Cæcidotæa stygia Packard, Amer. Naturalist, v. 752, Figs. 132, 133, 1871.
Cæcidotæa microcephala Cope, Amer. Naturalist, vi. 411, 419, Figs. 109, 110, July, 1872; "Mammoth Cave and its Inhabitants", etc., 19, 1872; Annals and Mag. Nat. Hist., Nov., 1871 (no name).
Cæcidotæa stygia Pack., 5th Rep. Peab. Acad. Sc., Salem, 95, 1873; Smith, U. S. Com. Fish and Fisheries, II. Report for 1872 and 1873, 661, 1874.
Asellus stygius Forbes, Bull. Illinois Mus. Nat. Hist., I, 11, 1876.
Cæcidotæa stygia Hubbard, Amer. Ent., III; Fig. 10, p. 79, March, 1880.

Generic characters.—Differs from Asellus in the much longer body, the absence of eyes, and in the longer and narrower head. The second (larger) antennæ are almost as long as the body; in Asellus only one-half or a little more than one-half as long as the body; the fifth joint nearly twice as long as the fourth; in Asellus it is but slightly longer than the fourth. The legs are also slenderer, the terminal joint much narrower, and the claws much smaller. The telson (abdomen) is very long and narrow, oblong, two-thirds as broad as long; whereas in Asellus it is not so long as broad, and is much rounded. The mouth parts also present some differences; the lobes of the maxilla are narrower; the penultimate joint of the palpus of the maxillipedes are one-half as thick as in Asellus, while the middle joint of the mandibular palpus is not so large and thick, and there are other differences, though of less importance.

In our first notice of this genus (Amer. Naturalist, v, 752) it was stated that it was closely allied to Idotæa. This was a most unfortunate comparison, my observations having been based on imperfect specimens, which lacked the cercopods or anal stylets, and also the larger antennæ. After comparing it with *Asellus communis* the error was noted.* Under these circumstances I earnestly desire to change the name Cæcidotæa to *Cæcasellus*, but defer to the present rule of nomenclature, that one author can not change a name based even on an unfortunate error.

The present genus has not been regarded as a valid one by Mr. Forbes, who thus speaks of it in his "List of Illinois Crustacea":

> This species has been peculiarly unfortunate. Described originally from an injured specimen, its structure and relations were misunderstood, and it was made the type of a new genus (*Cæcidotæa* Packard). It was soon redescribed by Professor Cope, under the specific name *microcephalus;* and these imperfect descriptions have since been supplemented by several fragmentary notices in various papers by Packard and Smith. * * * A detailed comparison of this species with undoubted Asellus, especially with the admirable plates of *A. aquaticus* in the Crustacés d'eau douce de Norvège, has failed to reveal any structural peculiarities which could positively serve as the characters of a distinct genus, and I have therefore united it to Asellus (p. 11).

It remains to be seen, however, whether Mr. Forbes has not somewhat overstated the case, and whether there are not a number of structural peculiarities which forbid our placing the two known species in the genus Asellus. The more obvious and important of these have been already noticed in the foregoing diagnosis of the genus. It should be observed that not only are *Cæcidotæa stygia* and *Cæcidotæa nickajackensis* without eyes, but that the body and appendages also differ a good deal from any of the known species of Asellus. The genus seems as well founded as many others in the Isopoda and other groups of Crustacea. We have little doubt but that Cæcidotæa has by modification and heredity been derived from Asellus, but because this is most probable it is no reason why, from a systematic point of view, we should disregard its evident generic characters; for it is now generally believed that somehow all the genera of Isopoda have descended from some primitive form or genus. Because, then, we do know with some degree of certainty that Cæcidotæa has recently diverged from Asellus, and can see that the generic characters it possesses have been the result of its under-ground life, we should yet, from a purely taxonomical point of view, regard it as a good genus. Of the genus Crangonyx some species are blind and others are not, but the blind species do not present other important differences. It is so with the species of Phalangodes, where the loss of eyes is not always acccompanied by other changes in form and structure; and so with other cases.

If we turn to the European *Asellus forelii* Blanc, a blind species from the abysses of Lake Leman (for specimens of which we are indebted to the kindness of Professor Forel), we see that it does not belong to our genus Cæcidotæa; although it has been referred to Cæcidotæa by Fuchs in his paper on the fauna of the deep sea. *Asellus forelii*, compared with specimens of *Asellus aquaticus* from Belgium (obligingly sent us by Prof. E. Van Beneden), is about half as long and broad as *A. aquaticus;* the body has retained about the same proportions; the telson (abdomen) is little if any narrower or more elongated. Both branches of the caudal stylets are of about the same length as in *A. aquaticus*. *Asellus forelii*, then, appears to us to be evidently a depauperated species, closely allied to *A. aquaticus*, which has lost its eyes by its life in supposed perpetual darkness at or near the bottom of Lake Geneva. Its generic characters are identical with those of its parent form, *A. aquaticus*. So also are those of *A. cavaticus* Schiödte, found in wells in Germany, and which closely resembles *A. forelii*, only differing in slight specific characters. It is evident that these two blind species were originally derived from *A. aquaticus*, and hence have retained the generic characters and specific marks of that European species as compared with our American *A. communis*.

When, however, we turn to our *Cæcidotæa stygia* and *nickajackensis*, we find that they are not only not congeners of the blind European Aselli, but that they are also not congeneric with the American *Asellus communis*, and that there are no intermediate forms connecting them, although the eyed species of Asellus are somewhat variable. Hence we feel warranted, on taxonomic grounds, whatever may be our theory about their origin, to retain the genus Cæcidotæa.

* See 5th Rep., Peab. Acad. Sc., Salem, 95, 1873.

Another point of interest is, that we should naturally expect that the abdomen (telson) in the blind European forms would be longer than in our American Cæcidotæa, as the abdomen in the European *Asellus aquaticus* has a telson slightly longer than in the American *Asellus communis;* moreover, the legs of the former are longer; the antennæ much longer, as well as the caudal stylets, and yet the European blind forms do not exaggerate any of these features of the eyed Asellus, from which they have originated, while the American species do.

Specific characters.—Normal and well-developed male and female from Mammoth Cave. Body long and narrow; head about as long as broad or slightly narrower than long, much narrower than the first thoracic segment, the latter not so wide and one-fourth longer than the second segment, which is crescentiform; third slightly shorter but like second segment in shape; fourth a little shorter than third segment, and fifth shorter than fourth and considerably shorter than the sixth; the seventh a little longer than first and considerably longer than sixth; the spaces between the thoracic segments large and deep. Abdomen nearly as long as the fifth to seventh, or last three thoracic segments; not quite but almost as wide as the thoracic segments; end of telson a little full in the middle.

First (smaller) antennæ; in large slender specimens total number of joints, twelve; in shorter less-attenuated females there are eleven to twelve joints. The proportions of the different joints, their relative length and size, do not essentially differ from those of *A. communis*, except that the two terminal joints are apt to be smaller, though the individual differences are marked, the joints being shorter in short-bodied than long-bodied individuals; so also the setæ vary in number and size; they are arranged much as in *A. communis.* Olfactory rods, usually three in number, situated on the three penultimate joints, like a cricket-bat in shape, rather more contracted at base, forming a cylindrical handle, than in *A. communis*; of the same size as in *A. communis*—certainly not smaller Owing to the usually much smaller size of the terminal joint the terminal olfactory rod is two to three times as long as the last joint, and the second rod is sometimes longer than the two terminal joints of the antenna collectively. Sometimes there are five olfactory rods (Fig. 8*a*). The auditory bristles (*Setæ auditoriæ*, Fig. 2 *c*, *a.s*) do not present any specific characters either in form or arrangement; there is a short one on the outer side at the end of the basal joint and three longer ones on the end of the second joint, one external, the other two internal. In *A. communis* one occurs at the end of the short fourth antennal joint (Fig. 3*b*). This has not been yet observed in *Cæcidotæa stygia.* (The variations in the shape and number of joints are noticed further on.)

Second antennæ with the four basal joints short, third longest of the four and scarcely longer than thick; the fifth and sixth very long, the sixth over one-third longer than the fifth; the remaining joints of the flabellum, eighty-five or less, the number variable; the joints frequently bearing single setæ.

The mandibles differ decidedly from those of *Asellus communis*; they are more triangular or pointed in the right (Pl. IV, fig. 1*a*); the teeth of the cutting-edge are very unequal, while the setose edge within the teeth is much more parallel with the outer edge of the mandible; the 2-jointed inner lobe is broader and with stouter longer setæ; the left mandible is longer and narrower. The palpi are three-jointed; second joint about half or one-third as thick as in *A. communis*, but the arrangement of the setæ nearly the same; third joint much as in *A. communis*, equaling in length the basal joint of the palpus, and with two terminal claws. The lobes in front of first maxillæ, forming the so-called under lip (Pl. III, fig. 2*h*), are provided with narrower lobes than in *A. communis.* The first maxillæ (Pl. III, figs. 2*e*, 2*f*), with the outer lobe a little narrower at base but broader at the end than in *A. communis*; the terminal spines of the outer lobe much slenderer, more hair-like than those of the inner lobe (Fig. 2*f*), which are spinulate, and much as in *A. communis.*

Second maxillæ (Pl. III, figs. 2*g*, 2*h*,) much as in *A. communis*, the two outer lobes with the inner stout setæ curiously denticulated on the inner edge; the hairs on the innermost lobe much longer and denser than in *A. communis.*

The maxillipedes (Pl. IV, figs. 1*b*, 1*c*) differ from those of *A. communis* mainly in the two terminal joints of the palpus; the fourth or penultimate joint is in *Cæcidotæa stygia* slender and about half as thick as in Asellus, but the terminal joint is a little shorter; the lateral lobes are much more full and rounded where the setæ are longest than in *Asellus communis.*

First pair of legs in the male a little slenderer than in *A. communis*, the second joint especially much slenderer, but the hand is but slightly narrower, and the finger is nearly the same in the female.

First pair of male uropoda with the basal joint as long as broad, much shorter than in *A. communis*; second joint not quite twice as long as broad, obliquely truncated at the end (regularly oval-rounded in *A. communis*), with a few minute setæ, while on the outside are nine setæ; this group not present in *A. communis*. Second pair minute and short compared with those of *A. communis*, and very different in shape (Pl. IV, fig. 1*i*). In the female the basal lamellate uropods oval, one-third as large as the second pair, which are also oval and very thin. Caudal stylets (last pair of uropoda) remarkably long and slender, between one-third and one-half the length of the body; basal joint linear; the second joint about half as long as the first and slightly more than half as wide, with 8 to 10 unequal terminal bristles, of which a single external one is stouter than the others and bulbous at the end; outer branch one third to a little over one-half as long as second joint, and bearing at the end three setæ, flattened at the base. The great differences from the last uropoda of *A. communis* may be seen by reference to Pl. III, figs. 1*b*, 1*c*, and Pl. IV, fig. 3*g*. There are no auditory setæ on the end of the last pair of uropoda. Length of body, male, 12^{mm}; width, 2.5^{mm}; of caudal stylets, 4^{mm}; the males a little smaller than the females.

This crustacean is abundant in the subterranean streamlets of Mammoth Cave, especially in one flowing through the Labyrinth, which we have named Shaler's Brook. The females May 1, 1874, had eggs in the brood-pouch. It also occurred in the River Styx, in the water of River Hall, and in the Dead Sea. Also in the pools in White's Cave and in Diamond Cave, as well as Salt Cave. It also occurs in Wyandotte Cave, where it was first discovered by Professor Cope, who named it *Cecidotœa microcephala*. Having, however, received Professor Cope's type-specimens from Wyandotte Cave, we have been unable to find any specific differences.* A variety (Pl. III, fig. 5*a*–5*d*) occurred in Long Cave, 2 miles from Glasgow Junction, Kentucky, in a water-trough nearly 1 mile from the mouth, May 11, 1874 (Sanborn). In the female, which is blind, the body is considerably broader, the head broader if not shorter, and the abdomen is shorter than in the Mammoth Cave form. Fig. 5*a* represents the first antenna, which has but 8 to 9 joints, and there are slight differences in the anterior feet (Fig. 5*d*).

From Walnut Hill Spring Cave, near Glasgow Junction, at a point 300 yards from daylight, May 16, specimens were collected by Mr. Sanborn; others collected by Mr. Sanborn in daylight, 50 feet from the entrance of Walnut Hill Spring Cave, Glasgow Junction, May 14, proved to exhibit no differences from Mammoth Cave forms. The first antennæ (Figs. 6, 6*a*) have 10 joints.

Those collected by us in Bradford Cave, Indiana, were exactly like the longer slenderer forms from Mammoth Cave. Fig. 7 represents the ten-jointed first antenna.

The Carter Cave specimens agree with those from Mammoth Cave, except that the first antennæ are much better developed, being larger and with several more joints (15 in all); moreover, there are as many as 5 olfactory rods, the first one on the seventh joint from the base (Figs. 8, 8*a*). The first pair of feet (Pl. IV, fig. 2) do not differ from those from Mammoth Cave.

We have received numerous specimens from wells in Illinois through the kindness of Mr. S. A. Forbes. They have narrower, more linear bodies than those in Mammoth Cave. They were 11^{mm} in length and 2^{mm} in width.

According to Forbes's sketches (his Pl. I, figs. 19, 20), the two pairs of male abdominal appendages are somewhat slenderer than in our Mammoth Cave specimens. Forbes also states that the first (upper) have 10 to 12 jointed flagella, "having a slender olfactory club at tip of each of the four or five joints preceding the last. * * * The lower antennæ are about two-thirds as long as the body in the female, in the male somewhat longer," the flagellum containing 75 to 80 joints. Forbes also remarks that the length of the rami of the caudal stylets varies greatly with age and sex. "In many old males the inner is very long and the outer minute."

Mr. Forbes adds to his description that it "is found quite frequently in deep wells of central Illinois in company with, but much more abundant than, *Crangonyx mucronatus*. After a long period of heavy rains during the last summer had greatly swelled the subterranean streams which

* See Fifth Rep., Peab Acad. Sci., Salem, 95, 1873.

these species inhabit, they appeared at the surface in springs, and even at the mouths of tile drains, in such numbers that a hundred could be taken in an hour. A few females were observed with eggs at this time (July)."

Upon the whole, the Illinois specimens are the most aberrant, *i. e.*, the farthest removed from *Asellus communis*, of any forms found in Mammoth or other caves. They are more linear than some specimens taken from wells in Annville, Lebanon county, Pennsylvania, kindly sent us by Mr. L. H. McFadden, who writes me that they also occur in the springs and wells in the limestone rocks of Cumberland and York counties.

The Pennsylvanian examples were large and well developed; the females were 16^{mm} in length; and the greatest width, 4^{mm}; length of first antennæ, 3^{mm}; of second antennæ, 15^{mm}, or almost as long as the body itself. The first antennæ were large, well developed, and sixteen to seventeen jointed. Pl. III, figs. 4; 4*a* represents the end of the antennule, showing three olfactory rods arising from the sixth joint from the end, this being probably an anomaly.*

CŒCIDOTÆA NICKAJACKENSIS Packard. Pl. III, figs. 9, 9*a*.

Cœcidotœa nickajackensis Pack., Amer. Naturalist, xv., 879, November, 1881.

Body longer, narrower, and slenderer than in *C. stygia.* The antennæ are sometimes very long, and reach to the end of the third joint of the second antennæ; they are sometimes nearly twice as long as in *C. stygia*, and are purplish-white, while the flagellum is provided with long hairs. Figs. 9, 9*a*, however, represents a short first antenna composed of only 8 to 9 joints with a single long olfactory rod on the sixth joint.

The second antennæ are as long as the head and extend backwards as far as the base of the abdomen. The legs are much longer and slenderer than in *C. stygia.* The abdomen is long and narrow, and the caudal appendages are moderately long in one specimen and short in another; in one individual the outer branch is much shorter and smaller than in the others, and in most it is as long as the basal joint. On the whole, the caudal appendages are no longer than the telson or terminal segment of the abdomen, while in *C. stygia* they are half as long as the entire body.

This species forms, in the antennæ and slightly purplish color and the proportions of the leg-joints, perhaps a nearer approach to the genus Asellus than that of Mammoth and Wyandotte caves; on the other hand, *C. stygia* approaches Asellus more in its shorter, broader body, with the shorter, broader abdomen. It seems quite evident that the two species must have descended from different species of Asellus. Whether there is an additional species in the Southern States from which the present species may have been derived remains to be seen.

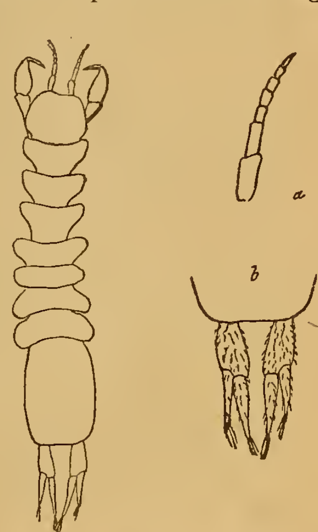

FIG. 7.—*Cœcidotœa nickajackensis*, Pack. *a*, antennule; *b*, caudal stylets; all enlarged.

The two specimens from Lost River, found by Dr. Sloan in that subterranean abode, were of the normal form and size of *A. communis*, but bleached as white as *C. stygia;* the eyes are black and distinct. This variety may be called *pallida.* It is interesting to note the occurrence of this bleached variety, which may have become thus modified after but a few generations; perhaps but one or two.

Besides *Asellus communis*, which is widely diffused throughout the Eastern and Central States, Mr. Forbes has described two species which occur in southern Illinois, neither having been detected in central or northern Illinois, although the most varied situations were carefully searched.

Our sketches (Pl. IV, figs. 3, 3*a*–3*g*) will give some of the details of structure of *A. communis*, which will serve as a basis of comparison.

Asellus intermedius Forbes, Bull. Ill. Mus. Nat. Hist., No. 1, 10.

This species, as remarked by its describer, is intermediate between *Asellus communis* and *A. brevicauda.* As will be seen by reference to Forbes' Fig. 14, the caudal stylets are like those of

* The auditory bristles of this species were mistaken by Mr. Hubbard for "an unknown ciliate Infusorian?" See his Fig. 10*b*, and Amer. Ent., iii, p. 80.

A. communis, only narrower, and with longer setæ, especially the terminal ones. The first antennæ are fourteen-jointed, while the olfactory rods and auditory bristles are essentially as in *A. communis*.

Mr. Forbes writes me that "there is some room for supposing that my *A. intermedius* is a dwarf form of *A. communis;* but I think no one could suppose that *A. brevicauda* was other than a distinct species. It occurs in the hill country of southern Illinois, and probably also farther south."

Asellus brevicauda Forbes, *l. c.*, p. 8.

In this form, which lives in clear rocky rills in Illinois, which is described in detail by Mr. Forbes, the first antennæ are fifteen-jointed. The auditory bristles are well developed, and there are five on the end of the second joint, where three are usually observed. The last olfactory rod is twice as long as the terminal joint of the antenna. The first pair of legs are shorter than in *A. communis*, while the head is much smaller, and of an entirely different shape. The caudal uropoda are dwarfed, very short, but the setæ much as in *A. communis*.

Remarks.—It follows from the foregoing statements that the geographical range of *Cæcidotæa stygia* is as great or greater than that of any other cave animal, unless *Pseudotremia cavernarum* be excepted. It also appears that upon the whole it does not vary much, being invariably white in color, blind, usually with no traces of eyes, and of a narrow, elongated shape. The parts which vary most are the organs of sense—*i. e.*, the first and second antennæ, especially the first pair. Its parent form is evidently one of the species described from Illinois, and as *Asellus communis* is widely distributed over the Mississippi valley and the Atlantic States, we are justified in regarding this as the parent form. It seems to be more abundant than any other species of the genus. This is evidently due to its immunity in its subterranean retreats from the attacks of the host of enemies—insect, crustacean, and fish—which prey upon the eyed out-of-door forms. Although blind, its loss of eye-sight is made up to it by its greater development of sense-appendages (antennæ), though after all the loss of sight is perhaps of little moment, since it is not exposed to the attacks of stronger animals. It breeds from April to May in Mammoth Cave, and probably all summer, since it was found by Mr. Hubbard with eggs in Cave City Cave, July 29, 1881, and in wells with eggs in Illinois by Mr. Forbes. The number of eggs produced and kept within the incubatory pouch appears to be no greater than in the out-of-door forms.

We think we have shown that on taxonomic grounds the genus Cæcidotæa is as well founded as many other genera which are accepted by carcinologists. It presents, at any rate, certain constant differences from the blind species of European wells and caves, as well as the dark abysses of Lake Geneva, and though exposed to the same general surroundings, has developed in different directions. It affords an interesting example of the origin of generic characters by changes in an environment the nature of which we can easily estimate.

CRANGONYX VITREUS Smith. Pl. V. figs. 1 to 4.

Stygobromus vitreus Cope, Amer. Naturalist, vi, 422, July, 1872.
Not *Crangonyx vitreus* Packard, Fifth Ann. Rep. Peab. Acad. Sci., Salem, 95, 1873.

The following description and accompanying sketches on Plate V have been kindly prepared by Prof. S. I. Smith, of Yale University:

All the Amphipods which I have seen from the Mammoth Cave belong to a single species, undoubtedly the same as the one badly described from the same locality by Professor Cope. In all I have examined five specimens, collected by Professor Packard in Shaler's Brook, the Labyrinth, and Willie's Spring.

The largest specimen, the one figured, is from Shaler's Brook, and was found under a stone. This specimen is a female, 5.2^{mm} in length (from the front of the head to the tip of the telson). The secondary flagellum of the antennulæ is minute, scarcely larger than the first segment of the flagellum, very slender, and composed of two segments, of which the terminal one is very minute, and about one-third as long as the first segment. The caudal stylets are all short and stout, the first and second pairs, with the outer rami, a little shorter than the inner, and both armed with spines which increase in length distally and at the tips are very long and slender; the third, or posterior pair, are almost rudimentary, being much shorter than the telson. The basal portion is very short but quite stout and wholly unarmed, while the single terminal segment or ramus is minute, scarcely longer than broad, and tipped with three spinules. The telson, as seen from above, is rectangular, nearly as broad as long; the posterior margin has a very shallow sinus in the middle, each side of which is armed with several slender spines. The other appendages are sufficiently well shown in the figures.

A smaller female, about 3.5^{mm} long, differs very slightly from the last. The flagella of the antennulæ are each composed of ten segments and those of the antennæ of four. In the second pair of legs the propodus is relatively not quite as large, is a very little narrower, and the palmary margin has one or two less spines on the outer side; all characters of a slightly less mature specimen.

The three other specimens are very small, and I have not been able to determine the sex of any of them. They may be either young males or immature females. One of these, about 2.7^{mm} long, differs considerably from the larger specimens, but only in such characters as immature specimens usually differ from the adults. There are only eight segments in the flagellum of the antennula and four in that of the antennæ. In the first pair of legs the propodus is a little more slender than in the adult, the palmary margin is not quite as oblique, and is armed with one or two less spines on each side. The second pair are only very slightly larger than the first, and of course very much more slender than in the adult. The propodus is narrower in proportion and scarcely wider than the carpus. The palmary margin is less oblique, not longer than the posterior margin, and is armed with fewer spines on each side. The first and second pairs of caudal stylets and the telson are armed with a few less spines.

I have been unable to discover even rudimentary eyes in any of the specimens.

This species agrees with Bates's description of the typical species of the genus in having the posterior caudal stylets "unibranched," and thus differs from the following species which we have referred to the genus, although in Bates's species the terminal segment or ramus of the stylet is as elongated as the outer ramus in *C. gracilis* and *C. packardii*.

In the structure and size of the posterior caudal stylets, in the stoutness of the second pair of legs, and in wanting eyes, this species approaches *C. tenuis*, from wells at Middletown, Connecticut, to which it is apparently more nearly allied than to any of the described American species. The *C. tenuis* is, however, a wholly distinct and quite different species. I know of no species with which this is closely enough allied to make its affinities of any value on the question of the origin of the cave fauna (S. I. Smith).

Figs. 1 to 4.—*Crangonyx vitreus*, female, 5.2^{mm} long: 1, lateral view, enlarged 20 diameters; 2, one of the first pair of legs seen from the outside, enlarged 48 diameters; 3, one of the second pair of legs, enlarged 48 diameters; 4, terminal portion of the abdomen, side view, enlarged 48 diameters; *a*, telson; *b*, posterior caudal stylet; *c*, second caudal stylet; *d*, first caudal stylet.

This species was not uncommon in the pools of Mammoth Cave, occurring in Richardson's Spring and Wandering Willie's Spring. It has the habits of Gammarus, scooping a furrow in the mud of the bottom of the pools in which it lives.

CRANGONYX PACKARDII Smith. Pl. V, figs. 5 to 11.

Crangonyx vitreus Packard, Fifth Ann. Rep. Peab. Acad. Sci., Salem, 95. July, 1873.
Not *Stygobromus vitreus* Cope, Amer. Naturalist, vi, 422, 1872.

This species is so closely allied to *Crangonyx gracilis* that it might readily be mistaken for it were it not for the peculiar structure of the eyes. The eyes of *C. gracilis* are composed of a few facets, and are abundantly supplied with black pigment. In all the specimens of *C. packardii* which I have seen the eyes are observable with difficulty, the black pigment being wholly wanting. The specimens received at first were very badly preserved, and I then thought the absence of the pigment might be due to this fact; but subsequent examination of more perfect specimens shows that this cannot be the case, and that the eyes are, in life, undoubtedly wholly without black pigment. The eyes are scarcely, if at all, observable in the ordinary alcoholic specimens, but when rendered translucent by immersion in glycerine the structure of the facets is distinctly observable, as shown in Fig. 5. As observed by Dr. Packard, the flagella of the antennulæ of *C. packardii* are a little shorter, and usually contain four or five segments less than in *C. gracilis*, but this is an uncertain character, and some specimens of *C. gracilis* from Lake Superior actually have only one or two more segments than the subterranean species. In the antennæ there are no constant differences. There are some very slight differences in the first and second pairs of legs, especially in the females, but not greater than usually exist in the individuals of a single species in allied genera, and any large series of specimens would undoubtedly show all the intermediate forms. In the third to the seventh pairs of legs there is a constant difference in all the specimens examined, the spines being more numerous, longer, and more slender in *C. gracilis.* The spines upon the first and second pairs of caudal stylets are a little shorter and more obtuse in *C. packardii* than they usually are in *C. gracilis;* otherwise there is no difference in the caudal stylets and telson.

These differences are all such as very naturally lead to the supposition that this subterranean form has been derived from the *C. gracilis* at no very remote period, although this supposition may well be held in reserve until we have a more complete series of the subterranean species for comparison. *C. gracilis* occurs as far south as Grand Rapids, Michigan, whence we have received specimens from Mr. N. Coleman, and it very likely occurs in the same region as *C. packardii.*

The figures are all from Professor Packard's original specimens, collected from wells in Orleans, Indiana, by Dr. Moses N. Elrod. Only one of these has the body entire; this is a female, 5.5^{mm} long, from which Figs. 5 to 8 were made. A larger specimen, a female about 7.5^{mm} long, unfortunately wanting most of the antennulæ and antennæ, collected from a well at New Albany, Indiana, by Dr. John Sloan, was sent to Dr. Packard for examination.

Figs. 5 to 11.—*Crangonyx packardii*, details all enlarged 48 diameters; 5 to 8, female, 5.5^{mm} long; 9 to 11, female, about 7.5^{mm} long: 5, lateral view of head; 6, terminal portion of one of the first pair of legs, outside; 7, same of second pair; 8, terminal portion of abdomen, lateral view; 9, one of the first pair of legs, outside; 10, one of second pair of legs, outside; 11, antennula and antenna, side view. [All the figures, 1 to 11, drawn by Prof. S. I. Smith.]

CRANGONYX ANTENNATUS Pack.

Crangonyx antennatus Pack., Amer. Naturalist, xv, 880, 1881.

The second crustacean discovered swimming about in the subterranean stream of Nickajack Cave was a species of Amphipod belonging to the genus Crangonyx, and has been described as

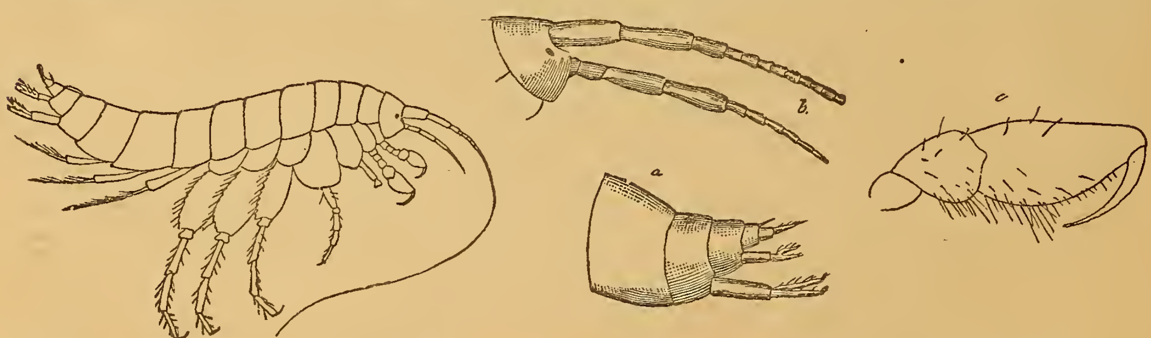

Fig. 5.—*Crangonyx antennatus* Packard. *a*, end of abdomen and appendages; *b*, head, with base of upper and entire lower antennæ and eyes; *c*, manus of second pair of feet; all enlarged.

Crangonyx antennatus Packard.* It is a large purplish species, with very long antennæ, and distinct, well-developed black eyes.

* It is a large and purplish species; the first antennæ very long; the flagellum with 20 to 24 joints; the entire antennæ being over one-half and nearly two-thirds as long as the body; the last joint of the peduncle being slightly more than half as long as the penultimate joint. Compared with *C. gracilis* Smith, from Lake Superior, it differs in the form of the eyes, the longer and stouter first antennæ, the flagellum having a greater number of joints, and in the different proportions of the joints of the peduncle; the second joint of the latter being much longer than in *C. gracilis*, while the first joint of the scape is much longer, and the second and third joints one-third longer in proportion than in *C. gracilis*. The fourth pair of epimera are unusually large and nearly square. The telson, together with the caudal stylets, is much as in *C. gracilis*, but the rami are slightly stouter and more polished, and the spinules a little stouter. It probably is a little larger species than *C. gracilis*, the specimens being 6 to 7^{mm} in length; the eyes are not so distinct, and are only one-fourth as large as in *C. gracilis*. It is very different from *C. vitreus* (Cope), of Mammoth Cave, and from *C. packardii* Smith, differing in its distinct eyes, and larger, more numerously-jointed antennæ.

CRANGONYX MUCRONATUS Forbes.

Crangonyx mucronatus Forbes, Bull. Illinois Mus. Nat. Hist., i, 6, Dec., 1876. Figs. 1 to 7.

This remarkable species, remarks Mr. Forbes,* is perhaps entitled to rank as the type of a new genus; but, until I have the material for a more general study of its relations than I am able to make at present, I prefer to place it with its nearest allies in the genus Crangonyx.

Colorless; blind; length, 9 to 10^{mm}; width, 1^{mm}. The head is a little longer than the first thoracic segment, its anterior margin concave at the bases of the upper antennæ, convex between them; the posterior margin straight in the middle and curving forward on the sides. The front angles of the first thoracic segment are uncovered and produced a little forward; the hind angles of the first five segments are rounded and produced strongly backward. The first three abdominal segments have the lateral margins and all the angles broadly rounded, and the posterior angles, as well as the posterior margin of the seventh epimeron, are slightly notched and bristled. The upper antennæ of the male are two-thirds to four-fifths as long as the body. The first and second joints of the pedicel are subequal, each about as long as the four basal joints of the flagellum; the third is one-third as long as the second. The flagellum is about five times the length of the pedicel, and is composed of 30 to 35 joints, each with a few short hairs at tip, and all except the seven or eight basal joints and the last with a slender olfactory club. The secondary flagellum contains two bristled joints, together a little longer than the first of the primary flagellum. Pedicel of lower antennæ longer than that of upper, the last two joints equal, each a little longer than basal joints of upper antenna. Flagellum nine or ten jointed, with olfactory clubs. Right mandible with dental laminæ; each with five conical, obtuse, subequal teeth. The anterior lamina of the left mandible is much the larger and stronger, with three very strong, blunt teeth; posterior lamina with three slender and acute teeth. Palpus, three-jointed; basal quadrate about half as long as second, which is clavate and nearly twice as wide as long, with about ten long hairs on its rounded hind margin, which are longest and closest distally. Last joint a little longer and narrower than second, regularly convex in front, straight on proximal half of hind margin, slightly concave on distal half, and fringed here with about twenty-four slender hairs, the three or four at tip becoming suddenly very much longer. A few scattered hairs on front margin of this joint.

Inner plate of anterior maxilla is nearly hemispherical, about half as long as outer, with four plumose hairs on the rounded margin, which are about as long as the plate itself. Palpus two-jointed; first quadrate, one-third as long as second, which is oval, pointed, tipped with two claws and some smaller spines. Laminæ of basal joints of maxillipeds short, neither hair extending beyond tips of succeeding joints.

First two pairs of feet equal. Dactyl of first pair in male curved, two-thirds as long as hand. The latter is broad-ovate, two-thirds as wide as long, the palmar and posterior margins forming a wide angle. Long hairs on posterior surface in transverse rows. Palm with about fifteen short, notched spines, each with a hair arising from the notch. Carpus subtriangular, three-fourths as wide as propodus, hind margin very short, with one or two pectinate spines and a few long hairs; second pair similar; propodus a little longer and narrower; carpus as wide as propodus, posterior margin longer, with about five transverse rows of long bristles, of which the distal row are doubly pectinate on terminal third. The three posterior pairs of thoracic legs increase in size backward, the first of these being not quite two-thirds as long as the last. The seventh epimeron is narrow, with the lower margin regularly arcuate. The tips of the first pair of anal legs extend beyond the tips of the second, and these beyond the tips of the third. The latter are therefore very short, about as long as the pedicel of the second pair. The outer ramus is ovate, truncate, half as long as the pedicel, and hairy at tip; the inner is an unarmed rudiment, one-fourth or one-fifth the length of the outer. The telson of the male is a smooth cylindrical appendage, usually about as long as the first three abdominal segments, and as large as the last joint of the pedicel of the lower antenna. It presents a very slight double curve, is obliquely rounded at the end, and tipped by a cluster of short hairs. In some cases this appendage is half as long as the body.

The female differs in the following particulars: The upper antennæ are only about half the length of the body, the flagellum not more than three times as long as the pedicel, and the secondary

* The following description is copied from Mr. S. A. Forbes' article.

flagellum is usually a little shorter. The propodus of the first pair of feet is similar in outline, but the palmar margin and dactyl are shorter, and the posterior margin longer. The second pair is extremely like the second of the male, but is decidedly smaller than the first. The telson affords a difference so remarkable, that the two sexes, at first sight, would hardly be referred to the same genus. In the female this is very similar to the telson of *C. gracilis* Smith. It is flattened and slightly emarginate, a little longer than broad, extending to the tips of the second pair of anal legs, and bears two terminal clusters of spines of four or five each.

This species was first discovered by me in a well at Normal, Illinois, during the summer of 1875. It was subsequently found by Mr. Harry Garman in great numbers in springs, and even at the mouths of drains, after a long period of heavy rains. With the advent of dry weather it entirely disappeared from these, but still occurs sparingly in wells. (S. A. Forbes.)

CRANGONYX LUCIFUGUS Hay.

Crangonyx lucifugus Hay, Amer. Naturalist, xvi., 144–5. 1882.

The following description is copied from Mr. Hay:

This is a small, rather elongated species, that was obtained from a well in Abingdon, Knox county, Illinois. As befits its subterranean mode of life, it is blind, and of a pale color. In length the largest specimens measure about 6^{mm}.

Male.—Antennulæ scarcely one-half as long as the body. The third segment of the peduncle two-thirds as long as the second; this, two-thirds the length of the first. Flagellum consisting of about 14 segments. The secondary flagellum very short, and with but 2 segments. Antennæ short, only half as long as the antennulæ. Last 2 segments of its peduncle elongated. Flagellum consisting of but about 5 segments, and shorter than the last two segments of the peduncle taken together.

Second pair of thoracic legs stouter than the first. Propodite of first pair quadrate, with nearly a right angle between the palmar and posterior margins. Palmar surface on each side of the cutting edge, with a row of about 6 notched and ciliated spines, one or two of which at the posterior angle are larger than the others. The cutting edge is entire. Dactylopodite as long as the palmar margin, and furnished along the concave edge with a few hairs.

Propodite of the second pair of legs ovate in outline, twice as long as broad. The palmar margin curving gradually into the posterior margin. The cutting edge of the palmar surface uneven, and having, near the insertion of the dactyl, a square projection. The palmar surface also armed with two rows of notched and ciliated spines, five in the inner row, seven in the outer. Dactyl short and stout.

Two posterior pairs of thoracic legs longest of all and about equal to each other. All the legs are stout and their basal segments squamiform.

Postero-lateral angle of first abdominal segment rounded; of second and third, from obtuse-angled to right-angled.

First pair of caudal stylets extending a little farther back than the second; these slightly exceeding the third. The peduncle of the first pair somewhat curved, with the concavity above, the rami equal and two-thirds as long as the peduncle. The peduncle of the second pair little longer than the outer ramus. Inner ramus nearly twice as long as the outer. Third pair of caudal stylets rudimentary, consisting of but a single segment. This somewhat longer than the telson, broadly ovate, two-thirds as broad as long, and furnished at the tip with two short spines.

Telson a little longer than wide, narrowing a little to the truncated tip, which is provided at each postero-lateral angle with a couple of stout spines.

Female.—In the female the propodite of the anterior pair of feet resembles closely that of the corresponding foot of the male. The palmar margin of the second propodite is less oblique than in the second foot of the male, and does not pass so gradually into the posterior margin. It is also destitute of the jagged edge and the square process of the male foot. There are fewer spines along the margin. One of the spines at the posterior angle is very long and stout.

This species appears to resemble *C. tenuis* Smith, but is evidently different. In that species, as described by Prof. S. I. Smith, the first pair of feet is stouter than the second, and has the palmar margin of the propodite much more oblique. The reverse is true of the species I describe. Nor do I understand from the description of *C. tenuis* that the posterior caudal stylets each consist of a single segment. There are some minor differences. From *C. vitreus*, judging from Professor Cope's description in American Naturalist, volume vi., page 422, it must differ in the caudal stylets. "Penultimate segment with a stout limb, with two equal styles," is a statement that will not apply to my species, whichever the "penultimate" segment may be.

CAMBARUS PELLUCIDUS (Tellkampf).

Astacus pellucidus Tellkampf, Arch. f. Anat., Phys. u. Wissensch. Med., 383, 1844.
Cambarus pellucidus Erichson, Archiv f. Naturgesch., xii, Jahrg. I, 95, 1846.
Orconectes pellucidus Cope, and *Orconectes inermis* Cope, Amer. Naturalist, vi, 410, 419, 1872.
Cambarus pellucidus Smith, Rep. U. S. Com. Fish., 1872 and 1873, 639, 1874.
Cambarus pellucidus Faxon, Proc. Amer. Acad. Arts and Sci., xx, 139, 1884; revision, 90, 1885.

Next to the blind-fish of Mammoth and other caves, the blind crayfish first discovered in 1842 by Dr. W. T. Craige has, from its size, attracted the most general attention from the public. We will extract the following remarks as to its specific character and affinities from the first monographer of the genus, Dr. Hagen:

The shape of the rostrum is somewhat analogous to that of *C. affinis*; the margins are more parallel at the base. The lamina of the antennæ is long, but strongly dilated nearer to the tip; the epistoma is shorter and broader than in the other species; the basal joint of the inner antennæ has a spine at the tip which in the other species is always nearer to the base. The fore border of the cephalothorax is not angulated behind the antennæ, as in all other species. Nevertheless the number of the hooked legs, the form of the abdominal legs, and the elongated body and hands, exclude *C. pellucidus* from the other groups. Some, no doubt, will prefer to regard *C. pellucidus* as a distinct group or genus, still, as I am convinced, without foundation. The most striking differences consist in the aberrations in the shape of the foreparts and of the limbs of the head (pp. 33, 34).

In speaking of the eyes, Dr. Hagen appears to be in error in stating that the "optic fibers" are not developed. If reference is here made to the optic nerve, it is, as we shall see further on, well developed, while, as he truly says, the "dark-colored pigments" are not developed.

The specimens from Wyandotte Cave described by Cope as *Orconectes inermis* are scarcely a variety of *C. pellucidus*, as originally stated by us in our paper "On the Cave Fauna of Indiana,"* Professor Faxon also remarks:

C. pellucidus is subject to considerable variation. In some specimens the rostrum is shorter than in typical specimens, and contracts more from the base to the lateral teeth, which are much less prominent. The spines of the postorbital ridge and sides of the carapace are slightly developed. This is the form described as a new species (*Orconectes inermis*) from Wyandotte Cave, Indiana, by Professor Cope, in 1872. I owe to Prof. A. S. Packard an opportunity to examine Cope's type. It is a male, Form II, with the first pair of abdominal appendages not articulated, a condition often found in the second form males of this species. After an examination of this specimen I can indorse the opinion of Hagen (Amer. Naturalist, Aug., 1872), and Packard (Fifth Ann. Rep. Peab. Acad. Sci. for 1872), expressed before seeing the specimen, that the variation is not of specific value. All the specimens which I have seen from the Indiana caves, amounting to six in number, belong to this form. But the same form also comes from the Mammoth and neighboring caves in Kentucky. In a gigantic female in the Museum of Comparative Zoology (No. 3417, collected in Mammoth Cave by F. W. Putnam) the peculiarities of Cope's form are intensified. The point of the rostrum does not reach the distal end of the peduncle of the antennule, and hardly attains the proximal end of the distal segment of the peduncle of the antenna.† The lateral rostral spines are reduced to salient angles. The postorbital ridges are destitute of spines, as in *C. bartonii*. The antennal scales reach but to the proximal end of the terminal segment of the peduncle of the antenna. The lateral spinules of the carapace are represented by granular tubercles. The spines of the meros of the cheliped are short and tooth-like, those on the upper surface are blunt, those beneath are irregularly disposed, without the clear biserial order seen in the typical form, and also in Cope's type of *O. inermis*. The hands are broad, flattened, and tuberculate.

This species is more widely diffused throughout the cavernous region of Kentucky and Indiana than is generally supposed.

A male collected by us from Bradford Cave, Indiana, does not differ from a male from Mammoth Cave.

In a male from one of the Indiana caves (which cave is not indicated) the cephalothoracic suture is much more acutely produced posteriorly than in a male from Mammoth Cave.

In the male the rostrum is narrower and its spines, both frontal and lateral, are longer and slenderer than in the female.

Comparing two males of the same form from Mammoth and Wyandotte caves, the former has the right hand the larger, and the Wyandotte one the left hand the larger. Although the Wyandotte male is a little the smaller, the large hand is about one-fourth larger and is broader than in the Mammoth Cave one. The rostrum of the Mammoth Cave example is broader and the sides less raised and thickened. In the Mammoth Cave specimen the inner edge of the end of the antennal scale reaches as far as the lateral spines of the rostrum; in the Wyandotte male the scale reaches far beyond the lateral spines, more than half way between the lateral spine and the end of the median spine. These I regard as simply individual differences, as in another male from Wyandotte or Bradford Cave the large hand is of the same relative size and on the same side as the Mammoth Cave male.

In the females from different caves in Indiana (received from Dr. John Sloan), one has a slightly narrower rostrum than the other, which is a larger individual.

In a female from Diamond Cave, which we collected, the larger hand is the left one, the rostrum and antennal scale are shorter than in a large female from Mammoth Cave; otherwise it does not differ essentially.

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* Fifth Rep. Peab. Acad. Sci., Salem, 94, 1873.

† In the typical form of *C. pellucidus* the rostrum equals or exceeds in length the peduncle of the antenna.

This species was also found by Mr. J. B. Proctor to occur in Bat Cave, Edmonson county, Kentucky, June 13, 1874. It does not differ from Mammoth Cave examples. The larger hand is on the left side. One female collected by Mr. Sanborn in a cave near Haunted Cave, same county and State, was rather small, but presented no differences from Mammoth Cave females.

In none of the specimens examined did the rudimentary eyes seem to vary.

Relation of O. pellucidus to out-of-door species of Cambarus.—In comparing *pellucidus* with *C. bartonii*, a young male of Form II, 1.30 inches long, from Mammoth Cave, it was found to differ from *C. bartonii* in the spinules on each side of the apex of the rostrum.

It seems to us that *O. pellucidus* is, in the proportions of the body and particularly the shape of the rostrum more like *C. bartonii* than *C. affinis*. *C. pellucidus* differs from *C. bartonii* in the longer hand and the fourth joint of the limb, while the thorax and rostrum are much longer. The antennæ are rather the stouter and shorter in *C. pellucidus*. The elongated body, long hands, and the limbs bearing them are changes such as we would expect to meet with in cave animals.

The *C. bartonii*, which is a good deal bleached, is as white and as pale as the *pellucidus*, except that the head and first pair of limbs and hands have scattered blackish speckles. *C. affinis* is evidently, however, the parent form of *C. pellucidus*. On comparing males of Form II of the two species, *C. pellucidus* has stouter and larger second antennæ; the antennal scale is broader at the end, the rostrum is wider, the head is rather wider and shorter, the hinder edge is less convex, the thorax is a third longer, the abdomen but slightly longer, the difference being in the cephalothorax. The ischium of first pair of legs is one-third as thick and about one-third as long, the meros one-half as thick and one-third longer; the carpus is of about the same length, but the hand is one-half as wide and a little longer than in *C. affinis*. Of the four succeeding pairs of feet the ischia are about the same length, the meros somewhat longer. The first antennæ are longer and slenderer.

The gonopods in Form II are very distinct from the out-of-door species, being nearly one-half shorter.

Cambarus rusticus, which is closely related to *C. affinis*, was found by us in abundance at a point only about 20 feet from the mouth of the cave in the brooks which flow out of Bradford Cave; inside of the cave *pellucidus* is not uncommon.

Remarks.—Two alternatives present themselves in considering the origin of the form *pellucidus*. First, it either is derived, with *C. affinis*, from a common ancester; or second, and what seems more probable, it is a modification of *C. affinis* or an allied species, *e. g.*, *rusticus*. The characteristics which separate *C. pellucidus* from *C. affinis* or *C. bartonii* or any out-of-door species are those which have been induced by its life in total darkness and the diminution in its food-supply. The close neighborhood of the habitat of the two forms at the Bradford Cave, the blind one living only a few yards away and in the upper part of the same brook as *C. rusticus*, is very significant, and this affords us the best means of ascertaining the origin of this form. It is paralleled by the probable origin of the Myriopod Scoterpes from Trichopetalum and of Pseudotremia from Lysiopetalum.

CAMBARUS HAMULATUS (Cope and Packard).

Orconectes hamulatus Cope and Packard, Amer. Naturalist, xv, 881, Pl. vii, figs. 1, 1 *a*, 1 *b*, Nov., 1881.
Cambarus hamulatus Faxon, Proc. Amer. Acad. Arts and Sci., xx, 145, 1884; Revision of the Astacidæ, Mem. Mus. Comp. Zool., x, 4, 81. Pl. iv, fig. 6, ix, figs. 1 *a*, 1 *a'*, Aug., 1885.

In this species the epistoma is much as that of *C. bartonii*, but shorter and broader; while the median terminal tooth is less marked than in *C. latimanus*, and the sides fall away rapidly from the front margin. It is entirely different in shape from that of *C. pellucidus*. The antennal lamina is shorter, broader, and much more rounded on the inner edge than in *C. pellucidus*, and in this respect differs from *C. latimanus*. The rostrum is narrower than in *C. pellucidus*, while the first pair of (large) claws are much slenderer, and the telson narrower than in *C. pellucidus*. The most obvious difference is seen in the modified first and second pairs of abdominal feet of the male, to which we may apply the term gonopod, for it is not properly an intromittent organ.* The first and second pair of gonopods differ decidedly from those of *C. pellucidus*, and closely resemble those of Form II of *Cambarus latimanus* (from Athens, Georgia, figured by Hagen), those of the first pair being shorter, thicker, and the last joint being much bent, hook or sickle-shaped, whence the specific name *hamulatus*. The first gonopods differ in the proportion of parts from those of *C. latimanus*, but the joint is much more acute than in *C. latimanus*.

The first pair of gonopods, compared with the *latimanus* form of *obesus* from Maryland, given me by Mr. Uhler, are much like it in general form, but the sinuous branch is longer and straighter, while the hook is much slenderer. In the second pair of accessory gonopods the knob is proportionately smaller. In other more important characters *C. hamulatus* is quite unlike the *latimanus* form of *C. obesus*, the scale of the second antennæ being very different, the chelæ one-half as wide, and the antennæ much longer, while the rostrum is much longer and more pointed. Length of the largest male, 5 centimeters.

Cambarus hamulatus is quite different from *C. pellucidus* of Mammoth and Wyandotte caves in the rostrum, the slender hands, the much broader antennal scale, and in the form of the gonopods, while the whole creature is slightly slenderer than *C. pellucidus*, though the rudimentary eyes are of the same proportion to the neighboring parts as in the other species.

It is obvious that the form from which *C. hamulatus* has been derived is quite different from that which has given origin to the blind crayfish of the Kentucky and Indiana caves. The most common species in Northern Georgia is *Cambarus latimanus*, which has been found at Athens and Milledgeville, Georgia, and probably is abundant in the northern limestone region of Alabama. At any rate, it is perhaps to *Cambarus latimanus* that we look for the ancestors of *Cambarus hamulatus*. On the other hand, in the form of the body, of the scale and rostrum, as well as of the upper lip and the chelæ (though not of the gonopods), *C. hamulatus* approaches *Cambarus affinis*. Now, of all our North American crayfishes, it would appear, as Mr. Uhler has told the writer, and as seems evident to us upon an examination of several types and the excellent figures of Dr. Hagen, that *C. affinis* is the more generalized form, and this is tantamount to saying that it is the ancestral form of our North American crayfishes. So, while our Nickajack blind crayfish may have been an immediate derivative of *C. latimanus* of the Gulf States, it probably ultimately originated from *C. affinis*, a more wide-spread species.

Prof. W. Faxon, in his "Revision of the Astacidæ," remarks as follows regarding this species, based on an examination of four males, Form II, and two females, the types of Cope and Packard's description:

In general form and appearance it bears a close resemblance to *C. pellucidus*, but the carapace is less spiny, and the male has hooks on the third pair of legs only, and the first pair of abdominal appendages are formed after the fashion of the *C. bartonii* group. The rostrum tapers towards the tip more than it does in the typical form of *C. pellucidus*, resembling, in this respect, the form *C. pellucidus inermis*. The terminal segment of the telson narrows at the hinder end more than in *C. pellucidus*. I do not find the differences in the mandibles, antennal scales, and chelæ mentioned by Packard.

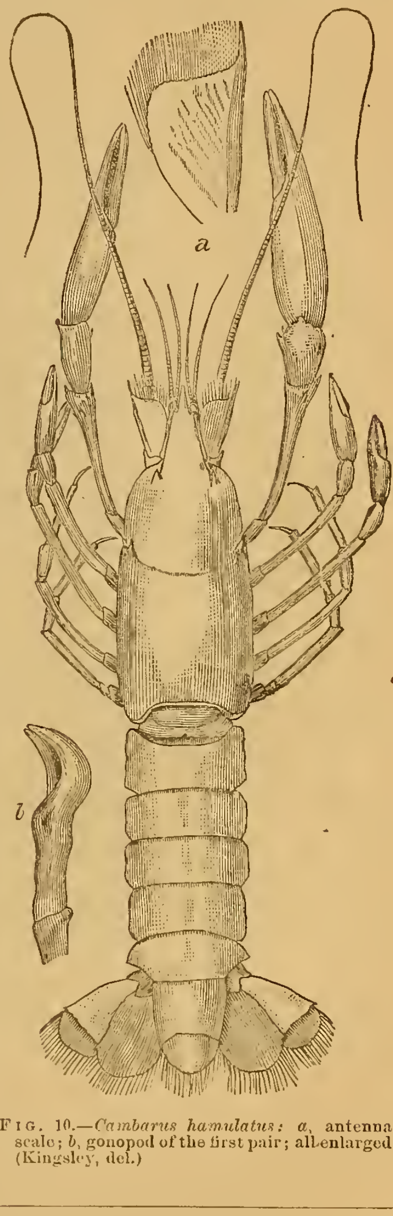

FIG. 10.—*Cambarus hamulatus*: *a*, antennal scale; *b*, gonopod of the first pair; all enlarged. (Kingsley, del.)

* *Note on the function of the gonopods.*—As stated by Milne Edwards and others, the gonopods of the crawfish are not intromittent, but simply rude gutters for the passage of the fertilizing fluid to the eggs. It is obvious that in the lobster the gonopods form simply a rude tube or gutter to conduct the seminal fluid to the eggs as they pass backward from the oviducts to the swimming feet of the female. During the process of fertilization of the eggs the male, without doubt, as in the crawfish, holds the female by the claws, she resting on her back. The term gonopod is applied for convenience in descriptive carcinology to the external reproductive organs of the Crustacea, since they are only modified limbs.

While Mr. Cope has proposed the genus Orconectes to include the two blind species of crayfishes (*C. pellucidus* and *C. hamulatus*) on account of the absence of eyes, and we were inclined, after the discovery of a second species (*hamulatus*) to adopt the genus, for the reason that the loss of the cornea and retinal elements, as well as the reduction in the size of the eye itself, is common to two species; yet we should hesitate to do so, from the fact that there are so many other genera of Arthropods in which there are both eyed and eyeless species—the character being one of great instability. At the same time due consideration should be given to the fact that such loss, total or partial, of the organs of vision is of profound significance, more so than the mere systematic zoologist is apt to recognize. Were there other good generic characters than those afforded by the reduction of the eye we should retain Cope's genus Orconectes; meanwhile it may stand as a subgenus.

ARACHNIDA.

ACARINA.*

Rhyncholophus cavernarum n. sp. (Pl. X, figs. 1, 1*a*, 1*c*)—This is a minute white species, .8^{mm} in length, found near the end of White's Cave; also by Mr. Sanborn in Long Cave, 2 miles from Glasgow Junction, Kentucky.

Bryiobia ? (or *Penthalæus ?*) *weyerensis* n. sp. (Pl. XI, figs. 1, 1*a*, 1*b*)—Body stouter, larger, and maxillæ slenderer than in the other species; legs very long. Color, dull white. Length, 1.1^{mm}. Weyer's Cave. Mr. A. D. Michael writes me that this is probably a *Labidostoma* Kramer, or *Nicoletia*.

Lælaps ? (or *Holostaspis ?*) *wyandottensis* n. sp. (Pl. X, figs. 2, 2*a*, 2*b*)—Body thick, oval; maxillæ very short, minute; maxillary palpi five-jointed, the terminal joint bearing a broad triangular plate; tarsal claws long, elbowed, and spatulate. Length, 1.8^{mm}. Little Wyandotte Cave.

Lælaps (= *Iphis ?*) *cavernicola* n. sp. (Pl. X, fig. 3)—Body oval; no eyes; pale horn color. Length, 1^{mm}. Labyrinth, Mammoth Cave, under *Oozonium auricomum* on sticks. Perhaps a Hypoaspis.

Gamasus (or *Hypoaspis ?*) *troglodytes* n. sp. (Pl. X, figs. 4, 4*a*, 4*b*, 4*c*)—Occurred in Mammoth Cave with the preceding species.

Gamasus stygius n. sp. (Pl. X, figs. 5, 5*a*, 5*b*, 5*c*)—Of the same form as in the preceding species, but the beak is nearly one-half shorter. Color, pale horn. Length, 1^{mm}. Bat Cave, Carter Caves, Kentucky.

Damæus (= *Delba*) *bulbipedata* n. sp. (Pl. X, figs. 7, 7*a*)—Head conical; abdomen orbicular; the legs long and slender, with all the joints more or less bulbous, and each bearing two or three long setæ. Fig. 8, Dr. Trouessart thinks, is perhaps the nymph of this species. The legs are a little shorter, and the setæ on the end of the abdomen much longer. End of Dixon's Cave.

Oribata alata n. sp. (Pl. XI, figs. 2, 2*a*)—This is a short, round species, with a stout conical head, and two large wing-like expansions on each side, extending in front nearly as far as the end of the head; the legs are long and slender. Collected at the end of Dixon's Cave.

Uropoda lucifugus n. sp. (Pl. X, fig. 9)—Body suborbicular, nearly as wide as long, with short legs, the longest about two-thirds as wide as the body. Found in New Wyandotte Cave, attached to Pseudotremia. Allied to *U. krameri* according to Trouessart (in litt.).

Sejus ? sanborni n. sp. (Pl. X, figs. 6, 6*a*)—Body thick, spherical, white. Length, 5^{mm}. Maxillæ and palpi very short, about one-third as long as the first pair of legs. Cave near Dismal Creek, Kentucky (F. G. Sanborn). Dr. Trouessart refers this form to Sejus ? or Zercon ?

Family CHERNETIDÆ.

OBISIUM CAVICOLA Pack.

Obisium cavicola Pack., Amer. Naturalist, xviii, 202, 203, with fig. February, 1884. †

This is certainly an aberrant species of the genus, whether we regard the size of the chelicerae or the shape of the cephalothorax. The latter is much longer than broad, widest just before the

* The descriptions of the mites are brief and imperfect, as little is known of the genera and species in the United States, and the following notices are only preliminary. The figures, it is hoped, will enable them to be recognized. (See also explanation of Plates X and XI.) I am indebted to Dr. Trouessart for most of the generic names.

† By an oversight the author's name was omitted at the end of the article.

middle, narrowing in front and behind, and between the chelicerae deeply cleft; a feature unusual in the genus. There are no traces of eyes, either of a cornea or pigment spot. The chelicerae are rather smaller than usual and separate at base, and more conical, less pyriform than usual; the manus is shorter, and the fingers longer than usual, both finger and thumb (the fixed finger) are curved, the tips acute, and the inner edge denticulate. The pedipalps are as long as the body without the chelicerae; they are rather thick, not especially long; the first joint is stout and of uniform thickness, as is the second, which is not contracted at the base, being of uniform thickness; it equals in length the width of the cephalothorax; the third is three-fourths as long as the second, is slightly contracted at the base, subconical in form; the hand is thick and heavy, it is about twice as long as the third joint, and the fingers are moderately curved. The abdomen is narrow and rather long, with the segments well marked. The body (in alcoholic specimens) is dull white, while the pedipalps are horn-colored, with a reddish tinge. Length of body, including the chelicerae, 2^{mm}. One specimen from the New Market Cave, Virginia.*

FIG. 11.—*Obisium cavicola* Pack.; enlarged.

CHTHONIUS PACKARDII Hagen. Plate XI, figs. 3, 3*a* to 3*j*.

Chthonius packardi Hagen, Zool. Anzeiger, II Jahrgang, 399. July 28, 1879.
Chthonius packardi Hagen, Amer. Entomologist, iii, 83. March, 1880.
Chthonius packardi Hubbard, Amer. Entomologist, iii, 83. March, 1880.

Body rather long and narrow; thorax rather flat, considerably longer than wide, nearly one-fourth, and about (perhaps a little less than) one-half as long as the abdomen; a little broader just behind the front edge, and narrowing somewhat on the hinder edge. The abdomen is considerably contracted at the base, especially on the second segment; it is rather narrow, less swollen in the middle than usual; it consists of ten distinct segments, of which the seventh and eighth are the widest. On the thorax is a lateral row of setae, five on each side and two in front, but none in the center, and two behind. In the young there are four in front. On each side of the abdomen are two rows of setae, of the same length as those on the thorax. There are no traces of eyes in three specimens; in a fourth rudimentary ones exist. General color (in alcohol) pale horn, with a reddish tint; body and legs of the same tint; the chelicerae of the same tint, but the hand of a little deeper tint, while the pedipalps are decidedly deeper in color than the rest of the appendages and body; beneath not paler than the upper side of the body.

Chelicerae (mandibles) of moderate size, full, and swollen towards the base; two-thirds as long as the thorax, and about as long as the latter is wide behind the middle; the movable claw or finger is shorter than the chelicera is thick, and the fixed thumb is about half as long as the body of the chelicerae. On the hand near the base of the finger are two hairs, and the finger itself bears two external setae within the middle; on the hand near the division into fingers is a group of three straight, stiff, barbed setae (Fig. 3*e*). On the inside of the middle of the long slender, regularly-curved finger are six teeth,† the distal one the largest. The serrula has eighteen divisions, the first one free, the distal one very acute. The pedipalps are long and slender, longer than the body by nearly the length of their finger. The third joint is about one fourth as long as the second; the manus is one-half as thick as long; the fingers are long and slender, nearly but not quite as long as the second joint; both are a little curved, with the extreme tips suddenly bent in; each finger with a series of fine acute teeth on the inner edge, which end in short setae. The legs long and slender, the posterior pair about twice as long as the abdomen; the two posterior trochanters twice as large as those of the second pair of legs, and the latter much larger than

* *Chelifer cancroides* L.—This species occurred in company with *Chthonius packardii* in Salt Cave in partial daylight, 50 to 100 feet from the entrance. This is a cosmopolitan species, being found everywhere in Europe and in the Atlantic as well as Pacific States. This is its first occurrence in caves; but its appearance in a single cave, may for the present, at least be regarded as accidental.

† These hairs form the so-called organs of smell of Stecker. (See Hagen, Zool. Anzeiger, July 28, 1878, p. 400.)

those of the first pair of trochanters; the terminal tarsal joints of first and fourth legs of nearly the same length, and quite setose, with scattered longer stiff setæ, each with a pair of slender curved hooks and a slender curved anchor-shaped plantula with a thin cylindrical shank.

Length 2.5 to 3 3^{mm}.

Labyrinth of Mammoth Cave, under stones and fungus (Oozonium), three specimens; and another from the same cave in total darkness; also Dixon's Cave (Packard and Sanborn). One specimen with rudimentary eyes occurred in Salt Cave, 50 to 100 feet in from the mouth, in partial daylight.

Of the four specimens from the Labyrinth three are totally blind, with no traces of eyes; the fourth one, of which the exact locality in the cave is unknown, has rudimentary eyes; the cornea could not be detected, and the presence of the eye was only indicated by a silvery-white pigment-spot situated on each angle of the front edge of the thorax, in front of the lateral setæ. One specimen from the New Wyandotte Cave, Indiana, was totally blind, with no trace of cornea or pigment-spot, and the body was white.

Our specimens agree with Hagen's description in the American Entomologist. My description is drawn up from males. His type-specimens were from Wyandotte Cave. Dr. Hagen's Kentucky specimens were from the bottom of the Dome, Mammoth Cave, "with dead bat," November 9, and Long Cave, near Glasgow Junction, Kentucky, 1 mile from daylight, May 11. Hagen writes as follows of the Mammoth Cave form with two eyes:

It is pale yellowish; the thorax, mandibles, palpi, legs, and segments of the abdomen about the same color; the base of the mandibles a little darker; the abdomen between the segments and on the sides paler. I have seen only three specimens in alcohol, all from the Mammoth Cave region, one couple from one locality and a female from another locality. I have compared all very carefully with *C.* (Blothrus) *packardi*, from Indiana. They are a little longer, 3 to 3.2^{mm} long, but a little darker, or perhaps a little less white, but all three have on each side of the thorax one eye, distant from the anterior border as far as the length of the diameter of the eye. The movable finger of the mandibles is not indented. The examination of all other details shows no difference.

In his article in Zoologischer Anzeiger, July, 1879, Dr. Hagen refers to this form as follows:

As the position and number of the eyes has hitherto furnished for Chelifer genera a trustworthy indication, I had described it as a new species.* A subsequent very close comparison with (Blothrus) *packardi* gave as a result that the two species appear to be identical; only the former has two eyes; the latter is blind. Further research showed that neither can be separated from the genus Chthonius, which has two eyes on each side. Consequently we have here the interesting fact that Chthonius living without the cave have two eyes on either side, and that within the caves live forms of this genus in which either the anterior pair of eyes is aborted or these two are wanting, and light-refracting cells (lichtbrechende Kerne) under the skin, at the base of the sensitive hairs, seem to form a partial substitute for the wanting organs of sight.

I append Mr. Hubbard's excellent description of this form.

Dr. Hagen has, with the greatest liberality, placed at my disposal his unpublished descriptions and figures of new Pseudoscorpions belonging to the genus Chthonius. The following is the description of the cave species. The few changes I have taken the liberty of making in his manuscript have been rendered necessary by new facts developed in correspondence, and in an article published in advance of the descriptions by Dr. Hagen in the Zoologischer Anzeiger, Leipsig, July, 1879.

"*Chthonius packardi* Hagen, n. sp —(Fig. 9, *a* male, enlarged fifteen times; *b* left mandible from below; *c* feathered bristle of the mandibles more enlarged; *d* movable finger of mandible, occasional in female; *e* chela of the palpus; *f* termination of tarsus; *g* plantula from above.) 'Dull whitish mandibles and palpi very light brown, segments of the abdomen yellowish white. Thorax flat, a little longer than broad, quadrangular; very little enlarged just before the anterior border, and a little narrowed behind in female; lateral borders nearly straight, a little convex just before the anterior border where the eyes should have been; angles rectangular, the hind ones scarcely rounded; no eyes; thorax smooth, with a few sensitive bristles, four on each side, two near the anterior border and two near the posterior one, two more in the middle each side nearer to the anterior border, which is a little produced in middle; mandibles large, one-third shorter than the thorax; base convex above, oblong, a little narrowed to the fingers, which are shorter than the base; the movable finger incurved, strongly pointed, with sometimes a small knob or external indentation before the tip; on the under side of the base, just before the division into fingers, internally, three long feathered bristles placed in a line, usually larger on the left mandible, sometimes wanting (or rubbed off?); abdomen less than twice as long as the thorax, scarcely broader at base, ovoid, thicker in the female; two rows of hairs on the segments 1 to 3, four rows on the three following segments, and six rows on the two following segments;† a transversal row of

* Under the manuscript name *C.* (Blothrus) *incertus*.

† The number of hairs is found to vary on the abdomen. (Hub.)

hairs on each ventral segment. Male with the second ventral segment triangularly excised; female with two small holes; palpi thin, longer than the body by about the length of their fingers; hypopodium oblong, incurved; trochanter short, enlarged at tip, incurved, about half as thick as long; femur very long, straight, cylindrical, slender, a little convex above before the tip, as long as the thorax and the three basal segments of the abdomen; tibia similar to trochanter, incurved, enlarged at tip, less than half as long as the femur; chela thin, one-half longer than the femur; the hand as thick as the tibia, cylindrical, a little enlarged below just beyond the articulation, straight, shorter than the femur; fingers as long as the femur; slender, straight, viewed in profile a little incurved, the tips hooked suddenly, the movable finger a little shorter; both with a series of sharp teeth inside; legs slender, the two anterior pairs as long as the body, the two posterior pairs extending beyond the body the length of the tarsus; hypopodia oblong, a little incurved, those of the first pair a little pointed before; trochanter short, a little longer than thick; femur long, cylindrical, tibia half as long as the femur; first tarsal joint as long as the tibia, second as long as the femur; the two posterior pairs with the trochanter and base of the femur enlarged; femur with a spurious articulation before the middle; first tarsal joint shorter than the tibia; all legs with long fine hairs; two very slender and strongly-curved hooklets on tip; between them an anchor shaped plantula with a thin cylindrical stem. The palpi of female are as long as those of the male. Length 2.3^{mm}=.09 inch. Habitat: Wyandotte Cave, Indiana; five males, one female, in alcohol. The female has a small external indentation of the movable finger of the mandibles; the finger of the males has no indentation, but in two specimens the tip is somewhat broader, more obliquely cut, and with a fine engraved line where the indentation should be.'"

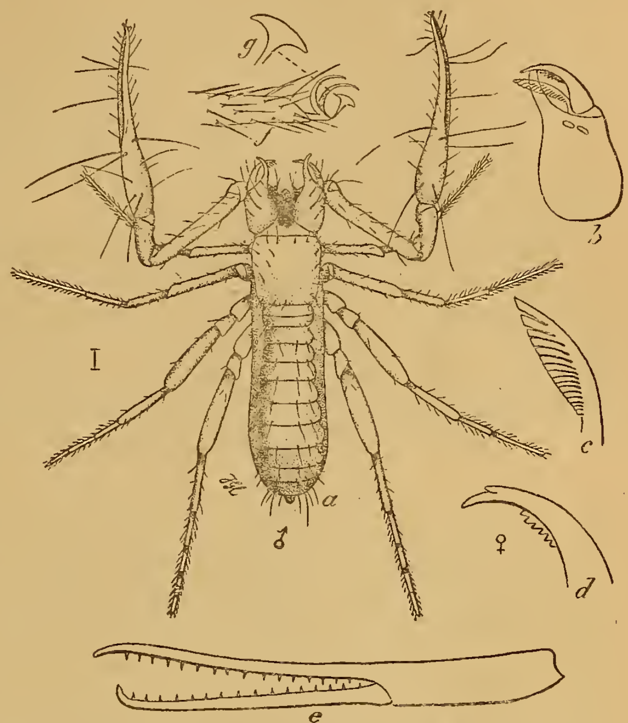

FIG. 12.—*Chthonius packardii*: *a*, male enlarged fifteen times; *b*, mandible; *c*, serrula of the mandible; *d*, finger of the mandible; *e*, chela of pedipalp; *f*, end of tarsus; *g*, plantula.—After Hubbard.

The discovery of this blind Pseudoscorpion in America is very interesting. It belongs without any doubt to Schiœdte's genus Blothrus, which, on careful examination, proves, however, to be merely Chthonius with undeveloped eyes, and is the smallest species known.

"*C.* (Blothrus) *spelæus* differs by the longer tibia of the palpi, and by the two anterior pairs of legs with a two-jointed tibia. The last statement is doubted by Mr. Simon, but Mr. Schiœdte's accuracy is so well known that his statements are to be accepted. (*B.*) *abeillii* has much longer palpi and legs, and the sexes of dissimilar development. (*B.*) *brevimanus* is only known to me by an insufficient diagnosis. (*B.*) *cephalotes* seems rather similar to (*B.*) *packardi*, only a little larger, the mandible granulated, nearly as long as the thorax; the fingers of the palpi equally longer."

Another form, with two eyes, occurs in the Mammoth Cave:

"It is pale yellowish; the thorax, mandibles, palpi, legs, and segments of the abdomen about the same color the base of the mandibles a little darker, the abdomen between the segments and on the sides paler.

"I have seen only three specimens in alcohol, all from the Mammoth Cave region, one couple from one locality and a female from another locality. I have compared all very carefully with *C.* (Blothrus) *packardi* from Indiana. They are a little longer, 3 to 3.2^{mm} long, a little darker or perhaps a little less white, but all three have on each side of the thorax one eye, distant from the anterior border as far as the length of the diameter of the eye; the movable finger of the mandibles is not indented. The examination of all other details shows no difference. Habitat, from the bottom of Dome, Mammoth Cave, with dead bat, November 9, and Long Cave, near Glasgow Junction, Kentucky, one mile from daylight, May 11."

My specimens, two males and two females, from the Rotunda in Mammoth Cave, have each two eyes, which, however, vary in the convexity of the cornea and are so faint as to be easily overlooked. The males are very white; one of the females shows traces of an indentation on the mandibular finger. The male from which the figure was drawn measures 3^{mm} in length, or, exclusive of the mandibles, 2.3^{mm}. The hairs upon thorax and abdomen, which are correctly represented in the figure, differ slightly from the description of the blind form, but they are probably variable.

To Dr. H. Hagen my grateful acknowledgments are due for invaluable aid and suggestions. I have added nothing to his observations on Pseudoscorpions; the portions indicated by quotation marks are copied almost verbatim from his manuscript.

Hagen states in his original notice in the Zoologischer Anzeiger, in which he speaks of the present species as *Blothrus packardi*, that "it certainly belongs to Blothrus, Schiœdte, and is the smallest known species."

Having received *C. spelæus* from Mr. Simon, I have been able to compare the two forms. It seems to us that the present species belongs at least to a separate section of the genus from *C.* (Blothrus) *spelæus.* This is seen not so much in the form of the body of *C. spelæus* (Schiœdte), though the cephalothorax is much narrower, as in the much greater length of the pedipalps. In *Chthonius packardii* the base of the hand, when stretched back, reaches the end of the abdomen; in *spelæus* the distal end of the second long joint reaches nearly to the end of the abdomen, hence the pedipalps are nearly as long again as in *Chthonius packardii*; the third joint is very slender, and three to four times as long as in *C. packardii.* The cheliceræ differ but little, as they do not vary much throughout the family, though they are smaller, and at the base are less swollen or pyriform, while the fingers are less bent. The legs in *C. spelæus* are much longer, the joints being longer and slenderer. It is twice the size of our Mammoth Cave species, and in alcohol it retains its bleached, white color.

Chthonius abeillei Simon closely resembles *C. spelæus*, agreeing with it not only in the slenderness of the appendages, but also in the great length of the third joint of the pedipalps. *Obisium* (Blothrus) *cerberus* (Simon) also agrees with the two foregoing species in the same characters. *Obisium cavernarum* appears to connect these three species with *O. simoni* Koch and the other out-of-door forms. Dr. Hagen remarks that *C. packardii* is nearest allied to *C. cephalotes* Simon, as shown by Simon's figure 20 (Pl. XIX). This must be the case, as the third joint of the pedipalps is short and broad and of the same form as in our *C. packardii.*

CHTHONIUS CŒCUS Packard. Plate XI, figs. 4, 4*a*, 4*b*, 4*c*.

Chthonius cæcus Pack.,* Amer. Naturalist, xviii, 203, Feb., 1884.

Body unusually short and broad, and the limbs short and thick; thorax a little shorter than broad, the sides parallel, slightly narrower behind than in front. The setæ on the cephalothorax and abdomen less distinct than in *C. packardii*, but arranged in nearly the same manner, though I could find none on the front of the cephalothorax; the disc is free from them, as in *C. packardii.* The eyes are entirely wanting, there being no traces whatever of them, not even any pigment-spot. The general color of the body (in alcoholic specimens) the same as in *C. packardii*, the body being pale horny, the abdomen whitish, the dorsal sclerites pale horn, the cheliceræ reddish, and the pedipalps a little paler. Cheliceræ very stout and thick, considerably more so than in *C. packardii*, the fingers quite blunt at the end, the thumb acute, with six distinct teeth; the serrula much as in *C. packardii.* Pedipalps unusually short, the second joint short and nearly twice as thick as in *C. packardii;* the third joint short, thick, conical, much as in *C. packardii*, except that it is somewhat thicker; the manus is very short and thick, really but little longer than the third joint; the movable finger nearly twice as long as the manus, and with long setæ; it is stout and very straight, and serrulate on the inner edge. The legs are very short and thick; the second trochanters very thick; the fourth or hinder pair of legs not much longer, if any, than the abdomen, while in *C. packardii* they are fully twice as long. Abdomen of 11 segments, broad and short, with the tergal sclerites rather more distinct than in *C. packardii.*

Length of body, with the cheliceræ, 1.5^{mm}.

Two specimens from Weyer's Cave, Virginia.

Remarks.—This species differs remarkably from the other cave species, being very broad and short, with straighter, less curved fingers of the pedipalps, while the hind legs are scarcely longer than the abdomen; and the cephalothorax is actually shorter than broad. It is totally blind, with no traces of even a pigment-spot. It is a notable exception to the law that blind forms have usually a slenderer body and attenuated extremities. Unfortunately I have no out-of-door species to compare it with. It agrees with the generic characters given by Simon in his great work on the Arachnida of France, the cephalothorax narrowing behind, and the fingers of the pedipalps being straight. It must be confessed, however, that these are very slight generic characters, though Simon of course mentions others. It seems to us that the three species of the suppressed genus Blothrus, *i. e.*, *B. spelæus*, *B. abeillii*, and *B. cerberus*, all of which have remarkably long pedipalps (the third joint being very long and slender), long

* The article containing the description of this species was by oversight unsigned by the author's name.

slender legs and no eyes, in reality differ more from the other species of Obisium than does the generally-accepted genus Chthonius. As we have attempted to show however, contrary to Hagen's opinion, the American *C. packardii* is not a true Blothrus; it could not properly be separated from *C. cœcus.* They both agree in the short, thick, conical third joint of the pedipalps.

It may be interesting in this connection to learn something of the habits of the species of the two genera Obisium and Chthonius. As almost nothing is known of the habits of our American species, we are obliged to compile the following account from M. Simon's excellent work.

The species of Obisium live in moss and vegetable detritus; they are very agile, and run backwards easily. Of seventeen species three (Blothrus) have no eyes and inhabit caves; these three have been already referred to by name. Of fourteen French species with eyes, one only (*O. cavernarum*) has "very small punctiform eyes." It is a cave-dweller. Of the fourteen species, only one other lives in caves; this is *O. lucifugum.* In this species the eyes are "very small." All the other species have either four or two eyes. We here see a very direct connection between cave-life and the eyeless forms in the species of southern and central Europe.

Turning to the genus Chthonius, there are seven French species described by Simon. He says that "the Chthonii also seek dark and damp places; several are peculiar to grottoes, and the ordinary species are sometimes met with in wood-piles and caves. Thus at Troyes M. J. Ray has observed in caves three species of Chthonius (*rayi*, *orthodactylus*, *tetrachelatus*), where they run with agility on the walls, and escape by hiding in the little fissures, in which they shoot forward as previously described."

Of the seven species of Chthonius enumerated by Simon one (*C. cephalotes*) has no eyes; it lives in caves. In *C. microphthalmus* the eyes are very small; it also usually occurs in caves. Thus the majority of the species occur in caves; three of them permanently so. It will also be seen that there is an obvious relation between those which are totally blind and live in caves; *i. e.*, those without eyes inhabit caves exclusively, those with very small eyes are found partly or mostly in caves, and those with perfect eyes are not cave-dwellers. The relations of cause and effect in the blind species of this family are, then, very marked, the adaptation to life in partial or total darkness involving the disuse and consequent atrophy of the organs of sight. It is so also with the North American species.

To return to the American cave species: It appears that in inhabitants of even one cave (Mammoth) there are individuals of *Chthonius packardii* existing, as regards the eyes, in three conditions, though all must be in total darkness. (1) Some have two eyes, with the cornea as usual; (2) some have no cornea, but the silvery dot indicating the retina is retained; while in others all traces of the eyes have disappeared. On the other hand, in those individuals existing in Salt Cave (a small cave not wholly dark) the two eyes are distinct. These facts would indicate that the Mammoth Cave examples must be the descendants of some out-of-door species, to which the Salt Cave individuals are nearest allied. Moreover, the difference between the eyed and eyeless forms are apparently individual rather than varietal.* The presence or absence of eyes in this case are not generic characters. The cave forms retain the generic characters of out-of-door species of Chthonius, both American and European. The characters in which individual variation of *C. packardii* occurs are apparently the parts of the eyes alone. This loss of eyes, partial or total, seems to us to be the result of the direct influence of the surroundings upon the organism. When we take into account both the European and American species as a whole (*C. cœcus*, with its stout body, being an as yet inexplicable exception), the eyeless species have, besides the loss of eyes, very slender bodies and remarkably attenuated pedipalps and legs, especially the hinder pair. We do not think that natural selection can in such a case as this be regarded as an efficient cause in producing the cave forms. The eyes are useless in total darkness; hence from disuse they gradually, after a few generations, disappear. On the other hand, the limbs tend to grow longer, to perhaps exert a tactile sense; and this trait, being favorable to the species, is gradually further developed, until it becomes fixed in the organism by heredity. The result is that all the

* Those from the Rotunda have eyes (Hubbard); those from the Labyrinth had pigment-spots or were totally blind. The Rotunda is much nearer the mouth of the cave than the Labyrinth (see map); hence the eyed forms may have been more lately introduced into the cave. Further research should be made in this direction. Dr. Hagen's specimens were mixed up, part from Mammoth and part from Long Cave.

individuals become long-limbed and blind. There is apparently no struggle for existence, but the direct influence of darkness, united with heredity, are plainly the immediate agencies in the transformation.

Family PHALANGIDÆ.

PHALANGODES ROBUSTA Simon. Plate XIV, figs. 2, 2*a*, 2*b*.

Scotolemon robustum Pack. Bull. Hayden's U. S. Geol. Surv. Terr., iii, 164, 1877.
Phalangodes robusta Simon, Arachnides de France, 156, 1879.

This species is here referred to at length, because it is the only out-of-door species of the genus yet known in the West; and by reference to the figures and description it will be seen how much the cave forms differ from it.

Eight females ?. Tegument deep reddish, with the hinder segments finely bordered with brown; tarsal joints paler, with dense blackish specks; cephalothorax a little paler red, marbled with reticulated darker lines. Body pyriform, two-thirds as long as broad; cephalothorax a little more than half as long as wide, the front edge slightly rounded, with the angles well marked. The eye-tubercle not so large and high as in *S. terricola* Simon, being of moderate size. Eyes black and large, fully developed, while those of *S. terricola* are nearly obsolete. Abdomen a little longer than broad; the first five segments well marked, the sutures being much more distinct than in *S. terricola* or probably any other European species, judging by Simon's drawings. The last three segments, with the outer edge of each segment, free, not united with each other, as are the five basal joints; last segment with the ventral slightly projecting beyond the tergal portion. Beneath are seven well-marked sterna, the first and second being united without suture.

FIG. 13.—*Phalangodes robusta* Pack., (enlarged). *a*, pedipalp; *b*, *c*, chelicera.

Chelicerae of the usual form, rather stout at base of first joint, but much as in *S. terricola*; second joint moderately long; hand of the usual form, a little unequal. Pedipalps unusually short and thick, much more so than in *S. terricola* or any other species described by Simon; basal joint broader than long, with a pair of stout, sharp spines and four small ones; second joint nearly two thirds as broad as long, full and swollen above, beneath with four large spines; third joint much slenderer, one half as long as the second; fourth joint nearly twice as long as broad, with five stout spines, of which the fourth is much larger than the others, the fifth minute; fifth joint as long as, but slenderer than the fourth, with five stout spines, the fifth and terminal spine much larger than the others, and as long as the joint is wide. This joint is a little hairy, while the others are nearly naked.

Legs stout, much more so than usual in the genus; anterior pair with three tubercles ending in hairs on the second joint; a larger tubercle on the fourth joint; the three other pairs are unarmed. Second pair of legs longer than the first by one-third of their length. The second and fourth pairs are of nearly equal length, the fourth pair differing in having the third joint considerably swollen; the third and first pairs of the same length. On the coxæ of the second pair of legs is a pair of stout conical spines, meeting over the median line of the body. The anterior tarsi are three-jointed, as in *S. terricola* of Europe, the middle one much shorter than the other two, which are of equal length; those of the second pair five-jointed; those of the third and fourth pairs four-jointed, the ends of the tibiæ being constituted so that the limbs appear as if they had five tarsal joints. Ungues rather long and moderately curved. The legs are stouter and shorter than in *S. terricola*, and none of my specimens have the long, singular, sinuate appendage on the first joint present in *S. terricola*. (They are not referred to by M. Simon in his description, though my specimens were received from him.)

Length of body, exclusive of the mandibles, 3.5^{mm}; breadth, 2.5^{mm}.

Compared with *S. terricola* Simon, from Corsica, which also lives under very large stones, and is found common at Porto-Vecchio after the heavy spring rains, but which has not yet occurred in caves, our out-of-door form is much stouter, with much shorter legs, and also differs in its well-developed eyes, dark brick-red tegument, and dark markings. It was discovered in Colorado in 1874 by Mr. Ernest Ingersoll, while attached to Hayden's Geological Survey of the Territories. He tells me that it did not occur in any cave, the exact locality and mode of life being forgotten. It will most probably be found under stones.

Compared with *Phalangodes flavescens* (*Erebomaster flavescens* Cope, Amer. Naturalist, vi, 420, 1872, from Wyandotte Cave, Indiana), which is allied to the European *S. piochardi*, which inhabits caves near Orduno, it differs in the basal segments being much more distinct, where the sutures in the tergum are obsolete in *S. flavescens*. The eye-tubercle is a little smaller proportionately, while the eyes themselves are much larger. The mandibles and maxillæ are shorter, while the legs are very much shorter and stouter. The color is deep red, the cave species being pale yellow. These are all differences such as we should expect to find between a cave dweller and one which has lived out-of doors under stones, etc. In these two species we have forcibly brought before us the great structural differences brought about by striking changes in the environment of the two species.

PHALANGODES FLAVESCENS (Cope). Plate XII; Plate XIV, fig. 1.

Erebomaster flavescens Cope. Amer. Naturalist, vi, 420. Figs. 114, 115. July, 1872.
Phalangodes flavescens Simon. Arachnides de France, vii, 156. 1879.

Male and female specimens. Body broad and stout, uniformly straw yellow, including the body and appendages. Cephalothorax broad and short, but little longer than broad, the sides widening a little toward the hinder edge, being wider on the hinder edge than elsewhere; it is somewhat constricted on the anterior third just behind the eyes; the surface is considerably rounded, the posterior edge is quite free and distinct from the abdomen; the latter is unusually short and broad, with three segments visible from above and six, in all, beneath, the basal one being the longest. The eye-tubercle is large and high, usually forming a cone slightly higher than broad at the base. The two eyes are black, distinct, and situated on each side, near the base of the conical tubercle. The cornea is underlaid by a broader dark mass forming the retina. Cheliceræ with the first joint rather long and slightly contracted in the middle; the second joint or hand is rather thick, not twice as long as thick; the outer finger is much larger than the inner, much curved and pointed, with a series of ten small conical teeth on the inner edge; the inner tooth is straight, with five large blunt teeth on the inner edge. Three short setæ can be seen on the outer half and two on the inner side near the fingers. Pedipalps less than twice as long as the body, but nearly twice as long as the cephalothorax; coxal joint very broad and short; first joint longer than broad, cylindrical, with a small setiferous external spine in the middle, and on the inside an anterior much larger spine bearing a bristle; second joint longest of all, with four subequal setiferous spines on the outside; on the inner side two large spines, the first half as long as the joint is thick, and bearing a stout movable spine as long as the joint is thick; the second spine is somewhat smaller; these are succeeded by four very small spines situated on the proximal half of the joint, while the edge, especially in the middle, is finely toothed; on the distal end is a group of three unequal spines, one large and long; third joint a little more than half as long as the second, with five or six unequal spines visible on each side, two of them being as long as the joint is thick; joint four is somewhat elongated, barrel-shaped, with four stout spines on the outer and three on the inner edge, the latter being long and slender, with long setæ, the basal one as long as the joint is thick in the middle; the fifth and last joint has four external stout curved spines, and three large and two minute straight inner spines; four of the setæ, though differing in length, are as long as the joint is thick; the terminal spine is shorter and thicker than the others, with a movable seta, which is as long and fully twice as thick as the others.

First pair of feet much smaller and shorter than the second pair, the last tarsal joint four-jointed; second pair slenderer than the fourth pair; the third joint not so much swollen; the last tarsal joint divided into twelve joints; length of entire leg, 8^{mm}; third pair a little longer than first pair, and one-third shorter than fourth pair; the latter pair 8mm in length, being of the same length as the second pair, but with the basal joint longer, the last tarsal joint being subdivided into but three joints. The penis is 1.25mm in length, the basal portion not curved, the smaller distal portion a little shorter than the basal, and ending in a corneous short cultriform thin appendage with four subacute teeth on the outer edge.

Length of body, not including the cheliceræ, 3mm; breadth, 2mm.

Subvariety *Weyerensis*. Those from Weyer's Cave, Virginia, all differ in habit from the Wyandotte forms, and are easily distinguishable, as seen in male and female specimens from Weyer's Cave. They are larger and darker, with brown specks, as seen in Plate XII, fig. —. The second pair of legs, as compared with those from the Wyandotte Cave, are shorter and thicker. The penis, however, is a little longer, being 1.5mm in length, rather slenderer, and the cultriform appendage differs a little in shape, while the basal half is much more curved at base. It should be borne in mind that these differences are such as we would expect to meet with in individuals from a smaller cave and one more liable to be reached from the outside world; and the differences, moreover, are such as ally this variety to the more robust and out-of-door forms.

One specimen from a cave near Dismal Creek (collected by Messrs. Sanborn and Beckham) was like Wyandotte specimens in size, and smaller than the var. *weyerensis*, but resembled the latter in color.

Variety 2, *cæcum*, (Pl. XII) 10 males and females from the Carter Caves (Bat Cave) are blind, the cornea being present, but with no retina. In all the specimens the cornea is equally colorless, and the individuals must be practically blind. The eye-tubercle is smaller and blunter than in Wyandotte examples. The individuals are a little smaller and paler than the variety *weyerensis*; the pedipalps are the same, except that there appear to be two spines on the inside of the second joint instead of one, as in *weyerensis* and the typical forms from Wyandotte Cave; the length and size of the second leg are identical with those of the typical Wyandotte examples, being slenderer and slightly longer than var. *weyerensis*, but the third joint is setose; that of the Wyandotte specimens, at least in some cases, being without setæ. The penis in *cæcum* is but slightly over 1mm in length; it is shorter and smaller than in the Wyandotte and Weyer specimens, the basal joint shorter as well as the second joint, and the teeth on the cultriform appendage are shorter and blunter.

Remarks.—While, as observed above, the Weyer's Cave specimens are a pretty well marked variety, and are more like out-of-door forms than the Wyandotte Cave examples, and this would be what we should expect to find in inhabitants of a larger and much deeper cave, it is singular to find that the individuals of var. *cæcum* from Bat Cave, which is a smaller cave and apparently more open to daylight than Weyer's Cave, should be a more attenuated and blind form. We should naturally expect that the Wyandotte individuals would be blind.

PHALANGODES ARMATA (Tellkampf). Plate XIII, figs. 1, 1*a*–1*h*.

Phalangodes armata Tellkampf, Archiv für Naturgeschichte, X Jahrg., Bd. 1, 320, Taf. viii, figs. 7 to 10. 1844.
Acanthocheir armata Lucas, Ann. Soc. Ent. France. 1860.
Wood, Proc. Essex Institute, 36. 1868.
Phrixis longipes Cope, Amer. Naturalist, vi, 421, July. 1872.
Phalangodes armata Simon, Arachnides de France, vii, 156. 1879.
Phrixis longipes Hubbard, Amer. Ent., iii, 39, Feb. 1880.

Male and female. Body rather narrow and long compared with *P. flavescens*, being considerably longer than broad; whitish straw-yellow, including the body and appendages, the young being white. Cephalothorax considerably longer than broad; the sides widen somewhat towards the hinder edge; they are not constricted near the middle; the surface is moderately convex, and the posterior edge is nearly straight and free from the abdomen, which is broad and short, but longer and more pointed than in *P. flavescens*, with five segments to be seen from above and six beneath, the latter being the number of uromeres in the genus Phalangodes; the last segment (seen from above) is less than half as wide as the last one in *P. flavescens*, and is narrow and conical in shape.

The eye-tubercle is about half the size of that of *P. flavescens*, and is conical in shape; there are no traces of the eyes, either of a cornea or dark pigment mass.

Cheliceræ slenderer than in *P. flavescens*, the fingers rather longer; the movable finger with about twelve teeth on the inner edge, the thumb with six obtuse teeth. Pedipalps slender; the coxa and basal joints much as in *P. flavescens*, but the spine on the inner side of the first joint twice as long; second joint (female) scarcely thicker than the first, inner edge not so serrulate as in *P. flavescens*, the two large spines twice as long as the joint is thick; the third joint a little more than half as long as the second, with two long spines on one side and two unequal much smaller ones on the other; fourth joint but slightly longer than the fifth, with two large long spines on each side; fifth and last joint not so thick as the fourth, only two long spines on each side, the terminal spine two-thirds as long as the joint itself.

All the legs remarkably long and slender, eight-jointed; the tarsus five-jointed.

First pair the shortest, not quite so long as third pair; second pair about one-third longer than the first, with remarkably attenuated tarsi, with a single weak claw; length, 18^{mm}; third pair with the coxal joint larger than in any of the other pairs (first and second, and even the fourth), and considerably shorter than the fourth; fourth pair of legs very long, but considerably shorter than the second pair, with six tarsal joints, the last somewhat swollen, considerably longer than the penultimate joint, and bearing two rather large, long, slender claws, and three long, large setæ.

The ovipositor* is a very large organ, being 1.5^{mm} in length, or more than a third as long as the body, and is as thick as the cheliceræ or the third pair of coxæ; it projects forward when fully protruded (at least in alcoholic specimens); it is not chitinous, is muscular, not jointed, is slightly curved, and ends abruptly, with (as seen in profile, Fig. —) about six fine setæ on each side, those on the extreme side being nearest together; these are probably tactile hairs (the eggs are probably laid in crevices).

The penis differs remarkably from that of *P. flavescens*; it is rather thick when extended, and slightly over 1^{mm} in length, or about one-third as long as the body; the basal segment is not much longer than broad, the second is over three times as long as the basal segment, of uniform width, and divides at the end into two lateral slightly-curved points, and a longer, straight, acute projection; the sides are setose, especially towards the end, including the lateral horns.

Length of body, 3 to 4^{mm}; breadth, 2 to 2.5^{mm}; of cheliceræ, 2^{mm}; of pedipalps, 5^{mm}. Labyrinth and Dead Sea, Mammoth Cave (Packard); Dixon's Cave (Packard); Martha's Vineyard, Mammoth Cave (Hubbard); White's Cave, several (Packard); Diamond Cave, Kentucky (Packard).

Tellkampf's figure was crude and imperfect, as the second pair of legs were wanting in his specimens, which were evidently young, while the tarsal joints of the remaining limbs were not correctly drawn; hence his description was incorrect as regards the limbs, as he says the length of the limbs differs little. Professor Cope, having specimens of this species with all the legs present, and basing his comparison with Tellkampf's genus on the latter's figure, copied by us in the American Naturalist, founded his genus *Phrixis* on the character of the "multiarticulate tarsi," although he says the tarsi of the "longest legs" were "not counted." His specimens were mature. Mr. H. G. Hubbard gives an excellent figure of the female, which he incorrectly considers to be a male.

The following note on this species is copied from Mr. Hubbard's paper.

Phrixis longipes Cope (Fig. 2).—In Professor Cope's description of this species (*l. c.* vi., 421) some confusion occurs as to the tarsi. In the longest legs the number of joints was not counted, although they are mentioned as "multi-articulate," and this, with the absence of eyes, is made to characterize the genus.

In the specimens before me the anterior and shortest pair of legs have five-jointed tarsi, ending in a single claw, without an opposing bristle, as given by Cope; the second and longest pair have nine tarsal joints, with a single claw; the third and fourth pairs are intermediate in length between the first and second, they have each six-jointed tarsi and a pair of claws. The first tarsal joints in all the legs equals or exceeds the femora and tibiæ; the second joint, though shorter than the first, is very long. The palpi (that of the left side is omitted in the figure) have five joints and a terminal spine; the basal joint bears a single spine; the second joint has five, three below the middle, springing from the outer edge, two above, springing from the inner edge; the third joint has one on the outer and two on the inner edges; the fourth joint has two external and three internal; and the fifth, two spines on

* This organ was mistaken by Mr. Hubbard in his description for the penis and figured as such. Amer. Ent., iii, 79.

either edge; the spines are all tipped with long bristles, bent towards and crossing those of the opposite row. The male *organ is cylindrical, without joint or median swelling, as thick as the coxæ, not chitinous, bearing at tip a few fine hairs; when fully protruded it equals one-third of the body in length. The abdomen shows but four narrow and one conical terminal segment beyond the cephalothoracic shield. The conical eminence at the anterior border of the dorsum, between the first pair of legs, is without trace of ocelli. Length without appendages, $2^{mm} = .08$ inch; longest leg, $18^{mm} = .72$ inch.

Two specimens in alcohol from Martha's Vineyard, in the Mammoth Cave.

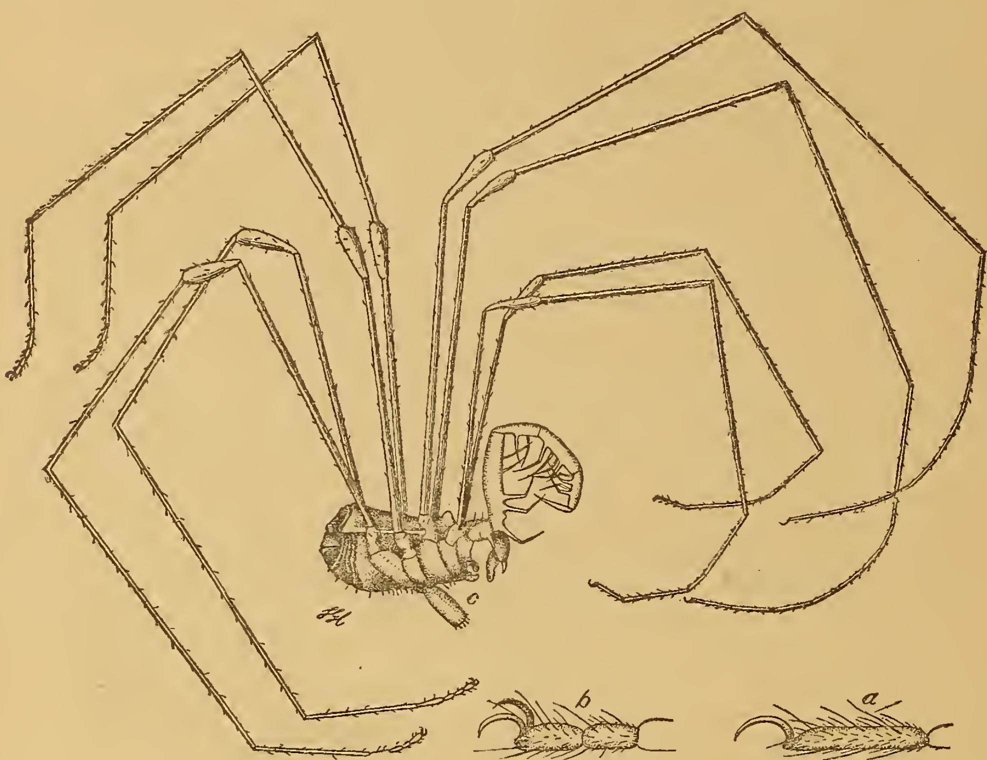

FIG. 14.—PHALANGODES ARMATA: *a*, claw of anterior tarsus; *b*, claws of posterior tarsi; *c*, enlarged ten times (after Hubbard).

Remarks.—This form, though living in Mammoth and adjoining smaller caves, and sometimes occurring near daylight, seems to undergo almost no variation, either as regards the absence of any traces of eyes or the remarkable length of legs. It is the extreme in a series of forms, including *Phalangodes flavescens*, var. *cæca*, *weyerensis*, and the terricolous *P. spinifera*, with the very stout short-legged *P. robusta.* Without much doubt *P. armata* has been derived from a form like *P. spinifera;* or from an earlier terricolous species, from which both diverged.

PHALANGODES SPINIFERA, n. sp. Plate XIII, figs. 2, 2*a*, 2*b*, 2*c*.

One female. Body rather broad and stout; more contracted on the sides behind the inter-ocellar spine than in *P. robusta.* Cephalothorax widening considerably behind the hinder edge; it is two-thirds as long as the body. The eyes are considerably smaller than in *P. robusta*, black, and placed unusually far apart; between them is a conical projection ending in a high, sharp, prolonged spine. There are five abdominal segments seen from above, the fifth narrow, conical, minute. The surface of the cephalothorax is rough, with sharp granulations, and the hind edge, with that of the succeeding segments, are adorned with a row of sharp spines, the median ones largest, those on the fourth segment being more numerous, large, and sharp, with a group of about five large ones of unequal size on each side of the body.

The chelicerae are 2.5^{mm} long, much longer and slenderer than in *P. robusta*; but closely like those of *P. armata* from Mammoth Cave, the first joint being similarly contracted toward the base;

* This appears to be the ovipositor of the female.

the second joint is a little stouter, but the fingers are larger. The pedipalps are remarkably long and slender, the terminal joint very long, and ending in a short, powerful. solid spine; the first joint is scarcely longer than the second is thick, with three inner teeth and a single stout outer one; second joint nearly as long as the third and fourth together; on the inside are two large basal teeth ending in hairs, and in the middle are three small unequal ones; third joint thicker than the second, a single distal internal seta, while the outer edge is finely denticulate; fourth joint nearly twice as long as the third, with four or five fine external spines; a stout setiferous basal internal spine and a much larger one on the distal third; fifth joint about the same length as the second, being very long, the inner edge nearly straight, the outer edge regularly curved, with no spines; on the inner are four large setiferous spines, the longest seta being somewhat longer than the joint is thick; the joint ends in a large, stout, short, solid spine; length 7^{mm}. Legs long and slender; first pair 4.5^{mm} long, with four tarsal subjoints; second pair 9^{mm} long, with eight small tarsal subjoints, while *P. robusta* has but five; fourth pair with five subjoints in the tarsus, and white in color. Color of the body dull honey-yellow; edge of the abdominal segments dusky; second pair of legs dusky, especially on the distal two-thirds; second, fourth, and fifth joints of the fourth pair dusky, except at the ends. Length of the body, including the folded cheliceræ, 4^{mm}.

This in some respects remarkable species differs from all the others of the genus either in Europe or this country in the spiny body, the very long pedipalps, with their long terminal joint ending in a short stout spine, also the long interocellar spine and the remote eyes. It has long legs for a terricolous species, the second pair having eight tarsal subjoints. It approaches *P. armata* in the shape and length of the pedipalps and cheliceræ, as well as in the many-jointed second tarsi. It is possible that the Mammoth Cave species has been derived from some such form as this. The present species was collected by us either in Key West or Tortugas, Florida, probably the former locality. No note was taken as to its exact habitat. The description is introduced here because it is the only out-of-door form east of Colorado as yet known.

Remarks.—Of the genus Phalangodes it may be said that while it was instituted by Tellkampf for a single species, that inhabiting Mammoth Cave (*P. armata*), it is evident that this is the most aberrant species of the genus, and that the terricolous species, as well as the more robust of the cavicolous forms, should more properly be regarded as the most typical species. On the other hand, as our figures and descriptions will show, *P. armata* should not be regarded as generically different from the eyed species formerly by Simon and ourselves placed under Scotolemon. We see that the differential characters are elastic and only specific, since, for example, *P. flavescens* has a blind variety.

Simon records six French species (two additional ones occur in Spain and the other in Italy) and says: "The Phalangodes are all essentially lucifugous; the most are cavernicolous, some are terricolous, others are found simply in the mosses of thick and humid woods. The *Phalangodes armata* Tellkf. of the United States presents no traces of eyes; in the European species these organs are, on the contrary, clearly visible, being colored black. Authors have founded on this character the genus *Scotolemon;* but I have recently found a species in which the eyes are extremely reduced, deprived of pigment, and even sometimes disappearing, thus compelling us to reunite the genera Scotolemon and Phalangodes. The fineness and length of the appendages are always in relation with the atrophy of the eyes; thus, in *P. armata*, which is blind, the limbs attain their maximum of development, while in *clavigera* and *terricola* they remain short and more robust, but other species, such as *lucasi* and *navarica*, make exactly the passage between the two extremes." *P. navarica* Simon, from a cave in the Lower Pyrenees, approaches nearest to *P. armata* in three of five specimens; "the eyes are excessively small, punctiform, and deprived of pigment; in the two others it is impossible to distinguish them; the feet are also slenderer and longer than in the other Pyrenean Phalangodes, without, however, attaining the dimensions of those of *P. armata*."

It appears that *P. armata* is in the form of its cheliceræ and pedipalps related to the Floridan *P. spinifera*, differing mainly in the slenderer body, the longer legs, and absence of eyes and spines on the body. It is from such a form as this that *P. armata* may have been derived.

PHLEGMACERA* CAVICOLENS Pack. Plate XIV, figs. 5, *5a–5g*.

Phlegmacera cavicolens Pack., Amer. Naturalist, xviii, 203, Feb., 1884.

Generic characters.—In this genus the body is not spiny, and is slightly compressed, much less flattened than usual, no broader than high, and the tergal as well as ventral surface is unusually convex and rounded. The cephalic plate bearing the eyes is about half as long as broad; behind the cephalic plate are two very short thoracic segments, both together not so long as the cephalic plate. The abdomen forms two-thirds of the length of the body. There are nine well-marked abdominal segments seen from above, and six short well-marked urosternites, besides the basal triangular urosternite. The cheliceræ are three-jointed, and the hands are bent inward somewhat as in Nemastoma. Pedipalps six-jointed, considerably longer than the body, the joints simple, not spiny; the fifth joint longer than the others, much swollen; the sixth oval, simple, not spiny. Second pair of legs (probably) ending in multiarticulate whiplash-like tarsi. One pair of legs, either first or third, with undivided tarsi.

This genus does not approach very near any of the European genera, such as Liobunum, Megabunus, Oligolophus, Acantholophus, etc. It approaches Prosalpia most in the form of the body, especially in the relations of the cephalic plate to the abdomen and the size of the cheliceræ; but differs in the pedipalps being simple, while the first and third pair of legs are probably quite different in the undivided tarsal joint. It appears to belong to Simon's subfamily Phalangiinæ, but has no very close affini ties to any of the European genera.

Specific characters.—Body dark brown; appendages of a pale horn color; cephalic plate between one-third and one-half as long as broad. Eyes large, prominent, contiguous, scarcely situated on an eminence; they are black and well developed. The abdominal segments above with numerous scattered dark granulations, which become larger dorsally; a series of large, short, but broad, dorsal transverse blackish discolorations; a broad, dusky, lateral, diffuse band low down on the sides of the tergal sclerites next to the upper edge of the urosternites. Cheliceræ pale horn color, black at the tips of the fingers. Second joint moderately long, equal to the hand of the third joint in length; manus rather thick, oval in outline; the outer surface with numerous fine setæ; the fingers very unequal, the outer or movable one about two-thirds as long as the manus, a good deal curved, with a single tooth near the end, and a series of about twenty-three or twenty-four separate, stiff, straight, even setæ, corresponding to the serrula in Phalangodes; inner finger (thumb) straight, not much over half as long as the other finger, with two or three teeth near the tip, and along the inner edge a sinuous series of small setæ of unequal length, which ends at the innermost tooth. The pedipalps are from one-fourth to one-third longer than the body; the first joint is as thick as long; second twice as long as thick; third twice as long as second and not so thick; fourth not so long as third but considerably thicker; fifth longer than any of the other joints and much swollen, oval in form; sixth no longer than fifth is wide, and obtuse at the tip, contracted at the base; all beyond the basal joints densely and finely setose.

Of the legs, which were unfortunately detached from the specimen, two were observed; what were perhaps the first pair are five-jointed, the basal joint minute, the second and fourth of equal length, the third not being much longer than second is thick at base, while the tarsus is long and slender, tapering to the minute claw; second leg (?) very long, first joint very small and short, second shorter than fourth, the third between one-third and one half as long as the second, the fourth, with joint five, divided at the end into nine minute joints, and the last joint (joint six) subdivided into twelve joints, the last being equal in length to the four preceding, and bearing a single minute claw. Length of body, 4^{mm}; thickness, 2.5^{mm}; width, 2^{mm}. Bat Cave, Carter county, Kentucky. (Packard.) Two specimens.

Family NEMASTOMATIDÆ.

NEMASTOMA TROGLODYTES Pack. Plate XIV, figs. 3, *3a*, *3b*, *3b'*.

Nemastoma troglodytes Pack., Bull. Hayden U. S. Geol. Surv. Terr., iii, 160, 1877.

Ten females. Body rather long and slender compared with the European *N. dentipalpis* Koch, the latter being short and ovate, while our species is contracted at the base of the abdomen. The eye-tubercle is rather large and prominent; the eyes themselves well developed, black in recently-

* Nov. genus; Φλεγμαῖος, inflated; Κέρας, horn or feeler.

molted specimens, but in others scarcely distinguishable from the dark-brown, finely-shagreened tegument. Behind the eyes the body contracts dorsally, as well as laterally. On the front edge of the cephalothorax is an acute median spine. The six basal abdominal joints are coalesced, forming a single piece, segments 3 to 6 being indicated by a pair of somewhat transverse, high, well-marked tubercles (not forming true spines as in *N. dentipalpe*). The four terminal segments are free; the terminal one subtriangular, one fourth shorter than wide. Beneath are seven well-marked sterna, with lunate, dark spiracles on the sternum of the second segment.

Cheliceræ (Plate XIV, fig. 3) hairy, with the basal joint not so long as broad; second joint of the same width throughout, not swollen toward the end; third joint bent downward and inward at right angles, the hand directed a little outward; the movable finger as long as the hand is thick. Pedipalps (Plate XIV, fig. 3*a*) very long and slender, hairy, nearly twice as long as the body, while in the European *dentipalpe* they are scarcely half as long in proportion; six-jointed (in *dentipalpe* five-jointed), the basal joint subtriangular in outline, owing to the upper edge being dilated; second a little longer and much slenderer than first, and slightly curved; third a little more than twice as long as the second, very slender; fourth a little shorter than third; fifth three-fourths shorter than fourth; and sixth slightly shorter than the second, rounded at the end, being cylindrical, ovate, and unarmed, though with rather stiff hairs.

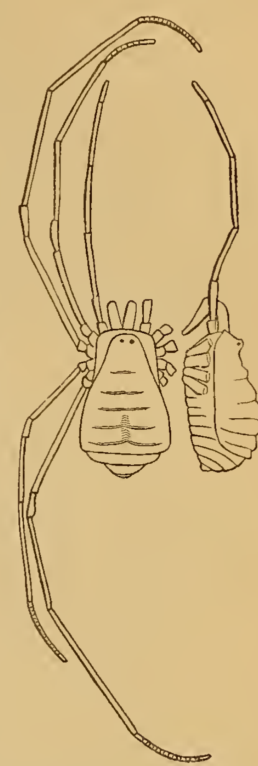
FIG. 15.—*Nemastoma troglodytes.* (Enlarged. Emerton, del.)

Legs much longer and slenderer than in *N. dentipalpe*, with all the coxæ of nearly the same size, the hinder pair being a little shorter and broader. First pair about twice as long as the body, with eight tarsal joints; joints four to seven, together a little longer than the terminal one; a single long, stout, curved claw. Second pair nearly three times as long as the body; length, 4^{mm}; tarsi very long and sinuous, like a whip-lash, the last joint divided into nine subjoints; the claw rather feeble; the second joint half as long as the first. Third pair of legs of the same length as the first pair; tarsi eight-jointed, the two terminal joints subdivided into two joints. Fourth pair nearly three times as long as the body; tarsi eight-jointed, the two last sometimes subdivided into two subjoints (internodes) Length, 3^{mm}.

Found under stones on the bottom of Clinton's Cave, Lake Point, Utah, in a damp place, not infrequent, July 28, 1875. Quite active in its movements. Most of the specimens were apparently distended with eggs.

This is the first occurrence of the genus in America. I have been able in drawing up the above description to compare our species with the European *Nemastoma dentipalpe* of Ausserer, a specimen of which was kindly loaned me for the purpose by Mr. J. H. Emerton. It differs from its European congener by the pedipalps being twice as long, while the tarsal joints of the three hinder pairs of feet are much fewer in number, there being twenty-four well-marked ones on the second pair of legs of *N. dentipalpe*, while the fifth joint of the leg (including the coxa) is subdivided in *dentipalpe* into thirteen subjoints, these divisions in *N. troglodytes* not being well marked.

From the European *N. bimaculatum* (Fabr.), French specimens of which have been kindly loaned by Mr. J. H. Emerton, our species differs in the body being much narrower and slenderer, while the maxillæ and legs are much longer, the tarsi especially being much slenderer and the joints very much less distinct. The back of *N. bimaculatum* is not tuberculated.

The European *N. dentipalpe* lives in moss in woods, while *N. lugubre* (Muller=*N. bimaculatum* Fabr.) is, according to Simon, common in moss and detritus, etc. The effects of a cave life on the American species is seen in the very long palpi and legs and the indistinct sub-joints.

NEMASTOMA INOPS Pack. Plate XIV, figs. 4, 4*a*–4*c*′.

Nemastoma inops Pack., Amer. Naturalist, xviii, 203, February, 1884.

Body of the usual form, in general like the European *N. lugubre* and our *N. troglodytes*, the abdominal segments being nearly the same, but as the specimen is immature it is not chitinized;

it is oval and somewhat flattened. The body is white, the appendages being slightly dusky. The eye prominence is rather large compared with that of *N. troglodytes* Pack. The eyes are wanting, the pigment being colorless, but with a dark line indicating the traces of a retina. Cheliceræ slender, rather long, the inner edge of each finger with short, stiff setæ; on the upper side, at the base of the immovable finger, are two straight, stiff hairs; the hand is not setose, as in that of *N. troglodytes.* The pedipalps are only of moderate length, being, in proportion, only about one-third as long as those of *N. troglodytes;* the second joint is not much longer than the basal, being slightly longer than thick; third joint three times as long as the second; third and fourth of the same length, but the fourth a little thicker; fifth slightly longer and thicker than fourth, with numerous stout setæ of nearly even length; sixth (terminal) two-thirds as long as the fifth and nearly as long in proportion as the terminal joint in *N. troglodytes;* it is very setose and the tip is rounded. Legs of second pair 3^{mm} in length, hairy, last tarsal joint undivided; fourth pair 4^{mm} in length, the last tarsal joint with nine subjoints, and the ungues smaller than in the second pair.

Length of the body, including the cheliceres, 1^{mm}

Locality, Bat Cave, Carter county, Kentucky.

The specimens found were immature, but the species is so characteristic that I have ventured to describe it. It differs from the Utah *N. troglodytes* chiefly in the much shorter pedipalps, with proportionally much shorter joints in its naked hand and much slenderer legs. The specific name is given it in allusion to its feebly-developed, degenerate eyes. It is the first species of the genus known to occur in the eastern United States.

ARANEINA.

It is in the small caverns of Carter county, Kentucky, and the two Weyer caves (Weyer's and the adjoining Cave of the Fountains), which are often but a few (less perhaps than a hundred) feet below the surface, that the variation and number of species of spiders is greatest. In each set of caves there are three species to one in Mammoth and Wyandotte caves. The individual variation was the greatest in *Nesticus pallidus*, and, as might be suspected, in the eyes. The degree of variation is indicated in Mr. Emerton's description.

The spiders occurred more abundantly in all the caves than we expected. The individual abundance was greater in the smaller caverns, especially the Weyer caves, than any others. In the Mammoth Cave the Anthrobia occurred under stones in dry, but not the driest, places on the bottom at different points in the cave. Sometimes two or three cocoons would be found under a stone as large as a man's head. The cocoons were orbicular, flattened, an eighth of an inch in diameter, and formed of fine silk, and contained from two to five eggs. They occurred with eggs in which the blastodermic cells were just formed April 25. The eggs were few in number and seemed large for so small a spider, being $\frac{25}{1000}$ inch in diameter. The chorion is very thin and finely speckled. The blastodermic cells seemed very large, the largest measuring nearly $\frac{4}{1000}$ inch in diameter. They were round, not closely packed, and showing no indications of being polygonal. They all had a dark, very distinct nucleus. I was unable to trace the development of the young and ascertain if the embryos are provided with rudimentary eyes. Two young Anthrobiæ hatched out May 3 in my room. The whole body, including the legs, is snow-white, with the legs much shorter than in the adult. The adult in life is white, tinged with a very faint flesh color, with the abdomen reddish. In some specimens the abdomen has beneath several large transverse dusky bands. The *Linyphia subterranea*, as observed living in Wyandotte Cave, is pale pinkish, horn-brown on the thorax and legs, while the abdomen is dull honey-yellow.

What constitutes the food of these diminutive, weak, sedentary spiders I can not conjecture, unless it be certain minute delicate mites or young Poduræ. They spin no web, though some of the spider's in Weyer's Cave (Cave of the Fountains) do spin a weak, irregular web, consisting of a few threads. The Sciaræ and Chironomus are too large and bulky to be captured by them. The probable insufficiency of food as well as light may account for their small size and feeble reproductive powers. The individuals were far less numerous than those of the Phalangodes and Chernetidæ.

NOTES ON SPIDERS FROM CAVES IN KENTUCKY, VIRGINIA, AND INDIANA.

The following remarks and descriptions, by J. H. Emerton, are copied from the American Naturalist, vol. ix, May, 1875:

The collection of cave spiders contained about one hundred specimens of eleven species. Two species were found only about the mouths of caves. These are *Theridion vulgare* Hentz, a spider found all over the country in shady places, and *Meta menardi*, which has been found in similar situations in Massachusetts and New Hampshire, and resembles *Epeira fusca* Blackwall. One young spider allied to Tegenaria was taken in Fountain Cave, Virginia, and four specimens of a species of the same family were found in small caves in Carter county, Kentucky; all were immature except one female, and none showed any subterranean characters. The remaining six species, all belonging to the Theridioidæ, were found in considerable numbers in the larger caves, where there is little or no light and the climate is little affected by outside changes. One species of Linyphia from Weyer's Cave, Virginia, has the eyes of the normal size and number, and the colors and markings of some specimens are as bright as on spiders of the same family living in cellars or shady woods. The other five species are all pale in color and show some unusual condition of the eyes, three species having the front middle pair very small, one having all the eyes small and colorless, with the front middle pair wanting in the males and some females, and one species being entirely without eyes. Following are descriptions of the last six species:

Nesticus pallidus n. sp. (Pl. XV, figs. 22 to 27).—Cephalothorax and legs pale orange-brown, abdomen yellowish-white, with brown hairs. Length of female 3.5^{mm}. Cephalothorax 1.5^{mm} long and nearly as broad, little elevated in front; three lines of hairs from the eyes to the dorsal pit. Front middle eyes black and half as large as the others, nearly touching each other; rear middle eyes separated from each other by their diameter and from the front middle eyes by half that distance; lateral eyes in pairs, separated from the middle eyes by half their diameter. Mandibles half as long as the cephalothorax. Maxillæ and labium short and wide. Palpal claw long and slender, with six teeth along the middle. Legs 1, 4, 2, 3; first pair, 10^{mm}; second, 8.25^{mm}; third, 8.15^{mm}; fourth, 9.6^{mm}; thinly covered with long hairs and without spines. Tarsal claws long and slender, the lower with two teeth, the upper with nine or ten. Epigynum (Fig. 27); the sacs showing through the skin in some specimens. The only male taken had not finished molting and was much distorted by the alcohol. The palpus which had cast its skin is shown in Fig. 26; the penis is raised from its natural position, which is in a groove passing spirally round the end of the palpal organ to a fleshy conductor. A long process, with two teeth at the end, branches from the base of the tarsus.

Fountain Cave, next to Weyer's, Virginia, among stalactites where there was no daylight. Several loose cocoons were found, one containing thirty or forty young just hatched (Packard).

Nesticus carteri n. sp. (Pl. XV, fig. 28).—Cephalothorax and legs light yellow, hairs shorter than in *N. pallidus*. Abdomen in some specimens with indistinct gray markings. Eyes smaller and farther separated from each other than in *N. pallidus*. Epigynum (Fig. 28). This species is otherwise much like *N. pallidus*. Bat Cave, Zwingle's Cave, Carter county, Kentucky (Packard). A cocoon collected by Mr. Packard from Bradford Cave, Indiana, contains young which had passed their second molt, probably of this species.

Linyphia subterranea n. sp. (Pl. XV, figs. 29 to 31).—Cephalothorax and legs yellowish-brown; in some specimens reddish. Abdomen white, with brown hairs; in two specimens from Zwingle's Cave gray, with white spots. Eyes eight (Fig. 30), white, surrounded by a dark border; in one specimen colorless, without dark borders. Front middle eyes very small, and in the two dark specimens from Zwingle's Cave obscured by dark markings on the head. Mandibles with seven teeth in front of the claw-grooves. Legs short 1, 4, 2, 3; spines on patella and tibia. Under claw of tarsus with two teeth, the upper claws with eight or nine; no claw on palpi. Epigynum external, as long as the maxillæ, extending backward along the under side of the abdomen (Figs. 29 to 31), or when the abdomen is distended projecting out from it at a right angle.

Under stones in Carter and Wyandotte caves (Packard).

Linyphia weyeri (Pl. XV, figs. 7 to 12).—Cephalothorax and legs yellow-brown, abdomen from dark gray to white. Length of female 2.25^{mm}. Cephalothorax wide and but little elevated in front in either sex. Front middle eyes near each other on a black spot, rear middle eyes separated by their diameter and by the same distance from the front middle eyes, lateral eyes in pairs, each pair surrounded by a black area and distant twice its width from the middle eyes. Mandibles long, spreading apart at the tips, and inclined backward toward the maxillæ, beyond the ends of which they extend a third of their length in the female and farther in the male; five long teeth in front of the claw-groove. No palpal claw. Legs 1, 4, 2, 3; first pair 4^{mm} long in female and 4.4^{mm} in male, with two spines on femur, one on patella, and two on tibia. Under claw of tarsus with one tooth, upper claws with nine or ten teeth. Epigynum with an oval opening behind twice as wide as long, in front of which is a short flexible appendage (Fig. 11). Palpus of male, Figs. 9 and 10. The tarsal process is a small hook on the upper side; the penis is long, and passes one and a half times around the palpal organ, supported through nearly its whole length by a wide thin conductor ending in a hard tooth. Under the end of the penis is a soft brush-like appendage, and beside it two hard processes.

Weyer's Cave, Virginia, in darkness, but not far from the entrance (Packard).

Linyphia incerta n. sp. (Pl. XV, figs. 13 to 21).—Length 2^{mm}. Cephalothorax and legs orange-brown, abdomen white, with short, fine, brown hairs. Cephalothorax 1^{mm} long and two-thirds as wide; in the male elevated in front (Fig. 20) and furnished with longer hairs than in the female. Eyes small and colorless, and separated far from each other (Figs. 18 and 21); the front middle pair are very small, hardly larger than the circles around the bases of the hair by which they are surrounded, and only distinguished from them by wanting the dark rim which surrounds the hair circles In five females from Fountain Cave all the eyes are present (Fig. 18); in one female one of the front middle eyes is wanting. In three males from the same cave both front middle eyes are wanting, as in Fig. 21; in one male one only of the front middle pair is wanting. In four females and one male from Bat Cave, Carter county, Kentucky, the front middle eyes are wanting. Mandibles long and spreading at the tips, inclined backward toward the maxillæ, seven teeth in front of the claw groove, which are longer in the males. No palpal claws. Legs 1, 4, 2, 3; longest 4.75^{mm}. Tarsal claws short and slender, under claw with one tooth, upper claws with seven or eight teeth. Spines on patella and tibia. Epigynum with a small oval opening behind, with dark brown border. Palpus of male (Fig. 17), having a sharply-curved process at the base of the tarsus. The penis is supported by a stout conductor nearly to its end, where it passes a soft brush-like appendage.

Fountain Cave, Virginia, among stalactites, in company with *Nesticus pallidus* (Packard); also in Bat Cave, Carter county, Kentucky (Shaler and Packard).

Anthrobia mammouthia (Pl. XV, figs. 1 to 6).—In 1844, Tellkampf described and figured roughly in Wiegmann's Archiv fur Naturgeschichte several Arthropods from the Mammoth Cave; among them an eyeless spider which he referred with doubt to the Mygalidæ, apparently because he saw only four spinnerets. The eyeless spiders, found by Dr. Packard in the Mammoth Cave in 1874 agree generally with Tellkampf's description, and his Fig. 13 represents quite well the outline of a specimen flattened by pressure between two glasses. No other eyeless spider was found, and no other which could be identified with Tellkampf's description. There seems, therefore, little doubt that these are spiders of the same species as those described by Tellkampf. Adults, 1.5^{mm} long, pale brownish-yellow; abdomen almost white, with brown hairs; ends of palpi, palpal organs, and epigynum reddish brown. Cephalothorax with scattered hairs in front. No eyes. Mandibles with four long teeth in front of the claw groove. Maxillæ short and wide. Sternum wide and hairy. Legs 1, 4, 2, 3; longest about 2.5^{mm}, hairy, with spines on patella and tibia. Under tarsal claw with one tooth, the upper claws with six or more short teeth. No palpal claw. Palpus of male (Fig. 3) with a long process on the outside of the tibia, ending in a sharp hook. The tarsal process forms a small thin hook. Palpal organ very simple: the penis very short, and accompanied by a soft, thin appendage. Spinnerets short; hypopygium one-third the length of the first pair.

Mammoth Cave and Proctor's and Diamond caves, under stones (Sanborn and Packard). Small flat cocoons were found with some specimens, containing small numbers of eggs, which were unusually large in proportion to the size of the spider.

[In this connection it may be of interest to learn the opinion of Dr. T. Thorell, the accomplished arachnologist of Upsala. Upon receiving a specimen of *Anthrobia mammouthia* which I sent him he writes me that "the Anthrobia, if it really is the true *A. mammouthia* Tellkampf, scarcely differs from the genus Erigone by anything more than the want of eyes; it may, however, be added as a peculiarity, that the three long and slender tarsal claws are quite smooth, neither dentated nor pectinated. The species belong most certainly to the family Theridioidæ."

On the other hand, on the receipt of a specimen of the same species of spider and from the same cave (Mammoth) as that from which the specimen was taken which was sent Dr. Thorell, M. Simon, of Paris, writes me that "the Anthrobia is not allied to Mygalidæ, as was supposed from the imperfect description of Tellkampf, but to our Dysderidæ, and the genus Leptoneta, only it is blind."—A. S. P.]

The following additional species have also been described by Count Keyserling, as I am informed by Dr. G. Marx: *Willibaldia cavernicola* Keys (closely allied to *Linyphia incerta* Emer.): *Phanetta subterranea* Keys (=*Linyphia subterranea* Emer.); *Erigone infernalis* Keys. The descriptions of the two last species appeared in Die Spinnen Amerika's Theridiidæ, 2te hælfte, 1886, pp. 125 and 180. *Liocranoides unicolor* Keys, from Mammoth Cave, should also be added.

MYRIOPODA.

In order to facilitate the identification of the cave Myriopods, all of which, except *Cambala annulata*, belong to the Lysiopetalidæ, I give the descriptions of the genera and species from my "Revision of the Lysiopetalidæ" in the Proceedings of the American Philosophical Society, xxi, 177, September 15, 1883.

LYSIOPETALUM Brandt.

Julus Say, Journ. Acad. Nat. Sci., Phil., ii, part i, 104, 1821.
Lysiopetalum Brandt, Recueil, 42, 1840.
Spirostrephon Brandt, Bull. Sci. Acad., 1841; St. Petersb., 1840. Recueil, p. 90, 1840.
Platops Newport, Ann. and Mag. Nat. Hist., xiii, 266, 1844.
Lysiopetalum Gervais (in part), Aptères, iv, 133, 1847.
Cambala Gervais, Aptères, iv, 134, 1847. Exped. à l'Amer. du Sud (Castelneau), Myriop., 17.
Reasia Sager, Proc. Acad. Nat. Sci. Phil., 109, 1856.
Spirostrephon Wood, Myriop. N. Amer., Trans. Amer. Phil. Soc., 192, 1865.
Spirostrephon Cope, Proc. Amer. Phil. Soc., 179, 1869.
Spirostrephon Ryder, Proc. U. S. Nat. Mus., iii, 526, 1881.
Not *Cambala* Gray, Griffiths, Cuvier An. King. Ins., Pl. 135, fig. 2, 1832.
Not *Reasia* Gray.
Not *Reasia* Jones, Todd's Cyc. Anat. Art. Myriop., 546.

Body segments numbering as many as upwards of sixty, with as many as one hundred and fifteen pairs of legs; the body unusually long and slender, tapering gradually towards the subacute tip. Head with the front flat, high, and narrow, more so than usual; the eyes in a rectangular triangle, composed of as many as forty to forty-one facets, and not depressed. Antennæ rather long, the joints subclavate, joint 6 not much longer than 4; joints 3 and 5 of the same length; joint 6 rather thick at the end; joint 7 short, thick, and conical, much more so than usual.

Body segments swollen and full, becoming suddenly depressed on the front edge; the swollen portion with numerous raised lines or ridges, with deep concave valleys between; the ridges projecting behind in an acute point. The segment next to the head rather narrower than the head, with the posterior two-thirds ridged; the sides of the segments are somewhat swollen high up on the sides, but not so conspicuously as in Pseudotremia. Legs rather stout and larger than in Pseudotremia; the first pair rather short and broad, with a regular comb of stiff setæ on the inner edge of the terminal joint. The seventh and ninth pairs of legs, *i. e.*, the pair immediately preceding and following the genital armor, are like the others, not being in any way modified, as in Pseudotremia, etc. The genital armature is large and better developed than in any other genus of the family; the outer lamina large, stout, spatulate-mucronate at the tip; inner lamina much shorter than the outer, and with two long acute forks; repugnatorial pores difficult to find.

The genus may be recognized by the long, slender body, tapering to a point, and by the very short conical seventh antennal joint; by the ribbed, swollen segments, which are very numerous; by the seventh and ninth pairs of legs being normal, like the others; and by the short, broad first pair, with the regular comb of setæ on the terminal joint.

The genus as here defined will apply to the two southern European species *Lysiopetalum carinatum* Brandt and *L. illyricum* Latzel, except that they are setose, while our species is not. I am indebted to Dr. Latzel for specimens for comparison.

In proposing the genus Spirostrephon, Brandt (Bull. Sci. Acad., St. Petersb., 1840) regarded Say's *Julus lactarius* as the type species, and adding that the eyes are in a triangular area, he indicates its generic difference from *Cambala annulatus*, with which it has been so often confounded.

Although I had originally retained Brandt's name Spirostrephon for our species, yet upon receiving from Dr. Latzel authentic types of European Lysiopetalum, it is plain that our *S. lactarius* is congeneric with them. The name Spirostrephon should, then, be considered as a synonym of Lysiopetalum. It is difficult to see why Brandt should have separated *lactarius* from his *L. carinatum*.

In his Recueil, page 42, Brandt thus characterizes his genus Lysiopetalum: "Laminæ pediferæ omnes liberæ, mobiles, cutis ope cum parte abdominali corporis cingulorum conjunctæ. Frons ante antennas dilatata et deplanata in maribus in simul depressa." The two species mentioned under the generic diagnosis are *Lysiopetalum fœtidissimum* (Savi) and *L. carinatum* Brandt.

Again, on page 90: "Subgenus seu genus II, Spirostrephon Nob." is thus characterized, and he apparently regards it as a subgenus of Julus: "Gnathochilarii pars media fossa haud instructa, sede jus loco aream tetragonam planam, plica seu linea derata duplici, superiore breviore et inferiore longiore, supra et infra terminatam, sed sutura longitudinali haud divisam offerens. Spec. 27. *Julus* (Spirostrephon) *lactarius* Nob......Differt habitu a Julis genuinis et Julo (Lysiopetalo) fœtidissimo et plicato affinis apparet. Annuli corporis, quorum posteriores brevissimi, incluso anali 53. Pedum paria 95. Longitudo 10 to 11'''; latitudo summa ⅘'''. Oculi triangulares—*Julum lactarium* protypo generis Cambala Grayi habuissem, quum figura ab hocce zoologo sub nomine *Cambalæ lactarii* data" (Griffith Anim. Kingd. Insect., Pl. 135, fig. 2). The generic characters are not very applicable in distinguishing the genus, the mention of the type alone rendering it possible to understand what the genus is.

The synonym will be further discussed under Cambala. In 1844 Newport, having been misled by the specimen of *Cambala annulata* alleged to have been sent by Say as the type of his *Julus lactarius*, places the latter in his genus Platops, which he proposes, with a doubt, thus: "Genus *Platops? mihi.*" The generic characters apply well to the present species, *S. lactarius*.

Dr. Wood, in his Myriopoda of North America, does not attempt, for want of material, to define the genus. Professor Cope characterizes this and the next genus thus:

Annuli without pores..*Spirostrephon*.
Annuli with two pores on each side the median line ....*Pseudotremia*.

As we have seen, there are pores in Lysiopetalum, while the "two pores" of Pseudotremia are two of the three setiferous tubercles on the side of each segment.

The genus appears thus far to be represented in North America by but a single species, which ranges from Massachusetts west to Iowa and south to Florida and Louisiana, while in southeastern Europe Lysiopetalum is rich in species.

LYSIOPETALUM LACTARIUM Say. Plate IX, figs. 3, 3*a*–3*h*.

Julus lactarius Say, Journ. Acad. Nat. Sci., Phil., ii, pt. i, 104, 1821.
Spirostrephon lactarius Brandt, Bull. Sci. St. Petersb., 1840. Recueil, 90, 1840.
Platops lineata Newport, Ann. Mag. Nat. Hist., xiii, 267, April, 1844.
Lysiopetalum lineatum Gervais, Aptères, iv, 133, 1847.
Cambala lactarius Gervais (in part), Aptères, iv, 134, 1847.
Reasia spinosa Sager, Proc. Acad. Nat. Sci. Phil., 109, 1856.
Cambala lactaria Gervais, Exped. l'Amer. du Sud (Castelneau), Myriop., 17.
"*Reana chinosa* Saeger," Gervais, Exped. l'Amer. du Sud (Castelneau), Myriop., 14.
Spirostrephon lactarius Wood, Myriop. N. Amer., Trans. Amer. Phil. Soc., Phil., Pl. ii, figs. 11, 11*a*, 192, 1865.

Spirostrephon lactarius Cope, Proc. Amer. Phil. Soc., Phil., xi, No. 82, 179. 1869. Trans. Amer. Ent. Soc., iii, 66, May, 1870.
Spirostrephon lactarius Ryder, Proc. U. S. Nat. Mus., iii, 526, Feb. 16, 1881.
Lysiopetalum lactarium Packard, Amer. Nat., xvii, 555, May, 1883.
Not *Cambala lactaria* Gray, Griff., Cuvier An. King. Ins., Pl. 135, fig. 2, 1832.
Not *Cambala lactaria* Newport, Ann. Mag. Nat. Hist., xiii, 266, April, 1844.

Two males, two females. Body segments, exclusive of the head, 61, with 115 pairs of legs. Body and head horn color, usually mottled and banded with dark blackish horn color. The head usually with a broad, interantennal, black, conspicuous band inclosing and connecting the eyes. Eyes (compound) of 40 to 41 facets. Antennæ dull, blackish brown; tip of the terminal joint pale, as also the other joints at their articulation. The body with a median dull yellowish dorsal stripe, and with a lateral row of concolorous diffuse spots, one on each longest lateral ridge (the spots vary much, sometimes covering four or five ridges and extending low down on the sides of the scute. Each scute has, except those near the head and at the end of the body, about twenty-five prominent ridges, the dorsal twelve larger than those on the sides; these ridges are high, with concave valleys between them; the end of the ridges are acutely conical and project over the ends of the scutes.

Length of the entire body, 35^{mm}; thickness, 2^{mm}.

The above description was drawn up from the Louisiana specimens, which were highly colored, banded, and spotted. In the Massachusetts specimen the color is uniformly light brown, without the yellowish dorsal line and the lateral spots. The antennæ are much darker, while the legs are paler than the body. The head is much paler than the body; it is dusky on the vertex between the eyes, but there is no definite interantennal band as in the Louisiana examples.

The Iowa specimens resemble in coloration those from Louisiana, but the yellowish dorsal band and lateral spots are not quite so distinct, though the interantennal blackish band is distinct.

Massachusetts and McGregor, Iowa. Mus. Agricultural Department, Washington, D. C. (Prof. C. V. Riley); Palatka, Florida, and Milliken's Bend, Louisiana (E. Burgess); "Eastern United States" (Wood); found under bark in the mountain regions of Tennessee and North Carolina (Cope); Saint Louis (Theo. Pergande).

Although this species is evidently the parent form of the cave-inhabiting *Pseudotremia cavernarum*, it has not yet been observed near the Indiana and Kentucky caves, though undoubtedly yet to be found in their vicinity, as it is a wide-spread species. It probably ranges through Central into South America. As Dr. Wood remarks: "I have seen a single specimen, a female, labeled as coming from New Grenada, which apparently belongs to this species." This specimen I have seen in the museum of the Philadelphia Academy of Natural Sciences, but did not compare it closely with our species; it is much larger than individuals from the United States.

PSEUDOTREMIA Cope.

Pseudotremia Cope, Proc. Amer. Phil. Soc., xi, No. 82, 179, 1869. Trans. Amer. Ent. Soc., iii, 67, May, 1870.
Spirostrephon Cope, Amer. Naturalist, vi, 414, July, 1872.
Pseudotremia Harger, Amer. Journ. Sci. and Arts, iv, August, 1872.
Pseudotremia Ryder, Proc. U. S. Nat. Mus., iii., 524, Feb. 16, 1881.

Body consisting of thirty segments; rather long and slender, with as many as fifty pairs of legs. Head with the muscular area (gena) behind the eye very full and swollen, globose, swelling out far beyond the side of the succeeding scutum; front a little longer than wide. Eyes present, black; the outline of the eye-patch narrow triangular, composed of about twelve to fifteen facets, arranged in four or five transverse oblique series. Antennæ longer and slenderer than in any of the other genera of the family; joint 3 is twice as long but not as thick as joint 2, but equals fifth in length, the latter, however, being very slender and clavate; the terminal seventh joint is unusually long, pear-shaped, and elongated towards the tip.

The body constricts in a neck-like fashion behind the head; segments (scuta) 5 to 20 especially have a lateral shoulder or raised portion characteristic of the genus Lysiopetalum; this swollen portion has on each side about six longitudinal ridges, with deep valleys between; above, especially on the posterior half of the body, the dorsal portion of the laterally-swollen scuta is coarsely tuberculated instead of ridged, and the rounded tubercles are rather flat and unequal in size. There are no setæ or lateral setiferous tubercles. The end of the body is as usual in the family, the last segment with three pairs of small setæ arranged one above the other.

Above the middle of the side of the posterior scuta, especially the last 6, is a tubercle like those in Scoterpes and Zygonopus, but much smaller, from which a minute hair arises, and above, on the upper part of the shoulder, there are two rudimentary very small tubercles.

The legs are long and slender, about one-third longer than the diameter of the body. In the male the eighth pair of legs are much less modified than in the succeeding genera; it consists of five joints, while in Trichopetalum, Scoterpes, and Zygonopus it is very rudimentary, consisting of but two joints. The basal joint is large and constricted near the middle, with a large setiferous tubercle on the inside; the constriction may represent an obsolete articulation, and thus the basal joint really represents the two basal joints of the other legs. The smaller multiarticulate extremity of the leg is composed of four well-marked joints, the basal as long as the three terminal ones without the claw, which is long and slender and nearly as well developed as in the other legs.

The male genital armature is well developed, nearly as much so as in the Julidæ. There is a median very long curved forked chitinous rod, a pair of median boot-shaped pieces, and a pair of lateral double blades or pseudorhabdites, composed of the usual *lamina externa* and *lamina interna*, which are variously spined and denticulated at their extremities, one supplementary spine being minutely and densely spinulated.

The genus was characterized by Cope thus: "Annuli with two pores on each side the median line." As already remarked, the so-called pores appear to be simply the lateral tubercles, giving rise posteriorly to minute setæ, which are difficult to detect with a half-inch objective.

The genus differs from Lysiopetalum in the slenderer, longer antennæ, the rudimentary eyes, the more swollen and prominent lateral bosses or shoulders of the segments, while the body has about half as many segments as in Lysiopetalum, and is much shorter and more fusiform. The generic characters are very marked, though the species is clearly enough derived from the common out-of-door *Lysiopetalum lactarium*.

PSEUDOTREMIA CAVERNARUM Cope. Plate VI, figs. 1, 1*a*–1*u*; 2, 2*a*–2*c*.

Pseudotremia cavernarum Cope, Proc. Amer. Phil. Soc., xi, No. 82, 179, 1869.
Pseudotremia cavernarum Cope, Trans. Amer. Ent. Soc., iii, 67, May, 1870.
Pseudotremia cavernarum Packard, Amer. Naturalist, v, 749, December, 1871.
Spirostrephon cavernarum Cope, Amer. Naturalist, vi, 414, July, 1872.
Spirostrephon (Pseudotremia) *cavernarum* Harger, Amer. Journ. Sci. and Arts, iv, 118, 119, August, 1872.
Pseudotremia cavernarum Ryder, Proc. U. S. Nat. Mus., iii, 526, February 16, 1881.

Eyes black, conspicuous, forming a somewhat irregular, narrow triangular patch, with from twelve to fifteen facets. Antennæ unusually long and slender, the joints pilose; joints 3 and 5 of the same length, or 3 a little longer; joints 2 and 6 of equal length; joint 7 elongate, pear-shaped, pilose, the extremity truncated, with two or three sense-setæ not so long as the end of the joint is thick.

The first scutum next to the head is scutellate in shape, rounded on the front edge, somewhat produced anteriorly in the middle; the margin behind slightly sinuous; it is about two-thirds as long as broad. The second scutum is a little wider than the first, the third somewhat wider, while the fourth is much wider; dorsal face of first scutum smooth; the posterior part of the second scutum a little swollen; that of the third more so; that of fourth scutum swollen and ridged much as in fifth and succeeding scuta. Scuta 5 to 20 are swollen high up on the sides into a shoulder, giving a quadrilateral instead of a circular outline to the segment, bulging out more subdorsally than below; the swelling has six longitudinal ridges, while the posterior swollen end of the scuta above, especially on the posterior half of the body, is coarsely tuberculated, the tubercles being rounded rather than flat and unequal in size. No well-marked setiferous tubercles on the side from the middle of the body to the head; but on the last six segments there are on each shoulder or scutal swelling two minute rudimentary swellings or tubercles; but in my specimens I can see no setæ except on the two terminal segments of the body in male and female, where, on the end of the last scuta, there is a seta arising from a basal movable joint; there are three pairs on the lateral anal plates (thirtieth segment). Length, 18^{mm}; thickness of the body, 1.5^{mm}.

The young when about half grown are white, the back of the antennæ and anterior segments having a very slight dusky tinge. In numerous mature specimens from the Senate Chamber, Wyandotte Cave, 3 miles in, the body is white, with a slight flesh-colored tint. In numerous (150) specimens from this locality the head and dorsal side of the anterior segments are slightly dusky; the antennæ are also usually slightly dusky, except the two terminal joints, which are white.

There is thus seen to be a slight amount of variation in color in specimens collected at the same date in the same chamber in Wyandotte Cave.

Among the 150 specimens taken at one time and place from Wyandotte Cave (Senate Chamber) and individually examined I could see none without black eyes, the pigment being well developed. There was a fair proportion of males.

Four specimens which I collected in Little Wyandotte Cave were of exactly the same size as those from Great Wyandotte Cave; they were white-tinged, dusky on the head and forepart of the body, the eyes are black, and the eye-patch of the same size and shape, while the antennæ are the same.

Six specimens from Bradford Cave, Indiana (which is a small grotto formed by a vertical fissure in the rock, and only 300 to 400 yards deep), showed more variation than those from the two Wyandotte caves. They are of the same size and form, but slightly longer and a little slenderer, especially joints 3 and 5; joint 7 is decidedly longer than in any others; whiter, more bleached. The antennæ are much whiter than in those from the Wyandotte caves, and the head and body are paler, more bleached out, than in most of the Wyandotte specimens. The eyes vary more than in the Wyandotte examples, one having but twelve facets, another fourteen, and another fifteen, with a few minute rudimentary facets between the others. It thus appears that the body is most bleached and the eyes the most rudimentary in the Bradford Cave, the smallest and most accessible, and in which, consequently, there is the most variation in surroundings, temperature, access of light, and changed condition of the air. Under such circumstances as these we should naturally expect the most variation.

Professor Cope's types were first found by him in Erhart's Cave, Montgomery county, and Spencer Run and Big Stony Creek caves, in Giles county, Virginia; also in Lost Creek Cave, on the Holston River, in Grainger county, Tennessee, and in other limestone caves of the valley of the Tennessee. Professor Cope afterwards (Amer. Naturalist, vi, 14) discovered this species in Wyandotte Cave, remarking: "The species is quite distinct from that of the Mammoth Cave, and is the one I described some years ago from caves in Virginia and Tennessee."

Var. *carterensis*. A decided approach to *S. lactarius* is seen in certain brown specimens, only partly bleached, found in the Carter caves, Kentucky, viz: Bat Cave, X Cave, and Zwingle's Cave, besides a cave across the road from the hotel, which is used as an ice-house.

In the specimens from Bat Cave the antennæ are slightly shorter, and a little slenderer, particularly joints 3 to 5; but joint 7 is much shorter and blunter than in the Bradford Cave individuals; the antennæ, however, are of the same length, though slenderer than those living in Great Wyandotte Cave. The eyes form a nearly equilaterally triangular area, with from twenty-three to twenty-five facets. The segments behind the head are 30. They differ from the Wyandotte examples in the posterior or swollen portion being rather more prominent than in the former, forming more marked lateral swellings, with about eight ridges on the side of each boss, and the body is larger and thicker, but the legs are of the same length.

The head is dark in front, mottled above and below with paler horn color. The antennæ are concolorous with the head and body, but the terminal joints are paler, as are the legs, which are also paler at the articulations. The entire body is dark horn-brown, mottled and irregularly lineated.

The smoother anterior portion of the scuta shows a tendency to be paler than the tuberculated portion, and of a bluish-gray tint. The tubercles are no more prominent than in the Wyandotte individuals.

The segments in both the Wyandotte species and var. *carterensis* rapidly decrease in size, the penultimate segment being pointed, and each segment is provided with regular, high-raised, parallel, prominent ridges on the shoulder or lateral boss; about forty to forty-five on a scutum on the sixth segment from the end of the body.

Length, 23^{mm}; thickness, 2.5^{mm}; the body being considerably larger and thicker than in the Wyandotte specimens. (See figs. 2, 2*a*–2*c*.)

Two specimens from X Cave are exactly in size and color like those from Bat Cave.

Three specimens from the ice-house cave only differ from those in Bat Cave in being somewhat paler, but the eyes and antennæ are the same.

A large and a partly grown one from Zwingle's Cave was collected by Mr. Sanborn August 23; these were also paler than those from Bat Cave. With them were associated a Ceuthophilus, with eyes well developed, and a Polydesmus.

This form or variety would be, perhaps, mistaken for *Lysiopetalum lactarium*, but it is true in all the generic details to Pseudotremia; at the same time it is what may be called a twilight species, living in small caves in situations partially lighted. It is probably derived from *L. lactarium*, or a closely-allied species. We doubt if it will ever be found living in the same situations as *L. lactarium*.

It is evident that the var. *carterensis* is the ancestral form of the now fixed species *P. cavernarum*, and that the former has been derived either from *L. lactarium* or from an allied species; hence the genus *Pseudotremia* has been probably derived from the genus *Lysiopetalum*, and was at first represented by *carterensis*, the latter being a twilight species, which gave origin to the *cavernarum*. We regard this series as the best and clearest proof of the derivative theory which we have observed, proof so clear as to amount almost to a demonstration of species- and genus-making by a change in the environment.

In Mr. Hubbard's collection from Wyandotte Cave (Aug., 1885) I found a single *carterensis* considerably larger than any from the Carter Caves, but the body and tips of the antennæ are perhaps a shade paler. The eyes are normal, black, while the two last joints of the antennæ are a little slenderer than in my types of var. *carterensis*, but the last joint is decidedly shorter than in the form *cavernarum*; the specimen is much larger than any *P. cavernarum* from Wyandotte Cave.

Genus SCOTERPES Cope.

Spirostrephon (Pseudotremia) Pack., Amer. Naturalist, v, 748, December, 1871.
Scoterpes Cope, Amer. Naturalist, vi, p. 409, 414, July, 1872.
Scoterpes Pack., Proc. Amer. Phil. Soc. Phila., xxi, 192, 1883.

Body very long and slender, not fusiform; consisting of thirty segments besides the head, and with about fifty-two pairs of legs, with the penultimate joint very long. Head rather large and unusually broad; no eyes present; the genæ unusually large, extending high up on the vertex, but not so globose as in Trichopetalum; the front is also carried farther up on the vertex than usual, and is much broader than long; the clypeus flat, slightly bilobed on the front edge. The antennæ are moderately long and hairy, with the sixth segment scarcely longer than in Trichopetalum, but more uniform in thickness, scarcely longer than thick; the terminal joint as long as the sixth, the end conical, more produced than in Trichopetalum or Zygonopus; at the tip are four rather long sense-setæ. Body segments becoming, as usual, smaller next to the head; the anterior of each division of the arthromere much swollen high up on the sides; each shoulder with three tubercles, which are arranged in a scalene triangle and bear much longer setæ than in the other genera, though not quite so long as the body is thick. The legs are long and slender, much more so than in Trichopetalum, and somewhat more so than in Zygonopus. In the male the eighth pair of legs are rudimentary, being two-jointed, the second joint only one-fourth longer than the basal, and ending in a well-developed stout claw. The genital armature minute and very rudimentary, pale, scarcely chitinous; the outer lamina short and thick, with a stout external recurved spine, and two terminal obtuse points; the inner lamina shorter, forming a truncated angular spine, and not much more than half as long as the outer lamina; between the inner and outer lamina, its base next to the inner lamina, is a middle spine ending in an irregular tuft of fine spinules.

The genus is distinguished from Trichopetalum by its want of eyes, its broader head, its long slender body, with long setæ, by the eighth pair of female rudimentary legs ending in a claw. From Zygonopus it differs in the shorter sixth antennal joint, its broader head, its slenderer legs, the sixth pair in the female not being unlike the others, and by the more prominent shoulders and longer setæ. The species of the two genera are of the same general form and size.

The genus Scoterpes was proposed by Professor Cope for the present species in the American Naturalist for July, 1872, page 414. The very brief and incomplete characters given are the "lack of eyes and of lateral pores;" the absence of the latter having been "asserted by Dr. Packard." Ignorant of the difference between the Mammoth Cave blind Myriopod and Lysiopetalum, the latter being the only genus of the family then known, we referred it to the genus Spirostrephon.

SCOTERPES COPEI Cope. Plate VIII, figs. 1, 1*a*–1*m*.

Spirostrephon (Pseudotremia) *copei* Packard, Amer. Naturalist, v, 748. December, 1871.
Scoterpes copei Cope, Amer. Naturalist, vi, 414, July, 1872.
Spirostrephon copei Harger, Amer. Journ. Sci., iv, August, 1872.
Spirostrephon copei Packard, Zoology, edit. 1–3, 1879–'81.
Scoterpes copei Pack., Proc. Amer. Phil. Soc., xxi, 193, 1883.

About twenty males and females examined. Body white, with no dusky discolorations; thirty segments besides the head in specimens 11^{mm} in length; and fifty-two pairs of legs; in one female individual 8^{mm} long there were forty-nine pairs of legs, including the eighth or rudimentary pair; in other individuals 6^{mm} long there were twenty-four segments behind the head. The head is provided with short, fine, erect hairs of different lengths, especially on the sides of the genæ. In the absence of a second species we can not distinguish all the specific from the generic characters. For minor specific characters the reader is referred to the figures.

The males and females are alike in size and form.

The specimens were most abundant in the Labyrinth in Mammoth Cave, but also occurred in other localities in the cave. It is also common in Diamond Cave, where I collected it, and was discovered by Mr. Sanborn in Poynter's Cave, 300 yards from daylight. In one of the specimens from the last-mentioned cave the antennæ were rather more slender than usual.

The genus Scoterpes and its single species *copei* appears to be limited to Mammoth Cave and the others near, in apparently the same system of caves. It was erroneously reported by me to occur in Weyer's and the Luray caves, as the specimens collected belong to *Zygonopus whitei*. Without doubt the genus is a modified Trichopetalum, which has become longer and slenderer in body, with longer legs and antennæ, as well as setæ; whether it is a descendant of *Trichopetalum lunatum* or not is uncertain; it may have descended from a different species, but there seems to be no reasonable doubt but that it is a modified form of a small hairy Lysiopetaloid form, with antennæ exactly like those of Trichopetalum. (For details of which genus see Plate VII, figs. 2, 2*a*–2*f*.)

ZYGONOPUS Ryder.

Zygonopus Ryder, Proc. U. S. Nat. Mus., iii, 527, February 16, 1881.
Zygonopus Pack., Proc. Amer. Phil. Soc., xxi, 194, 1883.

Body rather slenderer than in Scoterpes. The head differs from that of Scoterpes in being much narrower and higher, the swollen sides or genæ being much less swollen; the vertex is swollen; the front as broad as long, with the upper edge a little hollowed, but quite distinct from the vertex itself. The eyes entirely wanting, as in Scoterpes. The antennæ are rather thick, and in this respect approach Scoterpes, but the sixth and seventh joints are much longer and rather more setose; the sixth joint is about two-thirds as thick as long, and the last (seventh) joint nearly twice as long as thick. The sides of the segments are swollen subdorsally as in Scoterpes, and the setiferous tubercles are arranged as in that genus, but the setæ are shorter; the lower posterior edges of the arthromeres below the shoulder or hump is chased obliquely with fine impressed lines. The feet are less in number than in Scoterpes. The diagnostic characters of the genus lie in the remarkably swollen sixth pair of feet of the male, in which the second joint is rather thick, while the third joint is long, and with the fourth joint remarkably swollen, with a series of about nine oblique retractor muscles diverging from the proximal end of the terminal joint, which is long and slender and straight, with a well-developed claw. The seventh pair of the male are of the normal form. The rudimentary or eighth pair are like those of Trichopetalum, the second (terminal) joint not ending in a claw, thus differing from those of Scoterpes. The male genital armature is entirely unlike that of Scoterpes, though it is rudimentary and minute; the outer lamina consists of a basal subtriangular portion, ending in a long, slender, curved spine, beneath which is a stouter spine, shorter and less curved; a minute median setose lamina is present, while the inner lamina is a weak, slender, setose filamentary outgrowth.

Mr. Ryder's generic characters are stated very briefly, as follows: "Sixth pair of legs very robust, and with the third joint greatly swollen." The generic characters are not contrasted by him with those of Scoterpes.

This genus differs from Scoterpes in the remarkably swollen, clasping, sixth pair of legs and in the male genital armature, while either sex differs from Scoterpes in the much narrower head and longer sixth and seventh antennal joints.

ZYGONOPUS WHITEI Ryder. Plate VII, figs. 1, 1*a*–1*o*.

Zygonopus whitei Ryder, Proc. U. S. Nat. Mus., iii, p. 527, February 16, 1881.
Zygonopus whitei Pack., Proc. Amer. Phil. Soc., xxi, 194, 1883.
Spirostrephon copei Pack., Amer. Naturalist, xv, 231, March, 1881.

Eight males, ten females. Body white, long, and slender; number of segments, 32. Head with scattered, fine setæ; antennæ with the second joint not quite one-half as long as the third, which about equals the fifth in length, both being rather long; the sixth is thick, barrel-shaped, not quite one-half as long as the fifth, but scarcely thicker; the seventh joint is unusually long, a little more than three-fourths as long as the sixth joint; the end thick and well rounded, with the usual tactile large flattened setæ; the third to seventh joints with long, dense setæ, a few on the end of joint 5 longer than any on joints 6 and 7. The setæ on the body arise from tubercles arranged, as usual, in a scalene triangle, and the setæ themselves are half as long as the body is thick; they are considerably shorter and finer than in Scoterpes.

The number of pairs of legs in the male is forty-seven in a specimen 8^{mm} in length; in the female there are forty-eight pairs. The sixth pair of legs of the male are somewhat longer and much swollen, the suture between joints 3 and 4 is very slight, the two joints together forming an ovate section of the leg a little thicker than the length of the second joint; terminal joint long and slender, considerably longer than joints 3 and 4 together. The two-jointed eighth rudimentary pair of legs are longer and larger than in *Scoterpes copei*, the basal joint nearly twice as long, while the second (terminal) joint is larger and swollen, and, besides being larger, ends in three or four fine minute setæ instead of a short claw, as in Scoterpes. Length, 8^{mm}.

The male genital armature is very minute and rudimentary, and has already been described in a general way. With but one species as yet known it would be unsafe to assign their specific characters. The two inner laminæ are quite unequal in length and development, and the armature in general shows signs of degeneration, as though the species had originated from some form in which the male armature was more completely developed. Nine specimens were found by us in New Market and Luray caves, and about twenty in Weyer's Cave, Virginia; Luray Cave, Virginia (Dr. C. A. White; Ryder).

This species in size and general appearance would be easily mistaken for *Scoterpes copei*, which we at first, from a too-hasty examination, supposed it to be. Mr. Ryder's excellent description characterizes the species, but his figures are indifferent, the third joint of the male is much more swollen in our specimens, and the normal leg (his Fig. 3) is drawn too slender, while the front of the head is not correctly rendered. In our specimens drops of a yellowish secretion were attached in alcoholic specimens to the base of many of the setæ, indicating the presence of repugnatorial glands, though no pores could be found. On breaking the body in two, nearly ripe eggs occurred in June; they were rounded-oval; length, about $\frac{2}{5}$^{mm}.

CAMBALA Gray.

Julus Say, Journ. Acad. Nat. Sci., Phila., ii, 103, 1821.
Cambala J. E. Gray, Griffith's Cuvier's An. Kingd., xiv, Insecta, i, Pl. 135, fig, 2, 2*a*, 2*b*, 2*c*, no descr., 1832.
Reasia R. Jones, Todd's Cyc. Anat. Phys., Art. Myriopoda, 546.
Cambala Gervais, Newport, Ann. and Mag. Nat. Hist., xiii, 266, 1844.
Cambala Gervais, Aptères, iv, 137, 1847.
Spirobolus (in part) Wood, Myr. N. Amer., 215, 1865.
Cambala Cope, Proc. Amer. Phil. Soc., xi, No. 82, 181, 1869.
Cambala Pack., Proc. Amer. Phil. Soc., xxi, 195, 1883.

The essential, diagnostic characters of this genus are the linear eyes, the long slender body, with keeled scutes, while the antennæ are short and thick, much as in Spirobolus.

The body consists of fifty-nine segments; the scutes with high keel-like ridges. The eyes are arranged in a linear row of ocelli, forming a straight line, situated far behind the insertion of the antennæ, next to the front edge of the first segment. The front of the head is somewhat longer than broad; the surface full and convex as in Julus. Antennæ are short and unusually thick, more so than in Julus or Spirobolus; seven-jointed; joint 2 a little longer and thicker than 3; fourth shorter and more clavate than third; fifth rather thicker at end than fourth, but of about the same length; sixth thicker than any of the others, about as long as fifth; seventh very short, round, no longer than broad. The feet are slender, not quite so long as the body is thick. On the fourth lower large ridge is a whitish microscopic spot, which under a half-inch objective is seen to be a short acute tubercle; these are Say's "stigmata," but they occur on each segment, and are doubtless homologous with the setiferous tubercles in Trichopetalum, etc.

The only species known has been mistaken for *Lysiopetalum lactarium* by Newport, Gray, and Gervais, hence the synonomy of the two genera is somewhat confused. Newport, adopting Mr. J. E. Gray's manuscript name Cambala, was the first to characterize the genus, remarking: "I have derived the characters of this genus from the specimens originally sent by Say to Dr. Leach." It is probable that Say by mistake sent an example of his *Julus annulatus* instead of a *L. lactarium*, as the two species would be easily confounded, although his *Julus annulatus* must have been of course familiar to him. The mistake was a natural one.

CAMBALA ANNULATA (Say) Cope. Plate IX, figs. 1, 1*a*.

Julus annulatus Say, Journ. Acad. Nat. Sci., Phil., ii, 103, 1821.
Cambala lactarius J. E. Gray, Griffith's Cuvier's An. Kingd., Pl. 135, fig. 2, 2*a*, 2*b*, 2*c*; Insecta i, vol. xiv; vol. ii, 784, 1832.
Cambala lactaria Newport, Ann. and Mag. Nat. Hist., xiii, 266, 1844.
Cambala lactarius Gervais, Ann. Soc. Ent., France, 1844.
Cambala lactarius Gervais, Aptères, iv, 137, 1847.
Spirobolus annulatus Wood, Myr. N. Amer., 212, 1865.
Cambala annulata Cope, Proc. Amer. Phil. Soc., xi, No. 82, 181, 1869.
Cambala annulata Cope, Trans. Amer. Ent. Soc., iii, 66, May, 1870.
Cambala annulata Pack., Proc. Amer. Phil. Soc., xxi, 196, 1883.

Body very long but blunt at the end, consisting of fifty-nine segments besides the head; eyes consisting each of six ocelli arranged in a straight line. The first segment behind the head is smooth, about half as long as wide, evenly convex, considerably broader than the head; the three succeeding segments are of about the same length, and each are about half as long as the fifth and succeeding segments. On the first segment are about ten bead-like tubercles seen from above; on the third about eight longer tubercles can be seen from above; on the fifth and succeeding segments there are about nine dorsal and subdorsal high, prominent, thick, parallel ridges, becoming sharp behind. On the middle segments of the body about six sharp ridges with broad hollow valleys between can be seen from above. These are mounted on each side lower down by about twelve less distinct ridges, becoming towards the lower edge of the scuta less and less convex and distinct, until they are indicated by simple impressed lines. There are thus about thirty ridges in all on each scute. The segments (arthromeres) are short, and the smooth spaces between the rigid portions are very short above. The color of the body is horn brown, the head, feet, and antennæ pale flesh-colored, and there is a dark median spot on the vertex between the eyes. The ridges are darker than the rest of the body. Length, 30^{mm}.

Little Wyandotte Cave, Indiana, and Cave of Fountains, next to Weyer's Cave, Virginia (Packard); Zwingle's Cave, Carter's Cave, Kentucky (F. G. Sanborn); Spruce Run Cave, on the Kanawha River, Giles county, Virginia (Cope), Wyandotte Cave (Hubbard). One of the most abundant of the Myriopoda in the mountain region of Tennessee and North Carolina (Cope).

This species is not unfrequently found in caverns, where *L. lactarium* more rarely occurs. This well-marked species may readily be distinguished from *Lysiopetalum lactarium* by the very short thick antennæ, linear eyes, and by the slenderer body, which, however, ends much more obtusely. We know of but one other species of Julidæ with the eyes arranged in a linear series; this is the *Trachyjulus ceylonicus* Peters of Ceylon, figured by Humbert.

The cave specimens which we have found are partially bleached, the result of probably a limited number of generations living in the darkness.

Besides these true cave-myriopods, Mr. Hubbard found a single specimen of *Polydesmus granulatus* Say, in Indian Cave, Barren County, Kentucky, not far from the mouth of the cave. It was bleached entirely white, although of nearly full size. Mr. Hubbard also found a bleached specimen of the same species in Lyon Cave, Kentucky.

INSECTA.

THYSANURA.

LIPURA? LUCIFUGUS n. sp. Plate XVI, fig. 1.

A small species of uncertain genus, with short, three-jointed antennæ, and with distinct eyes, occurred in Wyandotte Cave.

TOMOCERUS PLUMBEUS Templeton, var. PALLIDUS.

One specimen from Zwingle's Cave was but slightly changed, being almost wholly plumbeous; it occurred one-quarter of a mile from daylight (Sanborn).

In a number of other specimens from Zwingle's Cave and others of the Carter caves the body is white, as well as the spring and the legs, but the tarsi retain a slight plumbeous tinge. The antennæ are partly pale, the two basal joints being bathed with leaden gray. Ten examples collected by us had distinct black eyes, but minute and angular in outline, having suffered a considerable reduction in size. Specimens collected by us from the ice-house cave were white, with dusky antennæ and black eyes, and were like those just described.

Specimens from X Cave were all bleached, like those from the other Carter caves, but in some examples the eyes were connected by a narrow black band.

Specimens from Weyer's Cave and the adjoining Cave of Fountains were just like those in the Carter caves, being white, with small black eyes, and dull purple leaden antennæ and tarsi. Those in the New Market Cave were white, with black eyes and dark lead colored antennæ.

In One Hundred Dome Cave, specimens said to have been collected one-quarter of a mile from the entrance were all dark, of the usual out-of-door plumbeous color.

Remarks.—It is evident that the var. *pallidus* has been produced by the influence of its cave life. Var. *pallidus* occurs in a cave near Salt Lake, Utah, and the specimens do not differ from the bleached ones in the Kentucky and Virginia caves. The trunk becomes bleached, while the extremities of the antennæ and legs retain somewhat of the colors of the out-of-door form. None have been found without eyes. The shallowest caves, such as the ice-house cave, in Carter county, Kentucky, as well as the deeper ones, possess this variety. We also find the normal *plumbeus* in similar caves, though probably near daylight, but the inference that the pale bleached variety has been produced by want of light is a natural and the only possible one. It is proved by finding in Zwingle's Cave a slightly-changed *plumbeus* associated with numerous *pallidus*.

LEPIDOCYRTUS ATROPURPUREUS n. sp. Plate XVI, figs. 3, *3a*, *3b*.

Body dark leaden-purple; eyes large and distinct; antennæ smaller and shorter than usual, but little longer than the head; the fourth joint equal in length to the second and third together. The last pair of legs with rather long scales, rather slenderer than in *L. marmoratus* Pack.; the larger claw not very broad, in this respect differing from *L. metallicus* Pack., and being more as in *L. marmoratus;* the single tenent hair about as long as the inner smaller claw. The terminal joint of the spring (elater) is very short; the middle tooth much shorter than the terminal one, which is also short compared with that of *L. metallicus.*

Length of body, without the antennæ and spring, 1^{mm}. Diamond Cave.

The species is described from alcoholic specimens in which the hairs have been rubbed off. In color it seems to be near *L. metallicus;* like that species it is stout-bodied, and has short antennæ, but in the present species the antennæ are still shorter, the entire antennæ being scarcely longer than the head; in this respect and the shape of the end of the elater the present species differs from any of the other described forms.

DEGEERIA CAVERNARUM n. sp. Plate XVI, figs. 2, *2a–2g*.

Whitish, with a slight yellowish tint; usually blind; no traces of eyes. Body of the usual form; antennæ of great length, two-thirds as long as the body and more than twice as long as the head; basal joint longer than usual; fourth joint very long and slender. Legs: last joint with fine slender scales; the claws much as in *D. grisea* Pack., but the spines on the larger claw are less distinct and the tenent hair shorter; the spring long and slender; the second joint serrulate along the under side nearly to the base; third (terminal) joint long and slender, ending in three teeth; the terminal tooth claw-like, as usual. The collophore (Fig. *2c*) is large and well developed.

Length of body, without the spring, 3^{mm}.

Fig. 2 represents an average specimen from New Wyandotte Cave, where we found this species in great abundance. It also occurred in Bradford Cave, Indiana; in general form and color it was like the New Wyandotte form, but as seen in Fig. *2c* the antennæ are much shorter, especially the fourth joint; also the end of the spring is slenderer. It has no eyes; the body is of the same size, and the feet nearly the same. While the Lepidocyrtus may be only an occasional visitor to the cave in which it was found, the present species being eyeless and bleached, besides being very numerous, is, without doubt, a true troglodyte.

Specimens found in the Carter caves, especially Zwingle's, about one-quarter of a mile from daylight, had antennæ (Fig. *2a*) with the fourth joint slightly longer than in the Bradford Cave examples, but much shorter than in those from New Wyandotte; and the spring (Fig. *2g*) is less hairy. It also occurred in Bat Cave, the specimens being certainly eyeless.

Specimens from Diamond Cave (Fig. *2d*) were identical in form, color, and length of antennæ with those living in the Carter caves. The color did not noticeably vary in specimens from any of the caves.

Unfortunately no specimens were found in the large Wyandotte Cave, if it occurs there. It does not appear to be an inhabitant of Mammoth Cave, though occurring in Diamond Cave.

The antennæ in this species are much longer than in any American form known to us, and are much longer than in any European species figured by Lubbock, though in this respect it approaches nearest to *D. annulata* (Fabr.), which is a pale greenish-yellow species, with remarkably long antennæ.

Remarks.—The result of the examination of specimens from different caves shows that this species varies most perceptibly in the length of the antennæ, especially the fourth or terminal joint, which is shortest in the specimens inhabiting the smallest, shallowest cave (Bradford), and longest in the deep, perfectly-dark New Wyandotte Cave. In caves like those of Carter county and Diamond Cave the individuals are nearly alike, the antennæ being a little longer than in the Bradford Cave specimens. It should be noticed that, compared with our American out-of-door species, the New Wyandotte examples have remarkably long antennæ.

SMYNTHURUS FERRUGINEUS n. sp. Plate XVI, figs. 4, 4*a*, 4*b*, 4*c*.

Ferruginous, mottled with bright orange-red; eyes distinct reddish, or deep brick-red; abdomen globular; antennæ moderately long and slender, ten to twelve jointed, with verticils of hairs; the spring rather large; the terminal joint acute, serrulate beneath, except at the end, which is obliquely truncated; the tarsus is perhaps rather slender; the claws only moderately stout. Length, 1.1^{mm}. Common in New Market and Weyer's caves, Virginia. The young when 0.8^{mm} long are white all over and with no traces of eyes. The antennæ are slenderer than in *S. rosea* Pack., and the claws are slenderer than in an undescribed Smynthurus from Massachusetts. It is doubtful whether this should be regarded as a true cave species any more than *Tomocerus plumbeus*, or *Lepidocyrtus atropurpureus*. Another white species occurs in Mammoth Cave.

CAMPODEA COOKEI Pack. Plate XVII, figs. 1, 1*a* to 1*i*.

Campodea cookei Pack., Amer. Naturalist, v, 747, December, 1871; Fifth Ann. Rep. Peab. Acad. Sci., Salem, 46, 1873.

Closely allied to *C. staphylinus* Westw. (common to Europe and America), but it is much larger; the antennæ are twenty-four instead of twenty-jointed, as in the other species, and are longer in proportion, reaching to the basal abdominal segment, while in *C. staphylinus* they reach only to the second thoracic; the terminal joints are much longer than in that species, the penultimate joint being one-third longer. The terminal joint (Pl. XVII, fig. 1e), as may be seen by comparison with that of the out-of-door species (Fig. 2), is very much slenderer, while the olfactory (?) area (*ol.*) at the extreme end is somewhat larger. Terminal abdominal segment longer and slenderer; hind femora longer than in *C. staphylinus*. Caudal stylets (cercopoda) about twelve-jointed, very long and slender (Fig. 1*f*). Entirely white, body somewhat pilose, some of the setæ spinulose (Fig. 1*i*). Length, .25 inch without the antennæ and cercopods. Frequent in Mammoth, White's, Salt, Diamond, Wyandotte (Packard), Indian Cave (Hubbard).

MACHILIS CAVERNICOLA (Tellkampf).

Triura cavernicola Tellkampf, Archiv für Naturgeschichte, x, 321.
Machilis cavernicola Pack., Amer. Naturalist, v, 747, 1871; Fifth Rep. Peab. Acad. Sci., Salem, 51, 1873.

This species is described as being white. It is rare, and my single specimen seemed immature and was mislaid. Mammoth Cave. A Machilis also occurred in Wyandotte Cave.

ORTHOPTERA.

HADENŒCUS SUBTERRANEUS Scudd.

Raphidophora subterranea Scudder, Proc. Bost. Soc. Nat. Hist., viii, 8, 1861.
Hadenœcus subterraneus Scudder, Bost. Journ. Nat. Hist., vii, 440, 1862.

The following description is copied from that by Mr. Scudder:

Fuscous,* under surface of body, the head except vertex, both pair of palpi except extremities, coxæ, under side of femora, terminal third of tibiæ, and the tarsi except the under edge

* The colors of both species are described from specimens dried after a long immersion in alcohol. (S. H. S.)

and extremities, paler; some faint reddish-brown spots on upper surface of thoracic segments. A much depressed, scarcely perceptible carina along the dorsum. All the appendages densely covered with short, fine, microscopic hairs.

Antennæ dark brown at base, becoming paler toward the tip; first joint stout, somewhat flattened anteriorly, obliquely truncated interiorly at the base; second joint half as long and as broad as first, compressed anteriorly; third cylindrical, as long as first, at base of the same breadth as second, but narrowing rapidly though but slightly; remainder of unequal length, but averaging at first half the length of the third joint, slowly diminishing in size, so that the whole tapers very gradually to the very delicate extremity. Tip of the last joint of the maxillary palpus with a slight excavation interiorly; eyes black, subovate, subglobose.

Four anterior coxæ carinated externally, the carina of the two anterior being produced into a central spine. A double row of distant, alternate, short spines on under side of the four anterior tibiæ, with two upon either side at the extremity, of which the lower is largest, embracing the base of the tarsi; posterior tibiæ with a double row of minute sharp spines, extending nearly the whole length of the hinder portion, raised at a very small angle, interrupted by longer, distant, and alternate ones, elevated to a higher angle; upon the anterior lower third are two approximate rows of distant spines; three spines at the extremity upon either side, embracing the first joint of the tarsi; the first and third of a nearly equal size and appearance to the larger tibial spines, while the second is three times as long and thickly covered with short, fine hairs; all the longer spines are movable, and tipped with reddish-brown, approaching to black; terminal half of claws black.

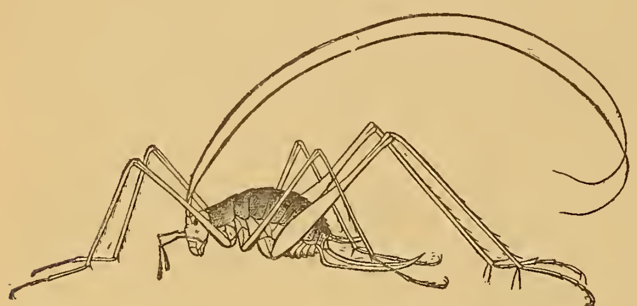

FIG. 16.—*Hadenœcus subterraneus* Scudder. Natural size. Emerton del.

Ovipositor rufo-testaceous, swollen at the base, flattened in the terminal two-thirds, nearly straight, slightly curved upwards and ensiform at the tip, produced to a sharp point, with five or six serrations on the lower edge of extremity of inner valves, but hidden by the outer ones; analcerci tapering to a fine point, furnished, besides the short hairs common to all appendages, with exceedingly fine long ones, shortening towards the apex.

Measurements (the average of many specimens): Anterior femora, .54 inch; anterior tibiæ, .59 inch; middle femora, .49 inch; middle tibiæ, .59 inch; posterior femora, .84 inch; posterior tibiæ, 1.08 inches; antennæ (longest), .4 inch; maxillary palpi, .50 inch; ovipositor, .52 inch; cerci, .26 inch; whole body (as curved), .66 inch.

"This species is the one inhabiting Mammoth Cave, of Kentucky, and the adjoining White's Cave; they were found throughout the cave to the remotest parts (7 miles or thereabouts), though not near the entrances, especially in damp, moist situations, where they abound; they were found in especial plenty about Martha's Vineyard and in the neighborhood of Richardson's Spring, where they were discovered jumping about with the greatest alacrity upon the walls, where only they are found, and even when disturbed clinging to the ceiling, upon which they walked easily; they would leap away from approaching footsteps, but stop at a cessation of the noise, turning about and swaying their long antennæ in a most ludicrous manner in the direction whence the disturbance had proceeded; the least noise would increase their tremulousness, while they were unconcerned at distant motions unaccompanied by sound, even though producing a sensible current of air; neither did the light of the lamp appear to disturb them. Their eyes and those of the succeeding species are perfectly formed throughout, and they could apparently see with ease, for they jump away from the slowly-approaching hand, so as to necessitate rapidity of motion in seizing them. Late in October females were obtained enormously distended with eggs." (Scudder.)

It will be interesting to know whether this cricket in small caves varied as to its eyes from those living in large ones. The specimens were compared with Mammoth Cave examples as standards.

LOCALITIES, WITH NOTES ON VARIATION.

(A) *Mammoth Cave region* (*Edmonson county*).—In forty males and fifteen females from Mammoth Cave (Packard) there was no variation in the size of the eyes. In two young females of the same size (length, 12^{mm}) the ovipositor is normal in one, in the other only one-third as long, the latter being less sexually mature. This shows that the principle of acceleration and retardation may work in caves as well as out of doors; in this case sexual development was much retarded.

In ten males and twelve females collected by C. Cooke in Mammoth Cave (Mus. P. A. S.) there was no sensible variation in the eyes or ovipositor.

Four males and eight females from Dixon's Cave (Packard coll.) presented no differences from those in Mammoth Cave.

Twenty four males and twenty-two females from White's Cave (Packard coll.), occurring from the end of the cave to within 5 feet of the mouth, did not differ in any respect from Mammoth Cave examples, the eyes being of the same size and the antennæ of the same length.

Eight males and six females from a small cave near Ice cave (near Mammoth), which was about 80 feet deep, had eyes which were certainly no larger than those Mammoth Cave examples and showed no other differences. We would naturally expect that the eyes of *H. subterraneus* from such a small cave as this and those from within 5 feet of the mouth of White's Cave would show larger eyes, but they were in no respect different, so far as we could see.

Eight males and two females from Salt Cave, as regards the eyes, were just the same as Mammoth Cave specimens.

Twenty-five males and fifteen females from Diamond Cave (Packard) all had eyes, both young and old, of the normal size.

Two males and two females from Mail Robber's Cave, near Glasgow Junction, which is 100 feet deep (Sanborn), were normal.

Eight males and four females from a cave near Baker's Furnace, collected by Mr. Sanborn (June 19) at a point nearly 100 feet from daylight, had eyes like Mammoth Cave examples.

In a pair (one male, one female) from One Hundred Dome Cave, near Glasgow Junction, collected by Mr. Sanborn (May 10) at about 200 yards from the entrance, the eyes are as in Mammoth Cave examples.

Six males and six females from Walnut Hill Spring Cave, collected May 14 by Mr. Sanborn 100 yards from daylight, were normal as regards the eyes.

Eight males and twelve females, collected July 24 by Mr. Sanborn in John and Fred's Cave, on the east bank of Dismal Creek, 200 yards in from the mouth, did not differ from Mammoth Cave forms.

Five males and females collected by Mr. Sanborn in Short Cave, near Glasgow Junction, had eyes of the normal size, as in Mammoth Cave individuals.

Twenty males and females collected by Mr. Sanborn in Proctor's Cave, 5 miles from Glasgow Junction, had eyes all of the same size and like those of Mammoth Cave individuals.

Two males and six females collected by Mr. F. W. Putnam (November 12) in Grand Avenue Cave had eyes of the normal size.

Two males and females collected by Mr. Sanborn in Little Lithographic Cave No. 2, Glasgow Junction, had eyes of a normal size.

Three males and one female, collected May 28 in Poynter's Cave (Sanborn), had eyes of normal size.

Fourteen males and three females from the cave under Gardiner's Knob, near Glasgow Junction (Sanborn), had normal eyes.

Ten males and five females from Sugar Bowl Cave, 3 miles west by north from Glasgow Junction (Sanborn), had eyes of the usual size.

Ten males and ten females from Wetzel's Cave (May 30, Sanborn) had normal eyes.

One male from One Hundred Dome Cave (Sanborn) had normal eyes.

Six males and two females from Haunted Cave (June 13, Sanborn) had normal eyes.

Four males from Emerson Spring Branch Cave (collected June 12 by John R. Proctor, esq.) had eyes of the usual size.

(B) *Carter County caves.*—Two females from Gray Tom's Cave (August 21, Sanborn), four males and seven females from Zwingle's Cave (Packard), four males and four females from Bat Cave (Packard), had eyes like those of Mammoth Cave.

Three males and three females from Van Meter's Cave, Grayson Springs (October 25, Sanborn), had eyes as usual.

Two females from Burchell's Cave, Carter county (August 18, Sanborn), had eyes of the usual shape.

(C) *Nickajack Cave.*—Three small specimens were found by Professor Cope in this cave, which only differed from Mammoth Cave individuals in having rather shorter, thicker maxillary palpi; but this is not even a varietal difference, as the antennæ and legs have the same proportions. (Amer. Naturalist, xv, 882.)

Remarks.—From the foregoing facts it will be seen that this species does not vary perceptibly, either in its eyes or appendages, whether occurring in large or small caves. or living in total darkness or in partial daylight.

CEUTHOPHILUS STYGIUS Scudder.

Raphidophora stygia Scudd., Proc. Bost. Soc. Nat. Hist., viii, 9, Jan. 2, 1861.
Ceuthophilus stygius Scudd., Bost. Journ. Nat. Hist., vii, 438, 1862.

Eight males and six females from Wyandotte and Little Wyandotte caves. The males of larger size than usual; front of head rather high and narrow, clypeus rather long and narrow, nearly twice as long as in *C. latens*. Maxillary palpi rather longer than in *C. latens* and *sloanii*. Antennæ a little more than twice as long as the body; basal joint large and swollen, subconical, much larger at the base than in *C. sloanii*, and nearly twice as large as in *C. latens*; second joint two-thirds as long as the third, where in *C. sloanii* it is only half as long as the third; the remainder dark, annulated at long intervals with white. Hind legs of the same length as the antennæ; hind femora long, much more so than in *C. maculatus*, *sloanii*, *latens*, or *lapidicola*, with the pale oblique spots and bars very distinct; a broad pale ring on the distal fourth; tips of tibiæ and entire tarsi whitish; spines whitish. Fore and middle legs white, except ends of femora and tibiæ; the latter pale at tip. Anal stylets (cercopoda) either wholly dusky or whitish on the basal half in male and female. Ovipositor rather long and slender, about as long as in *C. maculatus*, and much longer than in *C. latens*, with five stout teeth, the end of the denticulated blades broader, with stouter teeth than in *C. maculatus*. Coloration rather dark, with broad irregular dark bands across the front between the eyes; a broad dark band on the front and posterior edge of the pronotum, and one on each succeeding body segment. The band on the front edge of the pronotum sends a median spatulate prolongation back nearly touching the posterior dark band. No pale dorsal median band as in *C. sloanii*, by which character it may at once be separated from the latter species, its companion cave-dweller, as well as from *C. maculatus*.

Male. Length of body, 31^{mm}; of antennæ, 72^{mm}; of hind femora, 25^{mm}; of ovipositor, 13^{mm}; male of the same proportions.

One male and six females from Wyandotte Cave are larger than from any other cave and decidedly paler, though the specimens vary considerably among themselves. Twelve males and females from Little Wyandotte Cave are like those from White's Cave, being smaller and darker than those from the Great Wyandotte Cave.

Five males and two females from a cave in Washington county, Indiana (Dr. John Sloan), are large, and colored much as in those from Wyandotte Cave. Three small males of the usual color from Georgetown, Floyd county, Indiana (Dr. Sloan).

Ten males and five females from White's Cave vary in intensity of coloration; in some the dark bands are more distinct than in others, which are more mottled with dark; all are immature. They were found from 5 feet from the mouth to the end of the cave, in company with *H. subterraneus*, on the sides and roof as well as on the columns of the caves.

One female from Diamond Cave, living in total darkness, was darker than usual.

One large male and three females from John and Fred Field Cave, near Dismal Creek, Bee Spring, Ky. (July 24, Sanborn), are darker than Wyandotte specimens; this and other facts showing that those living in the smaller caves are darker, less bleached, than those in the larger caves.

Two males and one female from One Hundred Dome Cave (Sanborn) were rather dark.

Two mature females from Laurel Cave, Carter county, Kentucky (Sanborn), were as large as those from Wyandotte Cave, and fully as pale, being lighter than usual. This species has not yet been detected out-of-doors, and, like *H. subterraneus* and *C. sloanii*, is, so far as known, exclusively confined to caves. The original locality mentioned by Mr. Scudder was Hickman's Cave, Kentucky (Hyatt).

CEUTHOPHILUS SLOANII Packard.

Ceuthophilus sloanii Pack., Fifth An. Rep. Peab. Acad. Sci., 93, July, 1873.

Six males and four females. Antennæ banded with pale rings, a little more than three times the length of the body;* the basal joint rather large; the second half as long as the third, the latter as long as the first. Palpi considerably shorter than in *C. stygius*. The head in front is much narrower than in *C. latens* and much as in *C. stygius*. Head brown above the eyes, with a narrow, triangular, pale median area, which is the beginning of the dorsal stripe; a dark median spot in front of the eyes. The species is at once known by the conspicuous pale dorsal band which extends from between the eyes to the fourth segment behind, dilating slightly on the front edge of segments 2 to 4; the brown portion has scattered pale dots on each side of the line, while on the terminal segments of the abdomen the body is densely spotted with brown, the spots being arranged in transverse bands. Cercopoda (anal cerci) dark. Hind femora unusually short and stout, though a little slenderer than in *C. latens*, and more distinctly barred and spotted than in that species.

Length of body, 14^{mm}; antennæ, 30 to 40^{mm}; hind femora, 10^{mm}. The ovipositor of the immature females only 2.2^{mm} in length, with none of the characters of maturity. Bradford Cave (Dr. Sloan); Little Wyandotte Cave (Packard).

A mature female was collected by Mr. Sanborn in John and Zed Field's Cave, near Dismal Creek, Bee Spring, Kentucky, July 24. It differs from the others in the pale dorsal median band not extending upon the head, but posteriorly it extends to the end of the abdomen. The markings on the hind femora are as in the other specimens.

The ovipositor is much shorter than in *C. stygius*, is rather slender, narrowing more at the acute, upcurved end than in *C. stygius*, the inner blades with five long slender teeth, increasing in length to the last, being longer and slenderer than in *C. stygius*. Length of body without the ovipositor, 16^{mm}; of antennæ, 32^{mm}; of hind femora, 11.5^{mm}; ovipositor, 5^{mm}.

This species may easily be distinguished from *C. stygius* by the short antennæ and palpi, and especially by the short hind femora and the pale conspicuous dorsal line on the head and thoracic segments. From *C. maculatus* it is distinguished by the short hind femora and the distinct dorsal line and longer antennæ.

CEUTHOPHILUS ENSIFER Packard.

Ceuthophilus ensifer Packard, Amer. Naturalist, xv, 882; Pl. vii, figs. 4, 4a, 4b; Nov. 5, 1881.

This species differs from *C. stygius* Scudd. in the much more pointed saber-shaped ovipositor, its tip being long, slender, and acutely curved, with six smaller teeth, there being but five in large

Fig. 17. *Ceuthophilus ensifer* Pack., nat. size; *a*, end of the abdomen, with the outer blade of the ovipositor turned up to show the shape of the toothed inner blade (the six teeth not, however, well shown); *b*, the same with the outer blade in its natural position. Kingsley, del.

individuals of *C. stygius*, in which the ovipositor is blunt and the tip obliquely truncate, while the hind femora are a little longer. The eyes are as well developed as in *C. stygius*. The color

* In *C. maculatus* the antennæ are just twice the length of the body.

and marking are much the same in the two species, both being thickly spotted with black-brown; *C. ensifer* has darker colors and more distinct spots than *C. stygius*, though the latter grows to a larger size. Length of whole body, not including the ovipositor, 22^{mm}; length of ovipositor, 8^{mm}; of hind femur, 20^{mm}; of hind tibia, 20^{mm}. It differs from *C. latens* Scudder and *C. sloanii* Packard in the longer legs, and can only be confounded with *C. stygius*.

Nickajack Cave (Prof. E. D. Cope).

Ceuthophilus maculatus Harris.

Ceuthophilus maculatus Harris.

This is not a genuine cave species, as it is abundant everywhere out of doors under stones and leaves. I have never seen it in any cave.

A specimen from the Hoosac Tunnel, Massachusetts, collected by Professor Shaler at a point 1,500 feet from the entrance, only differs from ordinary examples in the want of the usual twist in the hind tibiæ; this, however, is not a constant character.

A specimen was found March 15, 1870, by Mr. R. P. Whitfield (and loaned me by Mr. J. H. Emerton) in Howe's Cave, New York, at a point half a mile in from the mouth. It is not different from other specimens found under stones, being no paler in hue.

It should be observed that *C. maculatus* is a boreal species, not having, so far as we are aware, been found south of the New England States; it is probably replaced in the Middle and Central States by *C. lapidicolus* (Pennsylvania to Georgia).

Psocidæ.*

I have only seen a few Psocidæ from caves, and such only from the Mammoth Cave. They represent two or three species.

Atropos divinatoria Muell.

Only one specimen mentioned in my monograph Atropina, Stett. Zeit., 1883, volume xliv., page 291. There is given a very detailed description of this species and figures, Pl. ii. Mr. Hubbard found the specimen upon offal from the Rotunda Cave, *after* it had been taken to Detroit. Though its occurrence is very probable in the cave (as its occurs everywhere), he considers, very judiciously, the specimen not as certain (Amer. Ent., Vol. iii, p. 84). Found August 21, 1879, not far from the mouth.

Hyperetes tessulatus Hagen.

Hyperetes tessulatus Hagen.

Fully described also in my monograph of Atropina, page 319, Pl. ii, fig. 2. I have stated that I have seen one specimen, partly crushed, collected on manure of bats in the Mammoth Cave. I do not find this specimen in the collection, and I do not remember by whom it was collected; but one of the two specimens of Hubbard is crushed, and shows the tip of the maxilla trifid, as in Hyperetes. Perhaps this has induced me to consider the specimen as Hyperetes, and it would need confirmation by other specimens. I think it belongs to the following species.

Dorypteryx pallida Aaron. Pl. XVII, Fig. 4, 4*a*. 4*b*.

Dorypteryx pallida Aaron, Trans. Amer. Ent. Soc., 1883, Vol. xi, p. 37, Pl. ix, fig. 3.

A few specimens in bad condition, in alcohol, were collected by Prof. A. S. Packard in the old mouth of Madison's Cave, in partial daylight. They are different in size, the largest a little more than 2^{mm} long, the smallest 1^{mm}. The fact that the tarsi are three-jointed induced me to say that they may perhaps belong to Elipsocus or Myopsocus, the only genera known with three-jointed tarsi and wings in the United States. My later studies showed the tip of the maxilla to be trifid, and so the affinities mentioned before can not be accepted. The Psocina have a bifid maxilla, the Atropina a trifid one. Only as far as known till now the fossil genus Empheria, belonging to the Psocina, has a trifid maxilla.

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* I am indebted to Prof. H. Hagen for the following account of the cave species of Psocidæ.

Though it is impossible to state if these cave Psocina belong to Dorypteryx, it is at least probable. I have before me only the *imago* of Dorypteryx, and the cave Psocina are all *nymphæ*. The narrow wing-cases are oval, only a little longer than the thorax, and in younger specimens much shorter; all show a little wing still in the cases. The color of the specimens is ivory white, a little yellowish (four obscure spots on occiput) on the head; the eyes are in the hind corner of the head, large, dark facets, in some convex (as in Clothilla); *no* ocelli; antennæ (only in one seven basal joints are present) long, thin; the two basal joints thicker, shorter, the following slender, cylindrical, long; maxillæ *trifid* at tip; the most external division longest, cut straight at tip, but its inner angle bent upward, so that the tip looks pointed; the middle tooth shorter, narrower, somewhat ovoid; the third or inner tooth more distant, short, strong, bent outwards. The mandibles are large, ending in a sharp incurved tip, with a tooth before it; the base of both mandibles show a strong molar tooth with transverse incisures; the three segments of the thorax narrow, separated; feet very long and slender; tibiæ much longer than the femur; tarsi three-jointed; basal joint long, the following ones short, of equal length; claws short, nearly straight; tip sharp, before it one inferior tooth; in some, at least certainly in one fore-leg, three internal teeth are to be seen (with a high power); there are no arolia between the claws; abdomen longer, more rounded, and ovoid in the apical half.

The principal difference between the cave specimens would be the wanting of the long marginal hairs of the wings; but these are only described for the *imago*, and I have not seen *nymphæ* (of Aaron) of Dorypteryx. Of the two specimens found by Mr. Hubbard (*l. c.*, p. 84), I have only one before me, and I believe I have returned the other (I think the crushed one is of another lot). The specimen before me has three black very faint ocelli, and the eyes more developed as regards the facets; but the wings are real *nymphæ* wings, and not, as I have stated (apparently form the returned specimen) fastened only to the external corner of the thorax. Otherwise the specimen is perfectly similar to those collected by Professor Packard. Indeed all the wings are more like those of the short-winged individuals of Termes. I should state that I am not yet sure that Dorypteryx and the cave Psocus belong to the Atropina, where the trifid maxilla would place it, the more so as the fossil Empheria has similar maxillæ. An additional objection is the fact that all the cave specimens lose the setæ of the antennæ in alcohol, whereas Atropina mostly retain the setæ, especially Hyperetes. The fact that among Atropina occasionally appear ocelli, as also in Clothilla (p. 305 Mon. Atrop.), explains their presence in the cave insects. I believe that more material alone would give more security as to the position in the system of these cave insects.

The following list of cave Coleoptera and remarks, with localities, were kindly prepared for me by the late Dr. J. L. Le Conte, and they are printed just as he wrote them. I have added copies of the original descriptions and remarks.

CAVE COLEOPTERA RECEIVED FROM DR. PACKARD.

Plates XVIII, XIX, and XX.

I.—TRUE SUBTERRANEAN SPECIES.

Anophthalmus Sturm.

[*Maxillary palpi with last joint shorter.]

1. *A. tellkampfii* Er., Müll. Arch., 1844, 384.

Mammoth Cave; Walnut Spring Cave, 100 yards from daylight; Long Cave, 1 mile in; cave under Gardener's Knob; Little Lithographic Cave, No. 2 (Engine Cave); Diamond Cave; Salt Cave; Poynter's Cave; White's Cave, near Mammoth Cave; Grand Avenue Cave, 70 feet deep, below Proctor's, Glasgow Junction; Proctor's Cave; Sugar Bowl Cave; small caves near Glasgow Junction.

[** Maxillary palpi with the last joint longer.]

2. *A. menetriesii*, Motsch. Etudes Entom., 1862, 41; *angulatus* Lec., New Spec., 1863, 18.

Walnut Hill Spring Cave, Glasgow Junction, 50 feet in, collected by daylight; Walnut Hill Spring Cave, Glasgow Junction, 100 yards from daylight; Little Lithographic Cave, No. 2; Poynter's Cave, 300 yards in; Diamond Cave; Grand Avenue Cave; One Hundred Dome Cave; Proctor's Cave; Mammoth Cave.

A. striatus Motsch, *ibid.*, seems to be a small variety of this species. The elytra are not entirely glabrous in this species, but are sparsely clothed with short erect hairs, visible only with a powerful lens; it is easily distinguished from the others by the side margin of the elytra behind the humeri being distinctly crenate for a short distance.

A. ventricosus Motsch. still remains unaccounted for in our collections. It was found in Mammoth Cave, and I see nothing in the description which forbids its reference also to this species, which, with a large series of specimens, is seen to vary slightly in form.

3. *A. pusio* Horn, Trans. Am. Ent. Soc., i, 125.

Carter Cave (X Cave). First described from Erhart's Cave, Montgomery county, Virginia.

4. *A. eremita* Horn, Trans. Am. Ent. Soc., iii, 328.

Wyandotte Cave (its original locality), one specimen.

5. *A. tenuis* Horn, *ibid.*, iii, 327.

Bradford caves, two specimens; first described from Wyandotte Cave, Indiana.

6. *A. pubescens* Horn, *ibid.*, i, 126.

Walnut Hill Spring Cave, near Glasgow Junction, 100 yards from daylight. First described from Cave City Cave.

ADELOPS Tellkampf.

A. hirtus Tellk., Wiegm. Archiv., 1844, i, 318, tab. 8, figs. 1 to 6.

Walnut Hill Spring Cave, 50 feet in, collected by daylight; Walnut Hill Spring Cave, 100 yards from daylight; Little Lithographic Cave; Poynter's Cave, 300 yards in; White's Cave; One Hundred Dome Cave; Proctor's Cave; Mammoth Cave, a widely-distributed species; no perceptible difference exists between the specimens from the different localities.

II.—SPECIES WITH DISTINCT EYES.

BATRISUS Leach. (Pl. XX, Fig. 10.)

B. spretus Lec., Bost. Journ. Nat. Hist., vi, 100.

Two females found in the end of Dixon's Cave, near Mammoth Cave. A common species from Vermont to Georgia.

QUEDIUS Leach. (Pl. XX, Fig. 11.)

Q. fulgidus Er. Col., March, i, 486; Staphyl., 525; *Staphylinus fulg.* Fabr.

Weyer's Cave; end of Dixon's Cave, near Mammoth Cave. A common species in the Middle and Western States. *Q. spelæus* Horn, Trans. Am. Ent. Soc., iii, 332, differs from this species by the more widely-flattened sides of the prothorax and the much more finely and densely punctured elytra.

CEUTHOPHAGUS Grav.

A. brunneus Say, Journ. Ac. Nat. Sci., iii, 158, ed. Lec.

Walnut Hill Spring Cave, 50 feet in, collected by daylight. Found throughout the Middle and Western States.

OXYPODA Mann.

An undescribed species, known to me from other localities, was found in Bradford's Cave.

SYNOPSIS BY DR. HORN OF THE SPECIES OF NORTH AMERICAN ANOPHTHALMUS.*

Penultimate joint of maxillary palpi longer than the last joint. Base of elytra obliquely prolonged. Thorax much longer than wide; hind angles rectangular; base truncate. Body glabrous..........*tellkampfi.*

Penultimate joint equal to last, or even slightly shorter. Elytra shining, not pubescent. Thorax longer than wide. Third angle of thorax strictly rectangular; base squarely truncate. Elytra elongate oval, feebly convex; striæ obsolete. Form slender..........*tenuis.*

Hind angles acute, slightly prominent, base distinctly prolonged at middle. Elytra broadly oval, more convex; striæ moderately deep and punctured. Form robust..........*menetriesi.*

Elytra subopaque, distinctly pubescent. Thorax as wide or wider than long. Elytral base never obliquely prolonged. Sides of thorax gradually narrowing to base, scarcely sinuate. Hind angles rectangular, or nearly so, but never acute and prominent. Thorax at base as wide as long..........*eremita.*

Thorax at base narrower than long; at widest portion not wider than long..........*pusio.*

Sides of thorax sinuately narrowing to base, hind angles acute, prominent outwardly. Elytra very distinctly pubescent..........*pubescens.*

We add descriptions, taken from Dr. Horn's article, of the less-known species, *A. audax* Horn excepted.

Anophthalmus tenuis Horn. Pl. XX, fig. 2.—Pale rufo-testaceous, shining. Head slightly darker in color, oval, and arcuately bi-impressed. Thorax broader than the head, slightly longer than broad, and sinuately narrowing to hind angles, which are exactly rectangular; median line distinctly impressed in its entire length, basal impression deep; base of thorax truncate. Elytra elongate oval, feeble convex, at base slightly flattened; two-thirds longer than broad. Humeri obtusely rounded; surface with feeble traces of striæ and three dorsal setigerous punctures on each elytron in or nearest to the position of the third stria. Body beneath similar in color to the upper surface; legs somewhat paler. Length, .18 to .24 inch=4.5 to 6^{mm}.

This species is closely allied to *menetriesii*, Motsch. (*angulatus* Lec.), but differs by its more elongate and less robust form and less convex surface. The elytra are smoother and with very feeble traces of striæ. The two species differ especially in the form of the hinder thoracic angles and base of thorax. In *menetriesii* the angles are acute, slightly prominent externally, and the base of the thorax slightly prolonged, while in the present species the angles are strictly rectangular and the base truncate.

A. eremita Horn (Pl. XVIII, fig. 3, XX, fig. 3).—Pale. Rufo-testaceous, feebly shining. Head oval, arcuately bi-impressed impressions moderately deep, intervening space feebly convex. Thorax wider at widest portion than long; sides moderately rounded in front, gradually narrowed to base; hind angles rectangular; base truncate and as wide as length of thorax; disk feebly convex, median line distinctly impressed, basal transverse impression moderate. Elytra oval, less shining than thorax, and sparsely clothed with very short erect pubescence; striæ obsolete; three dorsal punctures on the line of the third stria. Length, .20 inch=5^{mm}.

The only species with which it might be confounded is that previously described by me under the name *pusio*, and although differing very notably on comparison in their general aspect, the points of difference are not easily made plain in a description. The present species is in all respects broader and less depressed without being convex, as in *menetriesi.* The thorax is broader, less narrowed behind, and sides more rounded. The elytra are less shining and the pubescence more distinct, although in both species the pubescence can only be observed by holding the specimen between the eye and the light, and then only with a good power. In the three species at the head of the accompanying table no signs whatever of pubescence can be observed. The elytral striæ are here also entirely obliterated; faint traces are discernible only at the base. The basal margin is not prolonged. The few remarks on the comparison of *tenuis* with the two as yet unknown species described by Motschulsky apply equally to this one.

A. pusio Horn (Pl. XX, fig 1).—Pale brownish testaceous. Head oval, slightly longer than broad; longitudinal impression faint, surface very finely alutaceous. Thorax trapezoidal, slightly broader than long, feebly emarginate anteriorly, sides moderately rounded anteriorly, slightly sinuate posteriorly, base feebly bisinuate, and emarginate at middle; surface smooth, shining, with median longitudinal line and a broad impression within each hind angle, angles rectangular. Elytra oval, sides moderately rounded; humeri distinct, obtuse; surface feebly striate, and sparsely covered with suberect, very short pubescence. Length, .15 inch.

This species may be readily distinguished from any of our others by the form of thorax, as well as by the pubescence covering the elytra and under surface of the body. The thorax is slightly broader than long, trapezoidal, narrower behind. The surface is less convex than any of the described species of our country, not only that of the thorax, but also of the elytra. The humeral angles of the elytra are well defined, and the bases of the elytra nearly transverse and not obliquely produced, as in *tellkampfii.* The head is relatively broader than in the glabrous species, and the thorax scarcely broader than the head. In this species the mentum tooth becomes very broad and obtuse, approaching in this respect Aphænops, in which the mentum has no tooth. The upper surface of the body is provided with setæ arising from punctures, those on the head being short. The thorax has one on each side about its middle; the elytra have three each, arranged in a row, one near the base, another median, and a third near the apex. Collected in Erhart's Cave, Montgomery county, Virginia, by Prof. E. D. Cope.

A. pubescens Horn (Pl. XX, fig. 4).—Pale testaceous, shining. Head oval, attenuate anteriorily, finely alutaceous, and with two longitudinal, faintly impressed lines convex internally. Thorax moderately convex, glabrous,

* Descriptions of new Coleoptera of the United States. Trans. Amer. Ent. Soc., iii, Nov., 1871.

one-third broader than long, trapezoidal, narrower behind, sides broadly rounded, sinuate posteriorly, angles acute and prominent, a longitudinal median line and two basal impressions, anteriorly feebly emarginate; base slightly produced and emarginate at middle. Elytra oval, moderately convex, with striæ evanescent at the sides and apex, base broadly rounded; humeri distinct, obtuse, surface clothed with rather dense suberect pubescence; third stria with three setiferous punctures. Beneath finely and more sparsely pubescent. Length, .23 inch.

Easily known by its pubescence, form of thorax, and very acute hind angles. The form of thorax is very nearly that of *Trechus rubens.* The pubescence covering the surface of the body is exceedingly fine in this and the preceding species, requiring a good lens for its detection. Collected in Cave City Cave by Mr. Charles Sonne.

We append the description of the last species of this genus discovered., I am indebted to Dr. George Marx for the excellent figure of this species.

Anophthalmus interstitialis Hubbard. Pl. XX, fig. 5.

Pale rufo-testaceus, shining. Head elongate-oval, deeply arcuately bi-impressed, nearly as wide as prothorax. Antennæ slender. Thorax longer than broad, narrowed behind, sides moderately rounded, sinuate posteriorly, hind angles rectangular, base truncate, median line impressed throughout its entire length, basal impressions deep. Elytra elongate-oval, feebly convex, moderately deeply striate, the striæ obsoletely punctate and scarcely fainter at the sides; sides sinuate immediately behind the humeri, which are obliquely rounded; base prolonged at middle; elytral interspaces distinctly but sparsely punctured, more distinctly outwardly from the fourth, the punctures on alternate interspaces almost uniseriate, and each bearing a short erect hair. Length, 5.4^{mm} = .21 inch.

A single female from Washington's Hall, in the Mammoth Cave.

The species is at once distinguished from all others in our fauna by the punctured outer interspaces of the elytra. Though plainly pubescent (the lines of hairs on the elytra are easily seen with a lens of moderate power), it differs from all other pubescent species by the thorax being longer than wide and the base of the elytra obliquely prolonged. The elytra, moreover, can not be called subopaque, and are hardly less shining than in *A. menetriesii.* It is most closely allied to *A. tenuis,* which it resembles especially in its very elongate form, but differs by the very distinctly striate elytra. The elytra are less truncate at base than in *A. menetriesii,* and the punctures of the striæ are much finer and less distinct. The antennæ are long and slender, as in *A. tellkampfii,* and the form of the body is even more slender. The penultimate joint of maxillary palpi is shorter than the last joint.

A specimen of *A. menetriesii* from Mammoth Cave in my possession is plainly but very sparsely pubescent, there being a single row of fine hairs on each elytral interspace. Twelve other specimens of the same species all show traces of pubescence. The smallest individual among these measures but 4.8^{mm} (=.19 inch) in length; is somewhat lighter in color, more elongate in form, and with the hind angles of prothorax less acute. (Amer. Ent., iii, 1880.)

THE LARVA AND PUPA OF ANOPHTHALMUS AND ADELOPS.

(Plate XX, figs. 6, 6*a*, 6*d*, 7, 9, 9*a*.)

It was a matter of much importance to discover the larvæ or young of the blind beetles, the true autochthones of these caverns, in order to ascertain whether the young are born blind, particularly as the larvæ of these genera, so far as we know, had not yet been discovered in Europe. Systematic research in different caves soon revealed several larvæ, both of Anophthalmus and of Adelops. The young Anophthalmus occurred in several caves, particularly in Salt Cave, on damp sand-banks, under stones. Fig. 6 represents what is without much doubt the larva of *A. tellkampfii.* This larva is more closely allied to that of the European *Pterostichus nigrita,* figured by Schiödte, than any other form with which I have been able to compare it, but the body is rather slenderer, the head much longer and narrower, and the mouth parts longer, while the caudal appendages are shorter. The end of the body is like those of Harpalus and Stenolophus, as figured by Schiödte, but the mandibles resemble those of Harpalus. There are no traces of eyes, and the body is white and rather soft, not chitinous, as in most Carabid larvæ. There is no sculpturing on the head, and but a single claw on the legs.

At the same time and in the same sand-banks occurred the pupa (Fig. 7, enlarged) of the same species. It rested in little pits or cells three-quarters of an inch long, under flat stones, and was eyeless and white, with the harder parts of the mouth honey-yellow in color. Whether this belongs to *A. tellkampfii* or to *A. menetriesii* remains, of course, yet to be proved.

That the specimens I found and described were really Carabidæ and the larva of Anophthalmus has been called in question both by Dr. Horn and Dr. Hagen, without, however, any reasons for their opinion. It seems to me, after again comparing the larvæ and figures we have shown, with the characters of the Carabid larvæ figured and described by Schiödte in Kröyer's Tidskrift, that they can not be referred to the Staphylinidæ or any group than Carabidæ. Unfortunately, the larva of Trechus, so far as we know, is unknown, and no Anophthalmus has yet been raised from the larval state; but since no other Carabid or even Staphylinid beetles occur in caves associated with Anophthalmus, there is every probability that the larvæ in question are those of Anophthalmus. I append the excellent description of Mr. Hubbard, with his carefully-drawn figures. He also is of the opinion that the larvæ can be none other than Anophthalmus. My own briefer, earlier descriptions appeared in the American Naturalist (September, 1874, p. 562, and May, 1876, Pl. II).

Anophthalmus sp.—Larva (Fig. 18: *a*, head, much enlarged; *b*, underside of same). No detailed description of this larva has yet been published. Packard's figure (*l. c.* x, Pl. ii) sufficiently well represents the form.

General form long and very slender, cylindrical, gradually narrower in front, more suddenly behind. Color brilliant white; head and legs honey-yellow, with the mandibles darker; dorsal shields of the thorax tinged with yellow, those of the abdomen colorless. Length of a somewhat distended specimen $8^{mm}=.32$ inch. Head rather small, inclined upwards, nearly quadrate, slightly narrowed behind, flattened above and below, sides almost straight, posterior border sinuate above, broadly emarginate below, with a few hairs, longer on the sides. Head above, with anterior border projecting between the mandibles in an obtusely tridentate clypeus, with thickened, slightly reflexed margins, a shallow, arcuate impression extending between the bases of the antennæ and following the frontal margin, an oval depression at the summit of the frontal elevation midway between the antennæ. Y-suture represented only by the upper portions of its branches, which extend from the base of the clypeal projection on each side backwards and inwards half way to the median line. Head beneath, with anterior border slightly rounded, lobed by the projection of the mentum. Eyes wanting. Antennæ placed above, in slight emarginations at the anterior angles of the head, projecting forwards, not longer than the mandibles; of four joints, the first uniformly cylindrical; the second shorter, enlarged anteriorly, with a single bristle; the third longer than the first, deformed, the basal half a thickened palm, bearing a small, oval, porrect lobe, and minute papillæ, the remainder of the joint a curved, cylindrical continuation, joining the palm on the inside, two bristles on the palm and one on the finger; fourth joint appendiculate, bearing several long lateral and one minute terminal bristles. Mandibles moderately long and thick, arcuate, with a short tooth near the middle. Maxillæ consisting of a very short cardinal piece, a stout cylindrical basal piece, longer than the mandibles, with two long and several short external bristles above, with a row of six or seven spinules near the inner margin, and two internal bristles near the apex, surmounted by a two-jointed internal lobe; the basal joint thicker and shorter than the terminal, and four-jointed palpus; the first and second joints thick, the first very short, the

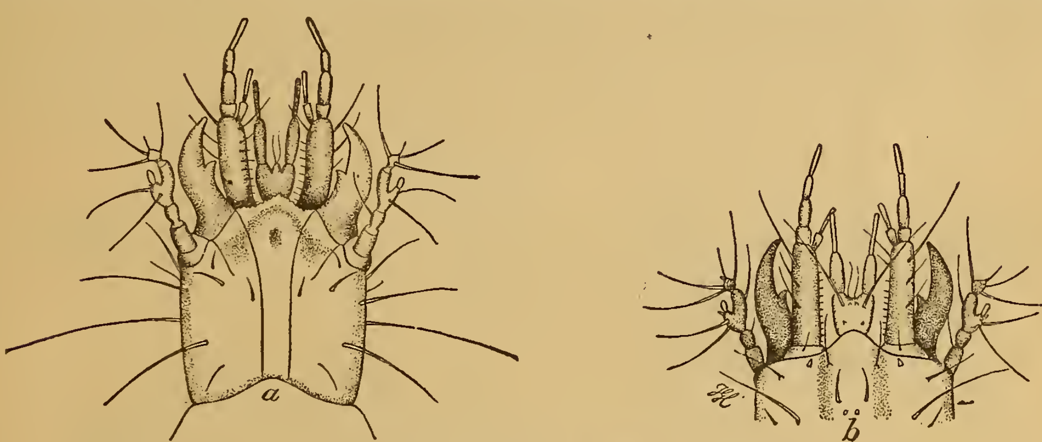

FIG. 18.—Larva of *Anophthalmus* sp.: *a*, head, much enlarged; *b*, under side of same (after Hubbard).

second much longer; third and fourth joints together equal to the first two combined, more slender; terminal joint longest. Mentum elongate, convex, separated from the under surface of the head only by shallow longitudinal parallel impressions, projecting slightly beyond the anterior border as a rounded lobe, surmounted by a convex palpiger not broader than long, somewhat obcordate, the anterior emargination deeper when seen from above. Labial palpi of two joints, equal in length, the first thick, the last slender. Ligula invisible from below, distinguishable from above as a minute papilla placed at the bottom of the emargination between the palpi, and bearing two hairs. Thoracic segments narrower than the abdominal segments, moderately convex above, flattened beneath; the prothorax oval, longer than broad, sides gently curved, anterior border sinuate, produced at middle; meso and metathorax broader than long, more strongly rounded on the sides, widest behind the middle; dorsal shields elliptical, fringed with short brown hairs; prothoracic shield larger than the following. Legs moderately long, subequal and similar, sparsely clothed with hairs; of five joints and a claw; coxæ widely separate, conical, stouter, and longer than the other joints; trochanter, femur, and tibia exactly equal; tarsal joint rather longer, more slender, tapering; tarsal claw shorter, curved, pointed. Abdominal segments nine in number, convex above and below, strongly rounded on the sides; dorsal shields transverse, elliptical, indicated by fringing, short, brown hairs. On the side of each segment a prominence bearing a few hairs. Segments one to four insensibly increasing in size, then decreasing to the seventh, which equals the first; eighth sensibly smaller; ninth much smaller, conical, ending in a pair of rather stout appendages, not exceeding the segment in length, curving inwards, bearing bristles, and a cylindrical and anal proleg, when distended, showing two diverging lobes equal to the appendages in length. Stigmata normal, one larger pair on the prothorax, placed posteriorly a little below the middle of the side, the following on segments one to eight of the abdomen, above and a little in advance of the lateral hair-bearing prominence, exceedingly minute, and, from their want of color, barely visible. The hairs of the body are few in number and very short, those of the head are no longer than are seen on most Carabid larvæ, and bear no comparison to the long sensitive hairs found upon all parts of the imago.

A single specimen in alcohol, found on wet sand near Hebe's Spring, Mammoth Cave, six miles from the entrance. The species may be either *A. tellkampfii* or *A. menetriesii*. Except in its very elongate form I can find no striking differences between this and other Carabid larvæ allied to Trechus.

ADELOPS HIRTUS. Plate XIX, figs. 4, 4*a*; XX, figs. 8, 9, 9*a*.

Though the pupa of the Adelops was not found by myself, two larva occurred, one in the Labyrinth of Mammoth Cave. Fig. 9 represents this interesting form, and 9*a* one of the antennæ magnified. It bears some resemblance to the larva of Agathidium (I know of no figure of a young Catops with which to compare it), but the head is very much larger, and nearly as wide as the prothoracic segments. The body tapers rapidly from the prothorax to the end, and is provided with long hairs; it is dull white. There are no traces of eyes. I add Mr. Hubbard's descriptions of both the larva and pupa of *A. hirtus*, of which he gives full details. I also insert Hubbard's figure of the cells of Adelops, of which, however, no description is given.

Adelops hirtus Tellkf.—The immature forms of Adelops have never been properly noticed. Packard's figure of the larva (*l. c.* vol. x, Pl. ii) represents a much contracted specimen, the body tapers too rapidly, and the thoracic segments are nearly one-third too wide; antenna (Fig. 4, *a*, of his plate) is incorrectly drawn.

The following description, made from numerous well-preserved specimens, is an attempt to give this larva the careful attention its importance deserves.

The body is stout and cylindrical, gradually tapering from the thorax, slightly compressed above, dorsal shields covering the segments, very thin and transparent. Color, dull white, with the head darker, and tips of mandibles alone testaceous. Length, 4.4^{mm} = .17 inch. Head free, nearly as wide as prothorax, rounded, convex, broader than

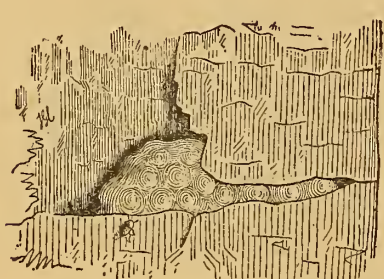

Fig. 19.—Cells of Adelops.

Fig. 20.—*Adelops hirtus*: *a*, head of larva from above; *b*, antenna; *c*, underside of head, with labrum and left maxilla; enlarged (after Hubbard).

long, sides slightly rounded, truncate in front, sparsely covered with fine hairs. No ocelli. Antennæ arising from the convex sides of the head, just before the middle, directed backwards; of four joints; the first tuberculous; the second elongate-cylindrical, slightly enlarged anteriorly; the third twice as long as the second, slightly curved, thickened on the inner (anterior) side, sparsely covered with bristles, a longer bristle on the inside at the thickest portion, a stout spine on the inside at apex; fourth joint appendiculate, bearing lateral bristles and a short spine at tip. Epistoma prominent trapezoidal, strongly angulate, edges straight. Labrum movable, deflexed, transverse, oval, bearing spines above and below. Mandibles stout, lobed at base, with molar surface striate, moderately curved, bidentate at tips, overlapping when closed. Maxillæ large, prominent, passing the mandibles, protuberant and strongly angulate at base, consisting of elongate cardinal and basal pieces, and a pyramidal palpiger, obscurely separated into two lobes by a longitudinal furrow, the upper lobe bearing internally four or five spines, the lower lobe terminating in a curved, ciliated crest; maxillary palpus, arising from the base of the palpiger, of two stout basal and one slender, spiniform, terminal joints. Labium with a large rounded mentum, broader than long, slightly narrowed behind, bearing long hairs; labial palpi, widely separated by the base of the ligula, of two joints and a palpigerous piece resembling a third joint. Ligula very large, prominent, elongate, with a square lobe in front, nearly reaching the tips of the palpi. Thoracic segments equal, larger than the abdominal segments, twice as wide as long, side margins produced, dorsal surfaces with two, and on the prothorax with several, rows of short, blunt spines. Sides of prothorax less strongly rounded than the following segments; each with a pair of moderately long legs, of two joints and a terminal claw-joint representing the tarsus; tibia clothed with spinules. Abdomen of nine strongly transverse segments, each with a row of six blunt spines above, which are replaced by sharp spinules on the ventral surface, terminal segments bearing a pair of moderately long appendages, with one short, cylindrical basal joint, the remainder setiform, very obscurely multiarticulate. Anal prolongation stout, tubular, ending in four fleshy lobes, which are usually retracted into the rectum. Stigmata, nine pairs; the first pair large, situated in the fold at the hind angles of prothorax, the eight remaining pairs on the first eight abdominal segments, at the middle of the edge of the dorsal shield, and immediately below a short tubular spine (the last spine of the dorsal row).

The larva of Adelops presents the general characters of Silphid larvæ as given by Erichson, but is most closely allied to those of Liodes and Agathidium. From the larger Silphidæ it differs notably in possessing a movable labrum, not soldered to the clypens, and from all described larvæ of the family in having the palpigerous pieces of the lower lip (labium) widely separated, forming in fact a third joint of the palpi, and in the size and prominence of the ligula. There are no long sensitive hairs upon any part. Of the larva of Catops, its nearest ally, no description is known to me, except that of *C. fuscus* Gyll. by Erichson, which is too short to be of use.

The pupa (Fig. 21: *a*, ventral; *b*, dorsal view, enlarged ten times; *c*, anal appendage, much enlarged), now first made known, is characterized as follows:

It is short, thick, almost conical, broadly rounded anteriorly, suddenly tapering behind, sparsely covered with fine hairs. Head bent downwards upon the breast, not visible from above; upper lip prominent, emarginate; tips of palpi projecting, free, constricted at the joints. Antennæ bent upwards and backwards, lying back of the knees, in the concavity of the prothorax, and projecting beyond the dorsal surface at its hind angles, constricted at the joints, the outer half a heavy club, each articulation of which bears large, spiny tubercles. Prothorax very large, almost hemispherical, covering the body like a hood. Wings folded over onto the ventral surface, lying under the anterior legs, covering the thighs of the last pair. Dorsal surface almost entirely exposed; at the base of the wings three conical protuberances placed close together, the largest on the median line covering the scutellum, the two smaller on either side upon the elytra; the tip of the metathorax protuberant, acutely prolonged over the first abdominal segment. Abdomen strongly arched downwards, terminating in two thigh-shaped appendages, with two or three long hairs on the sides, and a curved bristle at their apices; between them, at the base, a lobe surmounted by two converging tubular processes. Color, transparent white. Length, 2.5^{mm}=.10 inch; width, 1.5^{mm}=.06 inch.

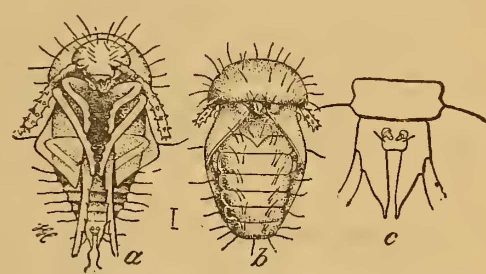

FIG. 21.—*Adelops hirtus*: *a*, pupa, under side; *b*, pupa, from above; *c*, anal appendages (after Hubbard).

VARIATIONS IN THE SPECIES OF CAVE COLEOPTERA.

Anophthalmus tellkampfii.—In twenty-seven specimens from a single area, the Labyrinth, in Mammoth Cave, there were very slight variations in size; all were about .30 inch in length, none over; the smallest was .27 inch long. Mr. Hubbard found "but little variation" in forty specimens.

In twenty-five specimens from Diamond Cave the only differences I could observe was in size; the largest was .30 inch, the smallest .25 inch.

Among sixty-five individuals collected by Mr. Sanborn in "Long Cave, nearly one mile from daylight, beetles at several damp localities, May 11;" the longest was .30 inch, the shortest was .25 inch, both being males. There were no other variations, except that the shortest has a very slightly broader prothorax, though this is almost imperceptible. The color of all is the same, and there is a remarkable uniformity in them, except a few pale ones recently out of the pupa state.

In fourteen specimens from Sugar-Bowl Cave, 3 miles northwest of Glasgow Junction, the largest individual was .30 inch and the shortest .25 inch in length. They did not differ from Mammoth Cave examples. Eleven specimens from White Cave did not differ from Mammoth Cave examples; they were .30 inch long. Twenty-two specimens from Salt Cave showed absolutely no difference from Mammoth Cave ones, and no perceptible variation from a length of .30 inch.

Anophthalmus menetriesii from different caves varies somewhat in size. In ten specimens from Diamond Cave the variation is only in size; the longest being .22 and the shortest .19 inch in length. ("Of twelve *A. menetriesii*, three show considerable variation in size and form and one is plainly pubescent." Hubbard.)

Anophthalmus tenuis.—Among eighteen specimens from Bradford Cave the largest measured .20 inch, the smallest .16 inch. There are greater differences among the specimens of this species than in *A. tellkampfii* from Mammoth and other caves, nearly a third out of eighteen specimens being smaller than the rest, where in *A. tellkampfii* only one or two out of that number are dwarfed.

From the foregoing remarks it will be seen that there is a very slight amount of variation in the species of Anophthalmus either in color or proportions; that the species inhabiting Bradford Cave, which is small and shallow, varies far more than those inhabiting the genuine and larger limestone caverns; moreover, the differences in size are probably due to variations in the supply of food, scattering individuals being somewhat dwarfed, probably from the scarcity of food during the larva state, the other physical surroundings of light, temperature, and soil being unvarying. It should be, however, noticed that, whereas we did not perceive any difference in proportion of parts, the more practiced eye of Dr. Le Conte detected in *A. menetriesii* such differences as to lead him to remark of this species that "a large series of specimens is seen to vary slightly in form." So much alike are all the species of Anophthalmus, that it is not impossible that all of them had a common ancestor.

Adelops hirtus.—Those found in the Labyrinth, in Mammoth Cave, varied in length; the largest of twenty-two specimens being .12 inch and the smallest .09 inch. Two-thirds of the number were males. This beetle varies more in proportion of parts than the species of Anophthalmus.

A few other unidentified Staphylinid beetles and Coleopterous larvæ are figured on Plate XX. (See explanation of Pl. XX.)

DIPTERA.*

1. Wyandotte, New Cave. Sciara. Borborus.
2. Fifty feet from mouth of Wyandotte. Phora.
3. Labyrinth, Mammoth Cave. Pupa of Sciara.
4. Wyandotte Cave. Chironomus (different from No. 8; larger).
5. Labyrinth, Mammoth Cave. Sciara, 2, in copula.

6, 6 *bis.* End of Dixon's Cave. Mammoth Cave. Borborus.

7. Diamond Cave. Sciara.
8. Dead Sea, Mammoth Cave, April 25. Chironomus, small species.

8. *bis.* Dead Sea, Mammoth Cave, A. S. Packard. Chironomus, small species.

9. Diamond Cave, May 2, half mile in (F. G. Sanborn). Small Dolichopodid; female.
10. Cave next to Ice Cave, 60 feet deep, 3 miles from Mammoth Cave. Rhypholophus (Eriopterina), allied to *R. nubilus* O. S. Blepharoptera.
11. Fountain Cave. Mycetophila. Blepharoptera. Anthomyia.
12. Carter Cave, front of hotel. Phora. Blepharoptera.
13. Bat Cave. Phora. Blepharoptera.
14. Old mouth, Cave of Fountains, partial daylight. Blepharoptera.
15. Bradford Cave, Indiana. Mycetophila. Blepharoptera. A pupa ?.

OBSERVATIONS.

Borborus (No. 1, 6) usually occurs on dung, excrements, etc.; some on decaying fungi.

Sciara (3, 5, 7); their larvæ live in decaying vegetable matter, fungi, etc. The Sciaræ are usually black; that taken in copula is remarkable for its very pale coloring.

Mycetophila (No. 11 and 15) larvæ in fungi.

Blepharoptera (family Helomyzidæ); larvæ in fungi. The same species occurred in all the bottles, 11 to 15. It seems to be n. sp., and is the only species in the lot which is perhaps worth describing.

Blepharoptera defessa n. sp.,† male and female.—A sparse pubescence on the under side of the pleuræ, a single vibrissa on each side of the epistoma, a single strong bristle above the middle tibiæ; costa beset with moderately long bristles; length, 5 to 6^{mm}.

Antennæ red, third joint brownish-red; arista rather long; front yellowish-red; frontal orbits grayish; a paler triangle on the vertex, bearing the brownish ocellar tubercle; anterior frontal bristle short, the one behind not quite twice as long. Thoracic dorsum yellowish-gray; the eight large dorsal bristles are inserted on brown spots, which

* These identifications and remarks were prepared several years ago by Baron Osten Sacken, and are based on the material collected in 1874.

† Afterwards the following description was published in Hayden's Bulletin U. S. Geol. Surv. Terr., iii, 168, 1877. It occurred in a cave at Manitou, Colorado.

are sometimes confluent; the finer pubescence on very minute dark spots, an often faint brown stripe in the middle and a still less distinct one on each side; humeral callosities reddish, the flat scutellum likewise. Pleuræ pale brownish-gray, darker below. Abdomen grayish-pollinose, the ground color being blackish; male hypopygium yellow, with delicate black pile; tip of the female abdomen also yellowish; hind margins of segments pale. Halteres whitish. Wings with a brownish-yellow tinge; bristles on the costa of moderate length; posterior cross-vein rather near the tip of the fifth vein, the last section of that vein being less than half of the cross-vein. Legs reddish-brown or brown; knees and base of middle femora paler.

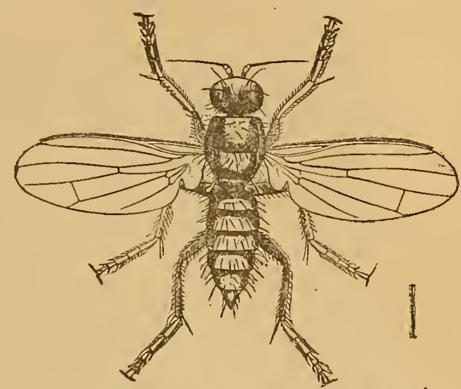

FIG. 18.—*Blepharoptera defessa* Osten Sacken.

Habitat.—Hundred Dome Cave, near Glasgow, Kentucky (F. G. Sanborn); a male and two females. The specimens, having been kept in alcohol, were very much injured. The species is related to *B. cineraria* Lw. (syn. *armipes* Lw.), but is easily distinguished by the absence of the peculiar armature on the hind femora of the male, the much darker legs, larger size, etc. The anterior frontal bristles of *B. cineraria* are much shorter, but the pair above them much larger than in *B. defessa*. In one of my specimens (the male), the tibiæ are somewhat yellowish in the middle; the frontal bristles were observed on the female, as they had disappeared from the male specimen.

Blepharopteræ are often found in caves, where they are said to breed in the excrement of bats. This species also occurred in Mammoth Cave, Wyandotte Cave (Packard), and numerous smaller caves, *i. e.*, Zwingle's Cave (one of the Carter caves), September 17, 20 rods from the entrance; Gray Town Cave, Curtin caves, Little Lithographic Cave, near Glasgow Junction; Hundred Dome Cave (Sanborn).

Phora (2, 12, 13) larvæ in decaying vegetable matter; some parasitical in other insects.

In order to give completeness to this paper I append Mr. Hubbard's description of the larva of the Phora, which I did not meet with:

Phora sp.—(Fig. 19: *a*, larva, enlarged ten times, profile; *b*, front view of head and thorax; *c*, anal proleg, from above; *a* and *b* much enlarged.) The larva of the smaller cave fly is cylindrical, narrowed in front, more suddenly narrowed behind. Head small, rounded, convex, deeply inserted in the thorax; above on each side an acute, three-jointed tubercle; in front a second pair of very minute tubercles, separated by a sutural line, which branches below them; space between the branches of the Y-suture excised, inclosing the buccal opening, which appears as a dark transverse slit. Three thoracic segments smaller than the abdominal segments, retractile, bearing at or near the anterior border a row of acute tubercles or spines; the prothoracic with a pair of tubular spines arising from depressions at the middle of each side. Abdomen of nine segments, each with three folds on the dorsal surface, the posterior fold bearing a row of spines similar to those on the thorax; sides wrinkled, with tubercular prominences between the segments, and one or two spines anterior to those of the dorsal row; ventral surface, each segment with three transverse ridges, one median, slightly in advance of the two lateral ridges; two last segments smaller, the terminal with an anal projection consisting of two large retractile tubercles, directed upwards and bearing spiracles, surrounded by six radiating spiny processes. Color, dull white, darker at the extremities. Length, when moderately distended, $5^{mm} = .21$ inch. Several specimens in alcohol.

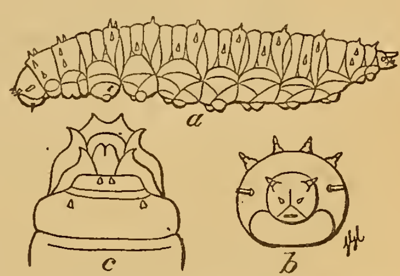

FIG. 19.—*a*, larva of Phora; *b*, front of head and thorax; *c*, end of abdomen, all much magnified (after Hubbard).

The larva of the European *Phora dauci*, observed by Bouché in rotten radishes, is figured without detail by Westwood (Int. to Classification, ii, Fig. 132, 12); that of *P. incrassata*, found in bee-hives, is reproduced in Packard's Guide. Both agree with this larva, as far as the figures and descriptions go. The pupa is visible through the skin of the larva, which becomes an indurated puparium, light red in color, oval, pointed at the ends, smooth and convex beneath, more depressed on the dorsal surface, which is margined, with the segments indicated by ridges. The extremities of the puparium show the parts of the larva unchanged. Length, $3.6^{mm} = .14$ inch.

FIG. 20. Phora.

All the stages were found on offal in Washington Hall, Mammoth Cave, August 21. Imagos appeared from pupæ taken to Detroit, Michigan, a week later.

IV.—SYSTEMATIC LIST OF THE CAVE ANIMALS OF THE UNITED STATES.

Class INFUSORIA.

Vibrio sp.
Chilomonas emarginata Ehr. in Tellkf., New York Journ. Med., 86, July, 1845. Mammoth Cave.
Chilodon cucullus Ehr. ? Mammoth Cave.
Monas, resembling *M. kolpoda*. Mammoth Cave.
Monas sp. Mammoth Cave.
Colpoda ? . Mammoth Cave.
Nassula ? or *Prorodon ?* . Mammoth Cave.
Bodo ? .
Synedra ulva Ehr.

Branch VERMES.

Vortex ? cavicolens Pack., Amer. Naturalist, Jan., 1883. Carter caves.
Dendrocœlum percœcum Pack., Zoology, 142, 1879. Mammoth Cave.
A Nematoid worm parasitic in rectum of larva of *Adelops hirtus* Hubbard, Amer. Ent., iii, 1880.
Lumbricus sp. Mammoth Cave. Hubbard, Amer. Ent., iii, 1880.

Class CRUSTACEA.

Cauloxenus stygius Cope. From bliud-fish taken from a well near Wyandotte Cave.
Canthocamptus cavernarum Pack., Zoology, 297, 1879. Mammoth Cave.
Cæcidotæa stygia Pack., Amer. Naturalist, 752, v, 1871. Mammoth and Wyandotte caves.
Cæcidotæa nickajackensis Pack. Nickajack Cave, Tennessee.
Crangonyx vitreus (Cope), Amer. Naturalist. Mammoth Cave.
Crangonyx packardii Smith. Wells in Orleans and New Albany, Indiana.
Crangonyx antennatus Pack., Amer. Naturalist, xv, 880, 1881. Nickajack Cave, Tennessee.
Crangonyx mucronatus Forbes, Bull. Ill. Mus. Nat. Hist., i, 6, 1876. Wells in Normal, Illinois.
Cambarus lucifugus Hay, Amer. Naturalist, xvi, 144. Well in Illinois.
Cambarus pellucidus (Tellkf.). Mammoth, Wyandotte caves, etc.
Cambarus hamulatus (Cope). Nickajack Cave.

Class ARACHNIDA.

Order Acarina.

Rhyncholophus cavernarum Pack. White's Cave and Long Cave.
Bryiobia ? or *Penthalœus ? weyerensis* Pack. Weyer's Cave. Mr. Michaels writes that this probably belongs to the genus Labidostoma (Kramer) or Nicoletia of Canestrini.
Lœlaps (or *Holostaspis ?*) *wyandottensis* Pack. Wyandotte Cave.
Lœlaps (=*Iphis ?*) *cavernicola* Pack. Mammoth Cave.
Gamasus (or *Hypoaspis ?*) *troglodytes* Pack. Mammoth Cave.
Gamasus stygius Pack. Bat Cave, Carter Caves, Kentucky.
Damœus (=*Delba*) *bulbipedatus* Pack. (Probably from Mammoth Cave. The form represented by Fig. 8, Pl. X, Mr. A. D. Michaels* thinks is "probably genus Notaspis.")
Uropoda lucifugus Pack. New Wyandotte Cave.
Oribata alata Pack. Dixon's Cave.
Sejus ? sauborni Pack. Cave near Dismal Creek, Kentucky.

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* While this paper was going through the press I sent proofs of the figures to Dr. Trouessart and also to Mr. A. D. Michaels, hoping to hear from one or the other before going to press, asking information concerning the genera of these mites, of which I have no special knowledge. Both kindly and promptly replied, but it is to be understood that they saw only rather indifferent figures, and that their determinations are largely conjectural, as in some cases my figures did not show either generic or specific characters. But the information was gladly received, for when some one takes up the study of our mites and collects in our caverns, he will undoubtedly be able to find the forms here referred to and to correctly place them in their proper genera. Meanwhile the information here given is better than none at all. At the same time due allowance must be given to the fact that the two naturalists above named who have kindly aided me have based their suggestions or determinations on my sketches alone, not having either drawings made by an expert or the specimens themselves.

Order Arthrogastra.

Obisium cavicola Pack. New Market Cave, Virginia.
Chthonius packardii Hagen, Zool. Anzeig., ii, 399, 1879. Mammoth and neighboring caves in Kentucky and Indiana.
Chthonius cæcus Pack. Weyer's Cave, Virginia.
Phalangodes flavescens (Cope), Amer. Naturalist, vi, 420, 1872. Wyandotte Cave.
Phalangodes var. *weyerensis* Pack. Weyer's Cave.
Phalangodes var. *cæcum* Pack. Carter caves, Kentucky.
Phalangodes armata Tellkf., Archiv f. Naturgesch., x, 320, 1844. Mammoth and neighboring caves, Kentucky.
Phlegmacera cavicolens Pack. Carter caves, Kentucky.
Nemastoma troglodytes Pack., Bull. Hayden's U. S. Geol. Surv., iii, 1877. Clinton's Cave, Utah.
Nemastoma inops Pack. Carter caves, Kentucky.

Order Araneina.

Nesticus pallidus Emerton, Amer. Naturalist, ix, May, 1875. Madison's Cave, next to Weyer's, Virginia.
Nesticus carteri Emerton, Amer. Naturalist, ix, May, 1875. Carter caves, Kentucky.
Linyphia subterranea Emerton, Amer. Naturalist, ix, May, 1875. Carter caves, Kentucky, and Wyandotte Cave, Indiana.
Linyphia weyeri Emerton, Amer. Naturalist, ix, May, 1875. Weyer's Cave, Virginia.
Linyphia incerta Emerton, Amer. Naturalist, ix, May, 1875. Madison's Cave, next to Weyer's, and Carter caves, Kentucky.
Anthrobia mammouthia (Tellkf.), Archiv f. Naturgesch., 1844. Mammoth and neighboring caves, Kentucky.
Erigone infernalis Keyserling.
Willibaldia cavernicola Keyserling.
Cœlotes juvenilis Keys., Verh. Zool.-Bot. Ges. Wien, 228, Pl. xi, Fig. 13. Mammoth Cave.
Liocranoides unicolor Keys., Verh. Zool.-Bot. Ges. Wien, 190. Mammoth Cave.
Usofila gracilis Keyserling, MS. Alabaster Cave, California.

Class MYRIOPODA.

Order Diplopoda.

Pseudotremia cavernarum Cope, Proc. Amer. Phil. Soc., xi, 179, 1869. Wyandotte, Bradford, Ind., caves; Erhart's and other caves, Montgomery, Grainger, and Giles counties, Tenn.; and caves in Virginia and Tennessee.
Pseudotremia cavernarum, var. *carterensis* Pack. Carter caves, Kentucky.
Scoterpes copei (Pack.), Amer. Naturalist, v, 748, 1871. Mammoth and adjoining caves, Kentucky.
Zygonopus whitei Ryder, Proc. U. S. Nat. Mus., iii, 527, 1881. New Market, Luray, and Weyer's caves, Virginia.
Cambala annulata Say, Journ. Acad. Nat. Sci., Phil., ii, 103, 1821. Caves in Indiana, Kentucky and Virginia.

Class INSECTA.

Order Thysanura.

Lipura ? or *Achorutes ? lucifugus* Pack.
Tomocerus plumbeus Templeton, var. *pallidus*. Carter caves, Kentucky; Weyer's Cave, Virginia; Clinton's Cave, Utah.
Lepidocyrtus atropurpureus Pack. Locality not given in my notes.
Degeeria cavernarum Pack. Wyandotte New Cave and Bradford Cave, Indiana; Carter caves and Diamond Cave, Kentucky.
Smynthurus ferrugineus Pack. New Market and Weyer's Cave, Virginia.
Smynthurus sp. Mammoth Cave.
Campodea cookei Pack., Amer. Naturalist. Mammoth Cave.
Machilis cavernicola (Tellkf.). Mammoth Cave.

Order Orthoptera.

Hadenœcus subterraneus Scudder. Mammoth, Carter, and other caves in Kentucky.
Ceuthophilus stygius Scudder, Proc. Bost. Soc. Nat. Hist., viii, 9, 1861. Hickman's Cave, Kentucky; Wyandotte and other caves in Indiana; caves in Kentucky, Laurel Cave, Carlin county, Kentucky.
Ceuthophilus sloanii Pack., Fifth Rt. Peab. Acad. Sci., 93, 1873. Bradford Cave, Little Wyandotte Cave, Indiana.
Ceuthophilus ensifer Pack., Amer. Naturalist, xv, 882, 1881. Nickajack Cave, Tennessee.

Order Platyptera.

Myopsocus or *Elipsocus* sp., Hubbard, in Amer. Ent., iii, 84, 1880. Mammoth Cave.
Dorypteryx pallida Aaron. Madison's Cave (Cave of Fountains).

Order Coleoptera.

Adelops hirtus Tellkf., Archiv f. Naturgeschichte, 1844. Mammoth Cave.
Anophthalmus tellkampfii Erichson, N. Y. Journ. Med., 85, July, 1845. Mammoth and other caves in Kentucky.
Anophthalmus menetriesii Motsch. Mammoth, Diamond, and other caves in Kentucky.
Anophthalmus pusio Horn.
Anophthalmus tenuis Horn. Wyandotte Cave, Bradford Cave, Indiana.
Anophthalmus eremita Horn. Wyandotte Cave.
Anophthalmus pubescens Horn.
Anophthalmus audax Horn., Trans. Amer. Ent. Soc., x, 272. Ronald's Cave.
Anophthalmus interstitialis Hubbard, Amer. Ent., iii, 52, 1880. Mammoth Cave.
Undetermined blind larva, Pack., Amer. Naturalist, May, 1876, Pl. ii, page 8.
Arnillus explanatus Horn. Alabaster Cave, California. Pl. xviii, fig. 5.

Order Diptera.

Chironomus 2 sp.
Borborus sp.
Sciara sp.
Mycetophila sp.
Blepharoptera defessa Osten Sacken, Bull. U. S. Geol. Survey, iii, 168, 1877. Mammoth and other caves in Kentucky; Wyandotte Cave, Indiana; cave in William's Cañon, Manitou, Colorado.
Anthomyia sp.
Phora sp. Hubbard, Amer. Ent., iii, 82. Mammoth Cave.
Pholeomyia leucozoma Bilim. Cave of Cacahuamilpa, Mexico.

V.—THE GEOGRAPHICAL DISTRIBUTION OF CAVE ANIMALS.

This, of course, is founded on that of the fauna of the upper world in the region of the caves, and yet within such a region there are, as one may see by an examination of the foregoing lists of the faunas of the better-known caves, radical differences in the fauna of Mammoth and Wyandotte Caves, which lie in the same faunal region of the upper world.

Beginning with the better-known groups, we will call attention to some features in their distribution in the caves of the Central and Middle Atlantic States. It will be noticed that *Adelops hirtus* only occurs in Mammoth and adjoining caves *i. e.*, Dixon's, Proctor's, Diamond, and other caves within 10 miles of Mammoth. None of the species of Anophthalmus which occur in Mammoth Cave have been yet discovered in Wyandotte.

Eight species of Anophthalmus are known, of which *A. tellkampfii* is the largest and most abundant, occurring in Mammoth and the neighboring caves. Next to this, *Anophthalmus menetriesii* of Motschultzy is most common. In grottoes near Mammoth Cave, Cave City Cave, and Walnut Hill Spring Cave, near Glasgow Junction, Mr. Sanborn found *Anophthalmus pubescens* Horn. In Wyandotte Cave *A. tenuis* Horn and *A. eremita* Horn are the only blind beetles found, (they are very rare there, as I saw none myself), and the former has been found in Bradford Cave, Indiana, by Dr. John Sloan and myself. The larger number of species occur in the Mammoth Cave region, while in the Carter caves of Eastern Kentucky only one species (*A. pusio* Horn) occurred, which was originally discovered by Professor Cope in Erhart's Cave, Montgomery county, Virginia. It is evident that the Mammoth Cave system of grottoes is the geographical center of Anophthalmus in the United States. No species of the genus has been discovered in Weyer's, Luray, or in Nickajack caves.

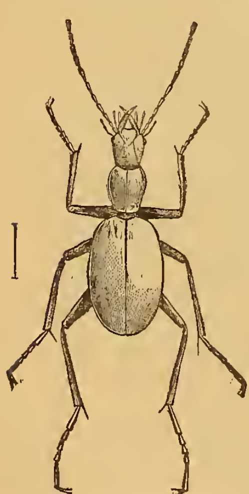
FIG. 21.—*Anophthalmus tellkampfi.*

The spiders were found not infrequently in all the caverns mentioned in the notes appended to Mr. Emerton's descriptions. I should say that the spiders were equally abundant in Mammoth and Wyandotte caves, but they were most abundant in Weyer's, where three species occurred. They were next commonest in the Carter caves. These are small caverns, none more than a mile in extent; but it is interesting to observe that in Mammoth and Wyandotte caves respectively, both between 5 and 7 or 8 miles in extent, so far as rude measurements show, there was but a single species. The following table shows the distribution of the six species of true cave spiders:

Mammoth.	Wyandotte.	Bradford.	Carter.	Weyer's.
Anthrobia mammouthia	Linyphia subterranea	? Nesticus carteri.	Nesticus carteri.	Nesticus pallidus.
			Linyphia subterranea.	Linyphia weyeri.
			Linyphia incerta.	Linyphia incerta.

It will be seen that the two largest and consequently most ancient caverns, Mammoth and Wyandotte, and in which the physical environment of the species is most unvarying, have but one species each. The *Anthrobia mammouthia* is only found in Mammoth and the small caverns, *i. e.*, Diamond and Proctor's, situated about 5 miles from it. No other species occurred in these smaller caves. The only spider found in Wyandotte Cave was the *Linyphia subterranea*, which also occurred in the Carter caves, while in the Bradford Cave occurred a Nesticus, thought by Mr. Emerton to be identical with *Nesticus carteri.* The Carter caves and Weyer's caves are small caverns, all perhaps less than half a mile in length, with the exception of Bat Cave, which is perhaps over a mile in length; the distances are uncertain, these caverns winding about very irregularly, and their length is only estimated by guess-work.

It is in the small caverns of Carter county, Kentucky, and the two Weyer caves (Weyer's and the adjoining Cave of the Fountains) which are often but a few (less perhaps than a hundred) feet below the surface, that the variation and number of species is greatest. In each set of caves there are three species to one in Mammoth and Wyandotte caves. The individual variation was the greatest in *Nesticus pallidus*, and, as might be suspected, in the eyes. The degree of variation is indicated in Mr. Emerton's description.

The spiders occurred more abundantly in all the caves than we expected. The individual abundance was greater in the smaller caverns, especially the Weyer caves, than any others. In the Mammoth Cave the Anthrobia occurred under stones in dry but not the driest places, on the bottom at different points in the cave. Sometimes two or three cocoons would be found under a stone as large as a man's head.

The pedipalp Arthrogastra follow nearly the same law in distribution as the spiders. *Phalangodes armata* is restricted, like the genus Anthrobia, to Mammoth Cave and its neighboring caves, while *P. flavescens* is a characteristic member of the Wyandotte fauna, a variety of it inhabiting the Carter caves, and another Weyer's.

As to the Myriopods, their distribution is very marked. *Scoterpes copei* is restricted to Mammoth Cave and neighboring grottoes, while *Zygonopus whitei* is confined to Weyer's and Luray caverns. *Pseudotremia cavernarum* is the most widely diffused, inhabiting Wyandotte, Carter, and Nickajack caves.

Of the Crustacea, *Cambarus pellucidus* and *Cæcidotæa stygia* occur in the caves of Kentucky and Indiana, while in Nickajack Cave they are replaced by different species.

VI.—LIST OF NORTH AMERICAN AND EUROPEAN CAVE ANIMALS.

NORTH AMERICA.	EUROPE.
PROTOZOA.	
Vibrio 2 sp.	*Amœba cellarum* Joseph. Carniola.
Chilomonas emarginata Ehr.	*Dendrocometes orcinus* Joseph. Carniola.
Chilodon cucullus Ehr. ?	*Peridinium stygium* Joseph. Carniola.*
Monas 2 sp.	
Colpoda ?.	
Bodo ?.	
Synedra ulva.	
Nassula ? or *Prorodon* ?.	

* In the spring, when vegetable and animal matter are borne in freshets into the caves, are found free-living Infusoria. Sessile forms occur in the gills of the Proteus, at the mouth-opening and abdominal appendages of the cave shrimps, and on the backs of the Isopods and Myriopods (Joseph).

NORTH AMERICA—Continued.	**EUROPE**—Continued.
PORIFERA.	
	Spongilla stygia Joseph. Carniola.
CŒLENTERATA.	
	Hydra pellucida Joseph. Carniola.
	Hydra sp. Fries. Very white. Falkenstein Cave.
VERMES.	
Vortex ? cavicolens Pack.	*Planaria cavatica* Fries. Falkenstein Cave, Germany.
Dendrocœlum percæcum Pack.	*Plectus* sp. A nematoid worm.
Nematoid worm.	
Lumbricus, sp.	
Trochosphæra sp.*	
Lepadella sp.	
Hydatina 2 sp.	
Apodoides stygius Joseph.	
sp.	
MOLLUSCA.	
	Hydrobia quenstedti Wiedersheim (var. of *H. vitrea* Drap.) (Also see Mr. Dall's letter, foot-note, p. 91).
CRUSTACEA.	
Canthocamptus cavernarum Pack.	*Cyclops hyalinus* Joseph. Caves in Carniola
	anophthalmus Joseph. Carniola.
	Bathynella natans Vejd. Wells at Prag.
	Cypris stygia Joseph. Carniola.
	Leptodera pellucida Joseph. Carniola.
	Estherea cœca Joseph. Carniola.
Cæcidotæa stygia Pack.	*Branchipus pellucidus* Joseph. Carniola.
nickajackensis Pack.	*Asellus cavaticus* Schiödte.
	Titanethes albus Schiödte.
	fracticornis Joseph. Carniola.
	brevicornis Joseph. Carniola.
	feneriensis Parona. Italy.
	Typhloniscus stygius Joseph. Italy.
Crangonyx vitreus Cope.	*Monolistra cœca* Gerstaecker. Italy.
packardii Smith.	*Niphargus subterraneus* Leach (*stygius* Schiödte).
antennatus Pack.	*puteanus* Val. St. Geo.
mucronatus Forbes. In wells.	*orcinus* Joseph. Carniola.
lucifugus Hay. In wells.	*Troglocaris schmidtii* Dormitzer. Carniola.
Cambarus pellucidus Tellkf.	*Cambarus stygius* Joseph. Carniola.
hamulatus Cope.	
MYRIOPODA.	
Pseudotremia cavernarum Cope.	*Polydesmus cavernarum* Peters. Carniola. Ariège, France
Scoterpes copei (Pack.).	*subterraneus* Heller. Ariège, France.
Zygonopus whitei Ryder.	*Brachydesmus subterraneus* Heller. Carniola and Moravia.
	Trachysphæra schmidtii Heller. Carniola.
	hyrtlii Wankel. Moravia.
	Craspedosoma simoni Fanz. Spain and Basses-Alpes.
	Strongylosoma bisulcatum Fanz. Ardèche.
	Blaniulus guttulatus Fanz. Ariège, France.
	Lithobius cavernicolus Fanz. Ariège, France.
	speluncarum Fanz. Ariège, France.

* In the cold cave waters of Carniola occur only species where out-of-door relatives live in fresh, clear water in spring, while forms are wanting which, like the Brachionidæ, live in warm, stagnant water. Nine species in all occurred, of which only six were identified (Joseph).

NORTH AMERICA—Continued. | **EUROPE**—Continued.

TARDIGRADA.

Europe:

Macrobiotus micronychius Joseph. Carniola.
Arctiscon stygium Joseph. Carniola.

ARACHNIDA.

ACARINA.

North America:

Uropoda lucifugus Pack.
Gamasus stygia Pack.
Gamasus (*Hypoaspis ?*) *troglodytes* Pack.
Lœlaps ? or *Holostaspis ? wyandottensis* Pack.
Lœlaps ? (*Iphis ?*) *cavernicola* Pack.
Bryiobia ? (or *Penthalœus*) *weyerensis* Pack.
Damœus bulbipedatus Pack.
Oribata alata Pack.
Sejus ? sanborni Pack.
Rhyncholophus cavernarum Pack.

Europe:

Uropoda vegetans De Geer, var. *pellucida* Joseph. Carniola.
    truncata Mégnin. Carniola, etc.
Gamasus longipes Joseph. Carniola.
Holostaspis niveus Joseph. Carniola.
Porrhotaspis gracilis Müller, var. *hirtus* Joseph. Carniola.
Periglischrus miniopteri Joseph. Carniola.
Linopodes subterraneus Wankel. Carniola.
Scyphius spelæus Wankel. Carniola.
Rhyncholophus stalitæ Joseph. Carniola.
Trombidium spelæum Joseph. Carniola.
Eschatocephalus gracilipes Frauenf. Carniola.
    crassipes Joseph. Carniola.
    frauenfeldi Koch. Muggendorf, Germany.

ARTHROGASTRA.

North America:

Obisium cavicola Pack.
Chthonius packardii Hagen.
    cæcus Pack.
Phalangodes armata Tellkf.
    flavescens (Cope).
Phlegmacera cavicolens Pack.
Nemastoma troglodytes Pack.
    inops Pack.

Europe:

Obisium deschmanni Joseph. Carniola.
    cavernarum Koch. France.
Obisium (Blothrus) *torrii* Simon. (Eyeless.) Cave in Venetia, Italy.
Obisium (Blothrus) *stussineri* Simon. (Eyeless.) Carniola.
    myops Simon. Sospel. Maritime Alps.
Chernes cavicola Joseph. Carniola.
Blothrus spelæus Schiödte. Carniola.
    abeillei Simon. France.
    brevimanus Frivalsky. Carpathian Mountains.
    brevimanus Joseph (*brachydactylus* Jos.). Carniola.
Sirophthalmus duricorius Joseph. Carniola.
Siro cyphopsilaphus Joseph. Carniola.
Ischyropsalis dispar Simon. France.
    robusta Simon. France.
    luteipes Simon. France.
    pyrenæa Simon. France.
Liobunum troglodytes Wankel. Moravia.
Phalangodes leprieuri Lucas. Italy.
    lespesi Lucas. Italy.
    querilhaci Lucas. France.
    lucasi Simon. France.
    piochardi Simon. France.

ARANEINA.

North America:

Nesticus pallidus Emer.
    carteri Emer.
    cordatus (Bilimek). Cacahuamilpa Cave, Mexico.
Linyphia subterranea Emer.
    weyeri Emer.
    incerta Emer.
Erigone infernalis Keys.
Liocranoides unicolor Keys.
Willibaldia cavernicola Keys.
Cœlotes juvenilis Keys.
Anthrobia mammouthia Tellkf.

Europe:

Nesticus speluncarum Pavesi. Spezia.
Linyphia cavernarum Koch. France and South Germany
    rosenhaueri Koch. South Germany.
    troglodytes Koch South Germany, Franconia.
    proserpina Simon. France, Lower Alps.
    sancti-vincenti Simon. France, Lower Alps.
Erigone lusisca Simon. France.
    spelæa Simon. France.
Chorizomma subterranea Simon. France.
Hadites tegenarioides Keyserling. Dalmatia.
Leptoneta convexa Simon. France.
    microphthalma Simon. France.
    infuscata Simon. France.
Stalita tænaria Schiödte. Carniola.
    schiödtei Thorell. Lesina Island, Italy.
    stygia Joseph. Carniola.
Troglohyphantes polyophthalmus Joseph. Carniola.
Nicthyphantes microphthalmus Joseph. Carniola.
Pseudophthalmus schmidtii Joseph. Carniola.

NORTH AMERICA—Continued.	**EUROPE**—Continued.

THYSANURA.

	Lipura sp. Fries. Falkenstein Cave.
	Anoura hirta Joseph. Carniola.
	infernalis Joseph. Carniola.
	cæcus Joseph.
	Anura sp. Moravia.
	Anurophorus ambulans De Geer. Carniola.
	stillicidii Schiödte. Carniola.
	gracilis Müller. Moravia and Carniola.
	Heteromurus margaritarius Wankel. Moravia.
	Tritomurus scutellatus Frauenf. Carniola.
	macrocephalus Kolenati. Moravia.
	Cyphoderus monocerus Joseph. Carniola.
Lipura ? Achorutes ?	*albinus* Nicolet. Carniola.
Tomocerus plumbeus, var. *pallidus* Pack.	*Tomocerus niveus* Joseph. Carniola.
Lepidocyrtus atropurpureus Pack.	*Achorutes spelæus* Joseph. Carniola.
Degeeria cavernarum Pack.	*Isotoma spelæa* Joseph. Carniola.
	Dicyrtoma pygmæa Wankel. Moravia.
Smynthurus ferrugineus Pack.	*Smynthurus niveus* Joseph. Carniola.
sp.	*longicornis* Joseph. Carniola.
	gracilis Joseph. Carniola.
	cæcus Joseph. Carniola.
Campodea cookei Pack.	*Campodea nivea* Joseph. Carniola.
	Campodea sp. Fries.* Falkenstein Cave.
	Nicoletia cavicola Joseph. Carniola.
	Japyx forficularius Joseph. Carniola.
	cavicola Joseph. Carniola.
Lepisma anophthalmum Bilimek. Cave of Cacahuamilpa, Mexico.	*Troglodromicus cavicola* Joseph. Carniola.
Machilis sp.	*Machilis bruneo-flava* Joseph. Carniola.
	Scolopendrella immaculata Newp., var. *anophthalma* Joseph. Carniola.

ORTHOPTERA.

Hadenœcus subterraneus Scudder.	*Hadenœcus palpatus* Sulzer. Sicily; cave in Pyrenees.
? *Hadenœcus sp.*† Matanzas Cave, Cuba.	
Ceuthophilus stygius Scudder.	*Ceuthophilus cavicola* Koller. Carniola.
sloanii Pack.	? *C. linderi* Dufour. Eastern Pyrenees.
ensifer Pack.	

PLATYPTERA.

Myopsocus or *Elipsocus* sp.	
Dorypteryx pallida Aaron.	

COLEOPTERA.

CURCULIONIDÆ.

	Otiorhynchus anophthalmus Schmidt. Carniola; also under sticks and stones out of doors.

PSELAPHIDÆ.

	Pselaphus heydeni Saulcy. Spain.
	Machærites spelæus Miller. Carniola.
	subterraneus Mots. Carniola.
	plicatulus Schauf. Carniola.
	doriæ Schauf. Italy.
	Linderia mariæ Duv. Pyrenees.
	armatus Schauf. Spain.
	claræ Schauf. Spain.

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* Characterized by its very long abdominal appendages (Fries).

† "Il est probable qu'il existe une espèce analogue [to *Hadenœcus subterraneus*] dans les grottes de Cuba, car j'ai aperçu, mais sans avoir pu réussir à m'en emparer, un insecte de ce genre dans la grotte de Matanzas (Cuba)" (H. Saussure, in Annales de la Soc. Ent. France, 1861).

NORTH AMERICA—Continued. **EUROPE**—Continued.

COLEOPTERA—Continued.

TRICHOPTERYGIDÆ.

North America	Europe
	Stenidium cæcum Joseph. Carniola.
	Ptilium pallidum Deg. Carniola.
	Ptinella anophthalma Joseph. Carniola.

SILPHIDÆ.

North America	Europe
Adelops hirtus Tellkf.	*Adelops*, 59 species.
	Leptodirus schmidtii Motsch. Carniola.
	hohenwarti Schmidt. Carniola.
	angustatus Schmidt. Carniola.
	sericeus Schmidt. Carniola.
	Pholeuon angusticolle Hampe. Hungary.
	gracile Frivald. Hungary.
	leptodirum Frivald. Hungary.
	querilhaci Lespès. France.
	Oryotus schmidti Miller. Carniola.
	Spelæochlamys ehlersi Dieck. Spain.
	Drimeotus kovacsi Miller. Hungary.
	kraatzi Friwald. Hungary.

STAPHYLINIDÆ.

North America	Europe
Quedius spelæus Horn.	*Lathrobium cavicola* (Müller). Carniola and Italy.
Unknown blind Staphylinid larva. Pl. XX, fig. 14.	

CARABIDÆ.

North America	Europe
Anophthalmus, 8 species.	*Anophthalmus*, 64 species. Southern Europe: Germany, Austria, Italy, Spain, France.
	Trechus saxicola Putz. Spain.
	uhagoni Crotch. Spain.
	navaricus Vuillefroy. Basses-Pyrénées, France.
	Aphænops tiresias La Brûlerie. France.
	pluto Dieck. France.
	cerberus Dieck. France.
	œacus Saulcy. France.
	crypticola Linder. France.
	leschenaulti Bonv. France.
	pandellei Linder. France.
	Sphodrus cavicola Schmidt. Carniola.
	schreibersii Küst. Carniola.
	paradoxus Joseph. Carniola.
	Pristonychus œacus Miller. Dalmatia.
	erberi Schauf. Dalmatia.
	redtenbacheri Schauf. Dalmatia.
	exaratus Hampe. Croatia.
	fairmairei Schauf. Spain.
	ledereri Schauf. Spain.
	Pterostichus microphthalmus Delarouzée. Basses-Pyrénées, France.
	Reicheia miribilis Miller. Herzegovina, Austria.

DIPTERA.

North America	Europe
Chironomus, 2 species.	*Chironomus viridulus.* Carniola.
Borborus, sp.	*Trichocera*, sp. Carniola.
Sciara, sp.	*Sciara*, sp. Carniola.
Mycetophila, sp.	*Gymnomus troglodytes* Loew. Carniola.
Blepharoptera defessa Osten Sacken.	*Heteromyza atricornis* Meigen. Hungary and Carniola.
Anthomyia, sp.	*Phora aptina* Schiner et Egg. Carniola.
Phora, sp.	*Nycteribia*, 5 species. Carniola.
Pholeomyia leucozona Bilim. Cave of Cacahuamilpa, Mexico.	

NORTH AMERICA—Continued. **EUROPE**—Continued.

HYMENOPTERA.

Typhlopone clausii Joseph. Carniola.

VERTEBRATA.

PISCES.

Amblyopsis spelæus DeKay. Mammoth, Wyandotte, and Emerson's Spring Cave, in a pool communicating with [Green?] river. J. R. Proctor. Caves and wells in Indiana and Kentucky.

Chologaster cornutus Agassiz. Subterranean streams in Mammoth Cave and in Tennessee.

agassizii Putnam.

Chologaster papilliferus Forbes. Subterranean streams and wells in Illinois.

Typhlichthys subterraneus Girard. Subterranean streams of Kentucky, Tennessee, and Alabama.

BATRACHIA.

Proteus anguineus Laur. Subterranean waters of caves in Carniola and Dalmatia.

VII.—LIST OF NON-CAVERNICOLOUS BLIND OR EYELESS ANIMALS.

It may be regarded as a matter of some interest to obtain a rough idea of the number of blind or eyeless Arthropoda and Vertebrata, which do not live in caves, for comparison with the list of cave animals. It will be seen that the lists are nearly of the same extent.

It will also be seen how very small a proportion the blind, non-cavernicolous animals of the two higher branches of the animal kingdom bear to those of normal vision. There are known to be not less than from one to two hundred and fifty thousand species of Arthropods and mammals, while the blind forms amount to a very small percentage of this number.

Before beginning our list we may glance at the groups of lower invertebrates which are eyeless, being either primitively without any organs of vision, or which belong to groups where all the species have become adapted to a stationary or parasitic (internal or external) mode of life.

Protozoa. Without exception eyeless, though some forms have sensitive "eye-spots."
Porifera. Without exception eyeless.
Cœlenterata. Many, perhaps a large proportion, eyeless.
Echinodermata. All, except Asteroidea, eyeless.
Polyzoa. All, without any known exception, eyeless.
Brachiopoda. Adult forms eyeless, the larvæ of some having temporary eyes.
Vermes. Cestoids, Trematoda, and nearly all the other parasitic forms, with Lumbricus, etc., eyeless.
Mollusca. All fresh-water Lamellibranchiata, and many marine forms, without eyes.*

* In regard to eyeless Mollusca I applied to Mr. W. H. Dall, who was kind enough to supply me with the following information:

"To fully answer your letter would take nearly a book of itself. But in a few words I will try to give you an answer, such as it is. I do not know of any eyeless Cephalopods. Among the Lamellibranchs the vast majority have no eyes; developed eyes are very exceptional, but sense organs sensible to light (but not exactly eyes) have been found in several species and may exist in many more. We know the characters of the soft parts in only about one species in five thousand, so that it is impossible to generalize with safety. Among Gastropods the majority have eyes. The presence or absence of eyes is not of much importance in classification, but their *position* when present is important. One species of a genus may be blind and another have eyes. Among littoral species those which burrow in the sand, like Natica, Sigaretus, Bullia, Scaphander, Philine, etc., are very apt to be blind, but others of the same habit are not. The Chitonidæ are all blind if we look for the eyes in the usual place; but in certain groups there is the wonderful apparatus for seeing through the shell, described by Moseley. Nearly all the Pteropods and Janthina are blind. Most of the Heteropods, though leading a similar life, have well-developed, movable eyes.

Class PYCNOGONIDA.

The deep-sea species are either eyeless or with rudimentary eyes.

Class CRUSTACEA.

Order Cirripedia.

Rhizocephala. All are eyeless, while the barnacles have rudimentary eyes.

Order Branchiopoda.

Bradya limicola Herrick. In mud in ditches, near Mobile, Ala.
Bathynella natans Vejovsky. Eyeless. Wells in Prague.
Canthocamptus cryptorum Brady. "Eyes wanting;" (?) none represented in the figure. In a coal mine, Newcastle, England.
Siphonostomata. All the members of this group of ectoparasites are eyeless.
Cypris eremita Vej. White and eyeless. Wells in Prague.

For preparing the following list of higher Crustacea, mostly deep-sea forms, I am indebted to Prof. S. I. Smith, of Yale University.

Order Amphipoda.

Anonyx calcaratus G. O. Sars. "No distinct eyes." North Atlantic, 600 to 1,200 fathoms.
A. typhlops G. O. Sars. "No eyes." North Atlantic, 1,700 fathoms.
Tryphosa pusilla G. O. Sars. "No eyes." North Atlantic, 1,000 fathoms.
Acidostoma laticorne G. O. Sars. "No eyes." North Atlantic, 200 fathoms.
Harpinia abyssi G. O. Sars. "No eyes." North Atlantic, 350 to 2,200 fathoms.
H. carinata G. O. Sars. "No eyes." North Atlantic, 600 to 778 fathoms.
H. mucronata G. O. Sars. "No eyes." North Atlantic, 150 to 600 fathoms.
H. serrata G. O. Sars. "No eyes." North Atlantic, 100 fathoms.
Urothor abbreviata G. O. Sars. "No eyes." North Atlantic, 600 fathoms.
Œdiceros macrocheir G. O. Sars. "No eyes." North Atlantic, 1,000 fathoms.
Mæra tenera G. O. Sars. "No eyes." North Atlantic, 417 fathoms.
Melita pallida G. O. Sars. "No eyes." North Atlantic, 1,300 fathoms.
Bruzelia serrata G. O. Sars. "No eyes." North Atlantic, 350 fathoms.
Danaia abyssicola G. O. Sars. "No eyes." North Atlantic, 447 fathoms.
Lilljeborgia æquicornis G. O. Sars. "No distinct eyes." North Atlantic, 95 to 147 fathoms.
Ampelisca odontoplax G. O. Sars. "No eyes." North Atlantic, 142 fathoms.
A. minuticornis G. O. Sars. "No perceptible eyes." North Atlantic, 350 to 634 fathoms.
Byblis abyssi G. O. Sars. "No eyes." North Atlantic, 350 to 620 fathoms.
Podocerus brevicornis G. O. Sars. "No eyes." North Atlantic, 146 to 767 fathoms.
P. tenuicornis G. O. Sars. "Eyes wanting." North Atlantic, 1,110 fathoms.
Unciola petalocera G. O. Sars. "No eyes." North Atlantic, 350 to 650 fathoms.
Dulichia macera G. O. Sars. "Eyes rudimentary." North Atlantic, 450 to 870 fathoms.
Hyperiopsis voringii G. O. Sars. Eyes rudimentary. North Atlantic, 1,280 fathoms.
Stegocephalus gibbosus G. O. Sars. "No eyes." North Atlantic, 120 fathoms.
S. auratus G. O. Sars. "No distinct eyes." North Atlantic, 100 fathoms.

Archibenthal and abyssal mollusks are often blind, as of course you are well aware, but many are not. I have not found any with exceptionally well-developed eyes. The Strombs, which live in shallow water, and some of the Cephalopods have eyes comparable to those of vertebrates. Many embryo mollusks have eyes which they lose on becoming adult. Cave land shells are frequently blind. The *Zonites subrupicola* I described from your Utah cave was blind; and, by the way, I have the same species from above ground, under stones in California, since, but not with the soft parts. The big Auriculas (*A. judæ*, for example) are blind. They live under dead leaves in forests. Several blind species of Zospeum and a *Helix* (Ammonitella) *hauffeni* are found in the grottoes of Carniola. On the other hand, the Onchidium of the tropics has, like some Chitons, eyes in its back, described by Semper, besides its normal tentacular eyes, while the very similar northern Onchidella has only the latter. Cæcilianella and Geostilbia are French cave land shells without eyes. The Sepia has lids to its eyes and is the only mollusk which can tip you a wink!"

Although living snails were found in nearly all the caves examined and collections of them made, which are mostly in the Museum of Comparative Zoology at Cambridge, they have not been carefully examined and identified. None are known to be peculiar to caves, and the shells are of the normal color, not bleached. It is, however, of interest to observe that De Rougemont in his essay on Hydrobia found in the wells of Munich and in Falkenstein Cave this species, not found in the upper world. He states that the existence of eyes in this species is not positively proved, although Wiedersheim, who first found this snail in the Falkenstein Cave, speaks of the existence of visual organs on the tentacles. De Rougemont adds that in the Hydrobia from Munich he has seen no such traces: "Les tentacules étaient d'une uniformité complète de leur base à leur extrémité" (Étude, etc., p. 45). Good transverse microscopic sections would probably readily enable one to settle the point whether traces of eyes exist in this interesting mollusk.

Andania pectinata G. O. Sars. "No distinct eyes." North Atlantic.
Stegoplax longirostris G. O. Sars. "No eyes." North Atlantic, 300 fathoms.
Bruzelia tuberculata G. O. Sars. "No distinct eyes." North Atlantic, 100 to 300 fathoms.
Podocerus tuberculatus Hoek. North Atlantic, 67 fathoms.

[*Bathyporeia pilosa* and *pelagica* are one species, according to Boeck (Scand. og Arkt. Amphip.), which is figured and described as having eyes.]

Niphargus fontanus Spence-Bate. England, in wells.
Niphargus kochianus sp. Bate. England, in wells.
Crangonyx subterrancous sp. Bate. England, in wells.

NOTE.—A blind species of the family Hyperiidæ inhabits deep water in China Sea. W.-Suhm, Zeits. wissen. Zool., xxvi, iv, 1876.

Order ISOPODA.

APSEUDIDÆ.

Apseudes spinosus (M. Sars). 180 to 729 fathoms. "No vestige of eyes" (Norman and Stebbins).
uncidigitatus Norm. and Stebb. Mediterranean. "No appearance of eyes."
obtusifrons Norm. and Stebb. Straits of Gibraltar, 128 fathoms (Norman and Stebbins).
lunarifrons Norm. and Stebb. Off coast of Algeria, 51 to 510 fathoms (Norman and Stebbins).
simplicirostris Norm. and Stebb. 100 miles south of Rockall, 1,263 fathoms (Norman and Stebbins).
grossimanus Norm. Off Portugal, 740 fathoms (Norman and Stebbins).
gracilis Norm. and Stebb. North Atlantic and Davis Strait, 1,450 to 1,785 fathoms (Norman and Stebbins).
Sphyrapus malleolus Norm. and Stebb. North Atlantic, 109 to 1,450 fathoms (Norman and Stebbins).
tudes Norm. and Stebb. South of Rockall, 420 fathoms (Norman and Stebbins).
anomalus G. O. Sars. Coast of southern Norway, 40 to 150 fathoms (Sars).

TANAIDÆ.

Alætanais serratospinosus Norm. and Stebb. 1,360 to 1,450 fathoms (Norman and Stebbins).
hastiger Norm. and Stebb. 1,750 fathoms (Norman and Stebbins).
lævispinosus Norm. and Stebb. Off Valencia, 370 fathoms (Norman and Stebbins).
Strongylura arctophylax Norm. and Stebb. Midway between Ireland and Rockall, 1,380 fathoms (Norman and Stebbins).
Tanœlla unguicillata Norm. and Stebb. English Channel, 96 fathoms (Norman and Stebbins).

The following genera of Apseudidæ and Tanaidæ are eyeless:

Sphyrapus G. O. Sars. Several species. Atlantic, 40 to 1,500 fathoms.
Typhlapseudes Beddard. One species. Atlantic, 450 fathoms.
Leiopus Beddard. One species. Atlantic, 1,000 fathoms.
Neotanais Beddard. One species. Atlantic, 1,200 to 1,900 fathoms.
Anarthura G. O. Sars. One species. Atlantic.
Strongylura G. O. Sars. Two species. North Atlantic, deep water.
Cryptocope G. O. Sars. Two species. North Atlantic.
Haplocope G. O. Sars. One species. North Atlantic.
Pseudotanais G. O. Sars. Four species. North Atlantic and Mediterranean.
Typhlotanais G. O. Sars. Many species. Atlantic, Pacific, and Southern oceans, shallow to 2,050 fathoms.
Leptognatha G. O. Sars. Many species. North Atlantic and Southern oceans, shallow water.
Tanœlla Norman and Stebbing. One species. North Atlantic, 96 fathoms.
Alaotanais Norman and Stebbing. One species. North Atlantic, 370 to 1,750 fathoms.

In several other genera of these families some of the species are eyeless and others furnished with eyes.

[I can find no reference to *Apseudes cæca* in Beddard's Challenger Isopoda.]

MUNNIDÆ.

The following genera of Munnidæ are eyeless:

Pleurogonium G. O. Sars. Several species. North Atlantic and Southern oceans.
Dendrotion G. O. Sars. One species. North Atlantic, 100 fathoms.
Nannoniscus G. O. Sars. Two species. North Atlantic, 100 to 1,163 fathoms.
Macrostylis G. O. Sars. Two species. North Atlantic and Pacific, 100 to 2,000 fathoms.
Ischnosoma G. O. Sars. Several species. Atlantic and Pacific, 700 to 2,000 fathoms.

MUNNOPSIDÆ.

All the genera of Munnopsidæ are eyeless, and inhabit deep water in all the oceans. There are five or more genera (Desmosoma, Munnopsis, Ilyarachna, Eurycope, Acanthocope) and more than thirty species described.

Examples of some of these are the following:

Eurycope robusta Harger. Gulf of St. Lawrence, 220 fathoms, muddy bottom.
Eurycope cornuta Sars. Norwegian coast.
Eurycope phalangium Sars. 30 to 60 fathoms, mud; Gulf of Christiania.
Eurycope mutica Sars. 30 to 60 fathoms, mud; Gulf of Christiania.
Eurycope gigantea Sars. Arctic Sea.
Eurycope latirostris Sars. Norway.
Ilyarachna sp. Harger. 106 fathoms, mud; 21 miles east of Cape Cod.
Ilyarachna longicornis Sars. 30 to 50 fathoms, mud; Gulf of Christiania.
Ilyarachna hirsutus Sars. 30 to 50 fathoms, mud; Gulf of Christiania.
Desmosoma lineare Sars. 15 to 50 fathoms, mud; Gulf of Christiania.
Desmosoma armatum Sars. 15 to 50 fathoms, mud; Gulf of Christiania.
Desmosoma aculeatum Sars. 15 to 50 fathoms, mud; Gulf of Christiania.

ARCTURIDÆ.

Arcturus myops Beddard. Southern Ocean, 700 fathoms. Eyes rudimentary.

ANCEIDÆ.

Anceus stygius G. O. Sars. No eyes. North Atlantic, 600 to 1,200 fathoms.
A. bathybius Beddard. No eyes. Atlantic, 900 fathoms.

CYMOTHOIDÆ.

Harponyx pranizoides G. O. Sars. No eyes. North Atlantic, 100 fathoms.
Anuropus branchiatus Beddard. Pacific, 1,000 fathoms.
Cymothoæ (Semper).

ANTHURIDÆ.

Paranthura chiltoni Beddard. Southern Ocean, 700 fathoms; and undoubtedly other species of the family.
tenuis G. O. Sars. Norway, 150 to 200 fathoms off Lisbon, 718 fathoms (Norman and Stebbins).
Anthclura elongata Norm. Off coast of Portugal, 740 fathoms.
abyssorum Norm. and Stebb. Near entrance of Davis Strait, 1,750 fathoms (Norman and Stebbins).
Ilyssura producta Norm. and Stebb. North Atlantic, 1,450 fathoms (Norman and Stebbins).
Calathura brachiata. North Atlantic, 20 to 1360 fathoms (Is this blind?) (Norman and Stebbins, etc.).

IDOTEIDÆ.

Glyptonotus megalurus G. O. Sars. North Atlantic, 1,000 to 1,700 fathoms (G. O. Sars).

ASELLIDÆ.

Janira abyssicola Beddard. No eyes. Pacific, 1,350 fathoms.
Iolanthe acanthonotus Beddard. No eyes. Pacific, 1,670 fathoms.
Trichopleon ramosum Beddard. No eyes. Pacific, 500 fathoms.
Neasellus kerguelenensis Beddard. No eyes. Southern Ocean, 100 to 600 fathoms.
Anthoniscula typhlops G. O. Sars. North Atlantic, 450 fathoms.

SEROLIDÆ.

Serolis antarcta Beddard. No eyes. Southern Ocean, 400 to 1,600 fathoms.

The eyes of the shallow-water species are well developed; those of the abyssal are more or less imperfect, without retinula, or even altogether wanting, as in *S. antarcta* (F. E. Beddard, Zool. Challenger, xi, Zool. Rec., 1884).

Order Cumacea.

The species of Leucon, Eudorella, Petalomera, and Eudorellopsis are said by G. O. Sars to be eyeless, and so also are many species of Diastylis, while other species are furnished with a small but well-developed eye.

[The eyes are inconspicuous in the majority of the species of the order, and their presence or absence is frequently not noted in the descriptions.]

Order Phyllocarida.

Nebaliopsis typica G. O. Sars. "Eyes rudimentary, without pigment or visual elements." Southern Ocean, 1,375 to 2,550 fathoms.

Order Schizopoda.

EUPHAUSIIDÆ.

Bentheuphausia amblyops G. O. Sars. Eyes rudimentary, very small, pigment whitish; "no true corneal facets or other visual elements." Atlantic and South Pacific, 1,000 to 1,800 fathoms.

[I can find no mention of "*Euphausia simplex* Will.-Suhm" in Sars's Challenger report, and unfortunately have not Will.-Suhm's papers with me; but as far as I know Bentheuphausia is the only Euphausiid with rudimentary eyes.]

MYSIDÆ.

Petalophthalmus armiger Will.-Suhm. Eyes thin, oval lamellæ, without trace of pigment or visual elements (G. O. Sars). Eye-stalks terminated by concave spherical plates, "but with no trace of any eye-like structure." South Atlantic, 2,500 fathoms.—Will.-Suhm.

Boreomysis scyphops G. O. Sars. Eyes, lamellar plates "without pigment or visual elements." North Atlantic, South Atlantic, and South Pacific, 1,100 to 1,950 fathoms.

Amblyops abbreviata G. O. Sars. North Atlantic, 100 to 300 fathoms.

A. crozettii G. O. Sars. Southern Ocean, 1,600 fathoms.

Eyes in both species flattened plates without visual elements.

Pseudomma roseum G. O. Sars. North Atlantic, 50 to 500 fathoms.

P. affine G. O. Sars. North Atlantic, 50 to 500 fathoms.

P. truncatum Smith. North Atlantic, 50 to 500 fathoms.

P. sarsii G. O. Sars. Off Kerguelen Island, 1,675 fathoms.

P. australe G. O. Sars. Off Bass Strait, 33 fathoms.

Eyes in all the species "broad petaloid expansions of the ocular segment, partially connate in the middle, not exhibiting the slightest trace of pigment or visual elements."

Mysidella typhlops G. O. Sars. Eyes with conical tips, without pigment or visual elements. North Atlantic, 150 to 200 fathoms.

Pseudomysis abyssi G. O. Sars. Eyes conical, without trace of pigment or visual elements. North Atlantic, 1,100 to 1,280 fathoms.

Order Decapoda.

Calocaris macandreæ Bate.

Bathyplax typhlus A. M.-Edwards. Described as having the eyes very small, immobile, and without corneæ. West Indies, 400 fathoms.

Eryoniscus cæcus Bate. Canary Islands, 1,675 fathoms. Eyeless.

Phoberus cæcus A. Milne-Edw. Caribbean Sea, 416 fathoms. "Eyes rudimentary, without corneæ."

Cymonomus granulatus A. M.-Edw. North Atlantic, —— fathoms.

C. quadratus A. M.-Edw. West Indies, 175 to 500 fathoms. Eye-stalks immobile, spiny rods, without a cornea.

Willemœsia leptodactyla Willem.-Suhm. Atlantic, 1,900 fathoms; Pacific, 1,375 fathoms.

W. forceps A. M.-Edw. West Indies, 1,920 fathoms.

Polycheles typhlops Heller. Mediterranean and North Atlantic, 200 to 250 fathoms.

P. crucifer (Will.-Suhm) Bate. West Indies, 450 fathoms.

P. helleri Bate. Pacific, 500 to 1,070 fathoms.

P. baccatus Bate. Pacific, 310 to 315 fathoms.

In the four previous species the eyes are not described by Bate. Said to be wanting (S. I. Smith).

Pentacheles sculptus Smith. North Atlantic, 250 to 1,081 fathoms.
P. lævis Bate. Pacific, 500 fathoms.
P. suhmi Bate. Pacific, 120 fathoms.
P. gracilis Bate. Pacific, 610 fathoms.
P. obscurus Bate. Pacific, 1,070 fathoms.
P. auriculatus Bate. Pacific, 610 fathoms.
P. enthrix Bate. Pacific, 315 fathoms.
P. validus A. M.-Edw. West Indies, 955 to 1,591 fathoms.
P. agassizii A. M.-Edw. West Indies, 118 to 1,058 fathoms.
P. spinosus A. M.-Edw. West Indies, 611 to 1,568 fathoms.

In the species here mentioned the eyes appear to be essentially as in *P. sculptus*, where the eye-stalks are without facets, but with two apparently cornea-like areas (S. I. Smith).

P. nanus Smith. North Atlantic, 705 to 1,917 fathoms. "No colored pigment or facetted surface."
P. debilis Smith. North Atlantic, 1,290 to 1,309 fathoms. "Eyes nearly as in the other species" (Smith).
Astacus zaleucus is not an Astacid, and is
Thaumastocheles zaleucus Wood-Mason, 1874. West Indies, 450 fathoms. "Eyes and eye-stalk wanting entirely."
Nephropsis stewarti Wood-Mason. Bay of Bengal, 260 to 300 fathoms.
N. agassizii M.-Edw. Straits of Florida, 1,500 meters.
N. agassizii n. sp. Wood-Mason. Andaman Island, 600 meters. In both species the eyes are rudimentary, and are like small tubercles deprived of corneæ (A. M.-Edwards).

Six or seven species of Nephropsis are now indicated, ranging over the Atlantic and Pacific in 100 to 800 fathoms. They are all very closely allied or identical, and it might be best to refer to the genus as a whole.

Orophorhynchus sp. blind (Wood-Mason).
Galathodes, 13 species. North Atlantic, West Indies, and Mediterranean, 51 to 2,376 fathoms. "Eyes small, with incomplete cornea."
Ethusina abyssicola Smith. North Atlantic. "Only a very few visual elements at the tips of the immobile eye-stalks" (Smith).
Ethusia (*Ethusina*) *challengeri* Miers. Pacific Ocean, 1,875 fathoms.
Pinnotheres (Semper).
Lyreidus channeri Wood-Mason. Blind. Bay of Bengal.

Class ARACHNIDA.

Order ACARINA.

In the family Bdellidæ the eyes are sometimes wanting; so also, in species of the family Ixodidæ. In the Gamasidæ, Oribatidæ, and Acaridæ the eyes are absent. The Tardigrada are eyeless, as well as the Linguatulina.
Geckobia latasti Meguin. Parasitic in adult state on a lizard (Bull. Soc. Ent. France, viii, 1878).
Eschatocephalus gracilipes Frauenfeld. Caves in Carniola and Hungary.
Eschatocephalus hispanus Schaufuss (?). Spain.
Eschatocephalus frauenfeldi Koch. Rosenmüller Cave, Germany.
Eschatocephalus seidlitzi Koch. Cave in Franconia, Germany. All parasites on pigeons or bats.

Order ARTHROGASTRA.

Chernes. All the species are blind.
Nyctalops tenuicaudata Cambr. Blind, allied to Thelyphonus. Ceylon.
Nyctalops crassicaudata Cambr. Blind, allied to Thelyphonus. Ceylon.

Class MYRIOPODA.

Family Scolopendridæ.

The species of Cryptops, Opisthemega, Scolopocryptops, and Newportia are eyeless; in Monops there is one simple eye on each side.

Family Geophilidæ.

All the species eyeless, or rarely with but a single pair of ocelli.

Family Polydesmidæ.

The species of Polydesmus are eyeless, and no American species of the family have eyes.

Family Siphonophoridæ.

The species of Siphonophora and Brachycybe are eyeless.

Class INSECTS.

In preparing this list I take pleasure in acknowledging the assistance of Dr. Sharp and of M. Bedel, whose letter I reproduce, as follows:

"PARIS, 15 *avril*, 1887.

"CHER MONSIEUR: Je suis fort embarrassé pour répondre à votre désir, car il est impossible de définir exactement les insectes qui forment la transition entre les espèces cavernicoles et les espèces non-cavernicoles; la série des passages existe presque partout, pour les mœurs comme pour l'atrophie des yeux. En outre, les découvertes se sont tellement multipliées, dans ces dernières années, qu'il est très difficile de donner, même approximativement, une liste de renseignements un peu complète. Voici quelques observations à ce sujet. Les derniers catalogues énumèrent:

"*Otiorrhynchus* (*Troglorhynchus*): *anophthalmus* Schmidt, Carniole; *grenieri* All., Corse; *martini* Fairm., Pyrénées; *mayeti* Fairm., Pyr.; *terricola* Linder, Pyr.; *latirostris* Barg., Italie; *camaldulensis* Rott., Italie; *baldensis* Czw., Mont Baldo; *myops* Reitt., Caucase. Aucun insecte de ce genre n'est vraiment cavernicole; les mœurs des larves s'opposent à leur existence dans les grottes.

"Genre Torneuma (insectes aveugles, vivant sous les pierres et à la racine des plantes), une seule espèce en Europe, *T. deplanatum* Hampe; on en a publié d'autres espèces (6 ou 7) du nord de l'Afrique (Maroc, Algérie, etc.), mais les espèces sont mal étudiées et leur nombre est très exagéré.

"Genre *Amaurorrhinus* (insectes aveugles, vivant dans le bois mort, les racines, etc.), une seule espèce en Europe, *bonnairei* Fairm.; les autres espèces décrites sont des variétés de l'*A. bonnairei*, qui est polymorphe.

"*Alaocyba* (dont *Raymondia* est synonyme), insectes aveugles, vivant sous les pierres enfoncées dans le sol: *A. sicula* Rott., Sicile; *sardoa* Perris, Sardaigne; *longicollis* Perris, Corse; *apennina* Dieck, Italie; *fossor* Aubé, France mérid.; *salpingoides* Kr., Dalmatie; *perrisi* Gren., France mérid.; *marqueti* Aubé, France mérid.; *benjaminis* Mayet, Pyrénées; *curvinasus* Abeille, France mérid.; *lævithorax* Perris, Corse; *damryi* Perris, Corse; *delarouzeei* Bris., France mérid.; *carinulata* Perris, Italie.

"Il est probable qu'il y a des espèces à supprimer dans le nombre. Il n'existe pas d'Adelops en Europe, comme l'a fait observer le Dr. Horn. Toutes nos espèces sont des Bathyscia. On connaît maintenant une nombreuse série d'espèces qui vivent en dehors des grottes, dans les mousses des forêts.

"*Anommatus* (insectes vivant sous les bois morts, à la racine des arbres, etc.): 12-*striatus* Müll., *pusillus* Schauf., *kiesenwetteri* Reitt., *vallombrosæ* Dieck, *diecki* Reitt., *planicollis* Fairm.

"Près de ce genre se place: *Abromus brucki* Reitt., insecte aveugle, qui vit sous les pierres dans les Pyrénées Orientales. Les *Langelandia* (aveugles aussi, vivant comme les Anommatus), *anophthalma* Aubé; *reitteri* Belon; *exigua* Perris; *callosipennis* Reitt., toutes d'Europe méridionale.

"*Lyreus subterraneus* Aubé vit aussi à la racine des arbres dans le bois mort. *Aglenus brunneus* se trouve de même et aussi dans les caves des maisons.

"Les genres Amaurops, Tychus, Leptomastax vivent dans les mousses ou au pied des arbres; les Tychus ont des yeux; les Leptomastax sont aveugles. Je crois que les Bythinus du sous genre Machærites sont les seuls Psélaphides qui fréquentent *l'entrée* des grottes; les autres genres ne s'y trouvent jamais, pas plus que les Scydménides. Les Staphylinides mentionnés dans votre liste sont tous terricoles, sauf *Mycetoporus spelæus* dont la capture dans une grotte paraît avoir été accidentelle.

"*Typhlocharis silvanoides* Dieck est du Maroc; voyez, au sujet des genres voisins, le travail de Ehlers (Deutsche ent. Zeit., 1883, p. 30), où est décrit le genre Geocharis, etc.

Du reste, tous ces genres, Anillus, Geocharis, Dichropterus, Typhlocharis, Scotodipnus, Microtyphlus, sont aveugles et vivent de la même manière.

"Parmi les Trechus aveugles (et non cavernicoles) je puis vous citer *Anophthalmus clairi* et *lantosquensis* Ab., des Alpes-Maritimes, qui vivent dans la terre, le long des torrents. Du reste, les Trechus présentent tous les degrés comme développement des yeux et genre de vie.

"Je vous signale le *Pterostichus microphthalmus* Delar., espèce des Pyrénées, qui se trouve, peut-être accidentellement, dans les grottes, et qui a les yeux moins grands que les autres espèces. C'est un insecte *noir*.

"Le genre *Reicheia* compte 5 espèces: *lucifuga* Saulcy, *urlaubi* Saulcy, *raymondi* Putz., *præcox* Schaum, *frondicola* Reitt., toutes de la région méditerranéenne. Elles vivent dans la terre humide et sont aveugles.

"La plupart des Læmostenus (Antisphodrus), aptères, vivent dans les caves et les grottes, aussi bien en Algérie et en Syrie que dans les montagnes d'Europe; leurs yeux ne sont pas modifiés; la plupart ne sont pas décolorés (sauf *ghilianii* et *schreiberii*).

"La difficulté qu'il y a actuellement dans l'étude des cavernicoles m'a fait renoncer à recommencer le catalogue que j'ai publié en 1875 avec M. Simon; la liste des espèces serait aujourd'hui doublée.

"Je souhaite que les notes précédentes puissent vous être utiles; elles vous prouveront que même en Europe il serait impossible de se faire une idée exacte sur la faune terricole sans de très longues recherches et le résultat serait à peu près négatif et sans intérêt.

"Je suis très heureux, cher Monsieur, d'avoir eu cette occasion d'entrer en relations avec vous, et je vous prie de me croire

"Votre respectueusement dévoué

"L. BEDEL,
"20, *rue de l'Odéon*."

Order PLATYPTERA.

Termes. The soldiers and workers are blind.

Order COLEOPTERA.

Family Curculionidæ.*

Otiorhynchus (Troglorhynchus) *anophthalmus* Schmidt. Caves in Carniola; also found by Schmidt in the open air under leaves, pieces of wood, etc.
Otiorhynchus baldensis Czwalina. Mount Baldo, under stones.
Otiorhynchus martini Fairmaire. Pyrenees, in Villefranca Cave.
Otiorhynchus terricola Linder. Southern France, under large stones buried in the soil.
Otiorhynchus grenieri Allard. Corsica.
Otiorhynchus camaldulensis Rottenb. Naples, under dead leaves.
Otiorhynchus latirostris Bargagli. Near Sienne, Italy, under a large block of marble.
Otiorhynchus mayeti Fairm. Pyrenees.
Otiorhynchus myops Reitt. Caucasus.
Torneuma deplanatum Hampe (Crypharis Fairm.). Europe.
Amaurorrhinus bonnairei Fairm.
Alaocyba Perris, 14 sp. (See Bedel's letter.)
Raymondia Aubé, sp. The species of this and the three foregoing genera are said by Bedel to live in the earth or under stones, equally blind or provided with very rudimentary eyes. They almost all inhabit the Mediterranean region.

Family Tenebrionidæ.

Alaudes singularis Horn. United States.

Family Colydiidæ.

Aglenus brunneus Gyll. Introduced into theUnited States; San Francisco, California (Lieutenant Casey).

* Bedel states: "On sait, en effet, que le développement en l'atrophie des yeux n'ont pas, pris isolément, de valeur générique, et déjà l'*O. planophthalmus* Heyden (Reise nach Süd-Spanien, 1870, p. 151), découvert sous des mousses, dans la Sierra Nevada, présente une transition marquée entre le type normal et les espèces aveugles; ses yeux sont petits, déprimés et composés de facettes au milieu seulement."—(Liste générale des articulés cavernicoles de l'Europe, p. 63). While the genus Otiorhynchus embraces about 350 species, the subgenus, Troglorhynchus, consisting of blind species, embraces only the nine above enumerated.

Family Trichopterygidæ.

Ptinodes pini Lec., male. United States.
Ptinodes quercus Lec., male. United States.
Ptinellodes lecontei Matth., male. United States.
Limulodes paradoxus Matth. United States.
Ptilius œdipus Flach. Deutsche ent. Zeit., xxx, p. 248.

Family Silphidæ.

Adelops aubei Kiesw. Presence discovered near Toulon, by Guérin-Ménneville, in a nest of Pompilius; others occurred under stones, and accompanied by *Microtyphlus schaumi* and *Amaurops aubei.* It is common under dead leaves near Marseilles; also in company with *Lyreus subterraneus*, under stones buried in the soil.
Adelops ovoidea Fairm. Southern France.
Adelops epuræoides Fairm. Southern France.
Adelops subalpina Fairm. French Alps.
Anommatus 12-striatus Müll.
Anommatus pusillus Schauf.
Anommatus kiesenwetteri Reitt.
Anommatus vallambrosæ Dieck.
Lyreus subterraneus Aubé.
Lyreus diecki Reitt.
Lyreus planicollis Fairm.
Langelandia anophthalma Aubé. Southern Europe.
Langelandia reitteri Belon. Southern Europe.
Langelandia exigua Perris. Southern Europe.
Langelandia callosipennis Reitt. Southern Europe.
Aglenus brunneus. Europe, whence introduced into the United States.
Pinodytes cryptophagoides Mann. United States.

The species of Anommatus, like those of Lyreus, Langelandia, and Aglenus, allied genera and equally blind, live under the bark of damp wood adhering to the soil, or under stones which cover rotten wood; they are terricolous, but none of them is peculiar to caves, though one species of Anommatus was observed by H. Müller in a cave in Carniola (Bedel, p. 63).

Family Pselaphidæ.

This family, like the Scydmenidæ, comprises a certain number of genera or species which live under stones or in the soil, whose mode of life is ultimately analogous to that of the cave forms (Bedel).

Amaurops.
Scotoplectus capellæ Reitter. Croatia; living in company with Adelops, under dead leaves, between blocks of limestone; = *stussineri* Saulcy. Carniola; *fide* Sharp).
Heteronyx heterocerus Saulcy. France.
Heteronyx aberrans Saulcy. France.
Nicotheus tibialis Casey. Eyes small in male, rudimentary in female. District of Columbia and Virginia.
Adranes cæcus Lec. United States.
Adranes lecontei Brendel. United States.
Eutyphlus similis Lec. United States.
Bythinus cristatus Saulcy. Found by Abeille de Perrin under an enormous stone at Ariège.
Bythinus bonvouloiri Saulcy. Hautes-Pyrénées; under moss.
Bythinus hypogeus Saulcy. Eyes much reduced. Pyrenees.
Bythinus cocles Saulcy. Eyes much reduced. Pyrenees.
(Eyes present in both sexes in the two last species, *fide* Sharp.)

Family Scydmenidæ.

Leptomastax sp.
Scydmænus sp.
Cephennium sp.

Family Leptinidæ.

Leptinus testaceus Müll. Europe and United States.

Family Platypsyllidæ.

Platypsylla castoris Rits. Parasite on the beaver. Its larva is also blind.

Family **Staphylinidæ**.

Lasthrobium cavicola Müller. The only true cave staphylinid; is also found under stones in Italy.
Xantholmus tenuipes Baudi. "Yeux rudimentaires" (Fauvel).
Xantholmus myops Fauv.

This species, according to Fauvel, Dr. Sharp tells me, has eyes. These two "subanophthalmous" species, says Bedel, are found under deeply buried stones, and the first notably in the neighborhood of caves. Bedel (p. 44) remarks: "The Staphylinidæ includes, especially in the Mediterranean region, a relatively considerable number of terricolous or lapidicolous species, of very small size, and for the most part blind. For example:

Phlæocaris (Scotodytes) *paradoxa* Saulcy. Pyrénées-Orientales.
Phlæocaris laticollis Fauv. Piedmont.
Leptotyphlus sublævis Fauv. Corsica.
Cylindrogaster cæcus Perr.
Scotonomus raymondi Saulcy. Italian islands.
Micrillus subterraneus Raffi. Algeria.
Apteranillus dohrni Fairm. Algeria.
Apteranillus raffrayi Fairm. Algeria.
Apteranillus convexifrons Fairm. Algeria.
Leptusa, etc.
Mycetoporus spelæus Scriba. Asturia, Spain. "Remarkable for the great reduction of the eyes" (Bedel).
Typhlocaris silvanoides Dieck. Morocco.

Family **Carabidæ**.

Illaphanus stephensii MacLeay. Australia; eyeless.
Pterostichus microphthalmus Delar. Pyrenees.
Trechus microphthalmus Miller (*spelæus* Reitt.). Carpathians, under flat stones; and caves of Demanova, under stones.

The following species of Trechus, says Bedel, have the eyes more or less reduced in size, and live under large stones, deeply buried in the earth, in the Alps. Dr. Sharp writes me: "The eyes in many Trechi are more or less reduced, but they are not blind beetles."

Trechus subterraneus Miller.
Trechus longhii Comolli.
Trechus baldensis Putz.
Trechus strigipennis Kiesw.
Trechus ochreatus Dej.
Anophthalmus clairi Aubé. Maritime Alps.
Anophthalmus santosquensis Aubé. Maritime Alps.
Anophthalmus pilosellus Miller. Is not a cave-dweller. Carpathians and eastern Galicia.

The group of Antiphodrus contains a certain number of species which are not known to be cavicolous, but whose habits approach those which are. Their eyes are reduced in size. They are:

Antisphodrus elegans Dej. Southern Austria and Turkey.
Antisphodrus pseudapostolus Schf. Country unknown.
Antisphodrus macropus Chaud. Lombardy.
Antisphodrus ghilianii Schaum. Italy and perhaps *köppeni*. Mots. from the Crimea and obtusangulus from Asia Minor.
Anillus debilis Lec.
Anillus fortis Horn.
Anillus dohrni Ehlers.
Petrocharis eggersi Ehlers. West Indies.
Reicheia lucifuga, etc. Six species almost blind, the eyes being aborted; peculiar to the Mediterranean basin.
Reichia urlaubi Saulcy.
Reichia raymondi Putz.
Reichia palustris Saulcy.
Reichia præcox Schaum.
Reichia frondicola Reitt.
Reichia baudii Rag.
Geocharis sp.
Dichropterus sp.
Scotodipnus 7 sp.
Microtyphlus 7 sp.

Grenier (Ann. Soc. Ent. France, 4e série, tome iv, pp. 137 to 140) has some observations on the traces of eyes in beetles reputed blind. Having found indications of eyes in Anophthalmus, he examined the other blind beetles, and found in Aphænops an excessively minute surface marking the position of the visual organ. In Leptoderus, Adelops, etc., no trace of an eye can be detected, but in *Glyptomerus cavicola* there is a very small one, presenting no facets, but distinguishable by its pale color. He suggests that in many cases the internal portions of the organs of vision may be sufficiently developed to enable these insects to perceive the faint rays of light that may find their way into the caverns; in others, however, it has been found that the visual nerves are either wanting or rudimentary, indicating that the sense of sight can hardly be exercised by these. Further observations on the anatomy of this part of the nervous system in the blind beetles inhabiting dark caverns and ants' nests are very desirable.

Order SIPHONAPTERA.

Hystrichopsylla obtusiceps (Rits). Eyes absent.
Typhlopsylla octactenus (Kol.).
Typhlopsylla caucasica Tasch. (=*Pulex typhlus* Motsch., from *Spalax typhlus*).
Typhlopsylla assimilis Tasch. (? =*Pulex talpæ* Bouché).
Typhlopsylla gracilis Tasch. (? = *P. talpæ* Bouché, nec Curtis). Eyes absent or rudimentary.

Order DIPTERA.

Family Polyctenidæ.

Euctenodes mirabilis Waterhouse. Allied to Strebla.

Order HYMENOPTERA.

Family Chalcididæ.

Eupristina S. Saunders. The male has neither eyes nor ocelli, while the female has large eyes.
Anthophorabia fasciata and *A. retusa* Newport. While the females have normal compound eyes, in the males the compound eyes are reduced to a minute simple one, and the wings are rudimentary. The species live in the darkness of the cells of Anthophora. The males probably do not leave the cells to impregnate the female, which are active, going from one nest to another. (See Newport, Mem. Linn. Soc., xxi, 81, 82.)
Ceratosolen Mayr. "Die Augen sehr klein oder fehlend" (Mayr).

Family Formicidæ.

Eciton (occasionally). (In these genera the workers alone are eyeless.)
Typhlatta.
Liomyrmex cæca (Smith). Eyes and ocelli wanting.
Typhlomyrmex.
Syscia Rog.
Amblypone Frichs.
Mystrium Rog.
Myopone Rog.
Strigmatomma Rog.
Ponera.
Anomma Shuck.
Labidus.*
Typhlopone Westw. Subterranean in their mode of life, like Termes (Mayr).
Rhogmus Shuck.*
Ænictus Shuck.*
Dichthadia.*
Dorylus F.
Dichthadia Gerst.

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* Workers unknown, though supposed to be eyeless. "I believe that Eciton is now supposed to comprise the workers of Labidus," states Mr. L. O. Howard, who has materially aided me in completing this list of Hymenoptera.

The following list of blind Coleoptera was kindly furnished me by Dr. David Sharp after this paper was sent to the Printer. It comprises both cave species and those living elsewhere.

EUROPEAN AND MEDITERRANEAN.

CARABIDÆ.

ANOPHTHALMUS Schm.

European and Mediterranean. Probably all without eyes.

Anophthalmus milleri Friv.
pilosellus Mill.
redtenbacheri Friv.
erichsoni Schauf.
kruperi Schaum.
doriæ Fairm.
picciolii Bed.
ghilianegi Fairm.
carantii Sella.
delphinensis Ab.
auberti Gren.
raymondi Del.
lespesi Fairm.
orcinus Lind.
trophonius Ab.
orpheus Dieck.
discontiguegi Fairm.
dalmaterius Mill.
suturalis Schauf.
gallicus Del.
rhadamanthus Lind.
gounelli Bed.
bucephalus Dieck.
amabilis Schauf.
bilinecki Sturm.
oszailensis Bed.
hacqueti Sturm.
suaneticus Reitt.
kiesenwetteri Schaum.
schmidti Sturm.
globulipennis Schmidt.
scopolei Sturm.
hirtus Sturm.
pubens Bed.
capillatus Jos.
minos Lind.
ehlersi Ab.
brisouti Ab.
nakeralæ Reitt.
budæ Kend.
balcanicus Friv.
paræcus Friv.
erkli Friv.
ognatus Friv.
egedusi Friv.
turcicus Friv.
eurydice Schauf.
reitteri Mill.
simoni Ab.
mayeti Ab.

ANOPHTHALMUS Schm.—Continued.

Anophthalmus clairi Ab.
lautosquensis Ab.
trophonius Ab.
siculus Baudi.
likanensis Schauf.
targionii Torre.
œrtzeni Mill.
doderii Gesh.
caneveæ Gesh.
gentillei Gesh.
spagnoli Gesh.
vaccæ Gesh.
apenninus Gesh.

APHÆNOPS Bonv.

Close to Anophthalmus, but optic nerve said to be wanting. All from Pyrenees.

Aphænops tiresias Brulerie.
pluto Dieck.
cerberus Dieck.
œacus Saulcy.
crypticola Lind.
leschnaulti Bonv.
pandellei Lind.

TYPHLOCHARIS Dieck.*

Typhlocharis diecki Ehlers.
bæticus Ehlers.
silvanoides Dieck.

ANILLUS Duval.

Anillus cœcus Duv.
mayeti Bris.
hypogæus Aubé.
convexus Saulcy.
florentinus Dieck.
corsicus Perris.
frater Aubé.
massinissæ Dieck.
florentinus Dieck.

GEOCHARIS Ehlers.

Geocharis cordubensis Dieck.
quadricollis Ehl.

DICROPTERUS Ehlers.

Dicropterus brevipennis Friv.

SCOTODIPNUS Schaum.

Scotodipnus saulcyi Dieck.
glaber Baudi.
subappinus Baudi.
hirtus Dieck.
affinis Baudi.
alpinus Baudi.

* This genus was placed by its describer in Cucujidæ.

MICROTYPHLUS Linder.

Microtyphlus pandellei Saulcy.
taurinensis Baudi.
guadarannus Ehlers.
schaumi Saulcy.
revelieri Perris.
baudii Saulcy.
aubéi Saulcy.
perpusillus Rott.

STAPHYLINIDÆ.

PHLŒOCHARIS Mann.

Phlœocharis paradoxa Saulcy.
diecki Saulcy.

MAYETIA Muls. and Rey.

Mayetia sphærifer Muls. and Rey.

LEPTOTYPHLUS Fauv.

Leptotyphlus sublævis Fauv.

CYLINDROGASTER Fauv.

Cylindrogaster corcicus Fauv.

SCOTONOMUS Fauv.

Scotonomus raymondi Fauv.
etruscus Saulcy.

MICRILLUS Raff.

Micrillus subterraneus Raff.

GLYPTOMERUS Müll.

Glyptomerus cavicola Müll.
apenninum Baudi.

TYPHLODES Sharp.

Typhlodes italicus Sharp. (Said to be identical with *Xantholinus tenuipes* Baudi, but that posessses rudimentary eyes and is non-cavernicolous, while *T. italicus* has not the least trace of eyes and is cavernicolous.)

TYPHLOCYPTUS Rey.

Typhlocyptus atomus Rey.

APTERANILLUS Fairm.

Apteranillus dohrni Fairm.
convexifrons Fairm.
raffrayi Fairm.

LEPTUSA Kr.

Leptusa cæca Eppelsh. (This is doubtful, as I have not access to the description.)

PSELAPHIDÆ.

CLAVIGER Preysl.

Claviger lederi Reit.
testaceus Preysl.
perezii Reitt.
carniolicus Reitt.
nitidus Hampe.
bruckii Saulcy.
piochardi Saulcy.
lusitanicus Saulcy.
duvali Saulcy.
pouzani Saulcy.
saulcyi Bris.
colchicus Motsch.
caspicus Reitt.
nebrodensis Rag.
revelieri Saulcy.
apenninus Saulcy.
longicornis Mill.
elysius Reitt.

AMAUROPS Fairm.

Amaurops aubéi Fairm.
diecki Saulcy.
sardoa Saulcy.
corsica Saulcy.
gallica Del.
abeillei Saulcy.
exarata Baudi.
carinata Baudi.
pirazzolii Saulcy.
koziorowiczi Saulcy.
revelieri Saulcy.
syriaca Reitt.
corcyrea Reitt.

MACHÆRITES Mill. (Bythinus pars auct. plur.)

Eyes wanting in female only; in several species male only is known, and blind females only inferred.

Machærites spelæus Mill.
subterraneus Motsch.
doriæ Schauf.
ludyi Reitt.
lucantei Saulcy.
cristatus Saulcy.
mariæ Duv.
claræ Schauf.
armatus Schauf.
revelieri Reitt.
myrmido Reitt.
bonvouloiri Saulcy.
algiricus Raff.
maritimus Reitt.
gladiator Reitt.
eppelsheimi Reitt.

TYCHUS Leach.

In one species only the female is known, and this has no eyes, viz, *anophthalmus* Reitt. In a few other species the female has very small eyes.

SCOTOPLECTUS Reitt.

Scotoplectus capellæ Reitt.

SCYDMÆNIDÆ.

CEPHENNIUM Müller.

Cephennium algeciranum Reitt.
cæcum Saulcy.
lesinæ Reitt.
judæum Reitt.
pygmæum Saulcy.
atomarium Saulcy.
aglenum Reitt.

Scydmænus, subgen. Tetramelus Motsch., with twenty-five species. "Augen klein oder fast fehlend," Reitt. All unknown to me; probably all have more or less eyes present.

EUDESIS Reitt.

Eudesis aglena Reitt.

LEPTOMASTAX Pirazzoli.

Eyes very minute, but probably always present. Seventeen species.

ABLEPTON Friv.

Closely allied to preceding. Blind, though traces (unpigmented) of eyes can be seen.

Ablepton treforti Friv.

PLATYPSYLLIDÆ.

PLATYPSYLLA Rits.

Platypsylla castoris Rits.

LEPTINIDÆ.

LEPTINUS Müller.

Leptinus testaceus Müller.

SILPHIDÆ.

LEPTODERUS Schmidt.

Leptoderus hohenwarti Schm.
angustatus Schm.

PROPUS Ab.

Propus sericeus Schm.

ANTROCHARIS Ab.

Antrocharis querhilaci Lespès.

TROCHARANIS Reitt.

Trocharanis mestrei Ab.

CYTODROMUS Ab.

Cytodromus dapsoides Ab.

APROPEUS Reitt.

Apropeus leptoderus Friv.

SPELÆODROMUS Reitt.

Spelæodromus pluto Reitt.

FERICEUS Reitt.

Fericeus kraatzi Friv.

DRIMEOTUS Mill.

Drimeotus kovacsi Mill.

ORIOTUS Mill.

Oriotus schmidti Mill.
micklitzi Reitt.

PHOLEUON Hampe.

Pholeuon angusticolle Hampe.
gracile Friv.

DIAPRYSIUS Ab.

Diaprysius caudatus Ab.
caudatissimus Ab.

HEXAURUS Reitt.

Hexaurus merkli Friv.
affine Friv.

PERRINIA Reitt.

Perrinia kiesenwetteri Dieck.

SPELEOCHLAMYS Dieck.

Speleochlamys ehlersi Dieck.

APHAOBIUS Ab.

Aphaobius milleri Schmidt.
heydeni Reitt.

BATHYSCIA Schiödte, subg. SOPHROCHÆTA Reitt.

Sophrochæta paveli Friv.
merkli Friv.
insignis Friv.

BATHYSCIA Schiödte, subg. BATHYSCIA i. sp. Reitt.

Bathyscia croatica Mill.
subrotundata Reitt.
freyeri Mill.
kherenhulleri Mill.
globosa Mill.
byssina Schiödte.
acuminata Mill.
dorotkana Reitt.
narenteria Mill.
erberi Schauf.
turcica Reitt.
hungarica Reitt.
persica Ab.
bosnica Reitt.
kerkyrana Reitt.
montana Schiödte.
hoffmanni Motsch.
celata Hampe.
fausti Reitt.

BATHYSCIA Schiödte—Continued.

Bathyscia lesinæ Reitt.
peyronis Ab.
pusilla Motsch.
corsica Ab.
domuzi Ab.
ovoidea Fairm.
tarsalis Kies.
sarteanensis Barg.
tarissani Bed.
villardi Bed.
galloprovincialis Fairm.
gestroi Fairm.
spagnoli Fairm.
doderoi Fairm.
majori Reitt.
grouvellei Ab.
muscorum Dieck.
doriæ Fairm.
frondicola Reitt.
subalpina Fairm.
aubéi Kies.
epuræoides Fairm.
brevicollis Ab.
pumilio Reitt.
wollastoni Jans.
opaca Ab.
lucidula Del.
chlersi Ab.
diecki Saulcy.
pyrenæus Lesp.
bonnevillei Saulcy.
novemfontium Pioch.
perieri Pioch.
longicornis Saulcy.
discoutignyi Saulcy.
curvipes Pioch.
bonvouloiri Duv.
piochardi Ab.
clavata Saulcy.
hecate Ab.
saulcyi Ab.
pandellei Ab.
abeillei Saulcy.
stygia Dieck.
chardonis Ab.
crassicornis Pioch.
aletina Ab.
speluncarum Del.
proserpinæ Ab.
cophosina Saulcy.
delarouzei Fairm.
inferna Dieck.
schiodtei Kies.
grenieri Saulcy.
larcennei Ab.
lapidicola Saulcy.
meridionalis Duv.
linderi Ab.
mialetensis Ab.
simonis Ab.
aspenela Fairm.

BATHYSCIA Schiödte—Continued.

Bathyscia ovata Kies.
fugitiva Reitt.
mazanedoi Uhag.
arcana Schauf.
triangulum Sharp.
crotchi Sharp.
filicornis Uhag.
cantabrica Uhag.
flavobrigensis Uhag.
seeboldi Uhag.
perezi Sharp.
cisnerosi Perez.
tropica Ab.
rugosa Sharp.
uhagoni Sharp.
adnexa Schauf.

COLYDIIDÆ.

LYREUS Aubé.

Lyreus subterraneus Aubé.

AGLENUS Er.

Aglenus brunneus Gyll.

LANGELANDIA Aubé.*

Langelandia anophthalma Aubé.
reitteri Bel.
exigua Per.
callosipennis Reitt.

ANGELANDIA Reitt.*

Agelandia grandis Reitt.

ANOMMATUS Wesm.*

Anommatus 12-striatus Müll.
pusillus Schauf.
kiesenwetteri Reitt.
valombrosæ Dieck.
diecki Reitt.
planicollis Fairm.

ABROMUS Reitt.*

Abromus brucki Reitt.

PHYSODIDÆ.

CLINIDIUM Kirby. (Eyes wanting in female.)

Clinidium canaliculatum Costa.

CURCULIONIDÆ.

OTIORYNCHUS, subg. TROGLORHYNCHUS Schm.

Otiorhynchus anophthalmus Schmidt.
grenieri All.
martini Fairm.
mayeti Fairm.
terricola Lind.
latirostris Barg.
camaldulensis Rott.
baldensis Czwal.
myops Reitt.

* These have been usually placed in Lathridiidæ, but go better in Colydiidæ.

TORNEUMA Woll.

Torneuma deplanatum Hampe.
raymondi Perris.
damryi Perris.
siculum Ragusa.
robusta Dieck.
strigirostris Fairm.
convexiuscula Fairm.
subterranea Fairm.
terigitana Dieck.

AMAURORHINUS Fairm. (Eyes present, but obsolete.)

Amaurorhinus bonnairei Fairm.
narbonnensis Bris.
crassiusculus Fairm.

RAYMONDIA Aubé.

Raymondia sicula Rott.
sardoa Per.
longicollis Per.
apennina Dieck.
fossor Aubé.
salpingoides Kraatz.
perrisi Gren.
marqueti Aubé.
benjaminis Marg.
curvinasus Ab.
lævithorax Per.
damryi Per.

ALAOCYBA Perris.

Alaocyba delarouzei Bris.
carinulata Per.

EXTRA EUROPEAN—EXOTIC.

SILPHIDÆ.

SCOTOCRYPTUS Gir. (Brazil, in nests of bees.)

Scotocryptus meliponæ Gir.
melitophilus Reitt.
parasitus Reitt.
obscurus Sharp.

CARABIDÆ.

ANILLUS Duv.

Anillus pallidus Brown. (New Zealand.)
integripennis Bates. (Guatemala.)

PETROCHARIS Ehl.

Petrocharis eggersii Ehl. (St. Thomas.)

ILLAPHANUS.

Illaphanus stephensi Macl. (Australia.)

STAPHYLINIDÆ.

CEPHALOPLECTUS Sharp.

Cephaloplectus godmani Sharp. (Panama.)

AMBLYOPINUS Solsky. (Parasitic on mammalia.)

Amblyopinus jelskii Solsky. (Peru.)
mnizechi Solsky.
jansoni Matth. (Tasmania.)

COLYDIIDÆ.

PYCNOMERUS.

Pycnomerus cæcus Brown. (New Zealand.)

CURCULIONIDÆ.

LIPOMMATA Woll.

Lipommata calcaratum Woll. (Madeira.)

HALORHYNCHUS Woll.

Halorhynchus cæcus Woll. (Australia.)

ONYCHOLIPS Woll.

Onycholips bifurcatus Woll. (Canary Islands.)

AMAURORHINUS Fairm.*

Amaurorhinus monizianus Woll. (Canary Islands and Madeira.)
bewickianus Woll. (Madeira.)

PENTATEMNUS Woll.*

Pentatemnus arenarius Woll. (Canary Islands.)
affinis Woll. (Cape Verde Islands.)

PSEUDOMESOXENUS Woll.*

Pseudomesoxenus subcæcus Woll.* (Canary Islands.)

HETEROPSIS Woll.*

Heteropsis lawsoni Woll. (New Zealand.)

*Eyes present, but "obsolete."

VERTEBRATA.

Class FISHES.

Amblyopsis spelæus De Kay. Caves and wells, Kentucky and Indiana.

Typhlichthys subterraneus Girard. Subterranean streams in Kentucky, Tennessee, and Alabama.

Lucifuga subterraneus Poey. Caves in Cuba.

Stygicola dentata (Poey). Caves in Cuba.

Umbra crameri. In subterranean lakes in Austria (Schmarda, Geogr. der Thiere, i, 13).

Gronias nigrilabris Cope. Eyes rudimental; "no lens" (Cope). Conestoga River, Lancaster county, Pennsylvania.

Pimelodus cyclopium Humboldt. South America. Eyes more or less rudimentary.

Helogenes. South America.

Agoniosus and other genera. South America.

Eutropius congensis. Africa.

Ailia, Shilbichthys, Bagroides, and other genera in Asia (Putnam). (See Semper, p. 420.)

Blind-fishes are said to exist in an artesian well in California by Hon. J. D. Caton (Amer. Naturalist, xix, 811, 1885), who kindly sent me the following correspondence in regard to the matter.

CHICAGO, *July* 12, 1886.

DEAR SIR: About a year ago I wrote you about eyeless fish said to have been thrown out of an artesian well at Santa Clara College, near San José, California. I wrote to the officers of the college for information, but could get no answer. When in San Francisco last spring I stated the matter to my friend H. B. Williams, who told me that he had a friend, J. T. Doyle, who was a great friend and patron of the college, who would learn all about it. So I wrote a letter to Mr. Williams, which he handed or sent to Mr. Doyle. I inclose you Mr. Doyle's answer, which I think is of some interest, not only on account of the fish but on account of the emission of the sawdust, which must have come from the red-wood saw-mills, 12 miles away, in the mountain.

The figure which Mr. Doyle gave of the sightless fish may not be of value, but his description may have its interest. At any rate I send it so that you may use the matter as you may think proper.

I received several other letters from Mr. Williams, in one of which he informed me that he had heard from another source that when the Santa Clara well was first sunk a few small sightless fishes were thrown out an inch or an inch and a quarter long; that Mr. Doyle had failed to get a response from the college authorities, but that he would persevere till he did get an answer; but after two months' waiting I concluded to send you this little installment.

Very truly, yours,

J. D. CATON.

Prof. A. S. PACKARD, Jr.

SAN FRANCISCO, *April* 30, 1886.

MY DEAR SIR: It is always a pleasure to do any service to you. I forward your letter and that of Judge Caton to the officers of the college.

I have some little knowledge of the matter inquired about myself. One of the fish in question was brought to me some years since, which had flowed from a well of my brother, near Menlo Park. The well, if I remember correctly, had ceased to flow as abundantly as before, and something was put down to stir up the bottom of it; whatever the provocation, the result was that the well vomited up an excessive quantity of red-wood sawdust, and shortly after the fish in question was taken from it and brought to me in a bottle. It was about two and one-quarter inches long by two-fifths of an inch wide, silvery belly, and reddish-gold back. My impression is that the place where eyes should be was well marked but the eye closed. The savans to whom it was shown whose knowledge of such subjects was confined, like my own, to what might be learned from the Alta California and the fish market, voted that the red-wood sawdust came from a saw-mill up in the coast range, of which there were three or four within 12 or 15 miles, and that the fish was of some sort of underground kind which had no immediate need of eyes, like those found in the Mammoth Cave of Kentucky.

As to a flow of them from a well in Santa Clara College, I never heard of such, and think if they had appeared there in any quantity we should have heard of them. The water in all the wells in the valley contains a good deal of salts of soda and magnesia, but are not considered mineral waters; they are merely hard (for washing), and some find them also hard to drink, without qualification.

Yours, truly,

JOHN T. DOYLE.

H. B. WILLIAMS, Esq.

The following statement bearing on this subject, is taken from a newspaper:

A curiosity has been taken by a Pierce City, Missouri, man from his well. It is a living fish about one and one-half inches in length. The external markings are those of a catfish, but there are no feelers about the mouth. The little creature is almost colorless, the red blood showing through the translucent flesh. It does not seem to have eyes, though it is hard to decide whether it has or not.*

Regarding the blind deep-sea fishes, I sought information from the highest authority, Dr. Günther, superintendent of the zoological department of the British Museum, who kindly wrote me the following letter in regard to them:

"British Museum (Natural History),
"*Cromwell Road, London, S. W., April* 25, 1887.

"Dear Sir: Your question is not quite so easy to answer as may appear at first sight. 'Eyeless' fishes there are none; all have at least a rudiment of the organ of vision preserved. 'Blind' fishes there are many, but some of them have well-developed eyes, only the integument which passes over the eyes is so thickened as to render the organ below functionless. In fact, there is the most perfect gradation from the most highly-developed organ to the most rudimentary; and in not a few fishes the adults are quite blind, whilst in the young the eye is comparatively not only larger, but covered with transparent skin and performing the functions of vision.

"Thus the following list may be open to criticism, but I will endeavor to enumerate those fishes which seem to have the organ of vision at a similar stage of abortion as Amblyopsis and Lucifuga (I do not know Gronias from autopsy); that is, fishes which are blind in consequence of the rudimentary condition of the eye-ball.

GOBIIDÆ.

Amblyopus. Several species.
Trypauchen. Several species.
Trypauchenichthys typus.

OPHIDIIDÆ.

Lucifuga. Several species.
Typhlonus nasus Günth. Deep sea.
Aphyonus gelatinosus Günth. Deep sea.

PLEURONECTIDÆ.

Soleotalpa unicolor.

SILURIDÆ.

Amblyceps. Several species.
Cetopsis. Several species.
Brontes prenadilla.

SCOPELIDÆ.

Ipnops murrayi Günth. Deep sea.

MYXINIDÆ.

Myxine. Several species.
Bdellostoma. Several species.

"All further particulars as regards localities, etc., which you may wish to ascertain you will find either in my 'Catalogue of Fishes' or in my 'Introduction to the Study of Fishes.' If I have some copies of the figures of the three deep-sea fishes I will send them by this post, and should have great pleasure in supplying any further information you may desire.

"Believe me, yours, truly,

"A. Günther."

* See also an article by A. W. Chase in Amer. Journ. Sci. and Arts, vii, 1874, p. 74. An article appearing in the Providence Journal January 4, 1887, states that "a well that for forty years has furnished water for a large community of negroes on the Coolewahee plantation, Georgia, was cleaned the other day," when "two crawfishes, perfectly white and without eyes," were taken out, with numerous articles of human manufacture.

Blind eel in a cave in the Tonga Islands.—Dr. R. W. Coppinger, during the cruise of the *Alert*, explored a system of caves on the south side of Tongatabu. "In the floor of the chamber were deep pools of water probably communicating with the sea, and said to be tenanted by a species of blind eel about 2 feet long, which we were told the natives sometimes caught with hook and line and fed upon" (p. 176). Unfortunately Dr. Coppinger failed to obtain a specimen.

Class BATRACHIA.

Cœcilia, Siphonops, and *Epicrium.* "Eyes only visible through the skin as small specks" (Claus's Zoology, English trans., ii, 187).

Proteus anguineus Laur. Subterranean waters of Carniola and Dalmatia. Eyes rudimentary.

Class REPTILIA.

Family Typhlopidæ.

Typhlops sp. "The small eyes are concealed each under a plate always larger than the eye itself. The latter is sometimes invisible, either because the loose epidermis becomes opaque, or because the visual organ is too small and too imperfect to be seen from without" (Jan, quoted by Duchamp, 40).

Family Calamariidæ.

Typhlogeophis brevis Günther. Possesses no external rudiments of eyes (Günther, Proc. Zoological Soc., London, January 14, 1879).

Mr. G. A. Boulanger kindly informs me that the following Lacertilia are "blind:" the species of the families Amphisbænidæ, Anelytropidæ, and Dibamidæ.

Class MAMMALIA.

Order INSECTIVORA.

Talpa cœca Linn. Blind mole; eyelids closed.

Order RODENTIA.

Spalax typhlus Pallas. Blind mouse. "Eyes rudimentary."

Ctenomys braziliensis. (See Darwin's "Origin of Species."*)

Bathyergus. South Africa.

Siphnus. Eastern Asia. Eyes like those of moles.

VIII.—ANATOMY OF THE BRAIN AND EYES (WHEN PARTLY DEVELOPED) OF CERTAIN BLIND ARTHROPODS.

THE BRAIN OF THE EYELESS FORM CÆCIDOTÆA.†

It is a matter of great interest to know just what, if any, changes take place in the brain or nerve-centers of the head of the eyeless forms related to Asellus; whether the modification is confined to the external parts of the eye, or to the optic lobes and nerves alone.

As previously stated, a blind Asellus-like form is abundant in the brooks and pools of Mammoth and other caves in Kentucky and Indiana, as well as in the wells of the cavernous and adjacent regions. The foregoing observations on the brain and eyes of the common Asellus of our brooks and ponds were made to afford a basis of comparison with the similar parts in the eyeless form.

Cæcidotæa in its external shape is seen to be a depauperate Asellus, with the body, however, much longer and slenderer than in the eyed form, and with slenderer appendages. It is not usually

* Dr. R. W. Coppinger, in the cruise of the *Alert* (1883), says that, contrary to Darwin's opinion that the tucutuco (Ctenomys) never comes to the surface, "the little rodents were commonly to be seen near their holes about the time of dusk, and that they invariably retreated to the burrows on the near approach of a human being" (p. 27). In a subsequent page he speaks of seeing one himself.

† This section is in part reprinted from the author's paper "On the structure of the brain of the sessile-eyed Crustacea." Memoirs Nat. Acad. Sci., iii, 1885.

totally eyeless. In a number of specimens from a well at Normal, Illinois, kindly sent us by Mr. S. A. Forbes, a minute black speck is seen on each side of the head in the position of the eyes of Asellus, just above the posterior end of the base of the mandibles. In some specimens these black dots are not to be seen; in others they are visible, but varible in degree of distinctness. In twelve specimens which I collected in Shaler's Brook in Mammoth Cave I could detect no traces of eyes, and infer that most, if not all, the Mammoth Cave specimens are totally eyeless. It thus appears that different individuals have eyes either quite obsolete if living in caves in total darkness, or, if living in wells, with eyes in different degrees of development up to a certain stage—that represented by black dots—which, however, are so easily overlooked, that we confess, after handling dozens of specimens, we did not suspect that the rudimentary eyes existed until our attention was called to them by Dr. C. O. Whitman when he sent the slides. The European *Asellus forelii* is also said to be blind. The specimens we received through the kindness of Professor Forel, which were, unfortunately, dried and spoiled, seemed to be entirely eyeless, though special search was not made for the eye-specks.

It will be seen that the eyeless Cæcidotæa differs from Asellus as regards its brain and organs of sight, in the complete loss of the optic ganglion, the optic nerve, and the almost and sometimes quite total loss of the pigment-cells and lenses.

After a pretty careful study of numerous vertical sections of the brain of *Cæcidotæa stygia* as compared with that of *Asellus communis*, we do not see that there are any essential differences, except in the absence of the optic ganglia and nerves. The proportions of the procerebral lobes, of the ganglion cells, their number and distribution, the size of the transverse and longitudinal commissures are the same. The head and brain as represented is smaller than in Asellus, the form itself being considerably smaller.

Careful examination of the sections passing behind the procerebral lobes and œsophageal commissures failed to show any traces of the optic ganglion of either division, or of the ganglion cells and myeloid substance composing it. Every part connected with the optic ganglia seems to be totally abolished. The same may be said of the optic nerve throughout its length. The entire nervous portion of the optical organs are wanting.

With the eye itself it is different. The modification resulting from a life in total darkness has left traces of the eye, telling the story of degeneration and loss of the organs of sight, until but the merest rudiments of the eye remain as landmarks pointing to the downward path in degradation and ruin taken by the organs of vision; the result of a transfer to a life in total or partial darkness, as the case may have been, in the well-inhabiting or cave-dwelling individuals.

Pl. XXIII, fig. 1*b*, represents a section through the head of *Cæcidotæa stygia* behind the procerebral lobes and œsophageal commissures, showing the absence of any traces of the optic ganglia or optic nerves, but indicating the rudiments of the eye, showing that the pigment mass of the retina and the lenses exist in a very rudimentary condition, while the optic nerve and ganglion are entirely aborted.

Figs. 1 *c* and 1 d–1 d^4 represent enlarged views of the rudimentary eye of two different specimens of *C. stygia* from Mammoth Cave. In the sections represented by Fig. 1 *c*, *a*, *b*, we see that the number of facets has been reduced apparently to two (*o*), the rudimentary lenses being enveloped by a black pigment mass. This section, examined by Tolles's $\frac{1}{5}$ A, is magnified and drawn to exactly the same scale as that of the eye of Asellus represented by Fig. 1 *a*. In that figure may be seen the normal size of the lenses and of the retina cells. It will be seen that in Cæcidotæa the retina cells are broken down and have disappeared as such, and that the rudimentary lens (or the hyaline portion we suppose to be such) which the retinal pigment incloses is many times smaller than in the normal eye of Asellus.

On comparing the eyes of the two specimens as shown in Figs. 1 *c* and 1 d'–1d''', it will be seen that the eyes in one are considerably larger than in the other specimen. Fig. 1 d'' shows that in the eye of this individual there were at least four lenses, if not more, not included in the section. At the point indicated by 1 *d*, on the edge of the eye, one lens is indicated (though the divisions are wanting), not wholly concealed by the pigment of the retina; a more magnified view is seen at Fig. 1 d^4. The four sections 1 d' to 1 $d^{4''}$ passed through the eye, the sections in front and behind not touching the eye itself.

It thus appears from the observations here presented that the brain of the blind Cæcidotæa differs from that of the normal Asellus in the absence of the optic ganglia (both divisions) and the optic nerves, while the eyes are exceedingly rudimentary, the retinal cells being wanting; the black pigment mass inclosing very rudimentary minute lens-cells, which have lost their transverse zonular constriction or division; the entire eye of Cæcidotæa finally being sometimes wanting, but usually microscopic in size, and about one-fifth as large as that of the normal Asellus.

The steps taken in the degeneration or degradation of the eye, the result of the life in darkness, seems to be these: (1) the total and nearly or quite simultaneous loss by disuse of the optic ganglia and nerves; (2) the breaking down of the retinal cells; (3) the last step being, as seen in the totally eyeless form, the loss of the lens and pigment.

That these modifications in the eye of the Cæcidotæa are the result of disuse from the absence of light seems well proved; and this, with many parallel facts in the structure of other cave Crustacea, as well as insects, arachnids, and worms, seems to us to be due to the action of two factors: (*a*) change in the environment; (*b*) heredity. Thus we are led by a study of these instances, in a sphere where there is little if any occasion for struggling for existence between these organisms, to a modified modern form of Lamarckianism to account for the origination of these forms, rather than to the theory of natural selection or pure Darwinism as such.

The brain of Crangonyx.—Sections were made of two species; one from Illinois with eyes (the species not identified), besides sections of the eyeless *C. vitreus*, from Mammoth Cave. In the Illinois Crangonyx the brain, as seen in section, is represented by Pl. XXVI, fig. 1. The eye was torn out in making the sections, so that the actual position of the eye and the relations to it of the optic lobes was not satisfactorily determined. Figs. 2 to 7 represent sections of a large specimen from in front backwards. In Fig. 7 are seen the relations of the optic ganglia and olfactory ganglia to each other.

When we compare with these Figs. 8 to 12 of Crangonyx from Mammoth Cave, especially comparing the sections represented by Figs. 7 and 10 *a*, we see very slight differences between the brains of the eyed and the eyeless Crangonyx. The optic ganglia have about the same proportions as do the other lobes and the arrangement of the ganglion cells. Perhaps striking differences should not be expected, as the eyes of the eyed species of Crangonyx are small compared with those of Gammarus.

STRUCTURE OF THE BRAIN AND RUDIMENTARY EYES OF BLIND CRAYFISH.

The first author to describe and figure the eyes of *Orconectes pellucidus* of Mammoth Cave was George Newport, in his memoir "On the Ocelli in the genus Anthophorabia," Trans Linn. Soc. (Tab. X, figs. 11–14). While the external form of the eye is rendered correctly, this usually accurate and painstaking anatomist makes some strange errors both in his description and figures of the internal structure of the eye. The eye itself, he correctly states, is destitute of a pigmentary choroid, but then he remarks that "the hardened tegument which clothes the entire organ is thinnest and most transparent in that part which forms the cornea (*b*) in other crustaceans; so that although the eye may be unfitted for distinguishing form, the creature may yet possess the faculty of perceiving the small amount of actinic rays of light which penetrate into its subterranean abode." The author then adds the following observations, with which our own observations on the eyes of *Cambarus pellucidus* and *hamulatus* do not at all agree: "The cornea also exhibits an appearance of being divided into a few imperfect corneales at the apex of the organ (Fig. 14), and the structure behind these into chambers, to which a small but distinct optic nerve is given (Fig. 13 *d d*)."

Mr. Newport's specimen must have been quite imperfect, as we have been unable to find any "corneales;" nor such a termination of the optic nerve as the distinguished author figures. Nor were such noticed by Leydig, whose work we now proceed to notice, giving an abstract of Chapter III, "Eyes and Antennæ of the Blind Crayfish of Mammoth Cave."

"*Cambarus pellucidus* Tellkf., known as 'the blind crayfish of Mammoth Cave,' must likewise awaken our interest regarding the question whether other structures of the body may not have a greater development in place of the atrophied eyes.

"In the blind crayfish of Mammoth Cave the not very high eye-capsules are almost wholly concealed under the rostrum, and are of the same white appearance as the rest of the animal. Where we would expect to find a facetted cornea, on the end of the eye-capsule, the skin is of the usual appearance. It consists of a laminated cuticula provided with pore canals and smooth externally. In the mass which fills the interior of the eye-capsule is distinguished the indistinct cellular matrix of the skin; then a delicately fibrous connective tissue, besides a cellular nucleated part, perhaps the remains of the optic ganglion; also transverse muscular fibers; finally, clumps of a darker appearance; indeed the same structures which appear as whitish bodies through the eye-capsule before it is opened. They may possibly be groups of dermal glands. They have a certain streaked appearance, which in part seems to point to a segregation of the plasma in the rods, and might also in part originate from the ruffling and splitting of a homogeneous membrane. Of crystalline lenses and eye pigment no trace was to be discovered. Should we compare with these results those obtained from an examination of *Gammarus puteanus*, the relations are similar. But in the blind Gammaridæ, which were investigated under better circumstances, there may be seen an optic ganglion, which curves over towards that place in the body where the eye is situated in species provided with organs of sight. A crystalline lens and layer of a dark pigment are also absent in *Gammarus puteanus*. It is not otherwise with *Asellus cavaticus*, in which in the region of the eyes neither crystalline lenses and pigment nor corneal borders are present. And of like kind are also the structures in *Cambarus pellucidus*, which likewise show that all the elements once composing an eye have become atrophied. Only the ganglion may possibly have persisted and may be detected in fresh specimens. The presence of striated muscles suggests the articulation of an eye-stalk."

THE EYE OF CAMBARUS HAMULATUS.

(Pl. XXI, figs. 3, 3*a*–3*g*.)

In shape and size the eyes of this species are closely similar to those of *Cambarus pellucidus*, and the figure of the latter will well serve to represent the shape of the eyes of the species under consideration. The total length of the eye itself without the short stalk is equal to half the breadth of the rostrum of the same specimen at its base. As in the Mammoth Cave form (Fig. 2, *c*), the cornea is entirely obsolete. Thin longitudinal sections of the eye which have been preserved for several years in alcohol showed that the facets, cones, or crystalline lenses, the retinal rods, with the retina or black pigment layers, were, like the cornea, entirely wanting. Figs. 3–3*b* show that only the optic ganglion with the optic nerve have survived the effects produced by the absence of light.

Fig. 3 is a longitudinal section through one side of the eye, passing through the optic ganglion (*op. gang.*), and through the origin of the ocular muscle; Fig. 3 *a* passes through nearer the middle of the eye, while Fig. 3 *b* represents a median section through the eye. It will be seen that the epidermis at the end of the eye, where the cornea is situated, in normal-eyed Cambari (Fig. 1), has the same lamellated structure as in other parts at the side or base of the eye. Along the side the epidermis is made up of about ten layers, which are seen to split off in portions of the sections. These layers partly disappear and partly continue, but thin out as they reach the thinner portion of the end of the eye; but there are no signs of facets or of cones in the integument.

The hypodermis consists of a single layer of cells (Fig. 3*f*) whose walls are broken down, seldom visible, while their nuclei are usually separate, rarely crowded; they are spherical, or oval, with the nucleolus consisting of numerous granules. In the angle made by the beginning of the stalk the hypodermal cells become elongated or fusiform, and are more distinct than elsewhere. It should be noticed that the hypodermis at the end of the eye in the corneal region of normal species is one-layered; or, if on the sides, two or three-layered, as in the hypodermis of the side of the eye as seen in the same section (Fig. 3).

The space between the hypodermis and the optic ganglion is filled by a loose connective tissue. Next to the hypodermis is a thick layer of dense, clear, structureless tissue, without nuclei.

Along the edge of this layer are seen to lie more or less free cells, filled with a dense protoplasm. In other portions the connective tissue cells are elongated, more or less polygonal or fusiform, empty of protoplasm, their walls somewhat irregular and shriveled, with small nuclei (Fig. 3 *c*). These cells are either crowded and their outlines indistinct (3 *e*), or the tissue is looser and the cells more polygonal (3 *c*). It will be seen by the sketches that the space in normal Cambari occupied by the rods and retina is filled in with this packing of loose connective tissue.

The optic ganglion survives in the blind crayfish, but it is difficult to homologize the different portions of the white or myeloid substance with that of the normal-eyed crayfish or lobster. By reference to Figs. 3 *a* and 3 *b* it will be seen that the fibers of the optic nerve pass into the bulb-like optic ganglion, and beyond are three much smaller lobes, and in Fig. 3 *b* a fourth smaller lobe. Whether these smaller lobes represent the inner and middle black pigment layer of the retina of the normal eye or not is difficult to state. These fine lobes or subdivisions of the central "puntz-substanz" or myeloid substance is enveloped by a layer, varying in thickness, of ganglion cells. The enveloping mass is sometimes ten cells deep. The distal end of this layer is prolonged so as to reach the hypodermis at the end of the eye, as at 3 *a*, 3 *b*, *a*. The ganglion cells are remarkably small and of very uniform size, their nuclei being no larger and with the same shape as the hypodermis cells. A few are represented at Fig. 3 *d* (× 225 diameters). Only one as large as that indicated by the *x* was observed, whereas in the lobster's optic ganglion there are many with a diameter three times as great. The ganglion cell-walls are indistinct, being in general broken down and rendered obsolete. The nuclei are very distinct, and take the stain well, while the nucleoli are composed of a number (sometimes a dozen) of small granules. The ganglion cells send nerve fibers into the myeloid substance, which is evidently, when seen in sections, the transversely-cut ends of such fibers passing in from all sides.

The muscle which moves the eye is well developed, as seen in Fig. 3–3*b*, *mus.*

To recapitulate: In both the species of American blind crayfish:

The integument of the eye, with its stalk, is present, but abnormally lessened in size.

The optic nerves and optic ganglia are present, but the latter are small and degenerate.

The facets and entire cornea, the cones and rods, and the three black pigment layers are totally abolished.

It will be seen that this is nearly the reverse of what takes place in Cæcidotæa, where the pigment mass and cones, as well as facets, may in certain individuals be retained, while the optic nerves and optic ganglia are the first to be abolished.

THE BRAIN AND RUDIMENTARY EYES OF BLIND MYRIOPODS.

(Pls. XXIV, XXV.)

A great deal of interest attaches to Newport's work on the brain of Myriopods, because he has figured dissections of the brain of certain eyeless species both of Chilopoda and Diplopoda. From his researches it appears that the brain of the eyeless Geophilus, as well as Polydesmus, is wanting in optic ganglia and optic nerves, only the procerebral and antennal lobes remaining. (Pl. XXVII.)

The brain of Chilopod Myriopods in general.—From the examination we have made of microscopic sections of the brain of Bothropolys and Cermatia, as well as the forms described below, the Myriopod brain is closely homologous with that of winged adult insects; differing, however, in wanting the calyces and their stalks; *i. e.*, the so called mushroom bodies, and perhaps the so-called "central body." In Cermatia (Pl. XXIV, fig. 1) the optic ganglia are large and unusually well developed, the eyes being compound and larger than in other Myriopods. The general structure of the myeloid substance, its proportions to the investing ganglion cells, the size of the procerebral lobes and their relations to the optic and commissural lobes are as in insects.

In Bothropolys, a genus closely allied to Lithobius, the optic ganglia are large and well developed, becoming contracted at the origin of the optic nerve, which gradually increases in size toward the eyes, as seen in Pl. XXVI, fig. 2.

THE BRAIN OF DIPLOPOD MYRIOPODS IN GENERAL.

(Pls. XXIV and XXV.)

The so called brain or supraœsophageal ganglion of a normal-eyed Myriopod is, as in insects, composed of four pairs of ganglia, viz, the antennal or olfactory ganglia, the procerebral ganglia, the optic ganglia, and lastly the commissural ganglia or lobes; the last pair of lobes being by no means of the physiological importance of the others.

Newport has described and figured the brain of the European *Julus terrestris*. In that species the eyes are evidently rather far apart, since the author remarks that the optic ganglion "is of an elongated, oval, and slightly conical form, from which nervous filaments radiate outwards and downwards in a triangular fasciculus to the cornea (*d*)." In the brain of *Spirobolus marginatus*, in which the eyes are rather large and near together, the optic ganglia are rather short, and the nerves to the facets form a conical mass, situated immediately behind the antennal nerve and extending decidedly upwards, as well as outwards, the optic nerves themselves being bulbous or clavate towards the facets. In Newport's figure the optic ganglia are large and about three-quarters as bulky as the procerebral ganglia. Newport's description and figure of the brain of *Polydesmus complanatus* (Plate XXVII) show that in this and probably the entire family Polydesmidæ the optic ganglia, optic nerves, and eyes are entirely atrophied. No observations have yet been made on any species of Lysiopetalidæ with complete eyes, the family to which Pseudotremia belongs, for want of good, fresh material; but it is probable that, as shown by the following description* and figures of *Pseudotremia cavernarum* and *Scoterpes copei*, the central nervous system is in the same place as in the Julidæ.

The brain and rudimentary eyes of Pseudotremia cavernarum.— The figures we present will give a better idea of the relation of parts than any description we can give. By referring to the longitudinal sections* (Pl. XXV, figs. 3 and 4) through the head of Pseudotremia one will perceive the relations of the brain to the rest of the head. Fig. 3 represents a section through the middle of the head, passing through the procerebrum (*pcl.*) and the subœsophageal ganglion and succeeding nervous tract, also the mouth and œsophagus. In Fig. 4 the section passes through one side of the head, involving several facets of the eye, the antennal lobe, and its nerve. In eighty longitudinal sections of the entire head of one specimen and thirty-two of another no traces of the optic nerves were to be seen, the rudimentary eyes being separate from the optic ganglia.

Transverse sections of two heads were made, one hundred and twenty-two of one and one hundred of the other. In none of them were any traces of the optic nerves discovered. Figs. 6 and 7 represent transverse sections of the brain, showing the well-developed olfactory lobes and the commissural lobes, but the sections in front show no traces of the optic lobes.

Of eighty horizontal sections of the head, passing from above downward, Figs. 9 and 10 represent the most instructive sections of the brain. In the section represented by Fig. 9 the eye is cut through and the procerebrum and optic ganglion of the left side shaved; the section also involves the subœsophageal ganglion. Fig. 10 represents a section a little lower down, through four of the facets and the end of the optic ganglion. Neither in this nor the succeeding sections could the optic nerve be perceived, unless a few nerve fibers passing through a small mass of myeloid substance ("puntzsubstantz") at *op. n. ?* be regarded as the remains of an optic nerve. It will be observed that the elongated conical end of the optic ganglion terminates very near the nearest facet, the substance of the ganglion consisting of ganglion cells and very few fibers situated at the apex of the conical mass.

The relation of the optic ganglion to the rudimentary eye and the absence of the optic nerve may be further seen by an inspection of the section succeeding that represented by Fig. 10 (Fig. 11). The optic ganglion ends in a point nearly in contact with the nearest facet, but, as may be seen by Fig. 11*a*, the end of the ganglion consists of a cortical layer of ganglion cells (*gc.*) pressing against the dark hypodermis (*hyp.*), while within is the myeloid substance (*my.*) with scat-

* I am indebted to Prof. H. C. Bumpus for sections of Pseudotremia and Scoterpes, as well as of the Crustacea, described in this paper.

tered cells and some fibers, the latter layer being quite distinguishable from the cellular layer and reaching nearer the eye.*

If there were a mass of optic nerves enlarging in bulk towards the retina of the eye, it seems to me we should, out of several hundred sections, horizontal, transverse, and longitudinal, have detected some traces of it, since it is so large in normal Julidæ. It would seem that if an optic nerve were present that at least one section would have shown the nerve corresponding to that represented by Graber† in his section of the head of *Julus sabulosus*. It is still possible that sections of other specimens may reveal a more or less developed optic nerve sending fibers to each facet.

The eyes are represented by the corneal lenses, the ends of which are buried in the thick, well-developed retinæ. Whether any retinal rods and cells, such as those discovered by Grenacher,‡ exist in the retina I have not attempted to discover. The corneal lens appears to be well developed in the case of each facet present.

Pl. XXIV, figs. 12 and 13 represent sections still lower down, passing through the facets, but below the optic ganglia.

In this connection we may draw attention to the normal development of the olfactory ganglion and the antennal or olfactory nerve arising from it (Pl. XXV, figs. 1 to 3). In Fig. 1 the procerebral lobes (*prc. l.*) and subœsophageal ganglion (*sg.*) are shown. In Fig. 2 the entire left olfactory ganglion is shown originating in lobular masses, and in the section it is of a slightly darker shade than the myeloid substance of the procerebrum. The antennal nerve is well developed. In a nearly horizontal section farther down (Fig. 3) the right olfactory lobe was cut through on one side, where it is separated at this point by a stratum of ganglion cells. The origin of the antennal nerve (*ant. n.*) is also well shown. The section also passed through the thick commissure connecting the supra- and subœsophageal ganglia, and in the section forming a thick ring around the œsophagus.

The brain of Scoterpes.—It is now interesting to turn to the brain of *Scoterpes* (from Mammoth Cave), which has even no traces of eyes, and study the modification to which the brain is subjected as apparently the result of the total atrophy and disappearance of the eyes. The heads of two specimens were each cut into fifty transverse sections. No traces of the optic ganglia, optic nerves, or any part of the eyes, including the pigment of the retina or the corneal lenses, were to be discovered. So far as these sections show, every trace of the organs of vision and the nerves and ganglia supplying them are wanting in this genus. On the other hand, it may be remarked that, so far as we have been able to see, the structure of the procerebral, olfactory, and commissural lobes remain unaltered. As in all the other blind or eyeless forms examined, the supraœsophageal nerve-centers are not affected by the loss of eyes. This is as we might expect, for, the sense of smell being rendered more acute, the olfactory organs are somewhat hypertrophied to compensate for the atrophy of the organs of vision. We should not expect the central portion of the brain, that controlling and co-ordinating the movements of the antennæ and other parts of the body, to be materially modified. Hence, as seen in the sketches we have made of selected sections, the brain is as large in the eyeless Scoterpes, the cortical stratum of ganglion cells as thick, and the myeloid substance of each ganglion as perfectly developed as in the allied forms with completely developed eyes.

Pl. XXV, figs. 4 and 5 represent sections through the brain of one specimen, and Figs. 6 to 10 thinner sections through the brain of the other specimen. In all the sections the optic ganglia were not to be found, and they evidently are atrophied, with no traces of any differentiation from the central procerebral lobes, unless the outer rounded portion of the upper or procerebral lobes be the rudiments of the optic ganglia, which scarcely seems probable.

* The lithographer has scarcely done justice to the author's drawings for Plates XXIV and XXV, having shaded parts left blank, and not having clearly brought out the eyes.

† Ueber das unicorneale Tracheaten- und speciell das Arachnoideen- und Myriopoden-Auge. Von V. Graber. Archiv für mikr. Anat., Bd. XVII, Heft 1, 58, Taf. VI, fig. 20.

‡ Grenacher's Ueber die Augen einiger Myriopoden. Archiv für mikr. Anat., Bd. XVII, Heft 4, 415, Taf. XXI, fig. 11.

In Fig. 6 the microtome knife passed through the front region of the right olfactory lobe, involving the antennal nerve; in the succeeding section the olfactory lobes of both sides are involved, and the left antennal nerve in the five succeeding sections are represented in Figs. 8 and 9.

Fig. 10 is an enlarged view of the section represented by Fig. 8. The cortical layer of ganglion cells supplying the tangled fibers composing the central myeloid substance is well developed; and here it should be observed that, as in Pseudotremia and the Chilopod brains examined, the ganglion cells are very small and numerous, with a distinct central nucleus rather than scattered nucleoli. The fibers from the upper surface of the brain on each side of the median line are seen to form two bundles, passing towards the center of each procerebral lobe. The olfactory lobes are well developed, and on the left side the portions in the section were darker, more clouded, than the myeloid substance elsewhere.

In this section were observed in the median line of the brain seven small areas, which remind one of the so-called central body of the insects. If these bodies, which are perhaps sections of bundles of fibers passing longitudinally through the middle of the brain, should prove to be homologous to the "central body" of insects, it will form an additional point of resemblance between the brains of Myriopods and the winged insects. But they need further examination and comparison with other out-of-door Myriopods.

THE ANATOMY OF THE BRAIN OF ANOPHTHALMUS TELLKAMPFII.

(Pl. XXII, figs. 1–4, 4 *a*–4 *f*.)

In order to understand the modifications in the brain of Anophthalmus due to a life in perpetual darkness we should compare it with the normal brain of another member of the same natural family, in which the eyes and brain are normal. It would be better, of course, if we could have examined that of a Trechus, but this has not been possible. Pl. XXII, fig. 1, represents a dissection of the head, with the eyes and brain, of a Carabid beetle, *Chlænius pensylvanicus*. Seen from above, after removing the integument and surrounding tissues and muscles, the brain of Chlænius is, like the other members of its family and beetles in general, composed of two procerebral lobes (*pcl.*), with the well-developed antennal lobes in front, from which the antennal nerves (*ant.*) take their origin. On each side, between the brain (procerebrum) and eye, is situated the optic ganglion (*op. g*), which in Chlænius is large and well developed, indeed only about a fourth smaller than a procerebral lobe. The eye is large and well developed.

Comparing with Chlænius the brain of Anophthalmus, it will be seen by a glance at Pl. XXII, fig. 2, that there is a total absence of the optic ganglia and eyes. Traces of neither can be detected in gross dissections or numerous horizontal, transverse, and longitudinal sections. It will be seen that the procerebral lobes are well developed, as well as the antennal lobes, an antennal nerve passing into each antenna.

The general relations of the brain (supracœsophageal ganglion) to the subœsophageal ganglion and other parts of the nervous system in the head are in part shown in Pl. XXII, figs. 3 and 3 *a*, which represent a median longitudinal section of the head of Anophthalmus; *pcl.* represents the brain or procerebrum, which is separated from the subœsophageal ganglion (*sœ.*) by the œsophagus (*œ.*). From the lower anterior aspect of the procerebrum passes a nerve to the frontal ganglion (*fg.*), and from it a nerve passes toward the labrum (*lbr.*). On the upper anterior aspect of the subœsophageal ganglion is what may be called the lingual ganglion, from which arises the lingual nerve (*l. n.*), which supplies the lingua (*l.*). From a larger, more laterally and ventrally situated pair of lobes arise a nerve (*mx. n.*) giving origin to the (first and second) maxillary nerves.

The horizontal microscopic sections represented by Figs. 4–4 *c* show that the optic ganglion, as well as the cornea, cones, rods, and retina, are all absent, with not even the rudiments left. Fig. 4 *b* represents the procerebral lobes, with the antennal lobes in front (*ant. l.*), from which arise the antennal nerve (*ant. n.*). Fig. 4 *d* represents the two small lobes at the base of the antennal nerves, which have apparently been hitherto overlooked.

Vertical sections of the brain are seen in Figs. 4 *e*–4 *g*. In these and other sections of this beetle no traces of the so-called "central body," or mushroom body, with its calyces, have been detected. As these bodies are well developed in the brain of the cockroach and locust and probably nearly all adult winged insects, their apparent absence in Anophthalmus is noteworthy. These sections establish, however, the fact of the complete absence of the optic ganglia as well as optic nerve, and show how total is their atrophy.

THE ANATOMY OF THE BRAIN OF ADELOPS.

(Pl. XXIII, figs. 3, 3′, 3″, 3 *a*, 3 *d*).

Transverse and horizontal sections* of the head of *Adelops hirtus*, from Mammoth Cave, reveal no traces of the optic ganglia or the optic nerves. The rudimentary eyes are situated each on a lateral projection of the head (Fig. 3′), and are represented by a circular, convex area equal in diameter to the thickness of the third antennal joint of the same insect. This area is bounded by a well-defined, thickened margin. It contains apparently not more than three minute corneal facets, which are pale, not black. There is no black pigment, but the minute corneal lenses or cones are surrounded within by a pale degenerate pigment mass.

The brain, or procerebral lobes, on the other hand, appear, as shown by Figs. 3 *a*, 3 *b*, to be of normal size and structure.

There are no tactile hairs on or near the site of the eyes, though there are numerous rather long ones extending from the top of the head around nearly to the eyes.

It thus appears that Adelops must be blind, though the eyes exist in a rudimentary state.

There are no optic ganglia or optic nerves.

The number of facets is greatly reduced.

There are only three, or nearly that number, of very rudimentary cones or corneal lenses.

There is no black pigment, the lenses being partly enveloped by a pale rudimentary retina.

THE BRAIN OF THE CAVE CRICKET.

Ceuthophilus maculatus.—In this cricket, which lives above ground under sticks and stones, the brain, as studied by gross dissection, is as usual in insects with well-developed eyes. The procerebrum is of the normal size, but the optic ganglia are small compared with the procerebral lobes, and the optic nerves are rather short and thick, the eyes being nearer together than in Hadenœcus.

Hadenœcus subterraneus.—In this cave cricket the eyes are but little smaller than in Ceuthophilus. The procerebrum is large and well developed, but the optic ganglia are small and of the same relative size as in Ceuthophilus, while the optic nerves are a little longer and slenderer, but no more than one would expect from the smaller eyes and their greater distance apart.

IX.—ORIGIN OF CAVE SPECIES AS AFFORDING FACTS FOR THE THEORY OF EVOLUTION.

The main interest in the foregoing studies on cave life centers in the obvious bearing of the facts upon the theory of descent. The conditions of existence in caverns, subterranean streams, and deep wells are so marked and unlike those which environ the great majority of organisms, that their effects on the animals which have been able to adapt themselves to such conditions at once arrest the attention of the observer. To such facts as are afforded by cave life, as well as parasitism, the philosophic biologist naturally first turns for the basis of his inductions and deductions as to the use and disuse of organs in inducing their atrophy. It is comparatively easy to trace the effects of absence of light on animals belonging to genera, families, or orders in which eyes are normally almost universally present. As we have seen in the foregoing list of non-cavernicolous animals, the eyes are wanting from causes of the same nature as have induced their absence in true cave animals. No animal or series of generations of animals, wholly or in part, lose the organs of vision unless there is a physical appreciable cause for it. While we may never be able to satisfactorily explain the loss of eyes in certain deep-sea animals from our inability to personally penetrate to the abysses of the sea, we can explore caves at all times or

* These sections were made for me by Mr. H. C. Bumpus.

day and night, of winter and summer; we can study the egg-laying habits of the animals, and their embryonic development; we can readily understand how the caves were colonized from the animals living in their vicinity; we can nicely estimate the nature of their food, and its source and amount, as compared with that accessible to out-of-door animals; we can estimate with some approach to exactitude the length of time which has elapsed since the caves were abandoned by the subterranean streams which formed them and became fitted for the abode of animal life. The caves in Southern Europe have been explored by more numerous observers than those of this country, and the European cave fauna is richer than the American, but the conditions of European cave life and the effects of absence of light and the geological age of the cave fauna are a nearly exact parallel with those presented in the foregoing pages. Moreover, the cave life of New Zealand and the forms there living in subterranean passages and in wells show that animal life in that region of the earth has been effected in the same manner. The facts seem to point to the origin of the cave forms from the species now constituting a portion of the present Quaternary fauna; hence they are of very recent origin.

The result of cave exploration shows that no plants, even the lowest fungi, with the exception of *Oozonium auricomum* Link, and perhaps one or two other kinds of fungi common to Europe and America in and out of caves, can so adapt themselves as to live and propagate their species in the total darkness of caverns. They are far more dependent on the influence of light than animals.

We will now briefly rehearse the facts relating to the changes in structure and color undergone by animals adapted to a life in total darkness in caves, premising that, so far as we know, the Protozoa detected in subterranean waters do not essentially differ from those living in the light. It appears from the following facts that eyeless animals change their color as well as those having eyes:

1. A sponge (*Spongilla stygia*) found by Dr. Joseph in the waters of Carniolan grottoes, instead of being green, is pellucid and bleached.

2. The Hydra (*H. pellucida*), also found by Dr. Joseph in the subterranean lakes of Carniola, was, as its name indicates, neither green nor brown, like the two species of the upper world, but pellucid, bleached out, or colorless.

Such was also found by Dr. Joseph to be the case with the smaller Crustaceans, such as certain cave species of Cypris, Leptodera, Estheria, and Branchipus (*B. pellucidus* Jos.).

3. As regards change of color, we do not recall an exception to the general law, that all cave animals are either colorless or nearly white, or, as in the case of Arachnida and insects, much paler than their out-of-door relatives.

The worms (planarians and earth-worms) are somewhat paler than their allies living out of caves, but as the normal environment of most planarians and earth-worms is much like those of cave animals, the difference is not so marked, though both of our cave planarian worms are white and eyeless.

All the cave Crustacea, both aquatic and terrestrial, are colorless or whitish, more or less vitreous, and pellucid, the pigment cells being degenerate and functionless. The effects of total darkness seem quite different from the influence to which the eyeless deep-sea Crustacea are exposed, since they, like their fellows with eyes normal or hypertrophied, are said to be of the same flesh and reddish tints common to deep-sea animals.

In the case of the cavernicolous Myriopods the bleaching of the body is very marked. In out-of-door Myriopods the normal tint of the integument is brown or rarely amber-brown; but the color of the cavernicolous species is white or flesh-white, like a freshly-molted Myriopod of normal habitat.

The cave species of Arachnida are usually pale whitish or pale amber-colored, or pale horn, with a reddish tint. Of the mites, some are white, others horn-color, or chitinous. In the family Chernetidæ the cave species are "dull white," or "pale horn with a reddish tint," or "pale yellowish."

We will now briefly note the effects upon the eyes and optic lobes of a life in total darkness; these are, as more fully stated in the previous chapter:

1. Total atrophy of optic lobes and optic nerves, with or without the persistence in part of the pigment or retina and the crystalline lens (Cæcidotæa, Crangonyx, Chthonius, Adelops, Pseudotremia).

2. Persistence of the optic lobes and optic nerves, but total atrophy of the rods and cones, retina (pigment) and facets (Orconectes).

3. Total atrophy of the optic lobes, optic nerves, and all the optic elements, including rods and cones, retina (pigment) and facets (Anophthalmus, Scoterpes, and ? Anthrobia).

An interesting fact confirmatory of the theory of occasional rapid evolution, as opposed to invariably slow action involved in pure Darwinism, is that we never find any rudiments of the optic lobes or optic nerves; if they are wanting at all, they are totally abolished; there is not a series of individuals with these organs in different degrees of development corresponding to the rudimentary conditions of the eye. The atrophy is comparatively rapid, sudden, and wholesale. On the other hand, we have series, as in Cæcidotæa or Chthonius, where there is but a single or two or three, or several crystalline lenses, partially enveloped in pigment.

These varying degrees of development in the peripheral parts of the eye, prove that the animals entered the caves at different periods and have been exposed for different lengths of time to the loss of light. For example, those individuals of *Chthonius packardii* which live in the Labyrinth of Mammoth Cave are eyeless or have merely pigment spots; those collected in the Rotunda (which is much nearer the entrance to the cave) have eyes, or at least lenses and a retina. While most individuals of Cæcidotæa are eyeless, a few have rudimentary eyes. Thus in the differing conditions of the eyes in different individuals we have an epitome of the developmental history of the genus Cæcidotæa and its species. Certain Aselli borne into caves or introduced into subterranean streams feeding deep, dark wells, losing the stimulus of the light, begin to lose their eyes and the power of sight. The first step is the decrease in the number of facets and corresponding lenses and retinæ; after a few generations—perhaps in four or five—the facets become reduced to only four or five; the eye is then useless; then all at once, perhaps after only two or three generations, as a result of disuse, there is a failure in forming images on the retina, and those complicated, elaborate structures, the optic ganglia and optic nerves, suddenly break down and are absorbed, though the external eye still exists in a rudimentary state. These imperfect lenses and retinæ, like all rudimentary organs throughout the animal world, are like ancient, decayed sign-posts, pointing out some nearly obliterated path now unworn and disused. The result of change of environment, with disuse and atrophy of the organs of vision, together with the inheritance of these defects and their establishment as fixed specific and even generic characters, results in the creation of a new natural genus with its assemblage of species, and, if we include all the cave animals thus produced, the creation of a new fauna. It would be a thorough test of the theory of descent if we could keep these creatures in confinement exposed first to twilight and then to the full light of day, and endeavor to breed a few generations of these blind animals and ascertain whether their descendants would not revert to the original ancestral eyed forms. The Cæcidotæa would perhaps be the best subject for such an experiment; it is so abundant and easy to breed. That the Cæcidotæa has been evolved from some species of Asellus hardly admits of a doubt. Our *Asellus communis* abounds under sticks and stones, submerged boards and logs throughout the Northern and Central States. From thence it could readily be carried, in cavernous regions like those of southern Illinois, Indiana, and Kentucky, into subterranean streams. The supply must be very great, as the individuals of *C. stygia* are very abundant; indeed, so far as we know, as much or even more so than those of *Asellus communis*.

In the blind crayfish of the caverns of Indiana and Kentucky, and of the similar species (*C. hamulatus*) inhabiting the Nickajack Cave of Tennessee, we have two aberrant forms belonging to a widely diffused group, whose center of distribution lies in the Mississippi Valley, and which is rich in species and in individuals. All the streams and ditches situated over or near the caves are densely populated with crayfish. I was interested, after finding *C. pellucidus* in a stream flowing through the Bradford Cave, near New Albany, Indiana, to find the common eyed crayfish of that region in great abundance a few yards from the mouth, outside of the cave, in the shallow brook issuing from the cave itself. That crayfish with eyes can readily enter a cave—probably in time of freshets—is proved by the fact that *Cambarus bartonii* is often found in Mammoth Cave;

where it finds food; and a small specimen has been found by Mr. Putnam a little paler than usual, *i. e.*, as pale as the darker specimens of *C. pellucidus*, but the eyes were normal, though it is doubtful if it lives long enough in the cave to breed there.

The nearest out-of-door ally of *C. pellucidus* is *Cambarus affinis*. On the other hand, the nearest lucicolous ally of *C. hamulatus* is perhaps *C. latimanus*.

It is instructive to find that, in regard to the development of the eyes, and the slenderness, size, and color of the body, these two cave crayfish closely resemble each other, though obviously originating, as Professor Faxon states, from species belonging to quite different sections of the genus Cambarus, and to a different, more southern, river valley. These facts appear to prove beyond question that the cave species of crayfish in the United States have descended from quite different species of Cambarus, belonging to different zoogeographical areas.* Had the two species of blind crayfish been produced instantaneously by special creation, as popularly supposed and advocated in the past by some naturalists, why should the accessory genital organs (gonopoda) differ so much that on this account they belong to different sections of the genus Cambarus?

The cave Phalangidæ, or harvest-men, whose habits and distribution in Europe as well as the United States, both as regards lucicolous and cavernicolous forms, have been given in detail in a previous chapter, illustrate clearly the theory that certain subterranean forms, living deep in the soil, under stones in the cave regions of both hemispheres, especially in France and Austria, have been carried into caves, have survived the loss of out-of-door conditions, becoming adapted to the new and strange environment, losing their eyes totally or in part from disuse of those organs, and have bred true to the new specific characters thus established, and are now as unchangeable as the physical conditions in which they live.

The cave spiders in all important respects exemplify the same rule. They belong to, or are closely allied to, genera rich in species in the cavernous regions they inhabit, and which live in dark places. Although scarcely necessary in its changed environment, where there are no hydrographic changes, no winter and summer, and few enemies to contend with, the most aberrant form, the completely eyeless Anthrobia of Mammoth Cave, still spins a silk cocoon around its eggs; while in Weyer's Cave *Nesticus pallidus* Emerton spins a cocoon for its eggs; and either this species or its fellow troglodyte, *Linyphia incerta* Emerton, or both species, spin a weak, irregular web, consisting of a few threads. Is not this a useless habit, a simple survival of ancestral traits?

It was noticed that the number of individuals of different species was greater in the smaller shallower caves, such as the Weyer and Carter caverns; each of these groups of caves has three species, while in Mammoth Cave there is but one, and the individuals are less common. Moreover, all are darker than Anthrobia, all have eyes, and the number of eyes is variable. These facts show that Anthrobia and the eyed forms have originated from species living in partial darkness at or near the mouths of the caverns. In Mr. Emerton's description of *Linyphia incerta* it will be seen how variable are the number of eyes. From this it may be inferred that the specific character of this form, as regards the eyes at least, have not been firmly established, and hence it has only recently become a true troglodyte.

In the foregoing examples we have as yet not discovered in this country any connecting links between the eyed and blind or eyeless species of cave animals. But in a series of specimens of a cave Myriopod, *Pseudotremia cavernarum*, which is abundant in the Wyandotte and Carter caves, we have what we regard as good, if not complete, evidence that this cave form has directly originated from a common and widely distributed out-of-door form. The cave Pseudotremia has black eyes, composed of from 12 to 15 facets arranged in a triangular area; of one hundred and fifty specimens examined none were found to be eyeless. In a large cave like Wyandotte there is little variation in this species as regards size, proportion, or color (being white with a slight flesh

* Dr. Joseph states that the Carniolan *Cambarus stygius* is very nearly allied to the American *C. pellucidus*. As only a single dry specimen from one cave and remains of the forceps or hand of another specimen have been found in another cave, it seems premature to draw conclusions from such limited facts. The question naturally arises why the genus Cambarus, not hitherto found in Europe, should alone be represented in caves. Its appearance in such a situation and on a continent where there are no other species of Cambarus, the genus Astacus alone living in Europe, has been thought to be a fact adverse to a derivation theory.

tint). But in Bradford Cave, a grotto in Indiana, only 300 to 400 yards deep, where the conditions are naturally more variable, the species likewise varied more in proportion of parts, and in respect to the eyes, which were more rudimentary, while the individuals were whiter.

We have attempted to show that the only known species of the genus Pseudotremia has been derived from the widely diffused *Lysiopetalum lactarium* (Say); it differs in having only about half as many segments as in its out-of-door parent form (this diminution in the number of segments being due to arrest of development); in the smaller, rudimentary eyes, while the antennæ are slenderer and longer. Now, in the Carter caves* we found specimens which prove to us that the cave form is only a modified *L. lactarium.* In those caves *Pseudotremia cavernarum* is only partly bleached, being brownish; the eyes are larger, having from twenty-three to twenty-five facets; and the general appearance of the specimens is such, especially the prominent ridges on the latero-dorsal tubercles, that the specimens might be mistaken for pale, partly bleached *L. lactarium;* yet the variety (*carterensis*) is true to its generic character, having half as many segments as in Lysiopetalum. Why the number of body segments should be so greatly diminished in the cave form is only explicable on the ground that it is due to an arrest of development, or that the cave form has descended from some unknown species of Lysiopetalum, with half the number of segments as *L. lactarium.*

In like manner the Mammoth Cave hairy Myriopod, *Scoterpes copei*, was evidently derived from some species of the hairy genus Trichopetalum. Scoterpes has no trace of eyes, and differs from Trichopetalum in the longer legs and slightly longer and slenderer antennæ. There is no reasonable doubt but that Scoterpes is a bleached Trichopetalum which has lost its eyes, and consequently has longer legs. Some systematists may yet refer it to Trichopetalum, to which it has the same relations as Anophthalmus to Trechus. It should be observed that several Myriopods found in twilight within the mouth of caves, such as species of Polydesmus and Cambala, are more or less bleached, showing the change wrought by a life in partial darkness after a limited number of generations.

The Podurans afford instances of the modification of color especially. Whether living in caves in the Central States or in Utah, the common cosmopolitan *Tomocerus plumbeus* is bleached, retaining its eyes, though they are of diminished size. This is, however, rather a twilight than a true cave species.

The beetles of the genus Anophthalmus and Adelops are the best known examples of cave animals. The Adelops of Mammoth Cave and a few adjoining caves—the only species in this country of the genus—is blind, but possesses rudiments of the outer eye, several corneal lenses surviving. On the other hand, the species of this or the closely allied representative genus Bathyscia, to which they are now referred by Dr. Horn, are very numerous in Europe, and are scavengers in habit. Bedel, in his list of the cave insects of Europe (1875), states that sixty-five species are known, and that several others were known but not described, and that probably further explorations in the region of the Pyrenees, both in France and Spain, will lead to further discovery of species. It appears that not all the species live in caves, but occur in the open air under large stones, moss, vegetable detritus, or at the entrance to caves. It is apparent, then, that the cave animals are emigrants from out of doors, and that the cave species, by isolation from the light and from interbreeding with out-of-door forms, as well as by adaptation to total darkness, have become fixed species with separate generic characters.

Equally instructive and explanatory of the origin of cave animals in general is the genus Anophthalmus. In the caverns of the central United States there are only eight species, and none occur elsewhere in America, though we have two or three species of Trechus, one at least not infrequent, and *Trechus micans* is common to both hemispheres. Not alone loss of sight and eyes, but other modifications of the body, legs, and antennæ, evidently the result of loss of sight, occur, so universal is the modification of the organism. It is evident that southern Europe is the zoogeographical center of this subgenus, for sixty-four species of completely eyeless beetles referred to this genus have already been discovered in the caves of Austria, Italy, France, and Spain. Lately, however, owing to the studies of Putzeys, and especially of De Perrin, the genus Anophthalmus

*Mr. Hubbard has also found this form in Wyandotte Cave.

has been united to Trechus, since there is a series of forms with more or less rudimentary eyes connected with the eyed species of Trechus. Bedel also tells us that in all the species of Trechus there is a natural tendency to penetrate into grottoes, even when ordinarily they live in the open air buried in the earth under stones.

It seems reasonable to conclude that the cave species, which are without optic ganglia, optic nerves, and any traces of eyes had originally, by adaptation to total darkness, become isolated, and that their characteristics after being fixed by heredity have been transmitted for generations, becoming as unchanging in their way as the physical conditions of darkness and uniform temperature surrounding them. Those living in the open air in the soil under stones, or at or just within the entrance to caves, vary most as regards the eyes, as we have found to be the case with the other forms previously mentioned.

This intimate dependence on the physical conditions of life is so plainly shown in these animals, that we can well understand how potent have been the factors (*i. e.*, change from light to total darkness and an even cave temperature) which have operated on out-of-door forms to induce variation. Given great changes in the physical surroundings, inducing loss of eyes from disuse, the abolition in some cases of the optic ganglia and optic nerves, the elongation of the appendages, isolation from out-of-door allies, and the transmission by heredity owing to close in-and-in breeding within the narrow fixed limits of the cave, and are not these collectively *veræ causæ;* do they not fully account for the original variations and their fixation; in short, can we not clearly understand the mode of origin of cave species and genera? What room is there in a case like this or in that of parasitic animals for the operation of natural selection? The latter principle only plays, it has seemed to us, a very subordinate and final part in the set of causes inducing the origin of these forms.

It is to be observed that from a taxonomical point of view the classification of nearly all the typical cave forms is in a state of uncertainty. What we are disposed to regard as distinct genera, such as Orconectes, Cæcidotæa, Pseudotremia, Scoterpes, Anophthalmus, Bathyscia, and others, have in some cases been referred to older-established well-known genera whose species live out of doors under ordinary circumstances. To enter into particulars would lead us into details already given under the head of these groups in the systematic portion of this work. But it is still an open question whether the above-mentioned genera are "good" genera. The tendency among systematists is to reunite the eyeless forms to the eyed genera if specimens with rudimentary eyes are found to connect them. We would draw attention to this point, for it is at present the opinion of a few naturalists that the eyeless genera are on the whole quite as characteristic and distinct as hundreds of genera and subgenera not called in question. The point now insisted on is the instability of the genera and certain of the species in question, and the difficulty felt by naturalists in coming to an agreement as to the exact limits of some of the species and genera peculiar to caves.

ON THE EMPLOYMENT OF CERTAIN GENERIC NAMES FOR BLIND ANIMALS.

The greater the increase of our knowledge of the species and varieties of eyeless genera as compared with their eyed allies, the more marked becomes the tendency of some writers to unite them in the same generic group. There is also the same general tendency to unite species and slightly separated genera the larger become our collections and the more widely extended our knowledge of species and the links connecting them. This tendency may be carried too far, and while we recognize the highly probable fact that certain genera may have been evolved from other, perhaps older and better known, generic forms, as a matter of convenience it is better, we think, to have names for such collections of species. They may be regarded as genera, or, if the stem-genus, so to speak, is a bulky, unwieldy collection of species, we may within due limits regard the more aberrant and easily recognized species as forming one or more subgenera. In the case of blind or eyeless "genera" it is certainly a great convenience to use special names for such groups of species. They are founded on characters which are certainly of more fundamental importance than hundreds and even perhaps thousands of genera which pass current at the present day, and are founded on characters of trivial importance. For example, let us take the old and usually accepted genus Anophthalmus. It was separated from Trechus on account of being eyeless and having slenderer fore tibia, and in general the body and links are slenderer than in the species of Trechus. But, remarks Bedel (in Liste gén. des articulés cavernicoles de l'Europe, p. 32):

Les nombreuses découvertes qu'ont amenéés, depuis quelques années, les explorations des grottes, celles de l'Ariège principalement, ont nécessité la réunion des Anophthalmus et Aphænops aveugles aux Trechus oculés.* C'est à peine si l'on doit les maintenir actuellement à titre de sous-genres, tous les passages existant entre ces types extrêmes qui semblaient tout d'abord si nettement caractérisé.

Bedel obviates the inconvenience of placing between one and two hundred species into one genus by retaining Anophthalmus as a subgenus of Trechus. It seems reasonable, then, so long as most of the species of Anophthalmus are both eyeless and very slender in body and limbs, to retain it under a distinctive name.

In some other coleopterous genera the distinctive characteristic appears to be chiefly the lack of eyes. Thus in Le Conte and Horn's Coleoptera of North America Adranes and Eutyphlus are defined thus: "Eyes wanting."

The eyeless genus of spiders, Anthrobia, is accepted as a distinct genus. Simon remarks: "L'Anthrobia présente presque tous les caractères des Leptoneta, mais elle est complètement aveugle." The completely blind Hadites is said by Simon to be near Agelena, differing "principalement par la proportion de ses pattes et la disposition de ses filières dont les antérieurs sont très longues et formées de deux articles."

For the same reason—*i. e.*, the lack of eyes and the great length of the limbs—the generic term Phalangodes should at least be retained for *P. armatus* of Mammoth Cave.

Coming to the Crustacea, there are the two generic names Cæcidotæa and Orconectes. The former name we applied to the cave and well-inhabiting *C. stygia.* The name is an unfortunate one, having been originally applied to an imperfect specimen without caudal stylets; it bore considerable resemblance to Idotæa, and I did not at first, from lack of specimens of Asellus, compare it with that genus. Cæcasellus would be a much more significant name. This genus has been usually received by American naturalists who have had occasion to refer to it, but Prof. S. A. Forbes, who has done excellent work on the species of this genus, refers *C. stygia* to Asellus. Besides the lack of eyes, the body is much elongated, and the limbs, especially the antennæ, are very long; putting all these features together I think it is a great convenience to designate the *C. stygia* and *C. nickajackensis* as generically different from the eyed species of Asellus, in which the body is much broader and the limbs shorter. Against this view it may be said that some individuals of *Cæcidotæa stygia* have rudimentary eyes. Moreover the genus Cæcidotæa has not been adopted by German and Swiss zoologists in referring to the eyeless *Asellus forelii* Blanc or *Asellus sieboldii* De Rougemont. But in the case of these species the body scarcely differs in shape from the common European *Asellus aquaticus*, the species apparently differing in their want of eyes, smaller size, and white color. Until carcinologists unitedly insist that Cæcidotæa is neither a well-founded genus or subgenus we think it will not be objectionable to retain the use of the term.

The second case is that of the genus Orconectes including what are generally known as *Cambarus pellucidus* and *C. hamulatus.* The generic term was first proposed by Professor Cope for *C. pellucidus*, and the second species, *C. hamulatus*, from Nickajack Cave, was also referred to that genus by him. Objection has been made to the use of the term Orconectes by Dr. Hagen, also by myself in 1873, before two additional blind species had been discovered. In his valuable "Monograph of the North American Astacidæ," published before the genus Orconectes was proposed, Hagen writes: "The most aberrant species [of Group I, type *acutus*] is *C. pellucidus.* Like the other animals living in caves, it is blind. * * * Nevertheless, the number of the hooked legs, the form of the abdominal legs, and the elongated body and hands exclude *C. pellucidus* from the other groups" of the genus. "Some, no doubt, will prefer to regard *C. pellucidus* as a distinct group or genus, still, as I am convinced, without foundation."

In his admirable Revision of the Astacidæ Prof. W. Faxon does not admit the validity of Orconectes, and states that *O. hamulatus* "resembles *C. pellucidus* superficially, but belongs to Group III, with hooks only on the third pair of legs in the male. The first pair of abdominal appendages are very different from those of *C. pellucidus*, being formed after the pattern of those organs in *C. bartonii.* The annulus ventralis of the female is also different" (p. 43).

* Voyez Putzeys, Trechorum oculatorum monographia (Stettin. ent. Zeit., 1870, p. 9); et Abeille de Perrin, Études sur les Coléoptères cavernicoles, 1872, pp. 9–12.

As regards Dr. Joseph's *Cambarus stygius*, based on an imperfect specimen from a cave in Carniola, it appears that it is still uncertain, from a strictly systematic point of view, whether it is a genuine Cambarus or Astacus, as Dr. Joseph does not say whether it comforms to the genus Cambarus in the number and arrangement of the gills or not. Joseph states that the hooks spring from the second segment of the leg, but Professor Faxon thinks this is an error, since in Cambarus these processes are always found on the third segment. Joseph apparently refers it to the genus Cambarus from its close resemblance to *C. pellucidus*, especially in the shape of the body and the form of the non-facetted eyes. So good an observer as Joseph would scarcely have made a mistake as to the position of the hooks, and this, at any rate, can scarcely be a character of importance. Systematists may carry trivial characteristics too far, and we do not see why the profound modification of the eye, involving the absence of corneal facets, of rods and cones, and of a genuine pigment, as well as the greater slenderness of the body and limbs, are not sufficient characters to isolate these three blind species under the name Orconectes, especially since there are no series of half or partially blind forms connecting the blind and normal species. On the other hand, no one doubts but that the American species of Orconectes has been derived from Cambarus, though the facts have not yet been discovered to show that the Carniolan species may not have been derived from the European Astacus.*

Finally, as regards all the eyeless genera in question, I do not see how we can in our system put nature into a straight-jacket, and regard as simply of specific value the loss of eyes, sometimes involving the total abolition of optic nerves and optic ganglia. It is a convenience not to lump such forms with a mass of other species, where they will lose their individuality, but rather to emphasize them by giving them distinct generic or at least subgeneric names.

COMPENSATION FOR THE LOSS OF EYES OR EYE-SIGHT.

As has been observed by some who have written upon cave animals, the atrophy of the eyes and consequent loss of vision have been made up, in part at least, by a corresponding hypertrophy of the organs of touch and smell.

The more apparent anatomical modifications of the Arthropods consist in the greater slenderness of the body and the increased length and tenuity of the antennæ and limbs.

In the planarian worms, however, there seems to be no other change than the loss of eyes and a general albinism or degeneration of the pigment cells.

Compensation by increase in the sense of touch.—It is in the Arthropods, whether Crustacea, Arachnida, or insects, that we see the most marked change in the form of the body and its appendages. When we compare the American species of Cæcidotæa with Asellus the body is seen to be much attenuated, and the antennæ much longer and slenderer, as well as the legs. The genus Crangonyx, according to Bate and Westwood, is nearest allied to a marine genus, Gammarella, but the European species (*C. subterraneus*) have shorter antennæ than the two species of Gammarella figured in the "British Sessile-eyed Crustacea." On the other hand, the antennæ of *C. antennatus* of Nickajack Cave are longer than in any American or European species known to us.

In the eyeless species of Niphargus the body is much slenderer than in the species of Gammarus, and though the antennæ are no longer, the last pair of uropoda are remarkably long and slender.

In the two species of blind crayfish the body is longer and slenderer than the normal Cambari; the legs are slenderer, particularly the hands, while the antennæ are not longer in proportion to the body than some species of Cambarus. Eyeless Myriopods, especially Pseudotremia and Scoterpes, have longer antennæ than in epigean species.

Coming to the blind Arachnida, the bodies of the blind Chernetidæ tend to become much longer, slenderer, and the cheliceres, as well as legs, much longer than is normal. This great length of the legs, which may be regarded as tactile organs, enabling them to be used for sounding objects, is most marked in *Phalangodes armata* when compared with the Coloradan *P. robusta*.

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* It may be observed that in his "Études" on Phyllopodes, in referring to Joseph's eyeless cave *Branchipus pellucidus*, M. Eug. Simon remarks: "Espèce aveugle qui deviendra sans doute le type d'un genre spécial."

The cave spiders appear to differ only in the lack of eyes from their congeners out of doors, their legs being scarcely longer than in the eyed species. In what anatomical respects nature has compensated Anthrobia for the loss of eyes is not very apparent.

It is in the blind cave insects that the tactile sense is evidently hypertrophied. In Rhaphidophora the antennæ, palpi, and legs are very long and slender, even compared with out-of-door wingless Locustarians, which have remarkably long antennæ and hind legs.

Still more clearly are the effects of a life in total darkness, resulting in the atrophy of the eyes and hypertrophy of the appendages accompanied by a slenderness of the trunk, seen in the species of Anophthalmus, as a glance at any of our native species, when compared with our native species of Trechus, will at once show. The same applies, though in a less marked degree, to Adelops and Bathyscia.

We will now review the facts known bearing upon the physiology of the tactile organs, involving the effects of sudden light, noises, and contact with these stygian forms, and it will be seen how remarkable has been the compensation for the loss of eye-sight. As the most detailed and striking results, and showing how completely nature has compensated these apparently hapless forms for their loss of eye-sight, and how remarkable is the degree of adaptation to so great a change of environment, we will cite the observations of Piochard de la Brulerie.* This author maintains that the sense of touch compensates for the loss of eyes. In all blind Coleoptera, he says, there is a tendency in their appendages to elongate, except in Claviger, which, living in the society of ants, are cared for and fed by them. The hairs on the antennæ and feet of blind insects are longer than in eyed insects. The long, stiff hairs of Anophthalmus are more developed than in any eyed Carabid.† This elongation is in direct relation to the loss of eyes, compensating for the latter defect, and they are rarely, if ever, present in epigean ground beetles.

This author also claims that the habits of the species of Trechus and Catops, which have well-developed eyes, are such as to indicate that Anophthalmus and Adelops have respectively been derived from them. The former habitually live in the open air, always seek obscure passages, and even like to penetrate into caverns, where they at times reproduce, and where their successive generations thus confined have lost by disuse organs become useless, at the same time that they acquire in those organs which survive the perfection rendered necessary by the disappearance of the organs of vision.

He then adds that the number of species of Anophthalmus and Adelops is greater than that of Trechus and Catops, and that the species are at the same time more localized. These facts are due to a double cause: "The differences in the conditions of life are more accentuated for the population of different caverns than for that of different points of the surface of the soil, and they are more absolutely isolated in these small hypogean worlds."

De la Brulerie then asks whether insects deprived of eyes are capable of being impressed by light. He first draws attention to Dr. G. Pouchet's essay in the Revue et Magasin de Zoologie treating of the action of light on eyeless dipterous larvæ, wherein he proves that they are affected by the luminous rays, though their movements are very simple compared with the complicated movements of Anophthalmus or Adelops in seeking their food or in escaping danger.

> Indeed, though deprived of eyes, these beings act exactly as if they saw clearly; as if they not only felt the impressions of the luminous rays which struck them, but appreciated the form of objects, both of those at a distance and of those that they touch. Nothing in their behavior suggests that they are blind. We see them walk, run, stop, explore the ground, seek their food, run from the fingers of the insect hunter who tries to seize them absolutely with the same facility as insects provided with eyes (p. 469).

When in a cave, the light of a candle surprises a blind Anophthalmus or a Pristonychus which has eyes. Both act in the same manner.

Light on the subject of adaptation to cave life is thrown by the recent studies of Graber, and especially those of Prof. Félix Plateau. The habits and environments of the family Polydesmidæ, which are all blind, and of Geophilus and other blind Chilopod Myriopods, show that the loss of eyes does not signify so much as would be the case with the eyed forms, which need or are capable of withstanding more light and less moisture. Graber, on depriving a cockroach (*Blatta*

* Annales de la Société Entomologique de France, 1872.

† These hairs are very well represented in some of the figures on Plates XVIII and XX.

germanica) of its eyes, observed that it could still perceive light. Plateau and E. Van Beneden have also made observations on *Niphargus puteanus*, whose incompletely developed eyes are wanting in pigment. Plateau's experiments were made on species of Geophilus and Cryptops found living under heaps of refuse. He appears to have proved—

1. That they perceived daylight and could choose between this light and darkness.

2. Both in Chilopoda with eyes and in Chilopods without them quite a long time is needed before these animals can perceive that they have passed from a relative or complete obscurity to daylight.

3. The length of this latent period is not greater in blind Myriopods than in those with eyes.

4. When either blind or eyed Myriopods placed on the ground run quickly into the first opening they find, this act is not simply to escape light; these animals also seek for a humid medium with which the greater part of the surface of their bodies may be in direct contact.

These experiments and conclusions are of great interest in connection with cave Arthropods, since it appears to show that total darkness with humidity are perhaps not so adverse to invertebrate life as would at first sight seem, and that perhaps the limited source of the food supply is an equally important factor in cave life. The loss of eye-sight, however, would seem to be amply made up to these beings by the senses of smell and touch.

Deprived of their eyes, cave animals in general are much more wary and guarded in their actions than their allies which enjoy good eye-sight. This point is well illustrated by Prof. F. W. Putnam's observations on the habits of the blind crayfish (*C. pellucidus*) from Mammoth Cave.* When food was offered to *C. bartonii* and to *C. pellucidus*, the difference in the action of the two species was striking, as showing the timidity and exceeding caution of the blind form. The *C. bartonii* seized the piece of meat or bread and hastily ate it, without showing any fear of its keeper. "The blind species, on the contrary, darts backward as soon as the food is dropped into the water and then extends its antennæ and stands as if on the alert for danger. After a long while, sometimes from fifteen to thirty minutes, it will cautiously crawl about the jar with its antennæ extended as if using them for the purpose of detecting danger ahead. On approaching the piece of meat, and *before touching it*, the animal gives a powerful backward jump and remains quiet for awhile. It then cautiously approaches again, and sometimes will go through this performance three or four times before it concludes to touch the article, and when it does touch it, the result is another backward jump. After another quiet time it again approaches, perhaps only to jump back once more, but when it finally concludes that it is safe to continue in the vicinity of the meat, it feels with its antennæ for awhile and then takes the morsel in its claws and conveys it to its mouth."

Regarding the sensibility to light of the blind Crustacea, the following notes are of interest: Mr. Putnam kept a *Cambarus pellucidus* from Mammoth Cave about ten months "exposed to the full light of day." He also states that "extremes of temperature do not affect these crawfish from the cave, as my several specimens have been a number of times retained for days in a heated room, and again have been exposed for weeks to such intense cold as to freeze the water in their jars." Crayfish possess unusual vitality, as is proved by the great number of species and individuals of the epigean members of the family; but the smaller blind Crustacea show great sensibility to light. Bate and Westwood state that *Niphargus puteanus* "perish in the light."

Compensation by increased olfactory powers.—It seems probable that the sense of smell is keener in animals which have lost their eye-sight. It is well known that the dog is more dependent on his remarkably keen scent than on his eyes in tracking game and the footsteps of his master,† while in insects the olfactory sense is exalted.

The first author, so far as we have been able to ascertain, to describe and figure the olfactory rods of the blind Amphipods and Isopods, and to show that they have a greater development than in the species with normal vision, was De Rougemont, in 1876. He agrees with Leydig, that the rods in question are olfactory; and, as will be seen by the following extract, he claims that

* Proc. Bost. Soc. Nat. Hist., xviii, 16.

† Ainsi le chien de chasse trouve la piste d'un lièvre au moyen de l'odorat, et suivant cette piste il arrive immanquablement au gîte du lièvre; si celui-ci part avant que le chien l'ait saisi, le chien le voyant le poursuivra non plus au moyen de l'odorat, mais au moyen de la vue (De Rougemont, Étude, etc., 13).

the blind forms have the longer olfactory rods, and that they are developed so as to compensate for the loss of vision.

Si nous comparons entre elles les baguettes de nos Amphipodes d'eau douce, c'est-à-dire celles des *Gammarus pulex*, *fluviatilis* et *puteanus* et celles de l'*Asellus aquaticus* et de la forme provenant des puits, nous verrons que ces baguettes n'atteignent pas chez toutes ces espèces le même développement; celles des *Gammarus pulex* et *fluviatilis* et celles de l'*Asellus aquaticus* sont courtes, atteignant à peine le tiers de la longueur de l'article suivant, tandis que les baguettes du *Gammarus puteanus* et de l'Asellus des puits égalent en longueur et même dépassent l'article suivant. (Je me sers ici de l'article suivant comme mesure comparative, vu que tous les articles des tigelles de ces espèces sont à peu près égaux entre eux et que les baguettes, fixées à l'angle des articles, sont dirigées parallèlement à l'article qui suit.)

Nous remarquerons ensuite que les baguettes courtes appartiennent aux espèces pourvues d'organes visuels et que les baguettes longues, que nous considérerons comme très développées, appartiennent aux deux espèces habitant les eaux souterraines et qui sont aveugles.

Comparant d'une manière générale l'importance du sens visuel et olfactif dans l'économie animale, nous verrons que l'un et l'autre sont d'une nécessité égale, ou que si l'un est atrophié, l'autre par contre s'est développé, s'est perfectionné de manière à pouvoir remplacer l'organe défectueux (*l. c.*, p. 12).

Afterwards Leydig, and also Fries, confirmed this view, and the former remarks in his Untersuchungen, etc., 1883:

In two Crustacea of our native dark fauna it has been for some time possible to indicate such a change in relations.* The olfactory rods on the larger flagellum of the upper antennæ in the eyeless *Gammarus puteanus* are more developed than in species provided with eyes. Short, and scarcely reaching in *Gammarus pulex* and *Gammarus fluviatilis* a third of the length of one flabellar-joint, they are in *Gammarus puteanus* nearly of the length of the succeeding flabellar joint. On the smaller antennæ of the blind *Asellus cavaticus* the olfactory rods are likewise much more developed than in *Asellus aquaticus* provided with eyes.

The olfactory rods in the species of Orconectes are longer, according to Faxon, than in normal Cambari and Astaci. Leydig, who was the first to examine these organs, claimed that the olfactory rods in these Crustacea were more numerously developed than in the normally eyed forms, and that this was a compensation for the loss of sight. Leydig counted on the outer flagellum of the first pair of antennæ thirty-six joints. Of the olfactory rods—for they are rod-like rather than like teeth (*Riechzapfen*, as Leydig calls them)—all occur on the distal end of the flagellum; two occur on the anterior end of the fifteenth joint, while on the succeeding joint there is a third one. On the distal ends of most of the succeeding joints there are four rods and in the middle three, or seven in all, but towards the end of the flagellum the number of rods again diminishes to two and finally to one rod, their greatest development being in the second third of the flagellum.

A single olfactory rod which Leydig figures (Taf. III, fig. 27) consists of a thick-walled stalk and a more delicate terminal tube, which is thicker than the stalk. The rod is perforate at the thickened end by a narrow opening which connects with the hollow interior. The substance of the interior of the stalk appears to contain coarse granules, that of the terminal part fine ones. Although Leydig does not say so, it is evident, in the light of the more recent studies of Hauser and Kraepelin, that this hollow olfactory rod, perforate at the end, is fundamentally homologous with the olfactory teeth of insects. Our own observations on the rods of *Orconectes hamulatus* confirm the accuracy of Leydig's description of those of *O. pellucidus* (see Pl. XXII, figs. 6, 6*a*, 6*b*, 6*c*).

Prof. R. Ramsay Wright (Amer. Naturalist, xviii, 272) examined these rods in *Cambarus propinquus*; finding the external branch of the first antenna composed of eighteen or nineteen joints. The distal nine of these alone bear olfactory cones, and only five of them (the eleventh, twelfth, thirteenth, fourteenth, and fifteenth) have the full number of eight on each joint; hence he concludes with Leydig that the olfactory rods "are present to a much greater number than in allied forms possessed of sight."

There however seems a greater variation than suspected in the number of joints to the outer flagellum, and it is the greater length of the rods in the blind species which indicates greater olfactory powers. In his "Revision," etc., Professor Faxon makes the following statement:

I have examined several specimens of *C. propinquus* with reference to this point, and find that the number of segments in the external flagellum of the antennule may be as high as thirty-five, fifteen or sixteen of which may

* As regards the latest statements, we might quote Leydig, Ueber Amphipoden und Isopoden. Zeits. f. wiss. Zool., xxx, Suppl., 1878. S. Fries, Mittheilungen aus dem Gebiete der Dunkelfauna. Zool. Anzeiger, 1879. Fries states: On the short upper antennæ of *Asellus cavaticus* not only do the number of joints vary, but also that of the olfactory rods. Sometimes only the two penultimate joints, sometimes three or four joints, are provided with these rods; in one instance I counted six such rods. Rougemont records five to seven long olfactory rods. The rods themselves are in *A. cavaticus* very considerably longer than those of *A. aquaticus*.

carry olfactory organs. In *C. affinis* I have counted as many as thirty-three segments in the flagellum, nineteen with olfactory setæ. A moderate-sized *C. blandingii* from New Jersey reveals about fifty segments, twenty-nine of them provided with olfactory setæ. It thus appears that Professor Wright's conclusion, that the number of antennulary segments and olfactory organs is increased in the blind species, is not supported by the facts. It is noteworthy, however, that the olfactory setæ of *C. pellucidus* are longer than in most species of Cambarus. In a specimen of *C. hamulatus*, the other blind cave species, there are thirty segments in the outer flagellum of the antennule, and the olfactory setæ are long, as in *C. pellucidus*.

The blind fish of Mammoth Cave (*Amblyopsis spelæus*), as is well known, is provided with tactile papillæ arranged in ridges on the sides and front of the head, as originally described by Tellkampf and by Wyman, and more fully by Leydig, who has, with other details, given a good figure of the head of this fish. Tellkampf regarded these papillæ "as without doubt increasing the tactile sense," and Prof. R. R. Wright suggests that "the want of sight in the blind-fish is compensated for by the development of the tactile ridges."* The extreme timidity and caution of the fish have been observed by Tellkampf and by Dr. Sloan.

Similar ridges, with a like arrangement, are described by Prof. F. W. Putnam and figured by him as existing on the head of *Typhlichthys subterraneus* Girard; so that the two genera are alike in this respect.†

What little is known of the habits of the blind-fish is embraced in the following extracts from Tellkampf‡ and in the subjoined letter from Dr. Sloan:

The blind-fish is found solitary and is very difficult to be caught, since it requires the greatest caution to bring the net beneath them without driving them away. At the slighest motion of the water they dart off a short distance and usually stop. Then is the time to follow them rapidly with a net and lift them out of the water. They are mostly found near stones or rocks which lie upon the bottom, but seldom near the surface of the water (p. 86).

Again, on page 92, he writes:

During my stay at Mammoth Cave I observed that the Amblyopsis, the black-fish [which we suppose to be the Chologaster], and the crawfish remained motionless while I moved a burning lamp around them, but that they were disturbed by a slight motion of the water, proving that the light made no impression upon their optic nerves, while their sense of touch was acute.

The following letter, from Dr. John Sloan, dated New Albany, Indiana, February 11, 1883, gives an excellent account of the habits and sensibility to light and sound of the *Amblyopsis spelæus*:

From 1866 to 1875 I made many explorations of caves in southern Indiana, and frequently had considerable numbers in my aquarium of the larger blind-fish (*Amblyopsis spelæus*). If you will look at the Report of the Geological Survey of Indiana you will see a notice of Lost River, a considerable stream, which disappears from the channel at several points 2 miles from Orleans, Orange county, and pursues its course underground for more than 7 miles. There are numerous sink-holes and no surface streams in that neighborhood.

There are no wells which furnish water in that country except those that strike some stream or body of water beneath this stratum, and blind-fish are frequently drawn up in the buckets.

There is a cave 4 miles west of Orleans, which extends to this subterranean channel of Lost River, in which the Amblyopsis are quite abundant. Soon after the publication of Professor Cope's article on the blind-fish of Wyandotte Cave I visited it with several of my friends for the purpose of testing their sensibility to light and sound. In a pool 10 by 15 feet, varying from a few inches on three sides to 4 feet on the other, there were large numbers of them. I tested their hearing by hallooing, clapping my hands, and striking my tin bucket when they were in easy reach and near the surface. In no instance did they change their course or notice the sound. We carried our lighted candles within a few inches of them when near the surface, but they seemed wholly insensible to their existence; but if a drop of tallow fell in the water near them they would swim rapidly away. I brought home twelve, as many as could live in my bucket. Of these twelve caught in September none died until next June, when the water became warmed to near 70°, when several of them died with *tetanic convulsions* (?). I put the remainder in my cellar, where the temperature ranged from 45° to 60°, where one, "Blind Tom," lived eleven months, making twenty months of existence without having taken any visible food. While in my aquarium they manifested total indifference to light and sound. Some of them would strike eagerly at any small body thrown in the water near them, rarely missed it, and in a very short time ejected it from their mouths with considerable force. I tried to feed them often with bits of meat and fish worms, but they retained nothing. On one occasion I missed a small one and found his tail projecting from the mouth of a larger one; I captured and released him. They manifest great sensibility on the back and sides to any approaching body, but do not notice an attack from below. It is not possible to capture one by a side sweep of a net, but by passing it under him a considerable distance below and bringing it up slowly there is no difficulty in taking them.

* American Naturalist, xviii, 272, 1884.

† American Naturalist, February, 1872.

‡ New York Journal of Medicine, July, 1845.

In their native pools and in the aquarium when disturbed they do not strike the bottom or sides of their surroundings, but seem to have a sense of resistance (if the term is pardonable) which protects them. I can only regret that I have not examined those recently caught to ascertain the nature of their food. I never observed any excrement voided by them.

Though the ears of Amblyopsis are said by Wyman to be "largely developed" and the otolite of the vestibule "quite large when compared with that of a Leuciscus of about the same dimensions as the blind-fish," yet according to Dr. Sloan's statement this fish is not sensitive to sounds. As he is a good observer, and has kept these fish in a large, spacious tank for twenty months, where I have seen them, his observations must be relied upon. Dr. Wyman, however, remarks: "It is said that the blind-fishes are acutely sensitive to sounds as well as to undulations produced by other causes in the water."* It is evident that further experiments on living blind fishes as well as more extended anatomical investigations are needed to settle the question whether the fish are generally sensitive to sound. It may be said in this connection that so far as is known most of the cave Arthropods, at least the insects, are not provided with organs of hearing, the olfactory being the prominent sense in eyeless insects. On examining the auditory sacs of *Orconectes hamulatus* and comparing them with those of an undetermined species of Cambarus with normal eyes, they are about one-third smaller, while the auditory setæ are remarkably small, being only one-third as long as in the Cambarus with normal eyes, while the hairs are only about as long as the seta is thick; whereas in the normally eyed Cambarus the hairs are very long, being from six to eight times as long as the seta is thick. Hence we infer that the ear of Orconectes is degenerate and the sense of hearing nearly if not quite obsolete. The ear of *O. pellucidus*, from a cave in Indiana, is also much reduced in size, being about as large as that of *O. hamulatus*.† (Compare Pl. XXI, figs. 4, 5, and 6.)

In the mole,‡ which has minute eyes, the sense of hearing, and probably of touch, compensates for the loss of eye-sight, which is of no advantage to it in its subterranean life.

In the Spalax of eastern Europe and western Asia, a mammal not a troglodyte, but living a subterranean life like a mole, we have, according to Dr. Duchamp, an interesting case of compensation for the loss of vision. The eyes are so atrophied, being covered by the skin, that this rodent is said to be practically blind, but as a compensation the sense of touch residing in the hairs situated about the mouth is exalted, while the auditory passage and internal ear are normally developed, though the outer ear is wanting.§

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* If these Amblyopses be not alarmed, they come to the surface to feed and swim in full sight, like white aquatic ghosts. They are then easily taken by the hand or net if perfect silence is preserved, for they are unconscious of the presence of an enemy except through the medium of hearing. This sense is, however, evidently very acute, for at any noise they turn suddenly downward and hide beneath stones, etc., on the bottom (Cope, Amer. Naturalist, vi, July 18, 1872).

† In a Cambarus 50^{mm} long from the tip of the rostrum to the end of the telson, with normal eyes, the basal joint of the first antennæ is 4.5^{mm}, while the length of the ear capsule is 2^{mm}; in *O. hamulatus*, 45^{mm} in length, the basal joint is 2.8^{mm} in length, and the length of the ear capsule is 1.4^{mm} long; in an *O. pellucidus* from Indiana 40^{mm} long the basal joint is 2.2^{mm} long and the auditory sac about 1.5^{mm} in length. It thus appears that the basal joints or scape of the first antennæ, as well as the ears, are much smaller in proportion in Orconectes than in the Cambarus with normal eyes.

‡ Savi has described "une variété complètement aveugle," Duchamp, *l. c.* "The eyes of moles and of some burrowing rodents are rudimentary in size, and in some cases are quite covered up by skin and fur. This state of the eyes is probably due to gradual reduction from disuse, but aided perhaps by natural selection. In South America a burrowing rodent, the tuco-tuco or ctenomys, is even more subterranean in its habits than the mole; and I was assured by a Spaniard who had often caught them that they were frequently blind; one which I kept alive was certainly in this condition, the cause, as appeared on dissection, having been inflammation of the nictitating membrane. As frequent inflammation of the eyes must be injurious to any animal, and as eyes are certainly not necessary to animals having subterranean habits, a reduction in their size, with the adhesion of the eyelids and growth of fur over them, might in such case be an advantage; and, if so, natural selection would constantly aid the effects of disuse" (Darwin's Origin of Species). Also compare foot-note on p. — .

§ Mais si l'œil du Spalax, caché sous la peau, est incapable de remplir ses fonctions, deux autres sens, l'ouïe et le tact, largement développés, viennent suppléer à l'absence du premier, disposition d'autant plus intéressante qu'elle est constante chez toutes les espèces de la faune souterraine.

Tous ces poils raides qui hérissent les bourrelets céphaliques et la région circumbuccale, probablement aussi ceux que l'on rencontre à la périphérie des pattes antérieures, sont autant d'organes tactiles qui, multipliant les sensations, ne permettent à aucun corps de passer inaperçu.

L'œil demeurant sans exercice s'est atrophié, le pavillon auriculaire qui gênait l'animal dans l'intérieur de ses

The following observations are taken from Dr. Joseph's rather rare paper, and are introduced here because they contain novel observations and bear more or less directly on the topic now under discussion.

Remarks by Dr. Joseph (Erfahrungen, etc., 1882) on the coincidence of partial darkness (1) *with the change of position (Lageveränderung)*; (2) *decrease in size, arrest of development with increase in number;* (3) *decrease in size without increase in number;* (4) *loss and compensation for the loss of organs of sight.*

(1) The at least considerable result in the effects produced by a partial want of light, such as is peculiar in certain rooms in caves, in which the darkness is not total at noon when the sun is highest, but for several hours of the day, mostly in summer (from 11 to 2 o'clock), is that there prevails a kind of twilight, which causes a change of position of the eyes. The twilight enters not from above but from the side into the chamber, while the roof is concealed by continual night-like darkness and radiates not the least light. In adaptation to this circumstance the eyes in *Cyphophthalmus duricorius* are not, as in its allies (*Phalangium, Opilio, Troglus*), placed in the middle of the upper side of the cephalothorax, but on the ends of projections on the side of the cephalothorax. The creature therefore has acquired the faculty of seeing sidewise and of moving as readily sidewise as backward. The flattened form of many Chernetidæ which live under the bark of trees, whose eyes are also situated on the side of the cephalothorax, show that similar results of adaptation occur outside of caves. Similar corrective aims seem to underlie the tendency in the eyes of Cyphophthalmus to project from the level of the sides of the body.

(2) The diminution in the size of the eyes in a great number of cave animals (*Hypochthon*), the fish of Mammoth Cave, and a considerable number of Arthropods (beetles, flies, Orthoptera, Arachnids, Isopods, and Myriopods) forms an opposition to the correction of changed light relations.

The correction for the partial want of light seems here to be abandoned. Another remedial principle of adaptation has prevailed. The eyes have only reached the grade of completion which is sufficient for orientation in the twilight.

The very great enlargement of the eyes in several deep-sea fishes, corresponding to the want of light, does not occur in cave animals. It is scarcely significant in the species of the genus Sphodrus living in the outermost chambers of caves. But, on the other hand, the diminution in extent of the circumference of the eyes by arrest of development is demonstrated, and is accompanied by the reduction of light-collecting refraction, conductive and sensitive properties. The small eyes of the cave triton, overgrown with the transparent skin, are provided only with a deficient musculature insufficient for adequate movements. The chorion contains only a small pigment layer, and the outermost thin layer of retinal rods corresponds with the sparse fibers of the feebly developed optic nerve; features which characterize the reduced eyes of the mole and blind mouse. In an analogous way the reduced eyes of several genera of beetles (*Trechus, Bythinus*, etc.) living in twilight seemed to undergo an arrest of development, since only from 50 to 80 corneous facets, crystalline lenses, and rods are associated together, while these organs in allied genera living in the upper world may be counted by hundreds and thousands in a single eye. The reduction is carried still further in certain spiders (*Nictyhyphantes mycrophthalmus*) and certain species of Myriopods and Asellids, whose eyes retrograde to simple diminutive, spider-like eyes, while their open-air allies are endowed with compound eyes.

Before this reduction reaches a complete absence, there seems in certain spiders and Podurids a sort of rise in number to serve as a correction to the partial want of light. The diminution and arrest of the eyes by this retarding influence becomes compensated by a multiplication of the same organs. Troglohyphantes shows sixteen, and several micro-orthoptera have a greater number of small eyes only perceptible in a very strong light. The Podurid *Anuroptorus stillicidii* described by Schiödte possesses twenty-four scarcely visible eyes.

(3) By constant residence in perpetually dark chambers the influence of disuse at work destroying the development of organs of sight completely prevails, and the possibility of sight has wholly disappeared.

The blind cave fauna is associated with the subterranean and deep-sea fauna, consisting of a considerable number of genera and species. The author refers to an earlier publication in Heft 228 of the Virchow-Holzendorf collection of popular scientific tracts, wherein he remarks:

(1) The discovery of extinct Arthropods inclosed in copal, amber, and the Solenhofen slates proves that in the earlier geological epochs a very considerable number of blind genera and species have inhabited more numerous and varied localities than in the present period of the earth's history.*

(2) Blind species could only maintain themselves where, as in the perpetual night of caves, the issue of the struggle for existence neither was nor is based on the possession of organs of sight.

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galeries a disparu; mais le conduit auditif persiste largement ouvert et l'oreille interne, organe essentiel de l'audition, est normalement constituée.

Si l'on observe le Spalax vivant, on reconnaît effectivement qu'il perçoit les sons avec la plus grande facilité. Pour le surprendre hors de son terrier, il faut s'en approcher avec une extrême prudence: on le trouve alors assis à l'entrée d'un de ses couloirs, la tête droite, écoutant attentivement de tous côtés; au moindre bruit il relève plus encore la tête, puis disparaît immédiatement sous le sol (Duchamp, pp. 38, 39).

* This may be an overstatement, since on mentioning Joseph's remark to Dr. Hagen, who in past years has paid so much attention to insects occurring in amber and copal, he writes me he knows of no eyeless amber or copal insects, except that "the very rare soldiers and workers of Termites in amber are blind."

(3) The cases of loss of the power of sight are either to be regarded as arrests of development during larval life, or as the consequence of a gradual reduction (up to extinction) through disuse.

While a great number of cases of the first category may be enumerated, the shrimp (*Troglocaris schmidtii*), living in subterranean waters, and the large *Cambarus stygius* afford striking examples of the loss of the power of sight by retrograde development. Both of these large species of Crustacea have eye-stalks (*Augäpfel*) of the same shape as in their allies of the upper world, but without a trace of the refractive medium or of nervous elements. They are therefore completely blind. The appearance of a sense organ in the usual external form without the internal contents, without endowment with the faculty of exercising the sense, would be absurd if we did not take into account the fact that the ancestors of these animals were provided with normally constructed eyes. This view is confirmed by Dr. Joseph's discovery that *the embryo of Troglocaris schmidtii is provided in the egg with eyes.** The present developmental history of each individual of this remarkable animal repeats briefly, and with evident truth, the history of the species in the distant past.

Of another Crustacean, also blind—*i. e.*, *Niphargus stygius*—Joseph found in the pools of water in the outer partially dark rooms of several caves some individuals with distinct corneous facets, crystalline lenses, optical rods, and nervous elements, but existing in small numbers and provided with a slightly developed pigment layer, while in other individuals the eyes seemed reduced to the condition of simple ocelli, like those of spiders. From all the cases which loss of the power of sight proves, there are those of the oldest date which show them losing, besides the former, every trace of eyes, also every indication of the same in embryonic life; and, on the other hand, specimens occur which, although in want of a definite power of sight, still in embryo possess the germs of organs of sight, and possess in a definite condition the external shape of such organs.

(4) As the last effort to compensate for the loss of sight there is the unusual development of tactile organs. In a species of Coleoptera, *Anophthalmus capillatus*, also in an Arachnid (*Siro cyphopselaphus*) allied to *Cyphophthalmus duricorius*, both of which occur in a Croatian cave, there is, in the place on the head where usually in the out-of-door genus Trechus and in *Cyphophthalmus duricorius* the eyes are placed, a slender small tubercle provided with a fine tactile hair. To the peculiarly formed interior of the tubercle there passes a fine nerve sent off from the subœsophageal ganglion. In place of this tactile hair the species of other blind beetles (Amaurops) possess a thick tactile bristle, or a delicate tactile rod, which rises from a tubercle with a rough nodular surface. A species of the Podurid genus Anurophorus, discovered by Dr. Joseph, also possesses in place of eyes tactile hairs.

For the tactile hairs of our American species of Anophthalmus and their position, the reader is referred to the figures on Plates XVIII and XX. Those of *Anophthalmus tellkampfii* were omitted by the artist. De la Brulerie, as stated on p. 124, has drawn attention to the fact that such tactile hairs are not well developed in epigean Carabidæ. In the figures of *Anophthalmus eremita* and *A. pusio* the two tactile setæ on the head are not represented; whether they are present I can not at the present writing of this paragraph state, as my specimens are not accessible.

By reference to Pl. XIX, figs. 1*a*, 3*a*′, 3*a*″, and 3*a*‴, it will be seen how well developed are the olfactory setæ on the antennal joints. Whether such highly modified setæ are to be found on the antennæ of epigean Caribidæ is an interesting question. The olfactory organs, as we suppose they are, of Adelops, are represented by Fig. 4. The palpi of none of these cave beetles are supplied with organs of special sense.

APPARENT EXCEPTIONS AND OBJECTIONS TO THE OPINION THAT A LIFE IN TOTAL DARKNESS NECESSARILY INDUCES ATROPHY OF THE EYE OR BLINDNESS.

A number of objectors and critics have strenuously opposed the view that absence of light causes blindness or atrophy, partial or total, of the organs of vision. We do not refer to the general belief advocated by naturalists and others of a former generation that blind cave animals were specially and suddenly created isolated types of life existing in harmony with their surroundings.

* The microscopical and alcoholic specimens here referred to were demonstrated in the session of the Silesian Society for the National Culture in Breslau for November 10, 1875.

In his excellent chapter on the influence of light* Semper, after remarking that "total darkness gradually destroys the eyes of animals originally possessing them, for, since these organs are absolutely useless in such circumstances, in the course of generations they must gradually disappear, according to the law of degeneration, in consequence of their disuse," a few pages beyond, however, adds:

> But, though we are thus fully justified in saying that darkness so complete as not to allow of the eyes being used at all has in most cases exercised an injurious effect on their existence and structure, it would nevertheless be wholly false to assume that the lack of light must necessarily lead to total or partial blindness. We know of a number of facts directly opposed to such a conclusion. Among the numerous cave insects there are many which have well-developed eyes and yet inhabit the same spot as blind species. In some caves in the Philippines and the Pelew Islands which I myself explored I found in spots where the most absolute and total darkness reigned only insects with eyes. Hadenœcus, a species of grasshopper which lives in the caves of Kentucky, has well-developed eyes like other animals found there at the same time. Why should not darkness have had the same effect on these animals as on others which have in fact become blind? It might be said—in fact it has been said—that the cave animals which can see have migrated into the cave only within a short period, and have not been exposed to the influence of the darkness long enough to suffer; while the blind or half-blind, having entered the caves at a remote period, have lost the use of their eyes, wholly or partially, in consequence of long desuetude. But this explanation contradicts the fact, previously mentioned, that every mole, Pinnotheres, etc., originally had eyes apparently capable of further development and of perfectly fulfilling their normal function; and that the influence of darkness is proved to be direct in each individual, and not hereditary. This explanation is also quite decisively contradicted by a fact which is little known generally, and even among zoologists is familiar to none but entomologists. I owe my own knowledge of it to my friend Dr. Hagen, of Cambridge, United States. In all the species of the cave beetle Machærites the females only are blind, while the males have well-developed eyes. In spite of this they both live together in ab olute darkness. This proves that the same result—total blindness—may come from different causes; for we may fairly regard it as impossible that in the last-named case the darkness of the cave has affected the females alone and been ineffective on the males; hence the blindness of the former cannot be caused by the darkness. In confirmation of this statement I may also adduce the fact that there are many blind or half-blind animals which live in well-illuminated situations, where the moderate intensity of the light would allow them the full use of the eyes. This is the case, for instance, with many bivalves—all fresh-water bivalves and many sea bivalves—with various Annelida (Chætogaster), Crustacea (Cyclopidæ), and others. I myself have found a perfectly blind small species of Cymothoe living in slightly brackish water in a basin overshadowed by limestone rock, but in spots where full daylight could penetrate.

In the case of Hadenœcus it should be remarked that, so far as we have observed in Mammoth and the other caves we have examined, this cricket not only lives in the entirely dark regions of the caves, but abounds in twilight and near the openings; *i. e.*, in places where the species of Anophthalmus and Adelops, etc., are never found. It is a twilight species, and, being active in its habits, may migrate from one part of the cave to another. Moreover it occurs, as will be seen on page 69, in many small partially lighted caverns and grottoes. There is no reason why those individuals which occur in total darkness may not cross with those living near the entrance, and thus the eyes may remain unimpaired. Moreover the eggs of this species have not yet been discovered, and we do not know whether it oviposits freely in totally dark or in partially lighted localities in the cave.

In the case of the Machærites (which does not occur in American caves), it may be said that further investigation may show that the species which have eyeless females and eyed males may be twilight forms rather than denizens of "absolute darkness." Machærites is stated by Bedel to constitute a subgenus of Bythinus, "a numerous genus, spread over all of Europe and in the United States. Most of the species are eyed and live in cool places under moss; some Southern species are lapidicolous or cavernicolous. The reduction, more or less complete, of the visual organs in the latter, and principally in the females, has served as the base of the subgenera Machærites and Linderia, which comprise all the species found in grottoes." Of *Machœrites spelœus* Miller only the female is known. Of the three other species no biological information is given by Bedel. Of the three species of Linderia, *L. armatus* is represented by a male and *L. claræ* by a female only. *Machœrites cristatus*, found at Ariège under an enormous stone before the entrance of a cave, is represented by a single male, whose eyes were obliterated, while *M. bonvouloiri*, found in moss, is represented by a male and female, both of which are eyeless.†

* Semper's Animal Life as Affected by the Natural Conditions of Existence, 1881.

† De Saulcy (Ann. Soc. Ent. Fr., 4e sér. tome iii, p. 649), referring to a statement of Grenier's, that the development or non-development of the eyes in *Machœrites* (*Linderia*) *mariæ*, as found in the cave of Villefranche, depends

As regards the species of Cymothoa referred to by Semper, and the few Cyclopidæ which are eyeless, we need to know more concerning their habits, whether they do not for the most part live in dark places, as do the eyeless species of the Myriopodous families Polydesmidæ and Polyzomidæ, which have apparently little use for organs of vision. Indeed, it may be laid down as an axiomatic truth that where eyes are defective or atrophied, it is owing to disuse induced by physical surroundings of such a nature as to enable the animals in question to dispense with organs of sight. In the foregoing list of eyeless non-cavernicolous animals, other than those living in the abysses of the ocean or of lakes, it will be seen how very exceptional is the absence of eyes in orders and classes of animals in which they are generally present. In regard to Chætogaster, the species of this genus are parasitic in their habits, and it is not improbable that most of the oligochete worms which are eyeless burrow in the mud, spending the greater part of their lives in dark places, where eyes would be of little or no service to them.

The bivalve mollusks are generally eyeless from the same cause; the clam and probably nearly all the burrowing Lamellibranch mollusks, which live deep in the sand or mud, in partial or perhaps total darkness, can afford to dispense with the sense of sight; while the Pectens, Lima, Spondylus, Tellina, Pectunculus, Arca, etc., which leave the mud or the sand to skip over the surface, have highly developed eyes, as do most of the Cephalophora and all Cephalopoda. The Scaphopoda, which live buried in the mud and are headless, have no eyes. Where the eyes of certain Cephalophora are absent, as in the Chitonidæ, we have also a degeneration involving the loss of a distinct head and tentacles in adaptation to their sedentary mode of life. Why in Pteropods the eyes should be either "absent or very rudimentary" (Claus) is difficult to explain, unless part of their life is spent at great depths in the sea, below the lighted portions.*

Besides Machærites and Hadenœcus, Semper mentions Anthomyia, Phora, and species of Nesticus and Linyphia, which have "well developed" eyes but live in caves, also "Spirostrephon." The latter-named Myriopod is undoubtedly *Pseudotremia cavernarum*, which, though it possess a facetted cornea, is, as we have shown, without an optic nerve, and is therefore blind. The *Scoterpes copei* of Mammoth Cave, as we have also shown, has neither eyes nor optic lobes nor optic nerves. The spiders referred to occur near the opening of the smaller caves, and may be regarded as perhaps twilight forms. At any rate, the eyeless Anthrobia of Mammoth Cave usually has no other spiders associated with it. Until the brain and optic nerves of these forms have been investigated by carefully made microscopic sections, one can not tell whether the optic nerves are present or absent. Experience has taught us that the simple presence of pigmented eyes does not necessarily prove that the creature has the power of sight.

The Phora fly, which passes its transformations in bats' dung, is a twilight species, while the so-called Anthomyia is Osten Sacken's *Blepharoptera defessa*, which is also a twilight species, being found near the mouth of the larger caves and in numerous smaller caves in different parts of the country from Virginia to Utah. It is possible that it may yet be found outside of caves.

As regards the little cave in Utah which we examined, it is of slight extent, only dark at the end, and the insects found in it were all to be compared with the twilight fauna of such a cave as Mammoth or Wyandotte; beside that, all the species of Polydesmidæ are blind.

It has been objected † that darkness has had little or nothing to do with the atrophy of the eyes of the blind-fish, because in Chologaster of Mammoth Cave and subterranean waters the eyes are normal, while it was alleged that the tactile organs were wanting. Prof. S. A. Forbes has ably disposed of this objection in the American Naturalist for January, 1882.

In a later number (March, 1881) of the same journal he briefly described a new species of Chologaster under the name *C. papilliferus*, taken from a spring in Union county, southern Illinois;

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upon the degree of light to which the specimens are exposed, maintains that the individuals with developed eyes are *males* and those with the eyes very small or entirely deficient are *females*. Grenier, in reply (l. c., p. 650), maintains that the characters upon which De Saulcy has founded his genus Linderia and those which he regards as indicative of sex, such as the development of the eyes and wings and the structure of the antennæ and palpi, are due solely to the influence of light upon the development of the larvæ.

* Tentacular eyes occur in the following genera of Lamellibranchs: Pecten, Spondylus, Lima, Ostrea (?), Pinna, Pectunculus, Modiola, Mytilus (?), Cardium, Tellina, Mactra, Venus, Solen, Pholas, and Galeomma. (Lankester in Ency. Britt., art. Mollusca, p. 693). Compare also Mr. Dall's letter on p.—.

† F. W. Putnam, Amer. Naturalist, January, 1872.

afterwards seven more specimens were taken from the same spring. As observed by Professor Forbes, this species "indicates a more advanced stage of adaptation to a subterranean life than that of its congeners. On all the surfaces of the head appear short rows of peculiar tubercles relatively wider than the papillæ of Amblyopsis, but also apparently shorter. They are much the largest about the anterior nostril and on the lower jaw, and are larger on the side of the head than on its upper surface. While the papillæ of Amblyopsis are set on ridges of the skin, those of this Chologaster are somewhat sunken within it, and are often placed in grooves; and it is not until they are freed from the adjacent epidermis by dissection that their full height is seen. When thus exposed they closely resemble the papillæ of Amblyopsis in form and size and are similarly cupped at the tip." Professor Forbes concludes that the discovery of a species of Chologaster which frequents external waters of an immediately subterranean origin supplies all needed proof that the genus either has a shorter subterranean history than Amblyopsis, or, at any rate, has remained less closely confined to subterranean situations; and that in either case the occurrence of eyes, partial absence of sensory papillæ, and persistence of color are thus accounted for consistently with the doctrine of "descent with modification."

Another example of a blind-fish with rudimentary eyes which does not permanently live in total darkness, but occasionally visits well-lighted places, is the *Gronias nigrilabris* of Cope. It is allied to the common horned pout and about 10 inches in length. It was taken in the Conestoga River, in Lancaster county, Pennsylvania, where it is "occasionally caught by fishermen, and is supposed to issue from a subterranean stream said to traverse the limestone in that part of Lancaster county and discharge into the Conestoga."

Professor Cope adds:

Two specimens of this fish present an interesting condition of the rudimental eyes. On the left side of both a small perforation exists in the corium, which is closed by the epidermis, representing a rudimental cornea; on the other the corium is complete. Here the eyeball exists as a very small cartilaginous sphere, with thick walls, concealed by the muscles and fibrous tissue attached, and filled by a minute nucleus of pigment. On the other the sphere is larger and thinner walled, the thinnest portion adherent to the corneal spot above mentioned; there is a lining of pigment. It scarcely collapsed in one, in the other so closely as to give a tripodal section. Here we have an interesting transitional condition in one and the same animal with regard to a peculiarity which has at the same time physiological and systematic significance, and is one of the comparatively few cases where the physiological appropriateness of a generic modification can be demonstrated. It is therefore not subject to the difficulty under which the advocates of natural selection labor when necessitated to explain a structure as being a step in the advance towards, or in the recession from, any *unknown* modification needful to the existence of the species. In the present case observation on the species in a state of nature may furnish interesting results. In no specimen has a trace of anything representing the lens been found.

THE PROBABLE ORIGIN OF BLIND ABYSSAL ANIMALS.

As has been observed, no vegetable life occurs in the sea below a depth of 300 to 500 fathoms. What can be the cause of the absence of even the lowest Algæ in the abysses of the ocean, unless it be the absence of light, it is difficult to imagine. In the absence of vegetable life, in the fact that numerous species of animals at the depth of the ocean and in the abysses of fresh-water lakes have either imperfect eyes or no traces of them whatever, and from the probability that at the depth at which they live there is total darkness, we have an interesting and suggestive parallel to the conditions of cave life. It is most probable that the causes of atrophy or blindness under one set of conditions are the same or nearly the same in the other.

The proportion of blind or eyeless deep-sea Crustacea to those provided with normal eyes is not as yet exactly known, but the results worked out by Prof. S. I. Smith* regarding the abyssal species of decapod Crustacea dredged by the *Albatross* in a restricted region of the western North Atlantic may afford an example of what probably obtains for the ocean depths in general. Of forty-four abyssal decapods, twenty-one are enumerated which are supposed to live at or near the bottom. "If we exclude from this examination all the species whose bathymetrical habitat is in any degree doubtful, and examine the twenty-one species given as inhabiting the immediate neighborhood of the bottom, we find that *Geryon quinquedens*, *Lithodes agassizii*, and *Sabinea princeps*

*Annals and Mag. Nat. Hist., March, 1886.

have normal, well-developed, large black eyes, apparently entirely similar to those of the allied shallow-water species; *Sclerocrangon agassizii*, *Bythocaris gracilis*, *Heterocarpus oryx*, *Nematocarcinus ensiferus*, and *N. cursor* have normal black eyes, a little smaller than the allied shallow-water species; *Ethusina abyssicola* and *Parapagurus pilosimanus* have distinctly facetted black eyes, which, though very much smaller than in most shallow-water species, are still fully as large and apparently quite as perfect as in those of some shallow-water species in which they are evidently sensitive to ordinary changes of light. The eyes of the species of Glyphocrangon are very large, with the facetted surface much larger than in the allied shallow-water species; but they are borne on very short stalks, with comparatively little mobility, and have dark purple instead of black pigments. The eyes of *Pontophilus abyssi* are lighter in color than those of the species of Glyphocrangon, but are facetted and apparently have some of the normal visual elements. All the species of Munidopsis and Pentacheles have peculiarly modified eyes, from which the normal visual elements are apparently wanting. Of these twenty-one abyssal species eight are thus seen to have normal black eyes, two have abnormally small eyes, and three have eyes with purplish or very light-colored pigment, while eight have eyes of doubtful function. If we confine the examination to the five species taken below 2,000 fathoms, we have one with well-developed black eyes, two with abnormally small black eyes, one with light-colored eyes, and one with eyes of doubtful function.

"These facts and the comparison of the eyes and the color of the abyssal species with the blind and colorless cave-dwelling Crustaceans certainly indicate some difference in the conditions as to light in caverns and in the abysses of the ocean, and make it appear probable, in spite of the objections of the physicists, that some kind of luminous vibrations do penetrate to depths exceeding even 2,000 fathoms. The fact that, excluding shallow-water species, there is no definite relation between the amount of the modification of the eyes and the depth which the species inhabit, many of the species with the most highly modified eyes being inhabitants of much less than 1,000 fathoms, might at first be thought antagonistic to this view. But when we consider how vastly greater the purity of the water must be in the deep ocean far from land than in the comparatively shallow waters near the borders of the continents, and how much more transparent the waters of the ocean abysses than the surface waters above, we can readily understand that there may usually be as much light at 2,000 fathoms in mid-ocean as at 500, or even at 200, near a continental border. These considerations also explain how the eyes of specimens of species like *Parapagurus pilosimanus* coming from 2,220 fathoms are not perceptibly different from the eyes of specimens from 250 fathoms.

"Although some abyssal species do have well-developed black eyes, there can be no question that there is a tendency towards very radical modification or obliteration of the normal visual organs in species inhabiting deep water. The simplest and most direct form of this tendency is shown in the gradual reduction in the number of the visual elements, resulting in the obsolescence and in some cases in final obliteration of the eye. The stages of such a process are well represented even among the adults of living species. The abyssal species with black eyes, referred to in a previous paragraph, contain the first part of such a series, beginning with species like *Geryon quinquedens* and *Lithodes agassizii* and ending with *Ethusina abyssicola*, in which there are only a few visual elements at the tips of the immobile eye-stalks. A still later stage is represented by A. Milne-Edwards's genus Cymonomus, in which the eye-stalks are immobile spiny rods tapering to obtuse points, without visual elements or even (according to the description) a cornea. Cymonomus is not known to be an abyssal genus, neither of the species having been recorded from much below 700 fathoms, and is a good example of the fact already mentioned, that many of the species with the most highly modified eyes are inhabitants of comparatively shallow water. There are, however, several cases of closely allied species inhabiting different depths, where the eyes of the deeper-water species are much the smaller; for example: *Sympagurus pictus*, 164 to 264, and *Parapagurus pilosimanus*, 250 to 2,221 fathoms; *Pontophilus gracilis*, 225 to 458, and *P. abyssi*, 1,917 to 2,221 fathoms; and *Nematocarcinus cursor*, 384 to 838, and *N. ensiferus*, 588 to 2,033 fathoms.

"In a large number of deep-water and abyssal species the ocular pigment is dark purplish, brownish, reddish, light purplish, light reddish, or even nearly colorless, while the number of visual elements may be either very much less or very much greater than usual. The eyes of the species of Glyphocrangon and of Benthonectes are good examples of highly developed eyes of this class. In many cases the presence of light-colored pigment is accompanied with reduction in the number of visual elements precisely as in black eyes, *Parapasiphaë sulcatifrons*, *P. cristata*, *Acanthephyra microphthalma*, and the species of Hymenodora being good examples.

"In other cases there are apparently radical modifications in the structural elements of the eye without manifest obsolescence. The large and highly developed but very short-stalked eyes of the species of Glyphocrangon, apparently specialized for use in deep water, probably represent one of the earlier stages of a transformation which results finally in the obliteration of the visual elements of the normal compound eye and the substitution of an essentially different sensory structure. In *Pontophilus abyssi* the transformation has gone further; the eyes, though fully as large as in the allied shallow-water species, are nearly colorless, not very distinctly facetted, and have probably begun to lose the normal visual elements over a portion of the surface. In the eyes of several of the species of Thunidopsis the normal visual elements have entirely disappeared, and there is an expanded transparent cornea, backed by whitish pigment and nervous elements of some kind. I am well aware that there is as yet no conclusive evidence that these colorless eyes are anything more than the functionless remnants of post-embryonic or inherited organs; but the fact that in some species they are as large as the normal eyes of allied shallow-water forms is certainly a strong argument against this view. In the species of Pentacheles there is still better evidence that the eyes are functionless; for, although they have retreated beneath the front of the carapace, they are still exposed above by the formation of a deep sinus in the margin, and the ocular lobe itself has thrown off a process which is exposed in a spinal sinus in the ventral margin. It is easy to conceive how these highly modified eyes of Pentacheles may have been derived from eyes like those of the species of Glyphocrangon and *Ponthophilus abyssi* through a stage like the eyes of Calocaris, which are practically sessile, have lost all of the normal visual elements, and have only colorless pigment, but still present a large, flattened, transparent cornea at the anterior margin of the carapace.

"It is interesting to note that the highly modified eyes of Pentacheles are found in a well-defined group, all the species of which have probably been inhabitants of deep water for considerable geological periods; while the equally deep-water species, with less modified or obsolescent eyes, are much more closely allied to shallow-water species, from whose ancestors they may have been derived in comparatively recent times."*

It seems from the foregoing statements that a large proportion—over one-third—of these deep-sea Crustacea have eyes in a greater or less degree of degeneration from disuse, and that the greater proportion are inhabitants of the deepest and consequently darkest portion of the ocean depths. It is possible that future researches may show that the forms with well-developed eyes are twilight forms, which live between the dimly lighted superficial and the deepest layers of the water, and not wholly restricted to the totally dark abysses. Moreover, it may be found that the forms without eyes burrow in the ooze or live under loose objects at the bottom, and thus live in a darkness still more profound than those which simply hover over the bottom. At all events there is, as different writers have observed, a striking parallelism between the deep-sea blind Crustacea and those inhabiting caves, and this seems due to a single cause—the absence of light. It will be a matter of great interest to make careful researches on the finer structure of the rudimentary eyes, and on the alterations which may have taken place in the brain, particularly the optic lobes and nerves, in order to ascertain whether they have been modified as in cave animals. As observed by A. Milne-Edwards and others, these blind or eyeless deep-sea Crustacea also resemble the cave forms in often having slender, elongated bodies and very much attenuated antennæ and limbs to compensate for the loss of eye-sight.

Professor Smith also states that the "large size and small number of the eggs is a very marked characteristic of many deep-sea Decapoda." This is also true of the cave eyeless spider *Anthrobia mammouthia*, whose eggs, as we have previously remarked, are proportionately very large and few in number (Pl. XX, fig. 16). As to the eggs of other cave animals, our knowledge is still too imperfect to allow us to institute any further comparison.

* Annals and Mag. Nat. Hist., March, 1886, pp. 194–197.

We will now turn to the following statement as to the condition of the eyes in the Crustacea of the Caspian Sea

O. Grimm enumerates several instances of Amphipods which live in depths from 35 to 250 fathoms in the Caspian Sea, and which, nevertheless, are provided with eyes in different degrees of perfection, some with red pigment, some without pigment. *Niphargus caspius* has very small eyes with dark pigment and much-developed cylindrical organs for smelling and touching (scarcely for hearing) on its upper antennæ; *Onisimus caspius* has eyes without pigment and much-developed cylindrical organs for touching hidden in the external plates of the maxillipeds, etc. He comes to the conclusion that in depths of 100 meters and upwards there is no absolute darkness, and that in such depths some animals are provided with very large eyes, others with imperfect eyes, but in compensation with other highly developed sensitive organs on various parts of their body.*

If there is no absolute darkness at such depths it is not said that there is not more or less obscurity, such as reigns in the Swiss lakes at a depth of 250 meters, and the fauna here described may be compared with the twilight fauna of caves and the fauna of wells where more or less light penetrates.

We now come to the deep-lake fauna of Switzerland, which has been so fully discussed in all its bearings by M. Forel and others. As regards the depth to which light penetrates, the carefully conducted observations of Prof. F. A. Forel, of Geneva, made upon the Lake of Geneva in 1874, proved, at least as far as the resources of photography and the human retina permitted, that the limit of absolute darkness in that lake was reached in summer at the very moderate depth of 45 meters and in winter at 100 meters. Under normal conditions of sight a shining object disappeared when immersed below 16 to 17 meters. Asper, who continued the researches of Forel upon the Lake of Zurich, found in 1881 that photographic plates sensitized with bromide of silver emulsion indicated the penetration of light to at least 90 meters. But while the researches here recorded fix the limit of luminous perception as dependent upon the powers of the human retina, they do not necessarily determine the same for the retina and visual nerves of the lower animals. Indeed, the presence of well-developed eyes in many of the animal forms inhabiting the greatest depths, no less than the varied coloring of their teguments, have frequently been taken in evidence to prove not only the existence of light there, but also the unequal visual powers of the different organisms.

A writer in the Nation, New York, states as follows:

The recently conducted investigations of a special committee of Swiss scientists, among whose names we find those of Sarasin, Soret, Pictet, C. De Candolle, and Fol, seem to affirm in a general way the conclusions reached by Forel; namely, that luminous penetration extends to only moderate depths. Three candles (contained in a lantern) immersed in the clearest water of the Lake of Geneva were visible at a depth of 30 meters, and an electric light at 3 meters farther. The distance of clear vision was found to be but very feebly dependent upon either the increase of brilliancy in the luminous body or its absolute magnitude. The extreme limit of the sun's luminous action was determined photographically to be 250 meters, beyond which absolute darkness was supposed to prevail.

Nature for November 20, 1884, p. 72, also contains a report of the Academy of Sciences, Paris, on the depth to which sunlight penetrates the waters of Lake Geneva, by M. M. H. Fol and Ed. Sarasin. From a series of experiments carried out in August and September of that year the authors conclude that light reaches a depth of 170 meters, and probably a little more, the luminosity at this point being about equal to a clear moonless night.

The deep-lake fauna of Switzerland as enumerated by Du Plessis, besides Protozoa, also common in shoal water, and the fresh-water sponge, a flesh-colored Hydra, several Polyzoa, and snails, as well as Platelminthes, includes *Planaria cavatica* Fries of caverns, which is white and ordinarily eyeless, though a goodly number had very small eyes. Among the oligochete worms occur *Lumbriculus pellucidus* Du Plessis, widely spread throughout numerous lakes and inhabiting a depth as great as 1,009 meters. The Entomostraca belong to mostly well-known species, though a purely bottom inhabitant is *Moina bathycola* Vernet, and perhaps a variety of *M. brachiata* or *Monoculus brachiatus* Jurine. The truly blind Crustacea are *Asellus forelii* Blanc, probably a variety of *A. cavaticus* of subterranean waters, and *Niphargus puteanus* Koch.

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* Arch. f. Nat., xlvi, pp. 116–126; translated, Ann. Nat. Hist. (5), v, pp. 82–92.

As regards the origin of the deep-lake fauna of Switzerland, Forel, in his Faune Profonde (4^me^ sér., 1879, p. 500), concluded as follows:

1. The lake fauna of our subalpine regions descended from animals which have immigrated since the glacial epoch.

2. From the fact that they are immigrants from other regions they have all had to adapt themselves to the special conditions of each lake.

3. The immigration was made for each of the three faunæ in a particular way, viz:

   a. Littoral fauna: by the passive migration of animals already adapted to lake life from other lakes, and by the active migration of animals having ascended the rivers and having consequently had to adapt themselves on the spot to a lacustrine life.

   b. Pelagic fauna: by the passive migrations of animals already adapted in other lakes to the lacustrine life.

   c. Deep-lake fauna: by the active or passive migration of animals coming from the littoral or pelagic faunæ of the same lake and having undergone on the spot an adaptation to the environment.

Lastly, in his Essai sur la faune profonde des lacs de la Suisse, 1885, Dr. Du Plessis-Gouret substantially adopts Forel's view, which he quotes. He also remarks:

The animals of the abyssal regions have originated by direct emigration from those which peopled the shores; and the former have themselves been brought into the lakes by running water under the form of affluents of all kinds, or by the stagnant waters of marshes and ponds communicating with the lakes by means of freshets. *En résumé,* our littoral lacustrine fauna is only a simple particular case of the fauna of running and stagnant waters of the surrounding country, and consequently the deep-lake fauna is but a special offshoot of the littoral fauna, like a part of the pelagic fauna, which has in a similar way detached itself from the animal life of the shores.

It appears, then, to recapitulate, that while the blind fauna of the world is but an almost infinitesimal portion of animal life as a whole, it is characteristic of the totally dark abysses of the ocean and of lakes as well as of caves. But while the deep-lake fauna and that of caves is generally conceded to be no older than the Quaternary period, that of the ocean abysses is probably much older, and directly descended from the Tertiary and even the Cretaceous periods, though it is believed with good reason by certain zoologists that all deep-sea life originally emigrated from the waters of comparatively shallow depths; namely, within depths less than a thousand fathoms.

THE BEARINGS OF CAVE LIFE ON THE THEORY OF DESCENT.

So far as we are aware, Lamarck was the first naturalist to refer the atrophy of eyes and loss of vision to disuse from a life in darkness, as may be seen by the following extract from the chapter in his Philosophie Zoologique entitled "De l'influence des circonstances sur les actions et les habitudes des animaux, et de celle des actions et des habitudes de ces corps vivans, comme causes qui modifient leur organisation et leurs parties." This work appeared in 1809, many years before the discovery of blind animals peculiar to caves.

Des yeux à la tête sont le propre d'un grand nombre d'animaux divers, et font essentiellement partie du plan d'organisation des vertébrés. Déjà néanmoins la taupe, qui, par ses habitudes, fait très-peu d'usage de la vue, n'a que des yeux très-petits, et à peine apparens, parce qu'elle exerce très-peu cet organe.

L'Aspalax d'Olivier (Voyage en Égypte et en Perse, II, pl. 28, fig. 2), qui vit sous terre comme la taupe, et qui vraisemblablement s'expose encore moins qu'elle à la lumière du jour, a totalement perdu l'usage de la vue; aussi n'offre-t-il plus que des vestiges de l'organe qui en est le siège; et encore ces vestiges sont tout-à-fait cachés sous la peau et sous quelques autres parties qui les recouvrent, et ne laissent plus le moindre accès à la lumière.

Le protée, reptile aquatique, voisin des salamandres par ses rapports, et qui habite dans des cavités profondes et obscures qui sont sous les eaux, n'a plus, comme l'Aspalax, que des vestiges de l'organe de la vue; vestiges qui sont couverts et cachés de la même manière.

Voici une considération décisive, relativement à la question que j'agite actuellement.

La lumière ne pénètre point partout; conséquemment, les animaux qui vivent habituellement dans les lieux où elle n'arrive pas, manquent d'occasion d'exercer l'organe de la vue, si la nature les en a munis. Or, les animaux qui font partie d'un plan d'organisation, dans lequel les yeux entrent nécessairement, en ont dû avoir dans leur origine. Cependant puisqu'on en trouve parmi eux qui sont privés de l'usage de cet organe, et qui n'en ont plus que des vestiges cachés et recouverts, il devient évident que l'appauvrissement et la disparition même de l'organe dont il s'agit sont des résultats, pour cet organe, d'un défaut constant d'exercice (2d edit., i, p. 241).

In his "Origin of Species" Darwin, after claiming that "natural selection would constantly aid the effects of disuse" in the case of moles and the burrowing rodents, then remarks in regard to cave animals: "As it is difficult to imagine that eyes, though useless, could be in any way injurious to animals living in darkness, I attribute their loss wholly to disuse" (p. 142). On the next page he writes: "By the time that an animal had reached, after numberless generations, the deepest recesses, disuse will on this view have more or less perfectly obliterated its eyes, and natural selection will often have effected other changes, such as an increase in the length of the antennæ or palpi, as a compensation for blindness."

It may be that the struggle for existence goes on even in the darkness of caves, and that the "fittest" of the limited population survive by reason of their adaptation to their untoward surroundings. How adverse to life of any sort caves are may be realized when we consider that only the lowest plants, and only a very few of those, live in caves. Without doubt the germs of fungi and the seeds of the higher plants are carried into the caves by freshets in subterranean streams and through sink-holes. Why, in spite of the darkness, we should not find more fungi even, and why one or two of the green algæ should not flourish in the pools and brooks of caves, or why the seeds of the higher plants should not germinate, even if the plants do not bear fruit, can only be explained by the absence of light; and perhaps this is an important cause of the absence of all plant life in the ocean below a depth of about 300 to 500 fathoms. Certainly there are ample means for the colonization of caves by vegetables; the temperature, moisture, and inorganic food are more favorable than the sum total of conditions on alpine summits or in the high polar regions, or in hot springs.

Animal life can apparently withstand greater physical obstacles than vegetable. As regards the struggle for existence, it possibly exists to a limited extent in cave animals. There is probably not enough vegetable or decayed animal food for all the animals, and some may die of hunger. The carnivorous beetles and Arachnida perhaps have a less favorable chance to obtain living food than the Crustacea, for the blind crayfish have a tolerable abundance of food in the Cæcidotæa, perhaps the most abundant form found in caves containing underground waters.

We may, with Darwin, for convenience, use the phrase "natural selection" to express the process by which the cave fauna was produced, but such a term to our mind expresses rather the result of a series of causes than a *vera causa* in itself. There is of course no doubt but that many animals carried by different means into caves cannot thrive there, and consequently die. It is only those which have been able, by certain peculiarities of their life in the upper world allied to cave existence, to adapt themselves to cave conditions, which permanently breed there. Such forms, it is convenient to say, have been by nature selected and are successful in colonizing the darkest and most forbidding and apparently hopeless corners in the earth's crust. But such a phrase as "natural selection," we repeat, does not to our mind definitely bring before us the actual working causes of the evolution of these cave organisms, and no one cause can apparently account for such a result. There is rather a complex assemblage of physical causes, all working together, to secure a harmonious result. The most important and potent of these causes, when we study them under such appreciable, because so extraordinary, conditions as the physical features of cave existence, would seem to be the following:

1. Change in environment from light, even partial, to twilight or total darkness, and involving diminution of food, and compensation for the loss of certain organs by the hypertrophy of others.
2. Disuse of certain organs.
3. Adaptation, enabling the more plastic forms to survive and perpetuate their stock.
4. Isolation, preventing intercrossing with out-of-door forms, thus insuring the permanency of the new varieties, species, or genera.
5. Heredity, operating to secure for the future the permanence of the newly originated forms as long as the physical conditions remain the same.

Natural selection, perhaps, expresses the total result of the working of these five factors, rather than being an efficient cause in itself; or at least constitutes the last term in a series of causes. Hence Lamarckianism in a modern form; or, as we have termed it, Neolamarckianism, seems to us to be nearer the truth than Darwinism proper or "natural selection."

The factors of organic evolution such as we have mentioned are of course theoretical, and the critic or unbeliever in a theory of descent demands facts in demonstration of the truth of the doctrine of the derivation of cave animals. Of the facts we have ourselves observed or which have been observed by others we will briefly summarize:

1. The variations in *Pseudotremia cavernarum* and *Tomocerus plumbeus*, found living near the entrance of caves in partial daylight.

2. The bleaching of Polydesmus and Machilis found living in small caves; the blindness of Neotoma, or the wood-rat of Mammoth Cave; of fish found in wells and subterranean streams; the atrophy of the mole's optic nerves induced in one generation.

3. The larger size of the eyes of the young than in the adult Troglocaris of Europe and the blind crayfish of American caves; Semper's history of the atrophy of eyes in the parasitic Pinnotheres; eyes of *Gammarus pulex* affected after living in darkness; the eyes of Gammaridæ in Lake Baikel becoming smaller the deeper they live; the instability in the eyes of Cæcidotæa.

Since this paper was written a few additional instances have come to our knowledge, and others are reported in periodicals bearing on this subject. While the eyeless and abyssal forms (both fresh-water and deep-sea) may have existed for many generations, for periods of hundreds and possibly thousands of years, yet the following facts tend to show that the bleaching of the body and atrophy of the eyes, as well as the adaptations to a life in darkness, may have been induced after but a few generations, perhaps but one or two only, resulting in the comparatively rapid evolution of cave species.

Thus, in a small cave near White's Cave, and at a point about 60 feet from the mouth, occurred a salamander (*Spelerpes longicaudatus* Green) which was apparently bleached, being nearly white, with dark-brown blotches. The common *Cambarus bartonii* occurs somewhat bleached in Mammoth Cave, and this may not be the result of inheritance, but occurs in young hatched without the cave and afterwards carried in, so as not to be exposed to the light, the shell remaining pale, as in the very young. Perfectly white, bleached specimens of the common *Polydesmus granulatus* Say occurred in Indian Cave. The pale variety of *Tomocerus plumbeus* is possibly the product of a single or at least very few generations; the white and blind Porcellio found by Mr. Hubbard in Little Wyandotte Cave, though possibly a true cave form, has not yet been found elsewhere, and may have been the young of a normal epigean species. But the most striking instance is the bleached specimen of *Asellus communis* from Lost River, referred to on pp. 15 and 33, which, though white, had eyes of normal size; there is good reason to suppose that these specimens were hatched in epigean waters, and that being carried into Lost River when young, the pigment in its skin owing to absence of light had failed to assume its normal dark color.

A parallel case is that mentioned by R. Schneider.*

The author gives an account of the subterranean variety of *Gammarus pulex* which is found at Clausthal. The first point of interest is its pale color, pigment being so completely absent from its body that it is milk-white and transparent; even the fat-cells, which are intensely red or orange-yellow in the ordinary *G. pulex*, are quite white. In the second place the eye is not normally developed, but is in the first stage of reduction; the crystalline cones show signs of degeneration, and the whole eye exhibits that "megalophthalmy" or proportionately greater size which is often the first indication of loss. The pigment has also begun to be reduced, and is of a dirty black, instead of a brownish color. The anterior pair of antennæ exhibit elongation, owing to the increase in the number of the joints.

There is, as compared with the ordinary forms, a considerable increase in the amount of calcareous deposits; and there is always a considerable amount of iron oxide in the contents of the intestine whence the iron makes its way to various parts of the body.

Fries† suggests that experiments should be made on the effects of rearing normal, eyed Gammari in darkness, and refers to Humbert's statement, that in the greater depths of Lake Baikal with an increase in depth of their habitat there is an increasing lack of development of the eyes in some Gammaridæ. Fries also states that he himself had previously observed a decrease in the pigment of the eyes in young examples of *Gammarus pulex* living in darkness.

Here should be cited the observations of Anton Stecker, who states that—

Chernes, usually said to be eyeless, has rudimentary eyes, represented by clear, somewhat transparent spots, the chitine forming them being devoid of the granulations covering the rest of the shield. Each cornea is supplied by a large and well developed optic nerve, proceeding from an optic ganglion in connection with the brain. But the layer of crystalline rods was wholly absent. About 30 to 35 per cent. of the specimens of *Chernes cimicoides* examined

* Unterirdische Gammarus von Clausthal. P. B. Ak. Berlin, 1885, p. 1087. Also: Abh. z. Programm k. Real-Gymnasiums Berlin, Ostern. Abstr. in: Journal Roy. Micr. Soc. (2), vi, p. 243.

† Zool. Anzeiger, Aug., 1879, pp. 36, 37.

possessed these eye-spots; in the remaining 65 to 70 per cent. they were absent, as well as the optic nerves; while there was only one, or even no, recognizable rudiment of an optic ganglion. He also found that the offspring of parents, both of which had eyes, were themselves provided with them; but that if either the father or the mother were blind, the young were also blind, having at most a feeble indication of optic lobes. Dr. Stecker considers this a most instructive case of the gradual atrophy of an organ by disuse, owing to the influence of changed conditions. There can be little doubt that the ancestors of Chernes possessed well-developed eyes; the first steps in the retrogressive process was the loss of the cornea and cones, the optic nerve and ganglion remaining after the true percipient apparatus had gone.*

Here is a fertile field for careful and long-continued observations on animals reared in different degrees of darkness. Such experiments will afford a crucial test of the theory of the comparatively rapid evolution of genera and species due to sudden changes in the environment.

It is evident that physiological experiments are needed as well as embryological studies to throw further light on the origin of cave animals. The blind-fish, blind crayfish, and Cæcidotæa, which might be reared in dark cellars, should be observed for a series of generations, to ascertain whether by breeding the eyes can not be restored and the species by artificial means be induced to revert to its ancestral type. The embryology of the cave beetles, with or without rudimentary eyes, of the eyeless spiders and of Myriopods, of the Cæcidotæa, and of the blind crayfish and blind-fish should be carefully worked out as regards the presence of organs of vision in a rudimentary state, though we should hardly expect to find rudimentary eyes in Anophthalmus when both larva and pupa do not possess them.

ISOLATION AS A FACTOR IN THE ORIGIN OF CAVE ANIMALS.

When any cave, such as Mammoth or Wyandotte, etc., is once colonized by emigrants from the upper world, and the colonists becoming adapted to the new conditions environing them, have lost their eye-sight or even all traces of eyes, and the new forms thus established begin to breed true to their recently acquired characteristics, it is obvious that this process of in-and-in breeding will continue as long as the new forms live in total darkness and are isolated from the allied forms or their eyed ancestors of the upper world of light. Though a subordinate factor, isolation is certainly of no little importance in securing the stability of the new species and genera. It is evident that if no stragglers from the upper world, as sp cies of Trechus to interbreed with the cave Anophthalmi, species of Choleva to cross with Adelops or Bathyscia, or species of Ceuthophilus to mix with the true cave Ceuthophili, or species of Myriopods or Arachnida to intercross with the cave forms, then the latter will tend to remain as fixed as we now find them to be. In the case of the crayfish of Mammoth Cave, the normal *Cambarus bartonii*, introduced at times of heavy rains or freshets into the cave, is not seldom found living in company with *Orconectes pellucidus*, the blind form, but belonging to a different section of the genus as regards the shape of its gonopods or first male abdominal appendages, and being of much larger size, it is probably incapable of fertilizing the eggs of the blind form, even if the latter, timid and sensitive to the least disturbance of the water, should allow itself to be approached by the larger-eyed form. It is also probable that *Cæcidotæa stygia* is seldom, if ever, brought in contact with *Asellus communis*, which abounds in the pools and streams throughout the cave region. I have never found a stray Asellus even partly bleached and with dimished eyes in any caves, nor seen such specimens in collections made by others, though they may yet be found. Whether living in caves or wells fed by subterranean streams, the bleached, eyeless, or nearly eyeless, forms breed true to their type and show no signs of intercrossing with lucophilous forms.

Should, however, these cave forms be placed in such circumstances as to be able to mix or intercross with their epigean allies, which are in all probability the very species to which they owe their origin, there would with little doubt be a constant tendency to revert to the ancestral eyed forms, and we should constantly find certain individuals with visual organs better developed, and with a darker integument, serving as connecting links. Such links may have been common enough when the caves were first formed and colonized, and in some species, as *Pseudotremia cavernarum*, they frequently occur at the present time, but, as a rule, owing to long isolation or seclusion, and the consequent impossibility of intercrossing, they are now rare.

*Morp. Jahrbuch, iv, 279, 1878; Journ. Roy. Micr. Soc., ii, 146, 1879.

But as circumstances are now, the total darkness, the temperature, the degree of dryness or moisture, and other physical conditions remaining the same, the cave fauna is almost completely isolated from that of the upper world; indeed, far more so than the deep sea fauna of the ocean or of lakes, or the faunas of deserts or of the polar regions, or the alpine inhabitants of lofty mountain summits. We thus realize that isolation may be a not unimportant factor in securing permanence of type, after the typical characters have once been established through adaptation and heredity.

After reflecting upon the influence of isolation upon cave animals as securing permanence of varietal, specific, and generic characters, one is led to realize as never before the importance of geographical isolation in general as a factor in preventing variation after the organisms have once become adapted to their peculiar environment, whether dependent on temperature, soil, humidity, or dryness, the absence of light, or any other appreciable characteristic in their surroundings. We know also that the existing desert, deep-sea, and polar faunas are the product of Quaternary times; that they were nearly contemporaneous in origin with the cave faunæ, though the deep sea fauna may date from the Cretaceus period. Finally, I may quote from Darwin's "Origin of Species" the following extract, which applies (though he did not make it applicable to any special case) with peculiar force to cave fauna: "If, however, an isolated area be very small, either from being surrounded by barriers, or from having very peculiar physical conditions, the total number of the inhabitants will be small, and this will retard the production of new species through natural selection, by decreasing the chances of the appearance of favorable individual differences" Fifth edition, New York, p. 105).

HEREDITY.

The action of this all-powerful factor in evolution is as constant in the underground world, and as difficult to comprehend in considering cave life, as that of the upper regions. It begins to act, of course, with the earliest generations, and continues to act with, so to speak, increasing force and precision as time goes on and the characteristics induced by a life in total darkness become more and more fixed.

It is evident that heredity has acted longest in those insects, such as the species of Anophthalmus and Adelops, whose larvæ are lacking in all traces of eyes and optic nerves and lobes. Heredity has here acted with unabated force throughout every stage of the metamorphosis; and, it will be a matter of great interest to ascertain whether any traces of the eyes may be met with in the embryo of these forms.

On the other hand, in those Arthropods in which the brain and optic nerves have persisted, with rudiments of the eyes (*e.g.*, Orconectes), where the eyes are larger in the young, it would seem as if heredity had been acting through a shorter period, and consequently, so to speak, with less momentum.

In the case of Machærites, in which the females only of certain species are said to be blind, while the males have well-developed eyes, we have an apparent exception to the continuous action of heredity; an exception paralleled, however, by animals living in the upper world, such as Termes, whose workers and soldiers are eyeless, though the males and females are eyed. As will be seen in the section on apparent exceptions to the action of disuse from the effects of darkness, we need further knowledge as to the exact distribution in caves of the species of Machærites. They perhaps are twilight species rather than inhabitants of totally dark localities in caves, and those living in twilight may intercross with those inhabiting the darker regions, and such a case as this, remarkable as it would appear, does not affect the general rule, that animals living in total darkness and never living in twilight, nor intercrossing with twilight forms, are eyeless, or at least blind.

Nor does the case of Hadenœcus, the cave cricket, with well-developed eyes and brains, affect the argument; for this is essentially a twilight form, though migrating to regions of total darkness and abounding there. The same may be said of the cave species of Ceuthophilus. A parallel case may be that of Chologaster as compared with Amblyopsis, the former living out of caves in ditches as well as in wells and caves.

Judging by the following statement, so eminent a naturalist as Professor Semper denies that heredity acts in the case of the mole. He says:

This almost total blindness in the mole is the result solely of complete degeneration of the optic nerve, so that the images which are probably formed in the eye itself can never be transmitted to the animal's consciousness. Occasionally, however, the mole even can see a little, for it has been found that both optic nerves are not always degenerate in the same individual, so that one eye may remain in communication with the brain while the other has no connection with it. In the embryo of the mole, however, and without exception, both eyes are originally connected with the brain by well-developed optic nerves, and so theoretically efficient. This may indeed be regarded as a perfectly conclusive proof that the blind mole is descended from progenitors that could see; it would seem, too, to prove that the blindness of the fully grown animal is the result not of inheritance, but of the directly injurious effects of darkness on the optic nerve in each individual.*

It may be objected, however, that each mole certainly inherits a tendency to weakness and atrophy of the optic nerves, just as the children of consumptive or strumous parents inherit a tendency to those diseases, and that when the conditions are favorable the disease manifests itself. We know there have been many generations of blind or partially blind moles, and it would be strange if heredity did not at a certain age act in such a case, and would not for at least a few generations even if the moles were kept out of the darkness. We have in the atrophy of the optic nerves of the mole a parallel case in the blind Myriopod *Pseudotremia cavernarum*, where the eyes survive, but the optic nerve is wanting, as also in a less marked degree in *Cæcidotæa stygia.*

THE FACTORS OF ORGANIC EVOLUTION.

The study of the conditions of existence in caves is of special value, because such conditions are so unusual and abnormal and the results upon certain organs so easily appreciated. It is by a study of life under unusual conditions that the attention is aroused and interest excited, and after acquiring experience in dealing with the more palpable, because somewhat abnormal, circumstances under which organisms exist, we can then more easily observe the effects of changes of ordinary conditions upon the organism.

From a study of cave life, of organisms existing in saline and in heated waters, of plants and animals exposed to great cold in alpine or polar regions, of those living in hot, dry deserts, we can turn to an examination of the results of adaptation to a parasitic mode of life. The strange modification of form, owing to disuse, in internal as well as external parasites of different orders and classes, the change of host necessitated, and the intensity of the struggle for existence in animals living under such exceptional conditions, embryology proving that they have arisen from animals of normal organization; such studies as these are of fundamental importance in a discussion of the origin of species and higher categories. Moreover, the study of the results of the incoming and cessation of the Glacial epoch, the effects on life arising from the elevation and depression of the land, involving not only change of land surfaces, but a change of climate; it is by a study of such marked changes as these in the conditions of life that we are prepared to examine the more subtle causes of variation throughout the organic world in general.

After the foregoing pages were written we read with much interest Mr. Herbert Spencer's recent essays entitled "The Factors of Organic Evolution."† While that author, it appears to us, lays too great stress on Dr. Erasmus Darwin's views, as compared with Lamarck's; the author of the Philosophie Zoologique having been a professional botanist and zoologist as well as a naturalist of the first rank, it is noteworthy that he sees clearly that natural selection is not the sole factor in organic evolution, as will be seen by the general drift of his essays, by his quoting with approval Huxley's significant remark that "Science commits suicide when it adopts a creed," and by the following extracts from his own essays:

> But now, recognizing in full this process brought into clear view by Mr. Darwin, and traced out by him with so much care and skill, can we conclude that, taken alone, it accounts for organic evolution? Has the natural selection of favorable variations been the sole factor? On critically examining the evidence we shall find reason to think that it by no means explains all that has to be explained (p. 9).

During that earlier period, when he was discovering the multitudinous cases in which his own hypothesis afforded solutions, and simultaneously believing how utterly futile in these multitudinous cases was the hypothesis propounded by his grandfather and Lamarck, Mr. Darwin was not

* Animal Life, etc., pp. 79, 80.

† New York, 1887, reprinted from The Nineteenth Century for April and May, 1886.

unnaturally, almost betrayed into the belief that the one is all-sufficient and the other inoperative. But in the mind of one usually so candid and ever open to more evidence there naturally came a reaction. The inheritance of functionally produced modifications, which, judging by the passage quoted above concerning the views of these earlier inquirers, would seem to have been at one time denied, but which, as we have seen, was always to some extent recognized, came to be recognized more and more, and deliberately included as a factor of importance.

In his references to the works and opinions of other naturalists Mr. Spencer confines himself almost exclusively to those of Mr. Darwin, who always opposed, and it must be confessed, with less than his his usual candor and fairness, the views of Lamarck as to the influence of a change in the environment upon organisms.*

It seems singular that Mr. Spencer should not be acquainted with the work of those who have brought together certain facts bearing on the physical factors of evolution.† The principal factors referred to by Mr. Spencer are use and disuse and the influence of light. In one place he does in concrete language sum up these agencies as follows:

> The growth of a thing is effected by the joint operation of certain forces on certain materials; and when it dwindles there is either a lack of some materials or the forces co-operate in a way different from that which produces growth. * * * That is to say, growth, variation, survival, death, if they are to be reduced to the forms in which physical science can recognize them, must be expressed as effects of agencies definitely conceived—mechanical forces—light, heat, chemical affinity, etc. (pp. 39, 40).

On page 70 Mr. Spencer remarks:

> But nevertheless, as we here see, natural selection could operate only under subjection. It could do no more than take advantage of those structural changes which the medium and its contents initiated.

Again, on page 73, Spencer suggests that natural selection, in order to act, must have had a limited number of organisms upon which to operate.‡ As he remarks:

> Though natural selection must have become increasingly active when once it had got a start, yet the differentiating action of the medium never ceased to be a co-operator in the development of these first animals and plants.

Finally, Mr. Spencer makes the following important admission:

> This general conclusion brings with it the thought that the phrases employed in discussing organic evolution, though convenient and indeed needful, are liable to mislead us by veiling the actual agencies. That which really goes on in every organism is the working together of component parts in ways conducing to the continuance of their combined actions in presence of things and actions outside, some of which tend to subserve and others to destroy the combination. The matters and forces in these two groups are the sole causes properly so called. The words "natural selection" do not express a cause in the physical sense. They express a mode of co-operation among causes, or rather, to speak strictly, they express an effect of this mode of co-operation (p. 40).

Here we have frankly intimated what the Neolamarckian has for years insisted on, that the phrase "natural selection" is not a *vera causa*, but rather expresses the results or effects of the co operation of a number of factors in organic evolution. In the case of too many naturalists the dogma or creed of natural selection has, it seems to us, tied their hands, obscured their vision, and prevented their seeking by observation and experiment to discover, so far as human intelligence can do so, the tangible, genuine, efficient factors of organic evolution.

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* It is surprising to read in Darwin's Life, by his son, the expressions showing his lack of appreciation of Lamarck and his work; Darwin seems from the first to have been strongly prejudiced against Lamarck's views, and never to have done them justice.

In the Origin of Species (p. xiv, note) Darwin writes, as quoted by Spencer: "It is curious how largely my grandfather, Dr. Erasmus Darwin, anticipated the views and erroneous grounds of opinion of Lamarck in his 'Zoonomia' (vol. i, pp. 500–510), published in 1794" (p. 29).

† In the writer's Introduction to the Standard Natural History, 1885, under the head of Evolution (pp. 1 and lxii), he has endeavored to bring together references to the different authors who have insisted on views which are in the line of those first suggested by Lamarck, a phase of evolution which he has called Neolamarckianism. The authors to whom Mr. Spencer might have with good reason referred are, in Europe, Semper, Kölliker, Wagner, Martins, Plateau, Weismann, and Dohrn, and in this country Haldeman, Leidy, Wyman, Clark, Cope, Hyatt, Walsh, Allen, W. H. Edwards, Dall, and the writer.

‡ This point is one which the writer has also made and published over twelve years ago in a communication to The Nation, holding that it is an important objection to the theory of natural selection, the very nature of which involves the existence of a world already stocked with life forms. What the theory of evolution should explain is the origin of these first ordinal and class forms. Given even a scanty fauna, isolated members of different orders and classes, and it is comparatively easy to account for the origin of the later more numerous descendants.

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EXPLANATION OF THE PLATES.

PLATE I.

FIG. 1. *Cauloxenus stygius* Cope.—1*a*, 1*b*, 1*c*, the same in different positions; *a*, *b*, antennæ; *c*, mandible (?); *x*, point of attachment of arms to its host. Highly magnified.

FIG. 2. *Canthocamptus cavernarum* Pack.—2*a*, head, showing the antennules and antennæ; *st.*, stomach; 2*b*, the second antennæ, more magnified; 2*c*, end of the body, dorsal view; 2*d*, the same, enlarged. Author del.

PLATE II.

FIG. 1. *Asellus communis*, from Indiana.—Antennule (first antenna); 1*a*, end of the same, showing the three olfactory rods; 1*b*, 1*c*, mandibles, with palpus (*palp.*); 1*d*, 1*e*, first maxilla (?) (compare Pl. III, fig. 2*i*); 1*f*, first maxilla of authors; 1*g*, second maxilla; 1*h*, the same, incompletely drawn; 1*i*, maxillipede; *st.*, stipes; *l. l.*, lateral lobe; *palp.*, palpus; *lab.*, lobe of the labium; *x*, delicate membranous processes connecting the opposing edges of the labial lobes; 1*j*, first pair of male genital armature; 1*k*, second or last pair of male genital armature; 1*l*, penis.

FIG. 2. *Asellus intermedius* Forbes (drawn from specimens labeled by him).—Antennule; 2*a*, second joint of the same, showing two auditory setæ; 2*b*, end of the same, showing three olfactory rods, the terminal joint ending in three setæ (one broken off); 2*c*, auditory setæ; 2*e*, an olfactory rod; 2*f*, one of the last uropoda, the setæ unusually long and numerous in this species.

FIG. 3. *Asellus brevicauda* Forbes (drawn from specimens labeled by him).—Antennule; 3*a*, second joint of the same, with four auditory setæ; 3*b*, end of the same, with three olfactory rods; 3*c*, a leg of the first pair, male; 3*d*, a uropod of the last pair (its mate was much shorter). Author del.

PLATE III.

FIG. 1. *Cæcidotæa stygia* Pack. Drawn by J. S. Kingsley from a specimen exactly like one from Mammoth Cave; the details drawn from a Mammoth Cave specimen. 1*a*, larger antenna; 1*b*, cercopod, ♀; 1*c*, cercopod, ♂; 1*d*, one of the terminal setæ, much larger than the others and bulbous at the end.

FIG. 2*a*. *C. stygia.*—Antennule of short form from the Labyrinth, Mammoth Cave; 2*b*, end of 2*a*, with the three olfactory rods; 2*c*, ♀ antennule; *ol.*, olfactory rods; 2*d*, the same, enlarged, showing the four terminal joints filled with nerve cells (*n. cells*), and the auditory bristle (*aud. s*); 2*e*, first maxilla (of authors); 2*f*, the same enlarged, the outer lobe bearing ten or eleven simple setæ, the inner lobe five spinulated setæ; 2*g*, second maxilla (of authors); 2*h*, end of same, enlarged, each of the two outer lobes bearing on the inner edge six or seven curious comb-like setæ (not very well represented in the plate), the other setæ transversely striated; 2*i*, the second pair of appendages behind the mandibles (first maxilla ?).

FIG. 3, 3*a*. *C. stygia* Forbes, from a well in Illinois.—Second joint of antennule, with three auditory bristles; 3*a'*, three basal joints of antennule from a Mammoth Cave individual, with an auditory bristle on the basal and two on the second joint.

FIG. 4. *C. stygia*, from Annville, Pennsylvania.—Antennule of seventeen joints—4*a*, end of the same, with six olfactory rods, three of which are on the sixth joint from the end.

FIG. 5. *C. stygia*, from Long Cave.—Antennule; 5*a*, antennule of another individual from the same cave, with but eight joints; 5*b*, 5*c*, antennæ of the same; 5*d*, a leg of the first pair, ♀ adult, with eggs.

FIG. 6. *C. stygia*, collected in daylight, 50 feet in from entrance of Walnut Hill Spring Cave, attennule; 6*a*, terminal joints of the same.

FIG. 7. *C. stygia*, from Bradford Cave.—Antennule of ten to eleven joints.

FIG. 8. *C. stygia*, from Carter (X) Cave—8*a*, terminal joints of the antennule, with five olfactory rods.

FIG. 9. *C. nickajackensis.*—Antennule; 9*a*, terminal joints.

All the figures except one drawn by the author.

PLATE IV.

FIG. 1. *Cæcidotæa stygia* Pack., from Mammoth Cave.—♀ mandibles (inside); 1*a*, right mandible (on the outside); *m*, muscles; *palp.*, palpus; 1*b*, maxillipede; *st.*, stipes; *l.l.*, lateral lobe; *palp.*, palpus; *lab.*, labium; 1*c*, labium and palpus of 1*b*; 1*d*, one of the first pair of feet, ♂; 1*e*, the same, ♀; 1*f*, seventh leg, ♂; 1*g*, the same, ♀; 1*h*, first abdominal legs, ♂; 1*i*, one of the second pair, ♂; 1*j*, under side of abdomen, ♂; 1*k*, the coupling organs, magnified; *x*, claspers; 1*l*, underside of abdomen, ♀; 1*m*, the same with the outer appendages removed.

FIG. 2. *C. stygia*, from Carter Cave.—One of first pair of legs, ♀.

FIG. 3. *Asellus communis* Say.—Antennule, ♂, showing the three auditory bristles; 3*a*, end of 3, with olfactory rods much shorter than in *C. stygia;* 3*b*, antennule ♀, with five auditory bristles; 3*c*, the same of another individual; 3*d*, antennule; 3*e*, antenna, ♂, from Illinois; 3*f*, mandible; 3*g*, one of the first pair of legs, ♂; 3*h*, left cercopod, ♂, from Irvington, Indiana. Author del.

FIG. 4. Asellus, sp. indet., from Gill's Branch, near Lancaster, Garrard County, Kentucky. Kingsley del.

FIG. 5. Undetermined; locality unknown. Kingsley del.

PLATE V.

FIG. 1. *Crangonyx vitreus* (Cope).—♀, 5.2^{mm} long, enlarged 20 diameters.

FIG. 2. One of the first pair of legs seen from the outside, enlarged 48 diameters.

FIG. 3. One of the second pair of legs, ×48.

FIG. 4. End of the abdomen, side view, ×48.—*a*, telson; *b*, posterior caudal stylet; *c*, second caudal stylet; *d*, first caudal stylet.

FIG. 5. *Crangonyx packardii* Smith (details all magnified 48 diameters; 5 to 8, ♀, 5.5^{mm} long; 9 to 11, ♀, about 7.5^{mm} long).—Lateral view of the head.

FIG. 6. End of one of the first pair of legs, outside.

FIG. 7. The same of the second pair.

FIG. 8. End of the abdomen, lateral view.

FIG. 9. One of the first pair of legs, outside.

FIG. 10. One of the second pair of legs, outside.

FIG. 11. Antennula and antenna, side view.

FIG. 12. *Crangonyx antennatus* Pack.—Terminal joints of the antennule, showing the olfactory rods.

FIG. 13. The entire antennule. 13*a*, basal joint with four auditory setæ; 13*b*, fourth joint of the same with its ramus.

FIG. 14. Antenna, with four auditory setæ.

FIG. 15. *Crangonyx mucronatus* Forbes, Illinois.—Antenna, end enlarged; 15*a*, the same more highly magnified; 15*b*, fourth joint still more magnified. (The setulæ of the auditory setæ are fewer than in Cæcidotæa.)

FIG. 16. *Crangonyx vitreus* Cope (?) .—Basal joint of antennule. (Compare with Fig. 13*a*.)

Figs. 1 to 11 drawn by Prof. S. I. Smith. Figs. 12 to 16 drawn by the author.

PLATE VI.

FIG. 1. *Pseudotremia cavernarum* (Cope), from Wyandotte Cave, enlarged.—1*a*, head; 1*b*, the same, front view; 1*d*, eyes. (Emerton del.) 1*e*, eyes of a Wyandotte Cave specimen; 1*f*, antenna much enlarged; 1*f*′, terminal joint highly magnified, filled with nerve cells, with numerous tactile setæ, and two tactile or olfactory (?) rods at the end; 1*g*, under lip or deutomala (compare Pl. VIII, fig. 1*f*, and explanation); 1*h*, labrum, with the three central teeth; 1*i*, external malella (*mal. e*), internal malella (*mal. i*), and labiella (*lab*); 1*k*, mandible of one side; 1*m*, the same on the other side; 1*n*, six bundles of setæ on the free edge of 1*m;* 1*o*, eighth pair of legs ; 1*o*′, one of the legs enlarged; 1*p*, a leg of the first pair, next to the head ; 1*q*, a leg of the last pair; 1*r*, a pair of normal legs; 1*s*, male genital armature; 1*t*, the same, different view ; 1*u*, end of the body; 1*v*, a segment (dorsal view). Author del.

FIG. 2. *P. cavernarum* var. *carterensis* Pack., enlarged.—2*a*, head enlarged ; 2*b*, side view of another specimen, ×6; 2*c*, dorsal view of a segment. Emerton del.

PLATE VII.

FIG. 1. *Zygonopus whitei* Ryder.—Anterior part of the body without the legs; 1*a*, front view of the head; 1*b*, male antenna; 1*c*, three segments, enlarged to show the mode of origin of the lateral setæ; 1*d*, 1*e*, origin of the same with the transversely striated area below the flattened boss from which the setæ arise ; 1*f*, one of the sixth pair of legs of the male, forming claspers; 1*g*, a leg of the seventh pair of the male ; 1*h*, a rudimentary leg of the eighth pair (without a claw); 1*k*, rudimentary male genital armature, with a rudimentary clawless leg on one side; 1*l*, 1*m*′, lamina interior ; 1*m*′, a bristly seta, very minute (compare Pl. VIII, fig. 1*i*′, *ml*); 1*n*, male genital armature, lamina exterior (*l. e.*) ; 1*o*, the latter enlarged (1*p*, 1*q*, antenna and labrum, etc., of Zygonopus (?) or Trichopetalum).

FIG. 2. *Trichopetalum lunatum* Harger.—Head and first three segments; 2*a*, nearly front view of head; 2*b*, antenna; 2*c*, two terminal joints still more magnified; 2*d*, leg; 2*e*, a rudimentary leg; 2*f*, two segments, showing the swollen area bearing three setæ.

FIG. 3. Antennæ of *Pseudotremia cavernarum.*—*a*, one from Little Wyandotte Cave; *b*, from Bradford, and *c*, from Carter (Bat) caves; 3*d*, 3*e*, 3*f*, not accurately copied by the artist from the author's camera drawings.

FIG. 4. Eyes of *Pseudotremia cavernarum* from different individuals from Bradford Cave.

FIG. 5. *Scoterpes copei* Pack.—A pair of legs.

All the figures drawn by the author with the camera lucida.

PLATE VIII.

FIG. 1. *Scoterpes copei* (Pack.), enlarged.—1*a*, transverse section of the body, showing the origin of the legs beneath, and, above, the position of the setiferous tubercles; 1*b*, front view of the head, ♂; 1*c*, antenna; 1*d*, the same still more magnified; 1*e*, terminal joint of the same, showing the position of the setæ as seen in outline, the nerve cells, and the three tactile or olfactory (?) rods (*o. r.*) at the end; *sd*, an abnormally enlarged seta; 1*f*, under lip, or deutomala; *hyp.*, "hypostoma;" *stip, i.*, internal stipes; *stip, e.*, external stipes; the former bearing the labiella, *lab.*, and malulella, the latter (external stipes) bearing the external (*mal. e.*) and internal malella (*mal. i.*); 1*g*, end of the under lip highly magnified; 1*h*, another view of the labiella and stipes of one side; 1*i*, genital of male, with the rudimentary eighth pair of legs (*p*), between which is the genital armature (1*k*), more highly magnified at 1*l*, having on each side a rudimentary lamina exterior (*l. e.*), a lamina interior (*l. i.*), and between them a stout spine, ending in a tuft of slender, stiff spinules; 1*j*, one of the two-jointed rudimentary feet, ending in a single claw; 1*m*, two of the lowermost etæ on the segment just behind the genital armature.

Figs. 1 and 1*a* were drawn by J. H. Emerton; all the others by the author.

PLATE IX.

FIG. 1. *Cambala annulata* (Say), enlarged.—1*a*, front view of head enlarged. Emerton del.

FIG. 2. *Cryptotrichus cæsioannulatus* (Wood). (2*a*, eyes of a species of Julus); 2*b*, antenna (from Alabama); 2*c*, the last two joints enlarged; 2*d*, antenna of specimen found two miles from Mammoth Cave, the last joint bearing two terminal olfactory (?) rods; 2*e*, a leg; 2*f*, a pair of legs; 2*g*, eggs, drawn in the same proportion as Fig. 2.

FIG 3. *Lysiopetalum lactarium* (Say).—Head and first four body-segments; 3*a*, eyes; 3*b*, end of the body; 3*c*, antenna; 3*d*, last joint of the same with four two-jointed olfactory (?) rods; 3*e*, a pair of legs; 3*f*, base of the same enlarged; *cx.*, coxa; *st.*, one side of the rudimentary sternum; 3*g*, one of the first pair of legs, with but four joints, the last bearing a comb-like series of setæ; 3*h*, genital armature, ♂, of one side; *lam. e*, lamina exterior; *lam. i*, lamina interior.

Figs. 2 and 3, with details, drawn by the author.

PLATE X.

FIG. 1. *Rhyncholophus cavernarum* Pack.—1*a*, the same drawn from another individual; 1*b*, two cheliceres and a pedipalp; 1*c*, end of third leg (second leg the same). All the figures much enlarged.

FIG. 2. *Lælaps ?* or *Holostaspis ? wyandottensis* Pack.—2*a*, pedipalp; 2*b*, end of first leg.

FIG. 3. *Lælaps* (=*Iphis ?*) *cavernicola* Pack.—Highly magnified.

FIG. 4. *Gamasus* (or *Hypoaspis ?*) *troglodytes* Pack.—4*a*, mandible and pedipalp; 4*b*, end of first leg; 4*c*, end of one of the third pair of legs, side view; the same, dorsal view.

FIG. 5. *Gamasus stygius* Pack.—5*a*, cheliceres (mandibles) and pedipalps; 5*b*, end of second leg; 5*c*, end of a pedipalp.

FIG. 6. *Sejus ? sanborni* Pack.—6*a*, mouth-parts and first pair of legs.

FIG. 7. *Damæus bulbipedatus* Pack. J. H. Emerton del.

FIG. 8. Perhaps the nymph of the preceding (Troussart), or a species of Hypoaspis (Michael). J. H. Emerton del.

FIG. 9. *Uropoda lucifugus* Pack. J. H. Emerton del.

All the figures, except 7 and 9, drawn by the author with the camera lucida.

PLATE XI.

FIG. 1. *Bryiobia ?* (or *Penthalæus ?*) *weyerensis* Pack.—1*a*, end of first leg; 1*b*, end of second leg

FIG. 2. *Oribata alata* Pack.—Dorsal view; 2*a*, the same, ventral view. Emerton del.

FIG. 3. *Chthonius packardii* Hagen.—3*a*, drawn from a younger specimen (Emerton del); 3*b* cheliceres (mandibles); 3*c*, one of the cheliceres, showing the comb-like appendage, or serrula (*s.*) within at the base; 3*d*, the same enlarged; 3*e*, barbed setæ on the chelicera; 3*f*, a pedipalp (chela); 3*g*, one of the first pair of legs; 3*h*, end of 3*g*; 3*i*, a fourth leg; 3*j*, end of a fourth leg. Author del.

FIG. 4. *Chthonius cæcus* Pack.—4*a*, cheliceres of right side; 4*b*, pedipalp (chela); 4*c*, a "finger" of 4*b*.

PLATE XII.

FIG. 1. *Phalangodes flavescens* (Cope), from Wyandotte Cave.—1*a*, the eyes seen from above; 1*b*, the ocellar eminence with the eye at the base; 1*c*, section through the same, involving one eye; 1*c'*, section through the lens and retina of the eye; 1*c''*, eye of example from Wyandotte Cave; 1*c'''*, seen sidewise in var. *cæcum*; 1*d*, a chelicer; 1*d'*, musculature of the same; 1*e*, a pedipalp, showing also its muscles; 1*f*, last three tarsal joints of the fourth leg (the claws not well copied by the lithographer); 1*g*, end of one of the second pair of legs; 1*h*, a second leg from a specimen from Weyer's Cave; 1*i*, 1*i'*, one of the second pair of legs, of example from Senate Chamber, Wyandotte Cave; 1*j*, the same from the same locality; 1*k*, the same from Bat Cave (Carter Caves); 1*l*, first tarsus of example from Weyer's Cave; 1*m*, penis of a Wyandotte example, ending in four teeth, the fourth the longest; 1*n*, lateral view of penis of *P. flavescens*, var. *cæcum*; 1*n'*, 1*n''*, other views of the same, with the muscles of the second joint.

FIG. 2. Chelicer of an example marked from Mammoth Cave; 2*a*, hand of the same, enlarged; 2*b*, pedipalp of the same; 2*c*, two terminal joints of the same.

FIG. 3. *Phalangodes robusta* Pack.—Chelicer; 3*a*, hand of the same; 3*b*, pedipalp of the same.

Fig. 1. Drawn by J. H. Emerton; the remainder by the author.

NOTE.—In reproducing the more delicate and slender appendages, such as the legs, the lithographer, in tracing the sketches, has made them somewhat thicker and clumsier than in the original drawings. This will also apply to the antennæ on Plates VI to IX, etc.

PLATE XIII.

FIG. 1. *Phalangodes armata* (Tellkf.), male, from the Labyrinth, Mammoth Cave.—1*b*, chelicer; 1*b'*, the hand of the same; 1*c*, a pedipalp, ♀; 1*d*, a leg of the second pair, 18^{mm} long; 1*e*, 1*e'*, one of the third (?) pair of legs; 1*f*, tarsus of one of the fourth pair of feet; 1*g*, penis (the shaded portions should have been left clear); 1*h*, ovipositor, 1.5^{mm} long.

FIG. 2. *Phalangodes spinifera* Pack., from Florida.—Chelicer; 2*a*, a pedipalp; 2*b*, a leg of the first pair, 4.5^{mm} long 2*c*, a leg of the second pair, 9^{mm} long.

Fig. 1 drawn by J. H. Emerton; Figs. 1*b* to 2*c* drawn by the author with the camera.

PLATE XIV.

FIG. 1. *Phalangodes*, sp. ×2 times.—The cave it inhabits and the species not determined. Emerton del.

FIG. 2. *Phalangodes robusta* Pack.—One of the second pair of legs, ♀; 2*a*, basal joint; 2*b*, tarsal joints.

FIG. 3. *Nemastoma troglodytes* Pack.—A chelicer; 3*a*, a pedipalp; 3*a'*, its basal joint; 3*b*, 3*b'*, one of the second pair of legs.

FIG. 4. *Nemastoma inops* Pack.—A chelicer; 4*a*, pedipalp; 4*b*, a leg of the second pair; 4*c*, 4*c'*, a leg of the fourth pair.

FIG. 5. *Phlegmaccra cavicolens* Pack., ×3, (Emerton del.)—5*a*, 5*b*, 5*c*, chelicer; 5*d*, pedipalp; 5*e*, leg of the second pair; 5*f*, nine terminal joints of the same; 5*g*, leg of first or third pair.

All the figures, except 5, drawn by the author.

PLATE XV.

FIG. 1. *Anthrobia mammouthia*, ♀.
FIG. 2. *Anthrobia mammouthia*, ♀, under side.
FIG. 2. *Anthrobia mammouthia*, palpus of ♂.
FIG. 4. *Anthrobia mammouthia*. ♀, side view.
FIG. 5. *Anthrobia mammouthia*, front of head and mandibles.
FIG. 6. *Anthrobia mammouthia*, foot of first pair.
FIG. 7. *Linyphia weyeri*, ♂.
FIG. 8. *Linyphia weyeri*, maxillæ and mandibles of ♂.
FIGS. 9, 10. *Linyphia weyeri*, palpus of ♂
FIG. 11. *Linyphia weyeri*, epigynum.
FIG. 12. *Linyphia weyeri*, foot.
FIG. 13. *Linyphia incerta*, ♂.
FIG. 14. *Linyphia incerta*, ♀ maxillæ.
FIGS. 15, 16. *Linyphia incerta*, palpus of ♂.
FIG. 17. *Linyphia incerta*, epigynum.
FIG. 18. *Linyphia incerta*, eyes of ♀, from Fountain Cave.
FIG 19. *Linyphia incerta*, foot.
FIG. 20. *Linyphia incerta*, ♂, side view.
FIG. 21. *Linyphia incerta*, ♂, front of head and mandibles.
FIG. 22. *Nesticus pallidus*, ♀.
FIG. 23. *Nesticus pallidus*, ♀, under side.
FIG. 24. *Nesticus pallidus*, ♀, side view.
FIG. 25. *Nesticus pallidus*, ♀, foot.
FIG. 26. *Nesticus pallidus*, palpus of ♂.
FIG. 27. *Nesticus pallidus*, epigynum.
FIG. 28. *Nesticus carteri*, ♀, epigynum.
FIG. 29. *Linyphia subterranea*, ♀, under side.
FIG. 30. *Linyphia subterranea*, ♀, front of head and mandibles.
FIG. 31. *Linyphia subterranea*, ♀, side view. Figs. 1—31 drawn by J. H. Emerton.
FIG. 32. *Willibaldia cavernicola* Keys.; 32*a*, head from in front; 32*b*, epigynum. Marx del
FIG. 33. *Erigone infernalis* Keys.; 33*a*, head; 33*b*, epigynum. Marx del.

PLATE XVI.

FIG. 1. *Lipura ? lucifugus* Pack., Wyandotte Cave. Emerton del.

FIG. 2. *Degeeria cavernarum* Pack., from Little Wyandotte Cave.—*c*, collophore; *2g*, antenna of an example from Carter caves (Zwingle's); *2b*, elater or spring of a Little Wyandotte specimen; *2c*, antenna of a Bradford Cave specimen; *2d*, antenna of a Diamond Cave specimen; *2e*, elater of a Bradford Cave example; *2f*, elater of a Diamond Cave example; *2g*, *2g'*, elater of an individual from Carter Caves (Zwingle's); *2a*, end of tarsus of leg of the second pair.

FIG. 3. *Lepidocyrtus atropurpureus* Pack., from Diamond Cave.—*3a*, end of one of the last pair of legs; *3b*, end of the elater.

FIG. 4. *Smynthurus ferrugineus* Pack., .08^{mm} long, from Weyer's Cave.—*4a*, antennæ; *4b*, end of one of the legs of the third pair; *4c*, elater.

Figs. 2 to 4, and details, drawn by the author with the camera lucida.

PLATE XVII.

FIG. 1. *Campodea cookei* Pack., enlarged.—*1a*, head, upper side; *1b*, the same, under side; *1c*, terminal joints of the antennæ, showing at (*ol.*) the olfactory (?) area; *1d*, *1d'*, antenna; *1f*, *1f'*, *1f''*, one of the cercopods; *1g*, end of the body, with a portion of a cercopod; *1h*, end of the body; *1i*, spinulated setæ on different parts of the body.

FIG. 2. *Campodea staphylinus* Westw.—Terminal joint of the antenna, showing the olfactory (?) area.

FIG. 3. *Hadenœcus subterraneus*, Mammoth Cave. Fungus (*f.*) growing from the end of the body. Kingsley del.

FIG. 4. *Dorypteryx pallida* Aaron.—Right maxilla from above; *4a*, the same enlarged; *4b*, end of a claw. Drawn by Dr. Hagen.

All the figures, except 1, *1a*, *1b*, 3, and 4, drawn by the author.

PLATE XVIII.

FIG. 1. *Anophthalmus tellkampfii* Erichs. (Emerton del.)—"The figure is a poor one; the antennæ, head, and thorax, and on the elytra the characteristic pair of sensitive hairs is entirely omitted; all other species have three sensitive hairs on each elytrum" (E. A. Schwarz in letter).

FIG. 2. *Anophthalmus tenuis* Horn

FIG. 3. *Anophthalmus eremita* Horn, Little Wyandotte Cave.—"A tolerably fair representation; the last joint of the maxillary palpi should be *longer* than the penultimate, and some indication of the elytral striæ ought to be given" (Schwarz).

FIG. 4. *Anophthalmus menetriesii* Motsch. (Emerton del.)—"This is a fair representation, except that the antennæ are altogether too heavy" (E. A. Schwarz).

FIG. 5. *Anillus explanatus* Horn. (copied from Horn).—The antennæ darwn by lithographer too stout and the setæ too coarse.

PLATE XIX.

FIG. 1. *Anophthalmus tellkampfii* Erichs., from Salt Cave.—Antenna; *1a'*, three olfactory setæ and two tactile setæ from the third segment from the end of the antenna; *1b*, terminal joint of left antenna of example from Mammoth Cave; *1c*, left maxilla of example from Salt Cave; *1c'*, end of left maxillary palpus; *1c''*, end of left galea; *1d*, labium of Salt Cave example; *1e*, end of a fore leg from a Mammoth Cave example.

FIG. 2. *Anophthalmus menetriesii* Motsch., from Diamond Cave.—Antenna; *2a*, terminal joint; *2b*, end of right maxillary palpus; *2c*, end of left galea; *2d*, labial palpus; *2e*, end of a leg of the first pair.

FIG. 3. *Anophthalmus tenuis* Horn, from Bradford's Cave.—Antenna; *3a*, terminal joint of the antenna; *3a'*, fourth joint from the end, showing the arrangement of the olfactory setæ; *3a''*, four of the same in the middle of the joint; *3a'''*, a number of olfactory setæ crowded together on the middle of the terminal joint of the antenna (they also occur in the same crowded condition on the penultimate joint, the third being much as the fourth joint from the end, but the setæ no more numerous); *3b*, end of maxillary palpus; *3c*, end of left galea; *3d*, a leg of the first pair; *3e*, end of the same, enlarged.

FIG. 4. *Adelops hirtus* Tellkf. Antenna, much enlarged, showing the olfactory organs (*ol.*) on the last four joints; *4a*, a maxillary palpus.

All thefigures drawn by the author with the camera.

PLATE XX.

FIG. 1. *Anophthalmus pubescens* Horn. Marx del.

FIG. 2. *Anophthalmus interstitialis* Hubbard. Marx del.

FIG. 3. *Anophthalmus tenuis* Horn. Marx del.

FIG. 4. *Anophthalmus eremita* Horn. Marx del. (The fine elytral striæ not clearly brought out by the lithographer.)

FIG. 5. *Anophthalmus pusio* Horn. Marx del.

FIG. 6. Anophthalmus larva (presumably of *A. tellkampfii*); Emerton del.—6*a*, antenna; 6*b*, maxilla; 6*c*, labium and labial palpi; 6*d*, labrum.
FIG. 7. Pupa, presumably of *A. tellkampfii*. Emerton del.
FIG. 8. *Adelops hirtus* Tellkf. Emerton del.
FIG. 9. *Adelops hirtus* Tellkf. Larva. Emerton del.—9*a*, antenna.
FIG. 10. *Batrisus spretus*. Emerton del.
FIG. 11. *Quedius fulgidus*. Emerton del.
FIGS. 12 and 13. Staphylinid beetles, not identified, from caves. Emerton del.
FIG. 14. An unknown eyeless Coleopterous larva from Bat Cave. Emerton del.
FIG. 15. A staphylinid larva, not identified, from cave. Emerton del.
FIG. 16. Blastoderm cells on surface of egg of the cave spider, (*Anthrobia mammouthia*). Author del.

PLATE XXI.

FIG. 1. Brain and eyes of an undetermined Cambarus with normal eyes; *c*, cornea; *op. n*, optic nerve; ant^1, first antennal nerve; ant^2, nerve of second pair of antennæ.
FIG. 2. Brain and rudimentary eyes of *Orconectes pellucidus*, lettering as in Fig. 1.
FIG. 3. Section of eye of *Orconectes hamulatus* Cope and Packard; *op. gang.*, optic ganglion; *g. c.*, ganglion cells; *hy.*, hypodermis; *mus.*, adductor muscle; *con. c.*, connective tissue cells.
FIG. 3*a*. Section of the same, near the middle of the eye; *op. n.*, optic nerve; *a*, a mass of ganglion-cells extending to the end of the cornea.
FIG. 3*b*. Section very near the preceding; 3*c*, connective tissue cells from the side of the optic ganglion; 3*d*, ganglion cells, with the walls nearly effaced; *x*, a large one surrounded by those of ordinary size; 3*e*, a few connective tissue cells in the place occupied by the rods and cones of the normal eye; 3*f*, hypodermis at end of the eye, in place of the cones of the normal eye, the cell walls mostly obsolete; 3*g*, nuclei.
FIG. 4. Auditory setæ from within the ear from an undetermined Cambarus, with normal eyes; 4′, one of the same more highly magnified.
FIG. 5. Setæ from *O. pellucidus* from Indiana; situated around the entrance to the ear; 5*a*, auditory setæ from the auditory sac of the same.
FIG. 6. Auditory setæ from the ear of *Orconectes hamulatus;* 6*a*, the same enlarged.
All the figures drawn by the author.

PLATE XXII.

FIG. 1. *Chlænius pensylvanicus*.—Head dissected to show the brain, with optic ganglia (*o. g.*) and optic nerves and eyes; *pc. l.*, procerebral lobes, or central part of the brain.
FIG. 2. *Anophthalmus tellkampfii*. Head, showing the central portion or brain proper, the optic ganglion and optic nerves with the eyes being totally abolished.
FIG. 3. *Anophthalmus tellkampfii*. Longitudinal or sagittal section of the head; *pel*, supraœsophageal ganglion; *s. œ*, subœsophageal ganglion; *f. g.*, frontal ganglion; *mx. n.*, nerve to the maxillæ; *mx. m.*, maxillary muscles; *mx*′, base of maxillæ; *l. n.*, nerve to the lingua (*l.*); *m.*, mouth; *md.*, mandible; *lbr.*, labrum; *com.*, commissure.
FIG. 3*a*. The same; longitudinal section on one side of the preceding; *sg*′, sg^2, salivary glands; *l*, lingua; *pv*, proventriculus; *st*, stomach.
FIG. 4 to 4 *e*, horizontal sections through the brain of *Anophthalmus tellkampfii;* 4*f*, vertical section. For the sections see Pl. XXIII, fig. 2 to 2*c*.
FIG. 5. *Orconectes pellucidus*, from a cave in Indiana. Olfactory rods on the terminal three joints of the outer flagellum.
FIG. 6. Setæ from near opening to the ears of *O. pellucidus*, from cave in Indiana.
FIG. 7. Olfactory rods of *Orconectes pellucidus*; 6*a*, 6*b*, 6*c*, the same magnified, with nerve-cells in the base.
All the figures drawn by the author with the camera lucida.

PLATE XXIII.

FIG. 1. *Asellus communis*. *Op. g.*, optic ganglion; *op. n.*, optic nerve; *e.*, eye; *rec.*, retinal cells; 1*a*, portion of the brain, with the optic ganglion and optic nerve and eye of the same enlarged; 1*b*, section through the head and brain of *Cæcidotœa stygia*, showing the entire absence of the optic ganglion and optic nerve, and the rudimentary eye; *ret.*, rudimentary retina; 1*c*, sections through the rudimentary eye, composed of two facets; 1*d* to $1d^{iv}$, sections through the eye of the same; at 1*d* a single facet; at 1*d*″ three; at $1d^{iv}$ a single lens surrounded by the retina.
FIG. 2 to 2*c*, vertical sections through the head and brain of *Anophthalmus tellkampfii*.
FIG. 3, 3*a*, 3*b*, 3*c*, 3*d*, sections through the head and eyes of *Adelops hirtus*, showing the entire absence of optic ganglia and optic nerves; at 3*a*′ the eye is seen with rudiments of three lenses surrounded by the rudimentary pigment.
All the figures drawn by the author with the camera.

Plate XXIV.

Fig. 1. Section though the head and brain of *Cermatia forceps*; *op. g.*, optic ganglion; *com.*, commissures.
Fig. 2. Section through the head of *Bothropolys*, showing the optic ganglion (*op. g.*), optic nerves (*op. n.*), and eyes.
Fig. 3. Longitudinal section through the head of *Pseudotremia cavernarum*; *pcl*, procerebral lobes or brain; *subœ.* subœsophageal ganglion; *com.*, commissure leading from it; *n.*, nerve from the central nervous system to the first pair of legs.
Fig. 4. The same passing through one of the eyes, and showing four of the facets; *ant. l.*, antennal or olfactory lobes; *ant. n.*, nerve to the antenna; *m.*, mouth.
Fig. 5. Transverse section through the head and brain of the same, showing no traces of an optic nerve.
Figs. 6 and 7. Transverse sections through the same specimen; *ol. l.*, olfactory lobe.
Fig. 8. Horizontal section through *Pseudotremia cavernarum* passing through the eyes and showing the absence of the optic nerves; *sg.*, salivary glands; *st.*, stomach.
Fig. 9. The same, drawn from a different section; *pre.*, brain; *subœ. g.* subœsophageal ganglion.
Fig. 10. Portion of Fig 9, passing through one eye highly magnified, to show at *gang. c.*, that the ganglion-cells impinge directly upon the eye, the optic nerve being atrophied, unless the fibers or myeloid substance at *op. n.* be the atrophied remains of the optic nerve. Four facets are cut through; *hy.*, hypodermis, passing at *ret.* into the retina.
Fig. 11. Another section through the same; the brain, or optic ganglion, reaching to near the eye, but with no true optic nerve.
Fig. 11*a*. Section through the eye on one side; *my.*, myeloid substance; *gc.*, ganglion cells; *c*, cones; *ret*, retina. (The figure is too heavily shaded, and does not do justice to the author's drawings.)
Fig. 12. Transverse section through the same.
Fig. 13. The section succeeding that represented by Fig. 12.
All the figures drawn by the author with the camera.

Plate XXV.

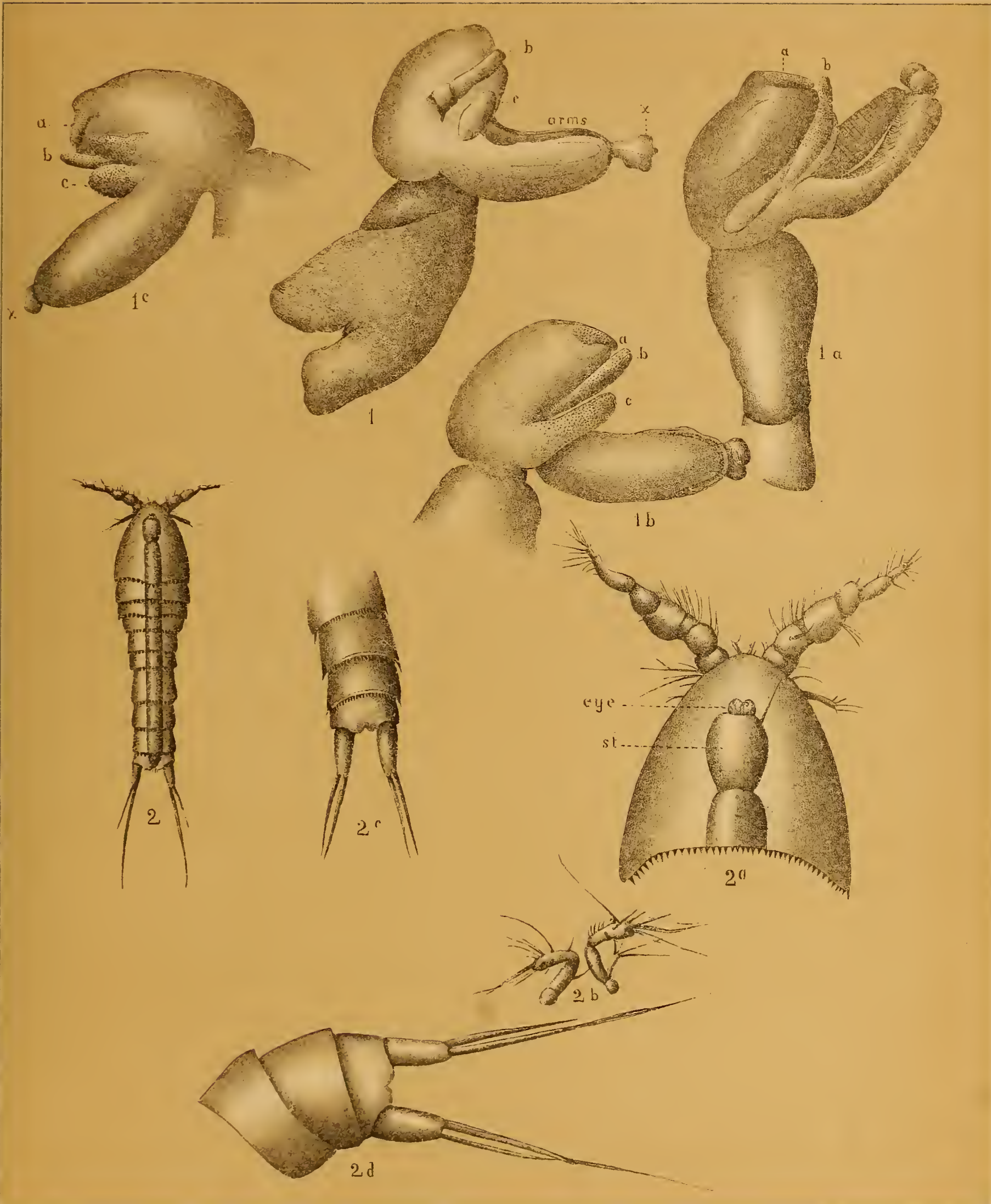
Fig. 1. *Pseudotremia cavernarum.*—Horizontal section through the head and brain; *ant.*, antenna; *œ.*, œsophagus; *sg.*, subœsophageal ganglion.
Fig. 2. Section through the same farther in front and passing through the olfactory lobes (*ol. l.*); antennal nerve (*ant. n.*); *c.*, *l.*, commissural lobes.
Figs. 3, 4–10. *Scoterpes copei*, sections through the head and brain, showing the entire absence of optic ganglia, optic nerves, and eyes; *g. c.*, ganglion cells; *p. c.*, procephalic lobe.
All the figures drawn by the author with the camera.

Plate XXVI.

Figs. 1–12. *Crangonyx vitreus*, from Mammoth Cave. Sections through the head and brain, to show the absence of the optic ganglia, optic nerves, and eyes.
Fig. 13. Section through the head and brain of *Gammarus maculatus* to show the well-developed optic ganglia and nerves, with the eyes; *op. l.*, optic lobes.
All the figures drawn by the author with the camera.

Plate XXVII.

Fig. 1. Brain of Geophilus. After Newport.
Fig. 2. Brain of *Polydesmus complanatus*, showing, as in Fig. 1, the entire absence of optic lobes and optic nerves; these myriopods being eyeless. After Newport.
Fig. 3. *Scoterpes copei*. Side view, enlarged. After Emerton.
Fig. 4. *Polydesmus cavicola* Pack.; dorsal and lateral view; *a*, antenna; *b*, section through the body; *c*, dorsal view of two segments, showing the tubercles on the surface; *d*, end of the body, side view. Emerton del.
Fig. 5. *Camtarus* (Orconectes) *pellucidus*, form *inermis*. After Cope.



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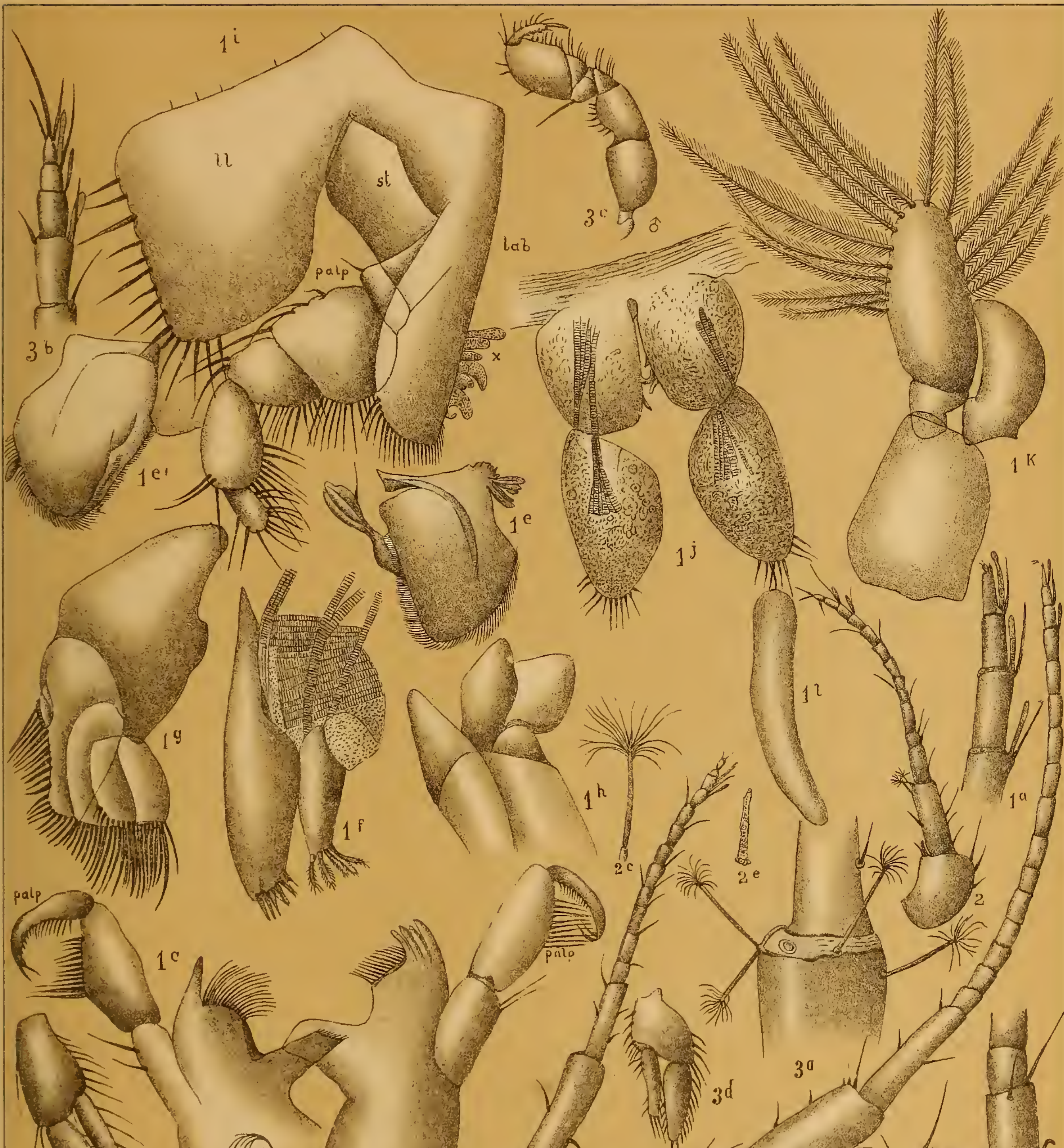
CAVE CRUSTACEA.



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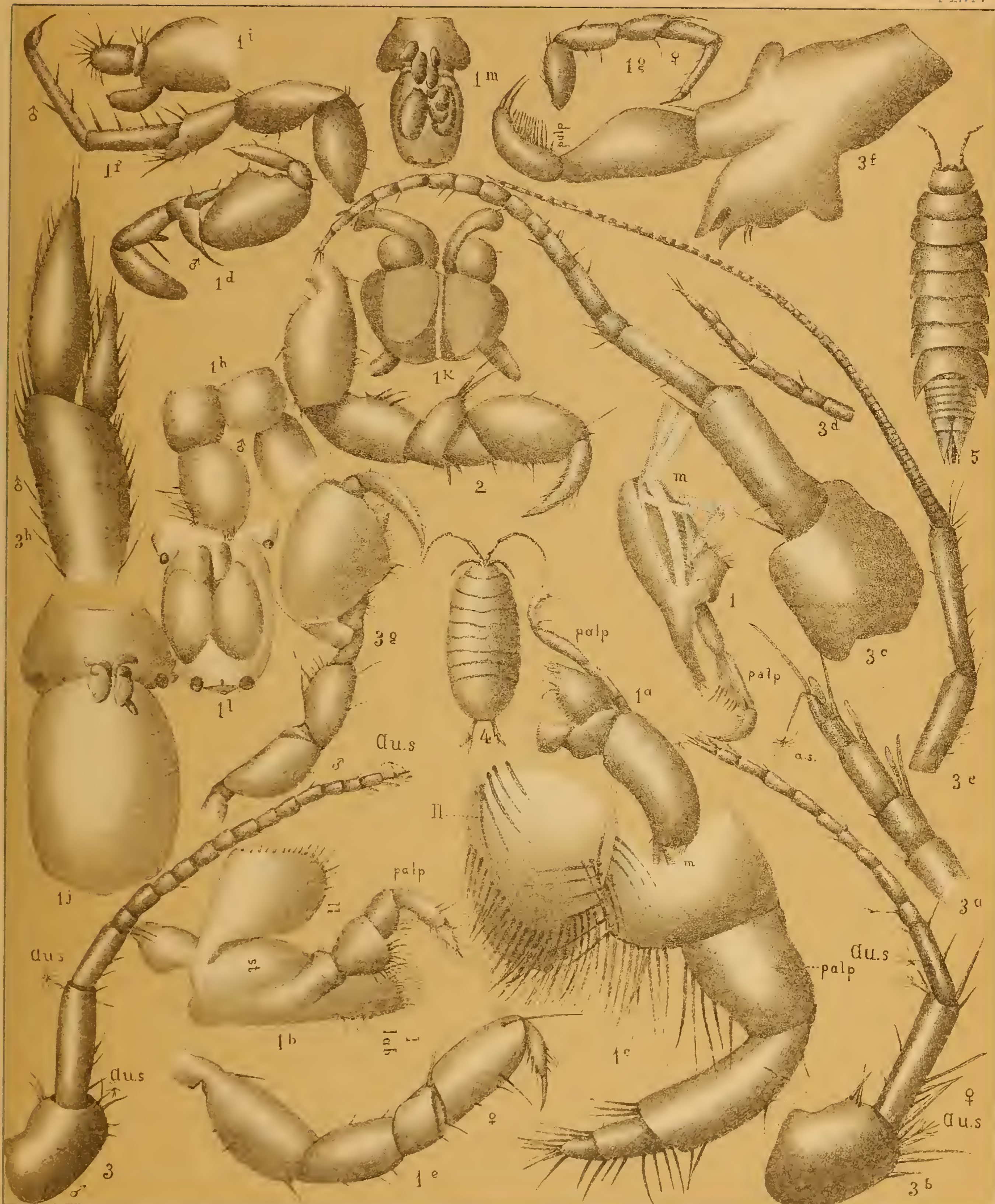
ASELLUS COMMUNIS, ETC.

CŒCIDOTÆA STYGIA.



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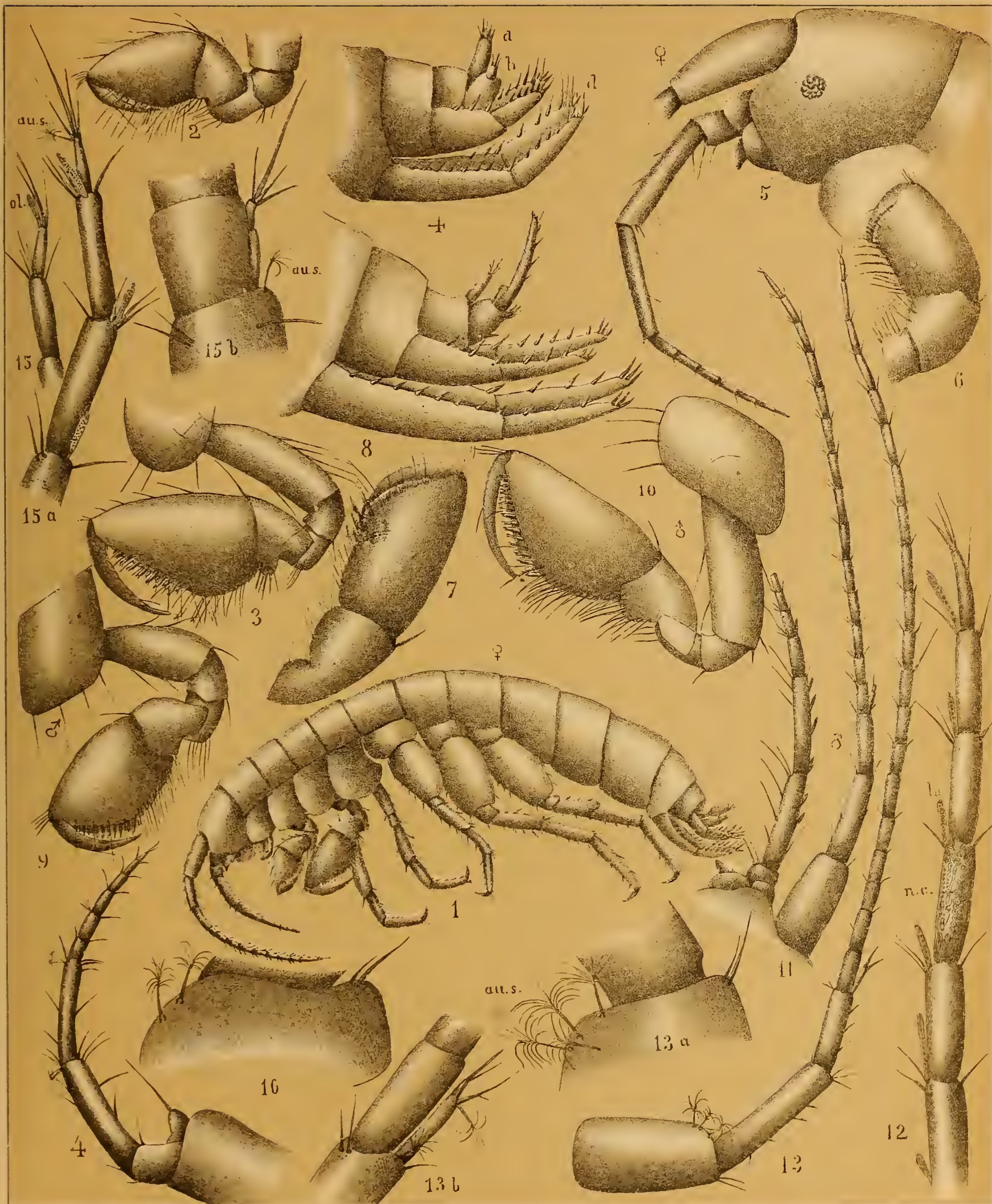
CŒCIDOTÆA AND ASELLUS.



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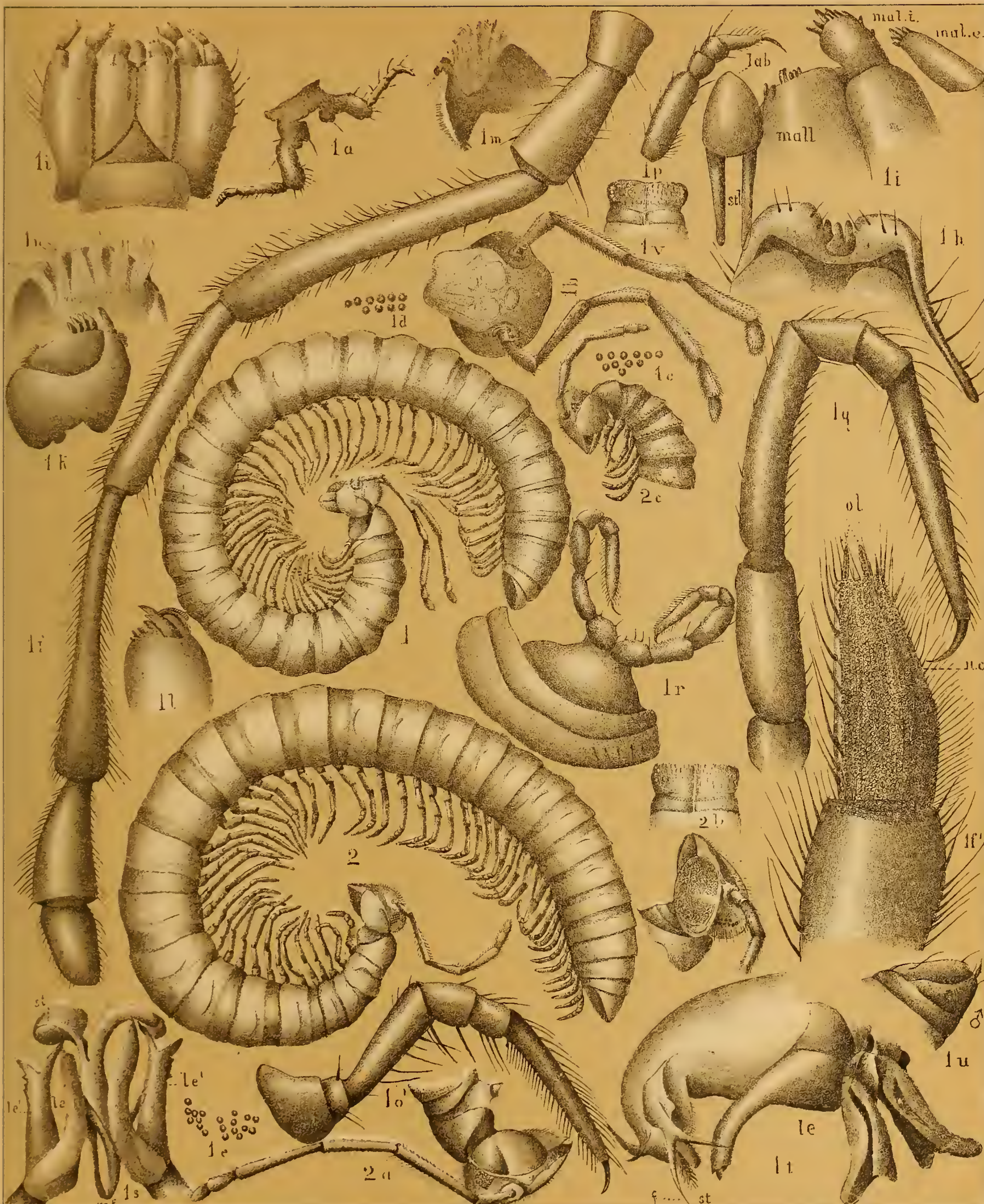
CRANGONYX VITREUS AND PACKARDII, ETC.



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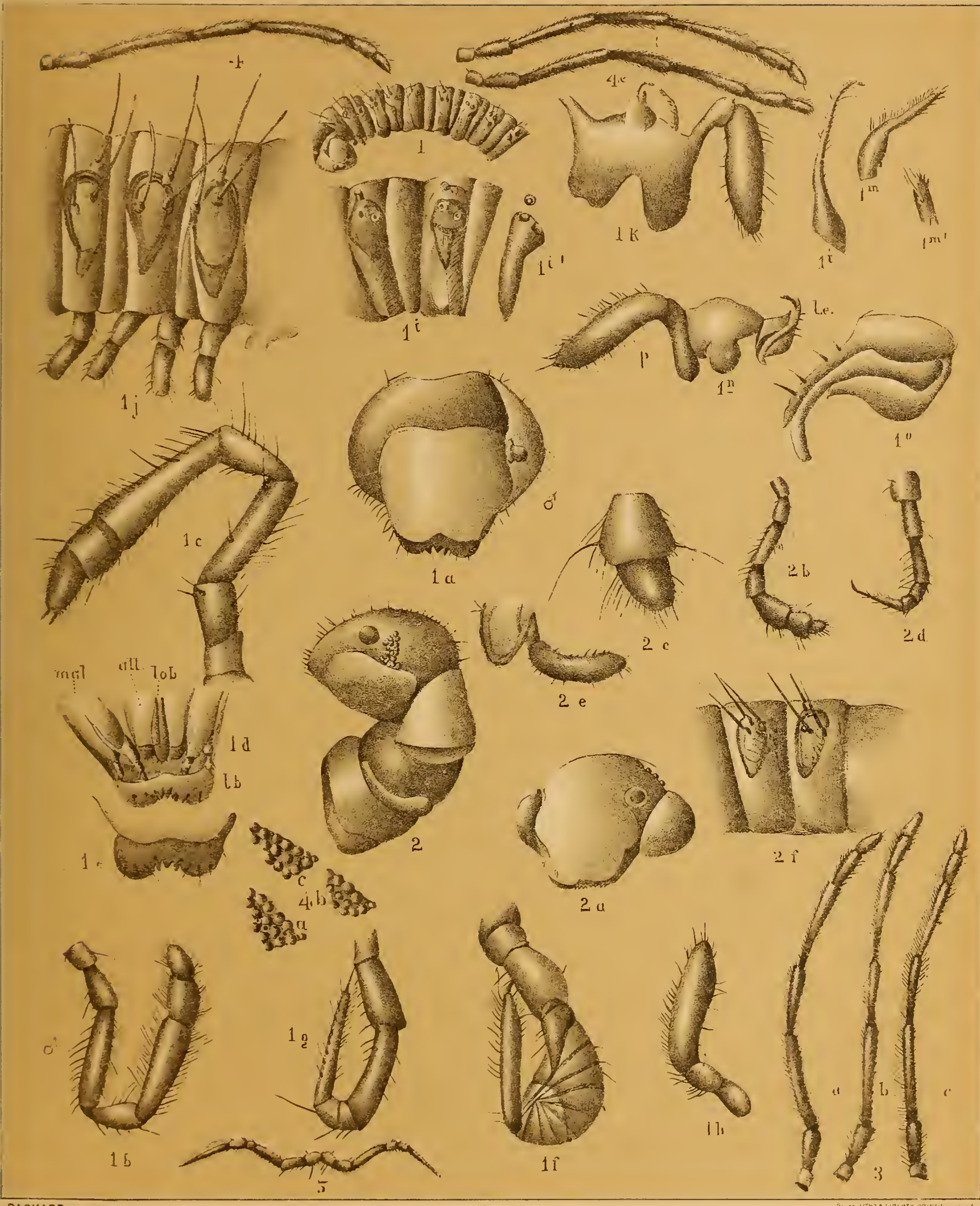
LYSIOPETALUM CAVERNARUM, ETC.



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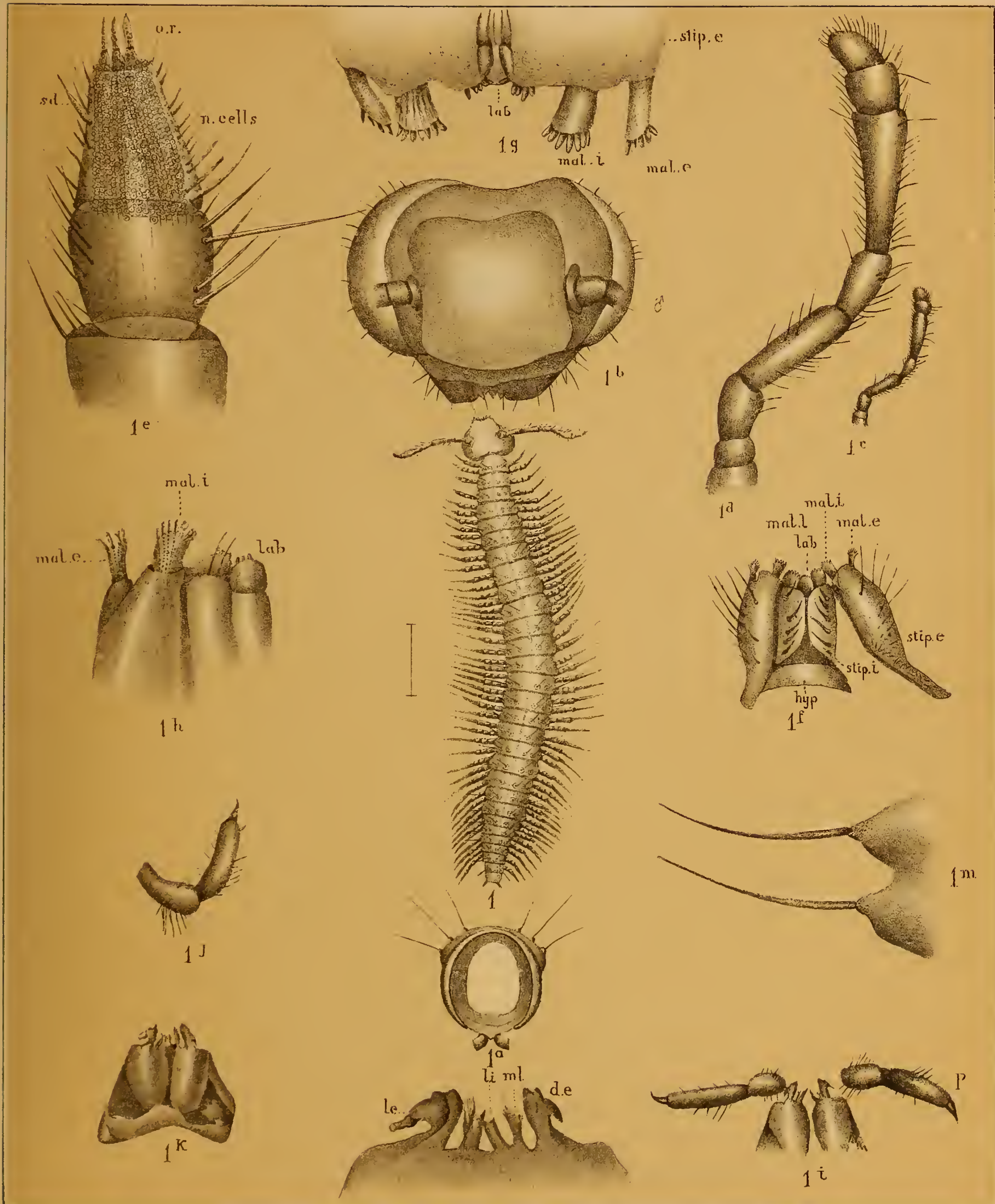
ZYGONOPUS WHITEI AND TRICHOPETALUM LUNATUM, ETC.



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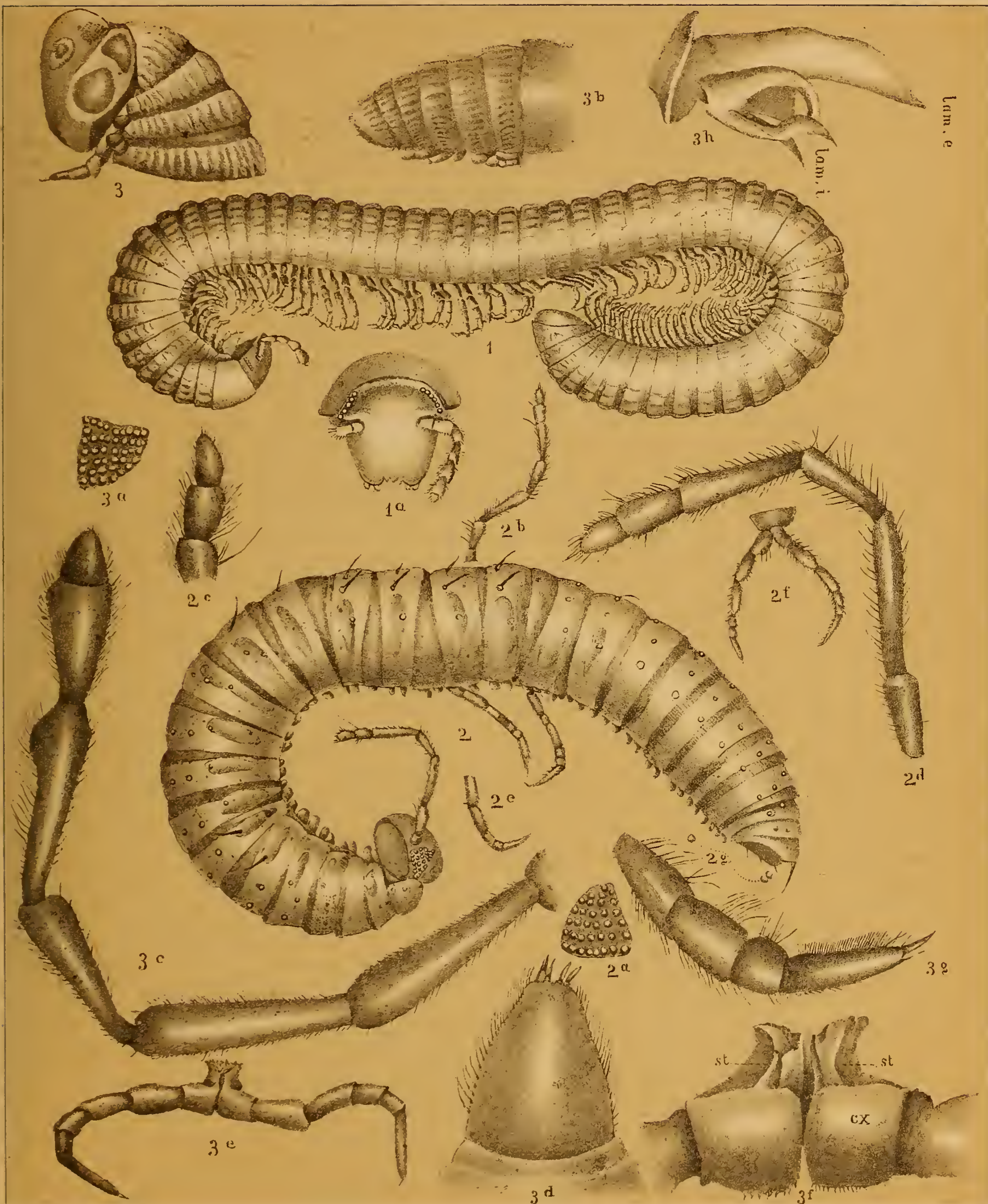
SCOTERPES COPEI.



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CRYPTOTRICHUS AND CAMBALA

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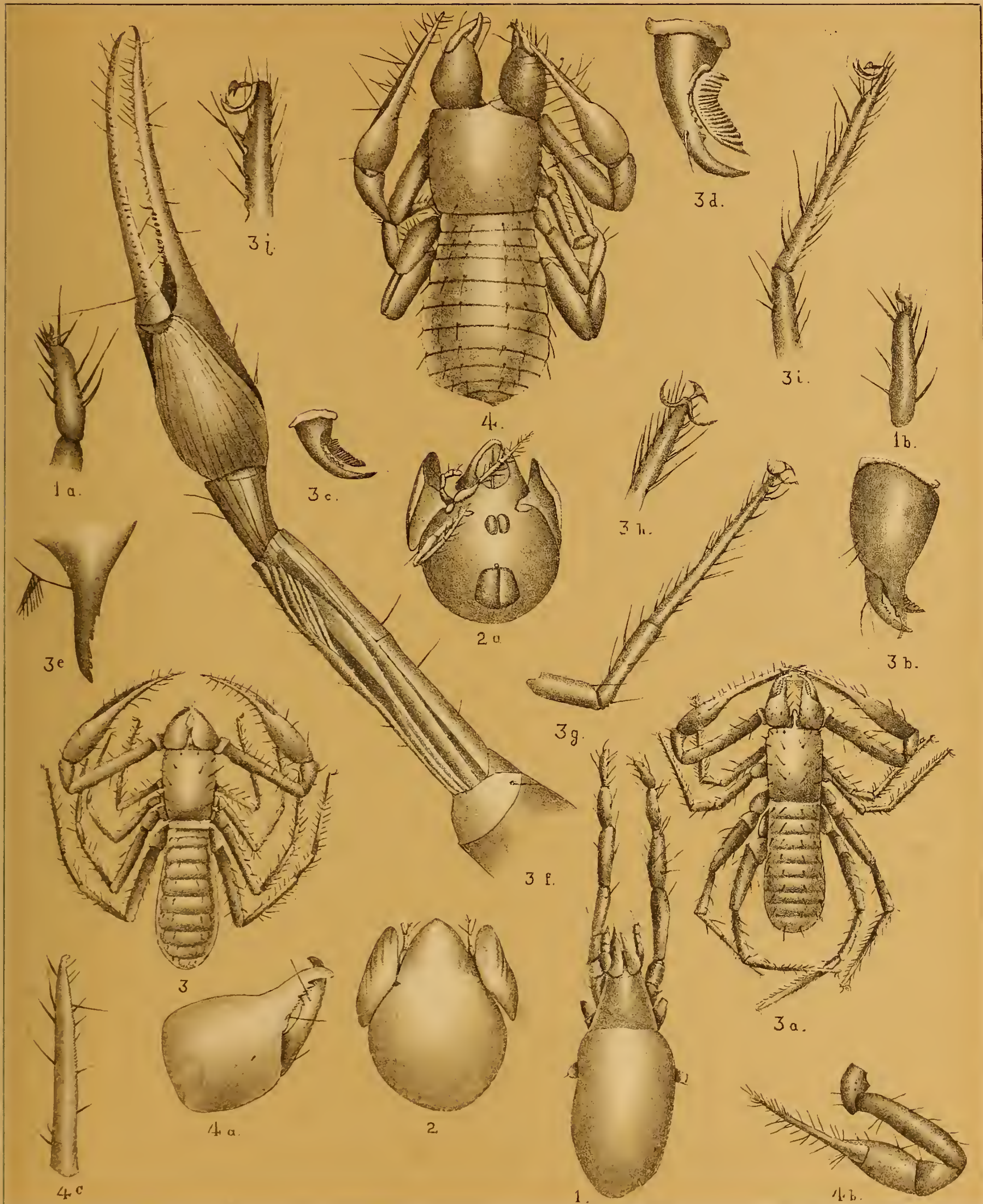
CAVE MITES.



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CAVE MITES AND CHERNETIDAE.

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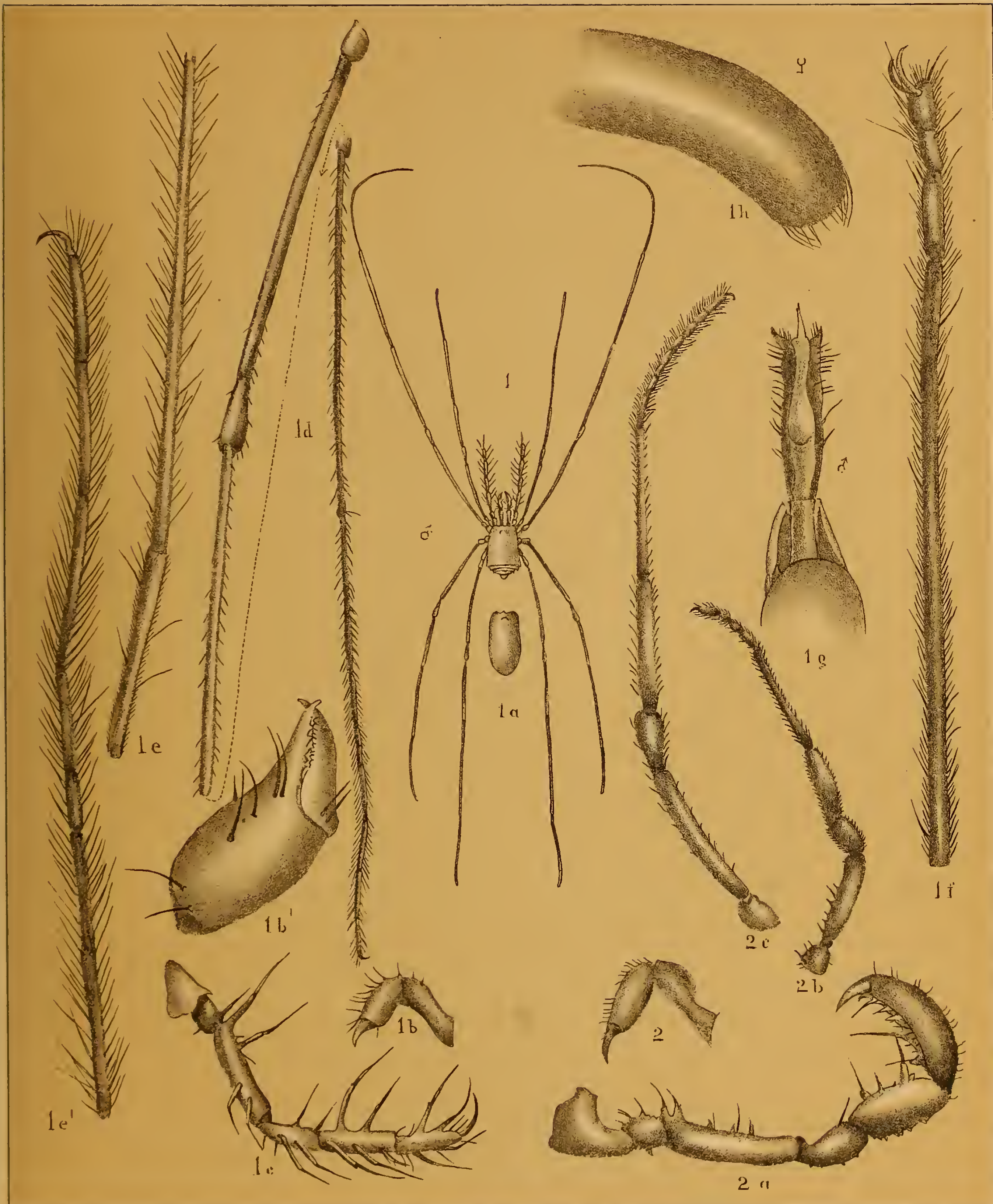

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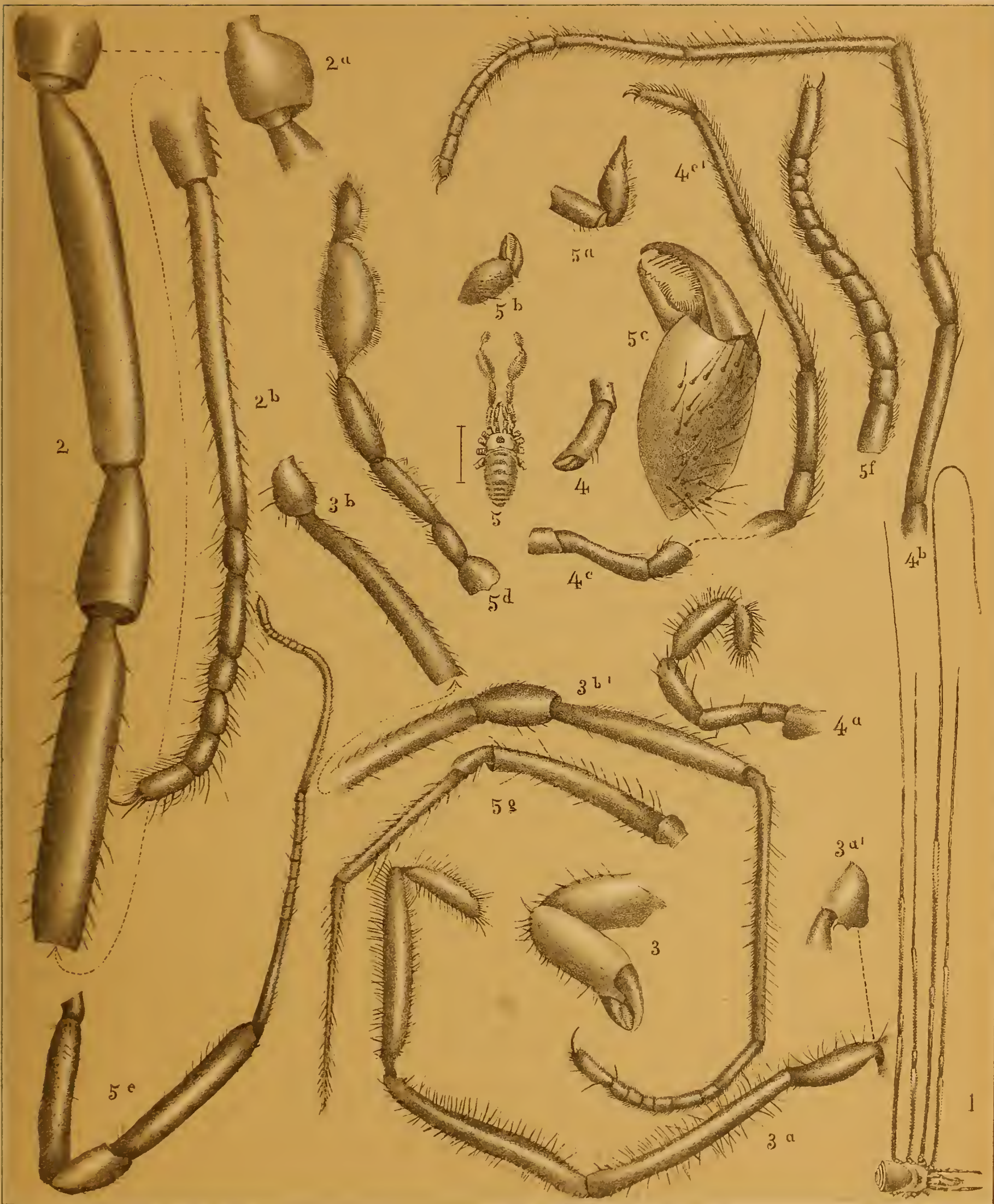
PHALANGODES ARMATA, ETC.



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PHALANGODES, NEMASTOMA, PHLEGMACERA, ETC.

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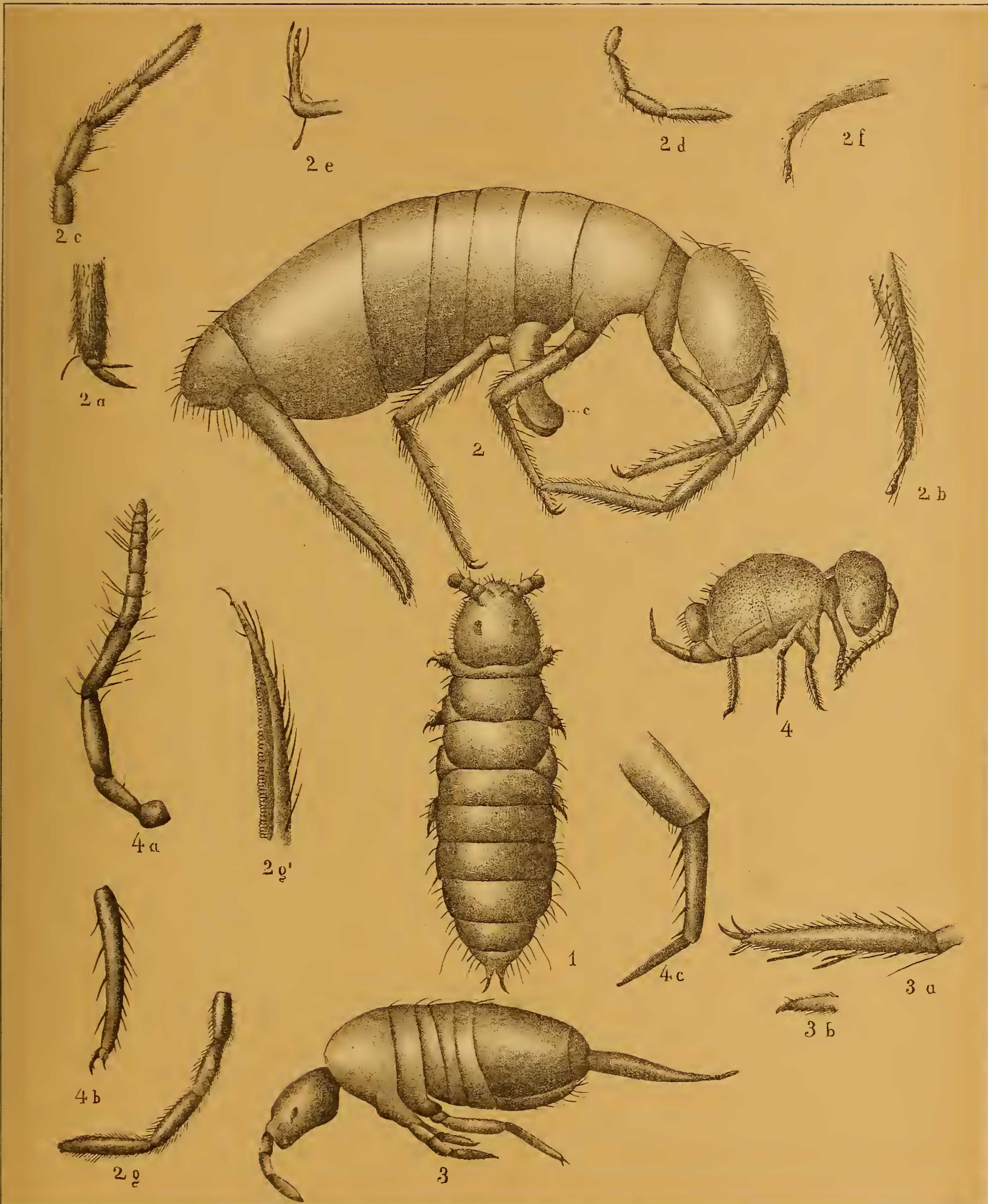
CAVE SPIDERS.



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CAVE PODURIDÆ.

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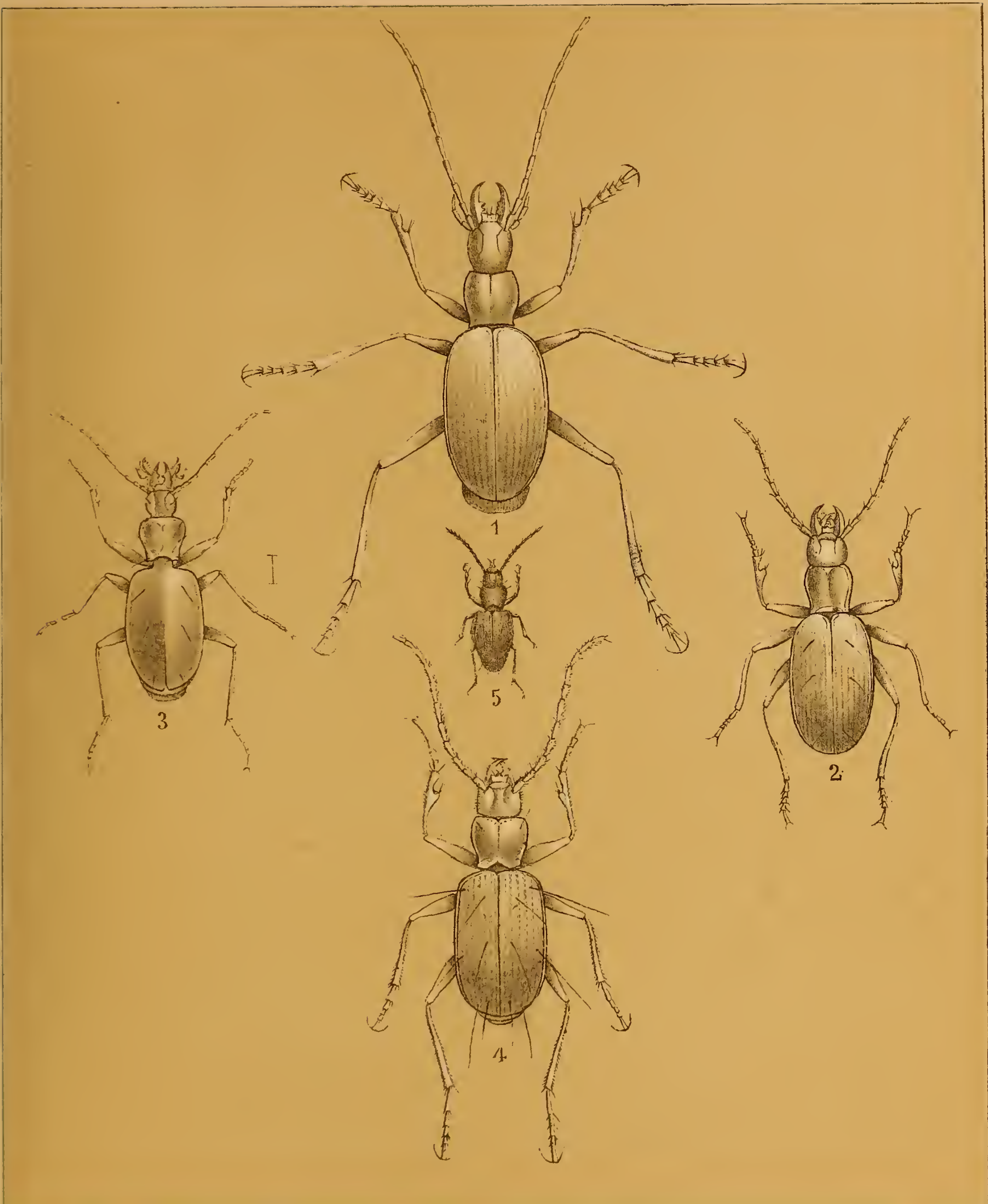
CAMPODEA COOKEI, ETC.



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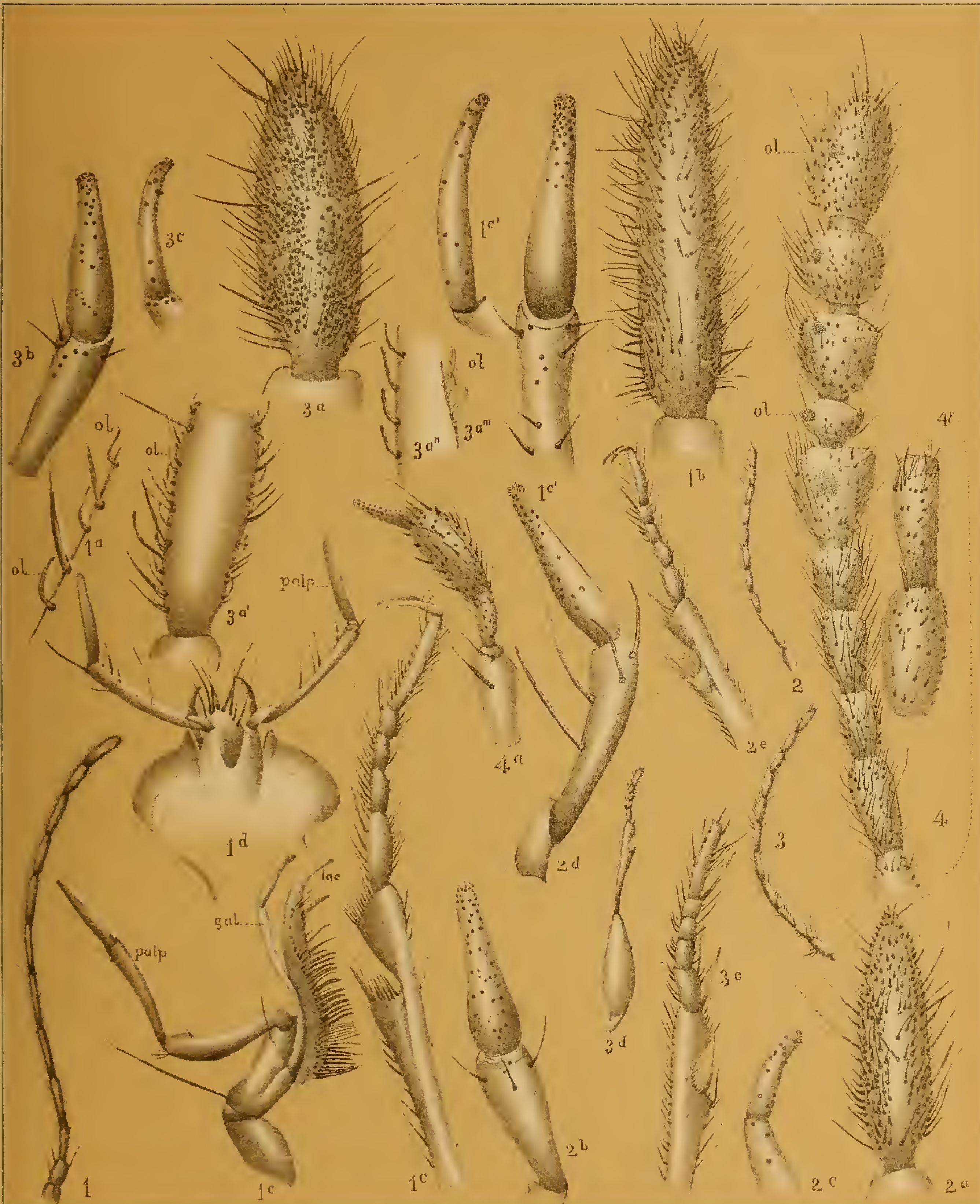
ANOPHTHALMUS AND ANILLUS.



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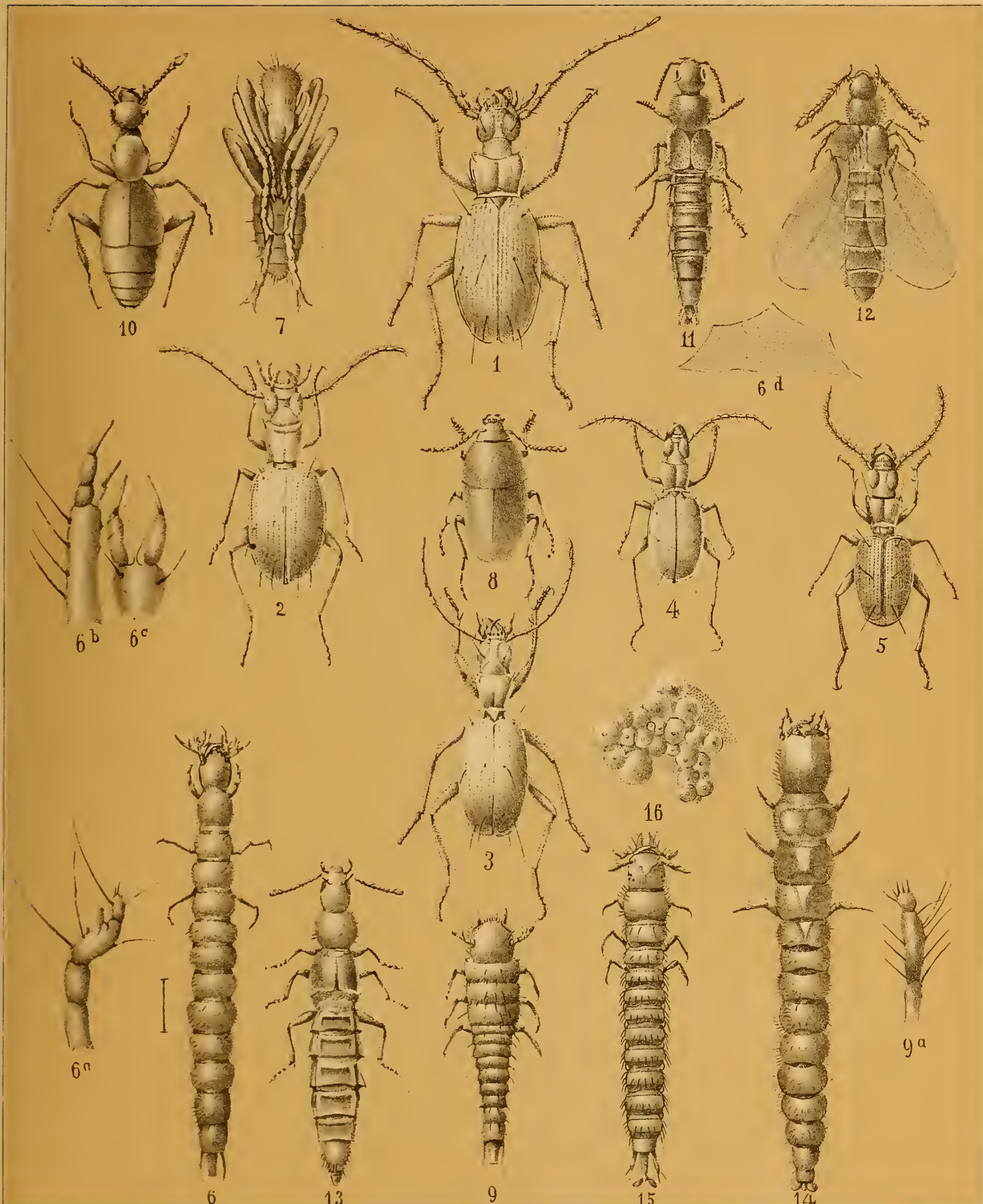
ANOPHTHALMUS AND ADELOPS.



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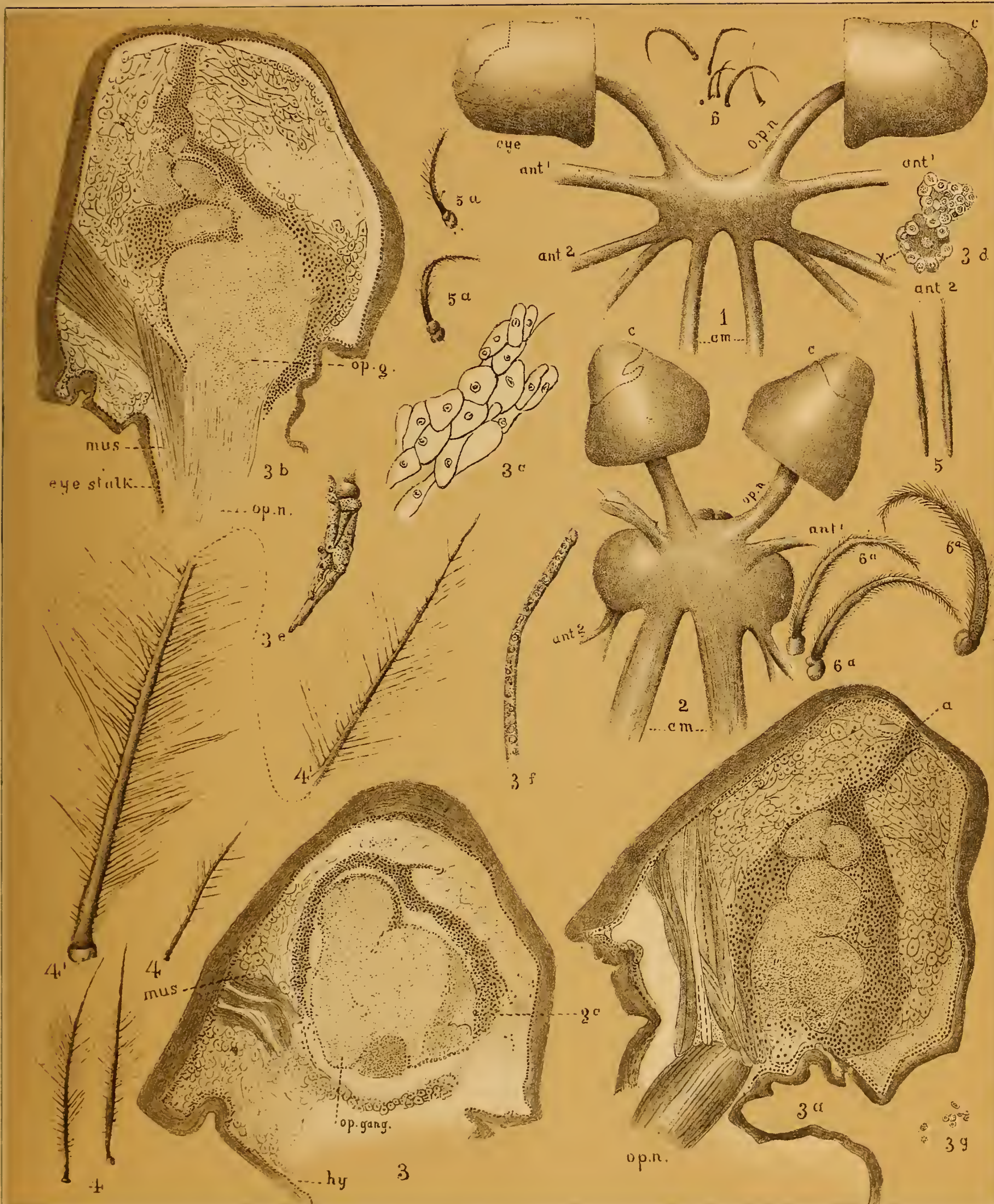
CAVE COLEOPTERA.



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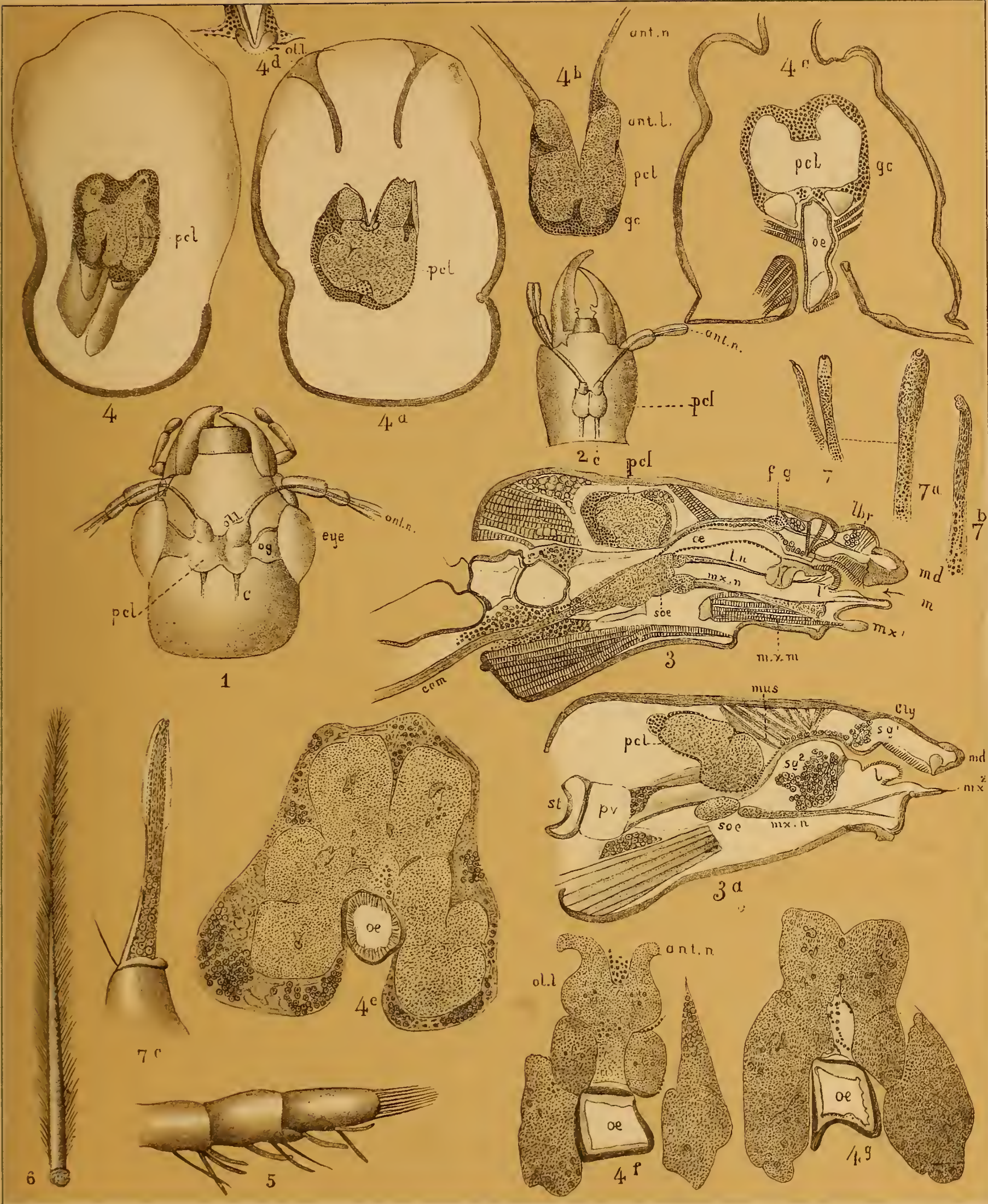
BRAIN, ETC., OF BLIND CRAYFISH.



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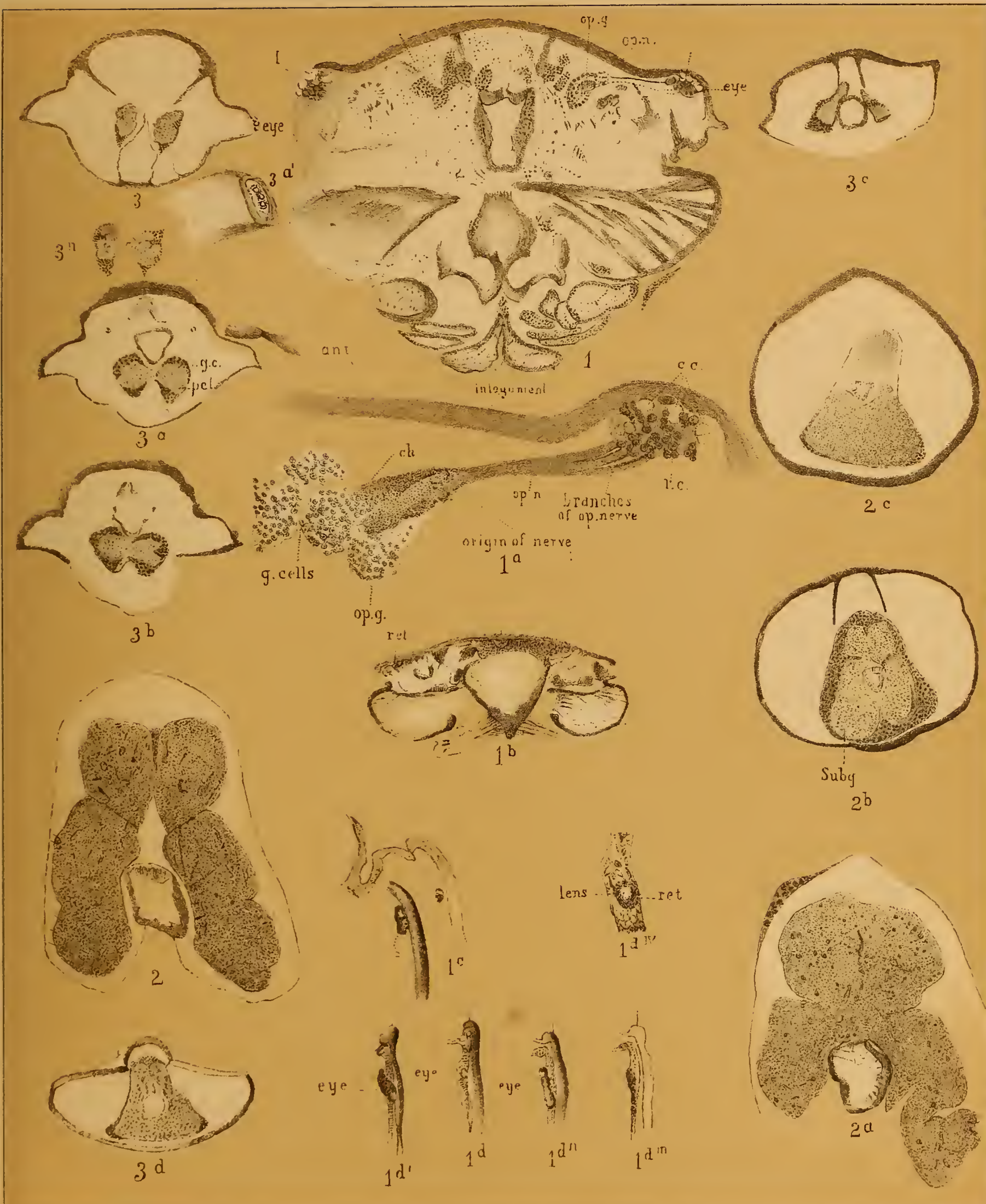
BRAIN OF ANOPHTHALMUS, ETC.



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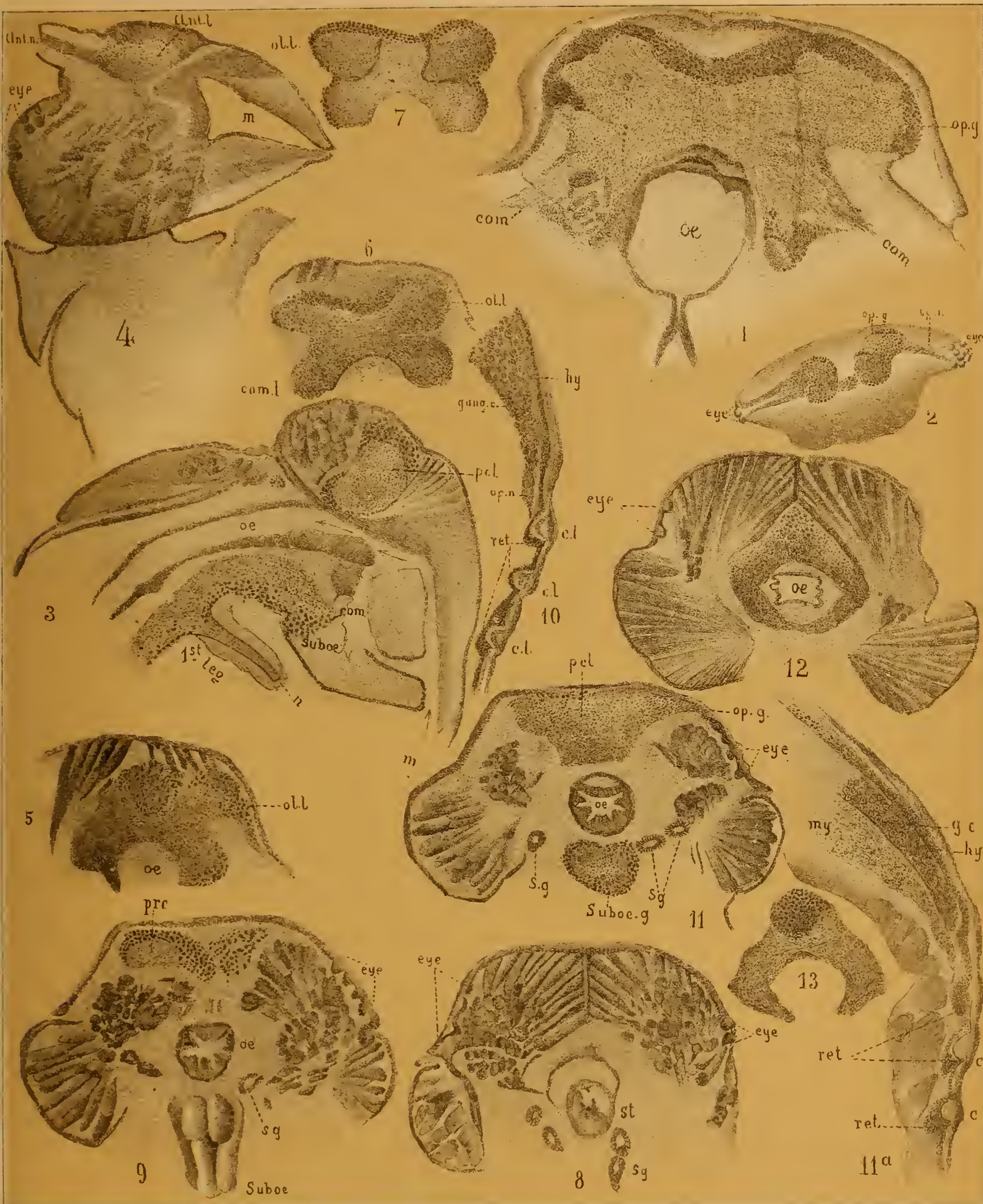
BRAIN AND RUDIMENTARY EYES OF CECIDOTÆA, AND BLIND BEETLES.



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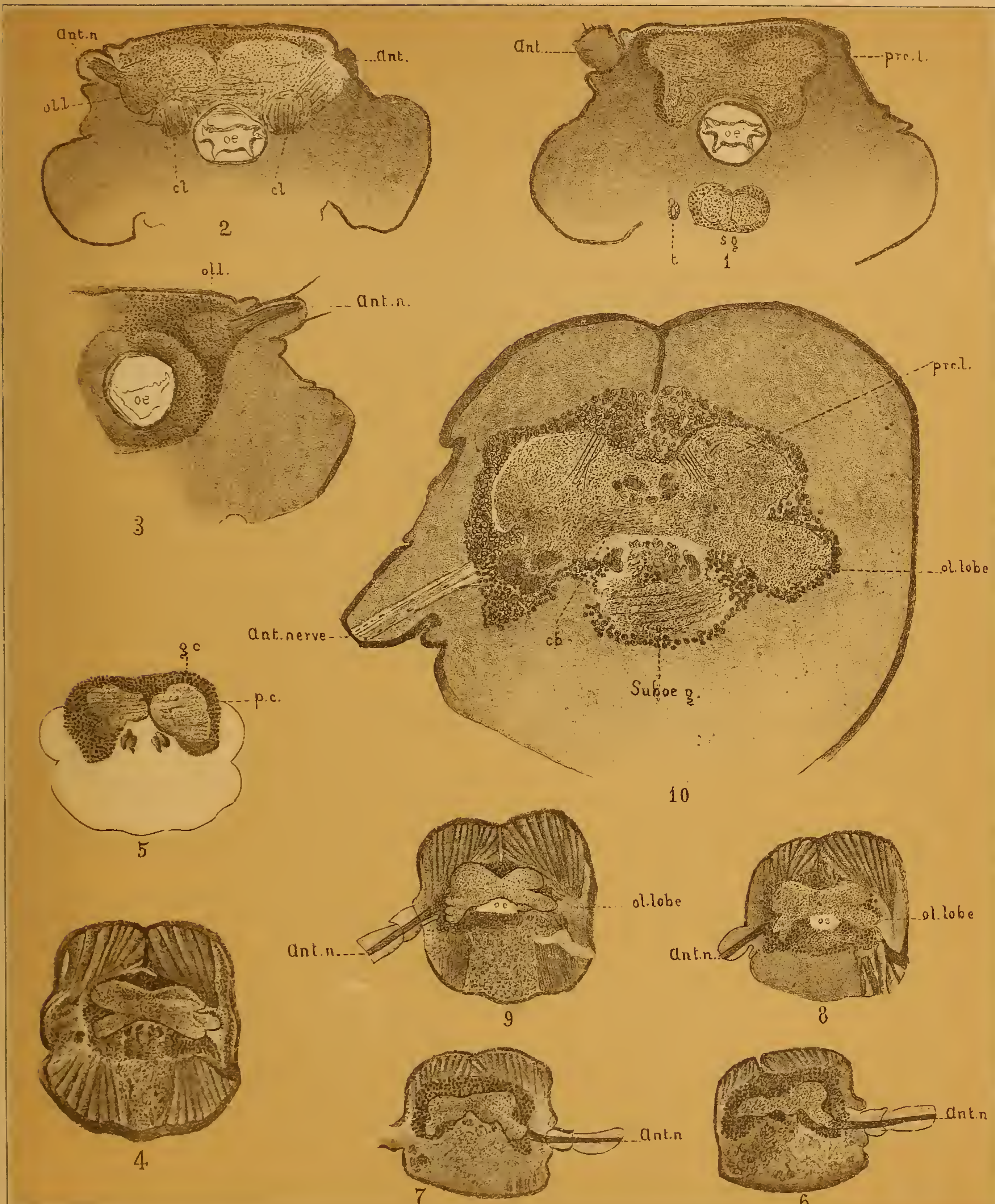
BRAIN OF PSEUDOTREMIA, ETC.



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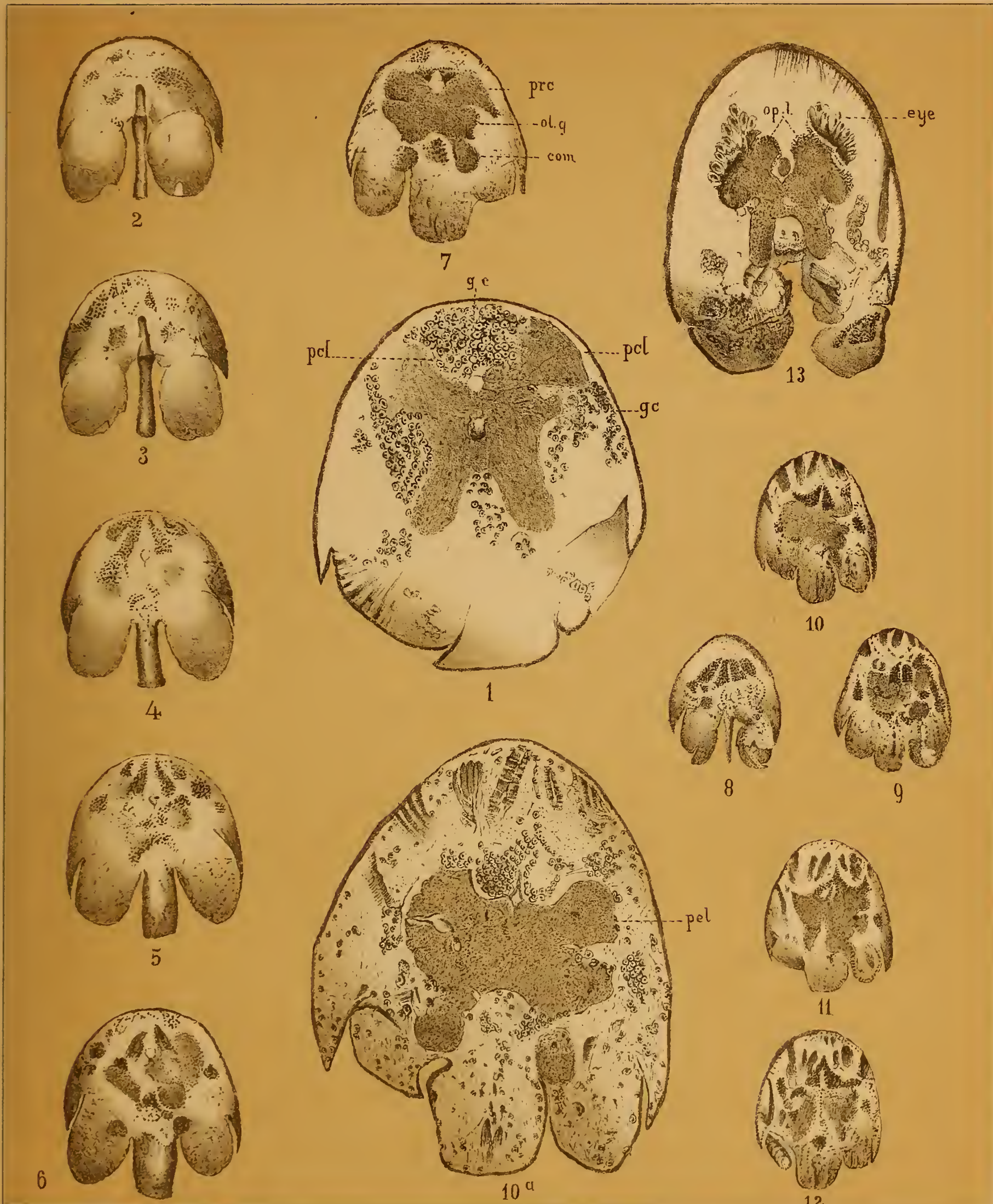
BRAIN OF SCOTERPES AND PSEUDOTREMIA.



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BRAIN OF CRANGONYX, ETC.

Fig. 3.

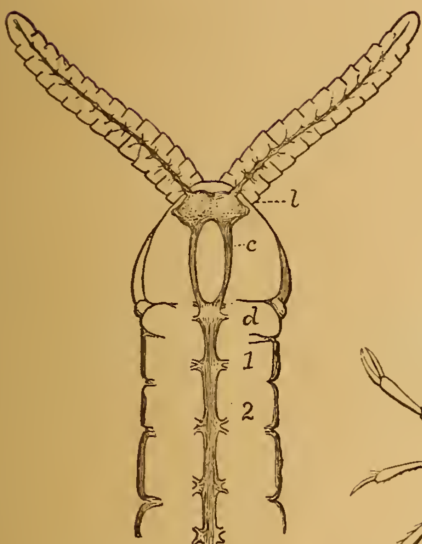

Fig. 1.

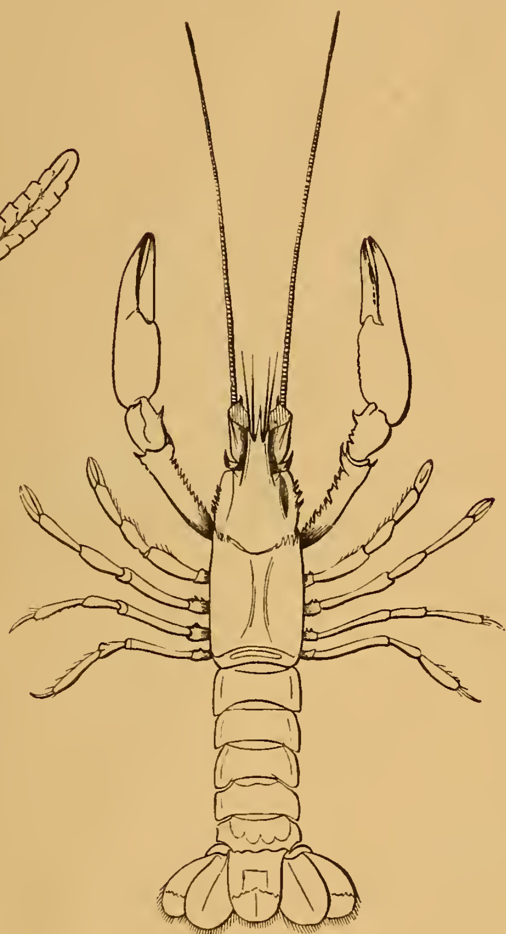

Fig. 5.

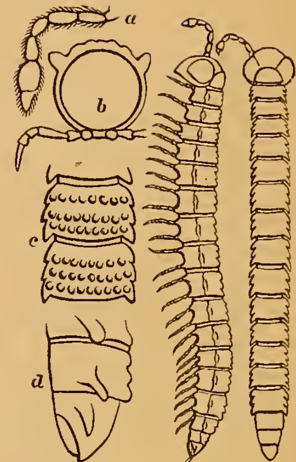

Fig. 4.

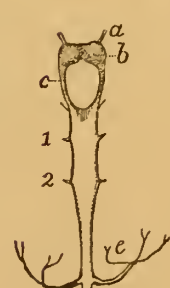

Fig. 2.