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NOTES ON THE MAMMALS OF ONTARIO.

By Gerrit S. Miller, Jr.

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No. 1.—*Notes on the Mammals of Ontario.*

By Gerrit S. Miller, Jr.

The following list of the mammals of the Province of Ontario, Canada, is only approximately complete. It is primarily based on collections which I made during August, September, and October, 1896, at three widely separated localities in the districts of Nipissing and Algoma. To the data thus obtained I have added the observations made by Mr. Allan C. Brooks of Chilliwack, B. C., during his residence of ten years in the Counties of Wellington and Hamilton. Before he left Ontario Mr. Brooks had sent me specimens of most of the smaller mammals occurring in the southern part of the Province, and he has recently given me an annotated list of the species that he observed, with permission to publish any part of it that might be of sufficient interest. I also include the records given on his personal authority by Dr. Gapper in a list of the mammals of the region between York and Lake Simcoe, published nearly seventy years ago.[1] A few other published records will be mentioned in their proper places. While the observations now brought together cover the greater part of the Province, further work in the extreme southwestern and northwestern counties and in the region of James Bay is necessary before the list of mammals can be made complete.

Localities visited by the writer.

North Bay (August 7 to September 8, 1896).—The town of North Bay is situated at the northeastern end of Lake Nipissing in the District of Nipissing. It is 240 miles north of Niagara Falls, 325 miles south of James Bay, and 230 miles east of Sault Ste. Marie. Its elevation above Lake Ontario is 420 ft. and above sea level 655 ft.[2] The town itself is situated on a plain only slightly above the level of Lake Nipissing. Toward the south and east this plain, broken by slight undulations only, extends as far as the eye can reach. North of the town, however, two abrupt ascents separated by

[1] Zoological Journal, Feb.–June, 1830, vol. 5, p. 201–207.

[2] 'Our Northern Districts.' Prepared under instructions from Hon. A. G. Hardy, Commissioner of Crown Lands. Toronto, 1894.

an irregular terrace a mile or more in width lead to an extensive table land several hundred feet above the lake. The surface of the country in every direction is irregularly ridged and furrowed, so that ponds and small streams abound.

The whole region is densely wooded with a heavy forest composed chiefly of conifers, maples, and paper birch. Settlement has so recently begun that the clearings, except in the immediate neighborhood of the town, are isolated by extensive tracts of unbroken forest.

My work was chiefly done about five miles north of the town, near the clearing belonging to Mr. L. W. Besserer. The land here is especially favorable for collecting, as it exhibits a great variety of features within easy reach. The clearing itself contains both dry hillside and wet lowland, while in the woods near by are two small lakes surrounded by quaking bogs. The Chippewa Creek, a cold spring-fed stream with firm banks and rocky bottom, flows through the forest near the clearing. Away from the small lakes the woodland near the clearing is mostly dry, though in many places it is swampy and densely carpeted with Sphagnum. Along the edges of the hills overlooking North Bay on the north are numerous rocky outcrops, but elsewhere the soil appears to be abundant and fertile.

Peninsula Harbor (September 25 to October 25, 1896).—Peninsula Harbor lies near the northeastern extremity of Lake Superior. It is about 480 miles nearly due north of Chicago, 300 miles southwest of James Bay, and 400 miles northwest of North Bay. In elevation the country near the harbor varies from 586 ft., the level of Lake Superior, to 800 and 1,200 ft. Some of the higher hills a few miles further west reach an altitude of probably nearly 1,500 ft. The surface is everywhere excessively irregular. It consists in part of rock,[1] bare or covered with a thin coating of soil, everywhere ridged and channeled by glacial action, and in part of masses of glacial till mostly arranged in terraces at various heights up to nearly 400 ft. above the present level of the lake. The constantly recurring contrasts of horizontal terraces and irregular, abrupt, and often precipitous rock masses give the region a peculiar and strikingly individual physiognomy.

Except in sheltered valleys the forest is stunted, low, and everywhere darkened by a heavy growth of pendant lichens. The trees

[1] A Laurentian gabbro I was informed by Dr. Coleman, of the Toronto School of Science, whom I met at Peninsula Harbor.

are mostly conifers and aspens, but paper birch occurs in some abundance.

Near the railroad the country has been so frequently swept by fire that large tracts are converted into open 'prairies' covered with reindeer moss, bearberry, blueberries of several kinds, mountain cranberry, and a stunted growth of scattered spruce, jack pine, tamarack, green alder, dwarf birch, buffalo berry, and in damp places Sphagnum and crowberry.

In receding from its former levels Lake Superior has left series of pools, ponds, and small lakes at various heights among the terraces and low hills. Some of these small bodies of water have rocky banks much like those of Lake Superior itself, while others are surrounded by bogs and caribou pastures. The shore of Lake Superior in the vicinity of Peninsula Harbor is mostly rocky, but in places there are extensive sandy and pebbly beaches which support a flora much like that of the Atlantic coast in the same latitude. The shore-line is very irregular, with many capes, peninsulas, and rocky islands.

Nepigon (September 9 to 24, 1896). — The railroad station and Hudson Bay Company's post of Nepigon are situated on the western side of the Nepigon River a few miles above its mouth. Nepigon is only about 85 miles west of Peninsula Harbor, and the general character of the country at the two places is much the same. Immediately above the settlement the banks of the river form steep bluffs of sand and gravel undergoing rapid erosion. Below this point, however, they are flat and marshy for a considerable distance. Still further down, the river flows under abrupt overhanging cliffs so steep and rocky that in many places they support no vegetation except a few rock-loving herbs and shrubs.

Localities visited by Mr. Brooks.

In a letter dated December 5, 1896, Mr. Brooks gives the following account of the localities in Ontario where his observations were made.

Milton. — "Milton is about half way between Hamilton and Toronto, and is in a flat, heavy clay country. The forest, where not cleared off, consists of maple, beech, red oak, white oak, elm, basswood, and two species of hickory. Black walnut and butternut grow along creeks and on hilly places. There are a few white pines scattered through the hardwood bushes, and some blocks of fine pine timber. Cedar [*Thuja*] and hemlock are small and occur only along creek bottoms except on the higher ground some miles north and west of the town, where they become larger and more numerous. North of the town there are extensive birch and cedar swamps."

Mount Forest. — Mount Forest is 55 miles northwest of Milton. Mr. Brooks writes: "At Mount Forest there are no hickory (except a few bitter hickory), walnut nor white oak, but cherry and yellow birch occur, both growing very large. There are more swamps and evergreen timber than at Milton, and less hard wood, though beech and maple grow much larger than they do there. The country is rolling and not flat. Hemlock and cedar grow to a large size, and in favorable situations there are numerous white spruce, black spruce, balsam, and tamarack."

Life Zones of Ontario.

The Province of Ontario extends from the shores of Lake Ontario and Lake Erie north to the Albany River and James Bay, a distance of more than 600 miles. Within its boundaries are represented at least three life zones, the Transition, Canadian, and Hudsonian, a brief review of which will aid in understanding the distribution of mammals in the Province. The following notes on the characteristics of the life of the Canadian and Hudsonian zones are based on my own observations, those on the Transition zone on data furnished by Mr. Brooks.

Transition zone. — The area covered by the Transition zone in Ontario extends from near the southern boundary [1] of the Province north to the region between Lake Simcoe and Lake Nipissing. Among its characteristic trees are beech, red oak, white oak, elm, basswood, black walnut, butternut, and at least two species of hickory. In suitable places arbor vitae and hemlock occur at least as far south as Milton and probably to the southern boundary of the Province, while toward the northern limit of the Transition zone

[1] It is probable that enough austral elements occur in the fauna and flora of the north shore of Lake Erie to include a narrow belt along the extreme southern border of the Province within the limits of the Upper Austral zone (Carolinian fauna).

damp, marshy localities furnish essentially Canadian conditions and support growths of spruce and balsam.

Among the birds which Mr. Brooks found breeding at Milton and Mount Forest are the following which may be considered more or less characteristic of the Transition zone: *Colinus virginianus*, *Zenaidura macroura*, *Melanerpes carolinus*,[1] *M. erythrocephalus*, *Antrostomus vociferus*, *Dolichonyx oryzivorus*, *Pipilo erythrophthalmus*, *Seiurus motacilla*,[1] *Geothlypis trichas*, and *Turdus mustelinus*.

In Ontario the characteristic mammals of the Transition zone are: *Lepus sylvaticus mearnsi*, *Peromyscus leucopus noveboracensis*, *Sciurus carolinensis leucotis*, *Adelonycteris fuscus*, and *Procyon lotor*. Others doubtless occur, but I know of no authentic records of their capture.

Canadian zone. — In central Ontario the boundary between the Transition zone and the Canadian zone lies somewhere in the region north of Lake Simcoe and south of Lake Nipissing. Recent extensive forest fires have so modified the appearance of the country near the railroad that I found it impossible to reach any conclusion concerning the boundary line further than that it lies somewhere between the two lakes just mentioned. During the afternoon of August 6, spent at Gravenhurst, about 80 miles south of Lake Nipissing, no forest could be found that had not been recently burned. Spruces grow on the rocky shore of Muskoka Lake near the wharf, but a distinct southern element in the life of the region was indicated by the abundance of towhees breeding among some stunted second growth, and by a green snake, probably *Cyclophis vernalis* (De Kay), and a blue-tailed lizard (*Eumeces*) seen on the railroad embankment a short distance south of the town.

At North Bay, on Lake Nipissing, the flora and fauna are purely Canadian. The forest is characterized by the dominance of spruce, balsam, arbor vitae, tamarack, sugar maple, moose maple, paper birch, and mountain ash, all attaining their full size, by the absence of hickory, butternut, black walnut, and white oak, and by the great scarcity of red oak, basswood, elm, and beech. Among the characteristically northern shrubs and herbaceous plants occurring in abundance at North Bay I found: —

[1] *Melanerpes carolinus* and *Seiurus motacilla* are more distinctly Austral types than any of the others in Mr. Brooks's list.

Clintonia borealis (Ait.).
Trillium undulatum Willd.
Habenaria obtusata (Pursh).
Habenaria orbiculata (Pursh).
Corylus rostrata Ait.
Alsine borealis (Bigel.).
Coptis trifolia Linn.
Ranunculus reptans Linn.
Ribes prostratum L'Her.
Ilicoides mucronata (Linn.).
Aralia hispida Vent.
Cornus canadensis Linn.
Ledum groenlandicum Oeder.
Kalmia glauca Ait.
Andromeda polifolia Linn.
Chiogenes hispidula Linn.
Vaccinium canadense Rich.
Schollera macrocarpa (Ait.).
Schollera oxycoccus (Linn.).
Viburnum alnifolium Marsh.
Linnaea borealis Linn.

I arrived at North Bay too late to find any birds breeding, but before any extensive migratory movement had begun. The following northern species were common during August: *Bonasa umbellus togata*, *Dendragapus canadensis*, *Picoides arcticus*, *Empidonax flaviventris*, *Perisoreus canadensis*, *Junco hyemalis*, *Zonotrichia albicollis*, *Spinus pinus*, *Sylvania canadensis*, *Geothlypis philadelphia*, *Troglodytes hyemalis*, and *Regulus satrapa*.

In Ontario the Canadian zone has for its characteristic mammals: *Peromyscus canadensis canadensis*,[1] *Zapus insignis*,[2] *Sorex fumeus*,[3] *Sorex hoyi*, and *Synaptomys fatuus*. *Evotomys gapperi*, *Sciurus hudsonicus hudsonicus*, *Sorex albibarbis*, *Mephitis mephitica mephitica*, *Putorius vison vison*, and probably a few others occur in both Hudsonian and Canadian zones, but, with some readily explained exceptions, are limited in their southward range by the southern boundary of the latter.

Hudsonian zone. — The bleak northern shore of Lake Superior supports a fauna and flora characterized by the presence of so many high boreal species that it must be considered as lying within the limits of the Hudsonian zone. Whether this Hudsonian area is confined to the immediate vicinity of the lake shore and is separated from the main transcontinental Hudsonian belt, or whether it is continuous with the latter are questions which cannot now be answered. Accounts which I heard while at Nepigon of the warmer climate and better forest in the region of Lake Nepigon lead me to believe that the former supposition may prove to be

[1] This animal is also found in the northern edge of the Transition zone, but only in cool, damp woods.

[2] The peculiarities of the single specimen taken in the Hudsonian zone indicate that the typical form may be there replaced by another subspecies.

[3] The distribution of this species is much the same as that of *Peromyscus canadensis canadensis*.

correct. The region through which I have traced the Hudsonian fauna and flora extends from Nepigon east to White River, a distance of about 150 miles.

The forest on the north shore of Lake Superior consists wholly of conifers interspersed with aspen and paper birch in the warmer drier situations. Spruces and balsams are the most characteristic trees, but hemlock and arbor vitae occur in considerable numbers. Jack pines (*Pinus divaricata*) are abundant as second growth on sandy or gravelly tracts where the original forest has been burned. Except in sheltered situations where the trees attain their normal size the forest has the appearance of that occupying the lower part of the 'timber-line zone' on mountain sides. Among the shrubs and smaller plants whose southern limit is nearly coincident with the lower edge of the Hudsonian zone, and which have been found on the northern shore of Lake Superior, may be mentioned [1]: —

Lycopodium annotinum pungens Spring.
*Alopecurus alpinus Linn.
*Poa alpina Linn.
*Scirpus caespitosus Linn.
*Tofieldia palustris Huds.
*Allium schoenoprasum Linn.
Betula glandulosa Michx.
*Polygonum viviparum Linn.
*Alsine longipes (Goldie).
*Anemone parviflora Michx.
Ranunculus macouni Britton.
*Saxifraga aizoon Linn.
Parnassia palustris Linn.
Rosa acicularis Lindl.
*Hedysarum americanum (Michx.).
Empetrum nigrum Linn.
*Chamaecystus procumbens (Linn.).
*Vaccinium caespitosum Michx.
Vaccinium uliginosum Linn.
Vaccinium vitisidaea Linn.
*Primula farinosa Linn.
*Primula mistassinica Michx.
Gentiana linearis lanceolata A. Gray.
Mertensia paniculata (Ait.).
Rhinanthus cristagalli Linn.
*Pinguicula vulgaris Linn.
Solidago virgaurea randi Porter.
Aster longifolius villicaulis A. Gray.

The birds found at Nepigon during September and at Peninsula Harbor during October give little if any clue to the breeding avifauna of the region. The presence of such species as *Zonotrichia querula*, *Z. leucophrys*, and *Melospiza lincolni* at Nepigon early in September cannot be taken as indication that the birds breed there, though there is every possibility that the white-crowned sparrow and Lincoln's finch may do so. *Parus hudsonicus*, *Picoides americanus*, and *Surnia ulula caparoch* were common at Peninsula Harbor during October, and about the middle of the month *Acanthis linaria* arrived in countless numbers. As the hawk owl was

[1] Species marked with an asterisk are given on the authority of Gray in Agassiz, 'Lake Superior,' p. 153–170. 1850. The others I collected myself.

observed by the Agassiz party on St. Ignace Island in Nepigon Bay late in the summer of 1848, it may be that the bird breeds on the northern shore of Lake Superior.

Characteristic mammals of the Hudsonian zone in Ontario are: *Rangifer caribou*, *Microtus pennsylvanicus fontigenus*, *Phenacomys latimanus*, *Peromyscus canadensis umbrinus*, and perhaps also *Arctomys monax melanopus*. The absence of deer and moose and their replacement by caribou is a feature especially characteristic of the Hudsonian fauna in eastern North America.

The occurrence of the genus *Chionobas* at Nepigon is a further indication of the high northern affinities of the life of the region, as the butterflies of this genus are wholly confined to alpine and arctic or subarctic regions.

List of Mammals.

Lepus sylvaticus mearnsi Allen.

A cottontail taken at Toronto is recorded by Mr. Outram Bangs in his review of the eastern races of *Lepus sylvaticus*.[1]

Mr. Brooks writes that the cottontail is common at Guelph and that it has recently extended its range north nearly to Mount Forest. At Milton it is now common, though its regular occurrence dates from about 1888 only.

Lepus americanus Erxleben.

Abundant everywhere at North Bay, Peninsula Harbor, and Nepigon.

Abundant at Mount Forest (Brooks). Tolerably common in cedar swamps and pine woods at Milton (Brooks).

Recorded by Gapper in 1830 from the region between York and Lake Simcoe.

These rabbits are often killed by trains on the Canadian Pacific Railroad, and I found several mangled bodies on the track near Nepigon. In one, taken on October 5 at Peninsula Harbor, the white winter pelage was beginning to appear on the ears and buttocks. Others killed about two weeks later had nearly completed the moult.

[1] Proc. Bost. Soc. Nat. Hist., 1894, vol. 26, p. 409.

Erethizon dorsatus (Linn.).

The porcupine is common at North Bay, Peninsula Harbor, and Nepigon. I secured no specimens, but saw a mounted skin at North Bay.

Mr. Brooks reports the animal not common at Mount Forest and very rare at Milton.

Not mentioned by Gapper.

The porcupine probably occurs throughout the heavily wooded parts of the Canadian and Hudsonian zones in Ontario and in the cooler parts of the Transition zone where the forests are sufficiently extensive to meet its needs.

Zapus hudsonius (Zimmermann).

The jumping mouse is common at North Bay and Nepigon, but I could not find it at Peninsula Harbor. My failure to secure it at Peninsula Harbor was probably due to the late date at which I collected there.

Mr. Brooks found the jumping mouse common at both Mount Forest and Milton.

It is also recorded by Gapper from the region between York and Lake Simcoe.

Measurements of Zapus hudsonius from Ontario.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	4244	♀	208	124	29	13
" " "	4245	♂	158	120	30	13.4
" " "	4246	♂	190	117	29.6	13
" " "	4247	♂	193	120	30	13.4
" " "	4258	♂	190	107	29	14.6
Nepigon, "	4251	♀	200	122	29.6	14
" "	5254	♀	213	131	30.4	15.4
" "	5255	♀	200	120	30	13
" "	5257	♀	200	120	29	14
" "	5252	♂	212	133	31	14
" "	5253	♂	205	126	31	14.8
" "	5256	♂	200	120	29	14

At North Bay this species occurred on the quaking bog surrounding a small lake and also in fields and clearings, but never in dense forest. Several were caught in pitfalls dug at the edge of a garden a few rods from the woods. At Nepigon it was common in an alder swamp bordering the river at a point a mile south of the settlement. I also took one in the edge of the forest on the bank of a small stream where I expected to find *Z. insignis.*

The series from North Bay and Nepigon are similar to each other and to specimens taken at the same season in central New York. A few, however, have ears slightly longer than in any others that I have seen.

Zapus insignis Miller.

The woodland jumping mouse is common at North Bay in all suitable places. I took one at Peninsula Harbor, but could not find the animal at Nepigon.

This species was not seen by Brooks or Gapper in southern Ontario.

The capture of *Zapus insignis* at Peninsula Harbor extends the known range of the species about 1,000 miles west of the type locality (Restigouche River, New Brunswick), and about 600 miles west of the most westerly points in New York and Pennsylvania from which it has hitherto been recorded.

At North Bay and at Peninsula Harbor I found the animal in its favorite haunts — the banks of cool streams in dense forest. As severe frosts had occurred at Peninsula Harbor before my arrival it is probable that most of the jumping mice had by that time hibernated. In any case persistent trapping in favorable places failed to yield more than one specimen. At Nepigon, where *Zapus hudsonius* was common in alder swamps and on the wooded banks of a small stream, *Zapus insignis* could not be found.

While the specimens of *Zapus insignis* taken at North Bay are in every way typical and indistinguishable from those trapped at the same season in New Hampshire and New York, the one from Peninsula Harbor differs in many slight details from any of the eastern examples with which I have compared it. In color it about matches the brightest autumnal skins from central New York and in size it slightly exceeds any from that region. The ear is distinctly shorter than in other specimens of approximately the same size.

The skull equals the largest eastern specimens in dimensions, but the mandible, especially in the region between the incisors and molars, is distinctly more heavily built than in any others that I have seen. The audital bullae appear to be slightly smaller than usual, though not peculiar in form. The zygomatic processes of the maxillaries are shorter than in any other skulls that I have seen, and as a result the zygomatic arches as a whole are more oblique to the main axis of the skull. The peculiarities of this specimen are so great as to suggest that the form of *Zapus insignis* inhabiting the north shore of Lake Superior is at least subspecifically distinct from the typical animal.

MEASUREMENTS OF ZAPUS INSIGNIS FROM ONTARIO.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	4259	♂	230	142	30	14.4
" " "	4260	♂	235	144	31	16.4
" " "	4261	♂	220	130	30	16.8
" " "	4262	♂	230	145	31	17
" " "	4266	♂	240	144	32	17
" " "	4267	♂	230	139	31	16.4
" " "	4263	♀	232	139	31.4	16.8
" " "	4264	♀	228	136	30	16
" " "	4265	♀	226	140	30.8	15.6
Peninsula Harbor, Ont.	4268	♀	255	160	33	16.6

FIBER ZIBETHICUS (Linn.).

The muskrat is very numerous at North Bay, Peninsula Harbor, and Nepigon.

Mr. Brooks found it common at Mount Forest and Milton.

Gapper mentions the species as occurring in the region between York and Lake Simcoe.

SYNAPTOMYS FATUUS Bangs.

The small lemming recently described by Mr. Bangs from Lake Edward, Quebec,[1] is common at North Bay, where I trapped seventeen specimens. I did not find the animal at Nepigon, but took three at Peninsula Harbor.

[1] Proc. Biolog. Soc. Washington, March 9, 1896, vol. 10, p. 47.

Mr. Brooks observed no lemmings of any kind, and Gapper does not mention their occurrence.

By the capture of this species at Peninsula Harbor its known range is extended 700 miles or more west of any of the localities from which it has hitherto been recorded.[1]

This lemming occurs in a great variety of damp, cool places though it is most numerous in bogs, either open or wooded. I could not find it in dry woods or on the banks of running brooks. It frequently occurs at the borders of clearings, especially near boggy places grown up to bushes. I caught one under the foundation of a disused log cabin in low ground near the woods, and secured others in pitfalls dug at the edge of a garden. Wherever the animal occurred it lived in cavities among roots covered with moss and Sphagnum. Even in the places where it was most abundant I could find no beaten runways. One was, however, caught in a vole trail in a grassy marsh at Peninsula Harbor. The associates of this animal are chiefly *Evotomys gapperi*, *Sorex personatus*, *S. albibarbis*, and Microtus, though occasionally other

MEASUREMENTS OF SYNAPTOMYS FATUUS FROM ONTARIO.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	4226	♂	124	22	18	12
" " "	4227	♂	134	22	19	13
" " "	4346	♂	121	19	18	10
" " "	4231	♀	120	19	18	11.4
" " "	4235	♀	119	19	19	12
" " "	4238	♀	132	20	19	12
" " "	4345	♀	129	19	19.4	11
" " "	4347	♀	118	20	18	11
" " "	4230	♂ juv.	108	16	17.4	10.8
" " "	4232	♂ juv.	115	16.8	17	12
" " "	4233	♂ juv.	116	18	19	12
" " "	4234	♂ juv.	99	17	17	10
" " "	4236	♂ juv.	100	17	18.8	10.6
" " "	4229	♀ juv.	112	19	17	10.6
" " "	4237	♀ juv.	100	15.4	18	11
" " "	4239	♀ juv.	90	19	17	9
" " "	4240	♀ juv.	97	18	17	10
Peninsula Harbor, Ont.	4242	♀	125	18	18	11
" " "	4243	♀	132	19	18	10
" " "	4241	♀ juv.	108	16	18	9.4

[1] For previous records see Merriam, Proc. Biolog. Soc. Washington, vol. 10, p. 58–59, and Batchelder, Proc. Bost. Soc. Nat. Hist., vol. 27, p. 186.

small mammals may be caught in the cavities inhabited by the lemmings.

I have compared my Ontario specimens with those taken in Quebec by Mr. Bangs and also with examples from New Hampshire and Maine in Mr. C. F. Batchelder's collection. They are in every way typical. A few of the older skulls are larger than any of those hitherto collected, but none show any approach to *Synaptomys cooperi*. Six of the females taken have well-developed mammae. As usual in the subgenus Synaptomys there are six of these, two inguinal and four pectoral. One caught at North Bay on September 1 contained three large embryos, and others taken during August showed indications of recent sexual activity.

Microtus pennsylvanicus pennsylvanicus (Ord).

The common meadow mouse is abundant in the clearings at North Bay.

Abundant at Milton and Mount Forest (Brooks).

Recorded by Gapper from the region between York and Lake Simcoe.

While *Microtus pennsylvanicus* probably ranges throughout Ontario, the typical subspecies is so far as known restricted to the Transition and Canadian zones.

Measurements of Microtus pennsylvanicus pennsylvanicus from Ontario.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	4082	♂	154	41	20.4	12.8
" " "	4083	♂	171	47	21	15.6
" " "	4086	♂	165	46	21	13
" " "	4087	♂	162	48	19	13
" " "	4088	♂	161	45	19	13.4
" " "	4090	♂	161	50	21	14
" " "	4091	♂	183	50	21	16
" " "	4092	♂	180	53	21	15.6
" " "	4094	♂	180	50	21	14
" " "	4084	♀	178	46	20	14
" " "	4085	♀	160	45	19	12.4
" " "	4089	♀	162	48	21	13
" " "	4093	♀	176	51	21	13.4
" " "	4095	♀	180	52	20	15
" " "	4096	♀	172	48	21 8	14

MICROTUS PENNSYLVANICUS FONTIGENUS (Bangs).

The northern form of the common meadow mouse, recently described by Mr. Bangs as *Microtus fontigenus*,[1] is abundant at Nepigon and Peninsula Harbor. It is probable that this form replaces *M. pennsylvanicus pennsylvanicus* in the Hudsonian zone throughout eastern North America. At present, however, it is known from Lake Edward, Quebec, and the north shore of Lake Superior only, localities about 700 miles apart.

At both Nepigon and Peninsula Harbor *Microtus pennsylvanicus fontigenus* occurs in great numbers and in very varied situations. At Nepigon it was especially numerous in the fields near the Hudson Bay post and among the rank weeds along the railroad embankment south of the station. At Peninsula Harbor it was common everywhere except in the thickest woods. In general the habits of this vole are the same as those of its larger southern relative. It appeared to be less inclined to form runways, however, and on the railroad embankment at Nepigon its presence was indicated merely by little collections of cut and partly eaten grass stems. In a marshy caribou pasture near Peninsula Harbor, on the other hand, the turf was honeycombed by a labyrinth of tunnels inhabited by field mice, lemmings, and shrews.

I have compared a series of over forty *Microtus pennsylvanicus fontigenus* from the north shore of Lake Superior with Mr. Bangs's specimens from Lake Edward, Quebec. They agree in all essential characters, though in the Lake Superior specimens the audital bullae average a trifle larger and the incisive foramina are just appreciably longer. While *Microtus pennsylvanicus fontigenus* differs noticeably from *M. pennsylvanicus pennsylvanicus* in its smaller size, longer, more silky fur, and in certain slight though constant cranial characters, as pointed out by Mr. Bangs, the two forms are so closely related that it appears most reasonable to treat them as subspecies of one wide-ranging species rather than as completely segregated types. It must be admitted that no clearly intermediate specimens have yet been seen, but these are almost certain to occur in the region between North Bay and White River, possibly as far east as Chapleau.

[1] Proc. Biolog. Soc. Washington, March 9, 1896, vol. 10, p. 48.

MEASUREMENTS OF MICROTUS PENNSYLVANICUS FONTIGENUS FROM ONTARIO.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
Nepigon, Ontario.	4098	♂	163	49	20	14
“ “	4107	♂	156	43	20	13
“ “	4105	♂	136	36	20	12
“ “	4106	♂	138	35	19	12
“ “	4113	♂	135	35	20	12
“ “	4114	♂	136	34	20	12
“ “	4100	♀	133	30	19	12.4
“ “	4102	♀	144	35	20	12
“ “	4103	♀	137	36	18	12
“ “	4104	♀	136	37	18.8	13
“ “	4108	♀	147	39	20	12
“ “	4109	♀	144	39	19.6	12
Peninsula Harbor, “	4121	♂	162	35	19.8	12
“ “ “	4127	♂	161	45	21	13
“ “ “	4122	♂	144	39	19	12
“ “ “	4123	♂	158	43	21	12.8
“ “ “	4128	♂	137	38	19.8	11.4
“ “ “	4130	♂	135	34	20	12
“ “ “	4132	♂	130	32	19.6	11.4
“ “ “	4134	♂	140	38	20	13
“ “ “	4135	♂	146	37	20.6	11
“ “ “	4115	♀	138	34	20	12
“ “ “	4116	♀	138	35	19	12
“ “ “	4118	♀	152	39	20	13
“ “ “	4119	♀	160	40	20	13
“ “ “	4120	♀	132	35	19.4	11
“ “ “	4124	♀	140	37	20	13
“ “ “	4125	♀	136	37	19	12
“ “ “	4126	♀	152	40	19	12
“ “ “	4129	♀	133	32	19	11
“ “ “	4131	♀	162	43	20	13

EVOTOMYS GAPPERI (Vigors).

Arvicola gapperi Vigors, Zool. Journ., 1830, vol. 5, p. 204 (red phase).

Evotomys fuscodorsalis Allen, Bull. Amer. Mus. Nat. Hist., 1894, vol. 6, p. 103 (brown phase).

The red-backed mouse is excessively abundant and universally distributed at North Bay, Peninsula Harbor, and Nepigon.

Common under mossy logs in thick evergreen woods and along creek bottoms at Mount Forest (Brooks).

Common on the steep banks of streams in woods between York and Lake Simcoe (Gapper).

The red phase of *Evotomys gapperi* occurs throughout the Hudsonian and Canadian zones in Ontario and penetrates the northern border of the Transition zone in such cool, damp localities as give it the necessary climatic conditions. In Ontario the brown phase has thus far been found on the north shore of Lake Superior only.

The series that I collected during August, September, and October, 1896, includes 29 skins (all in the red phase) from North Bay, and 51 skins (46 in the red phase, 5 in the brown phase) from the north shore of Lake Superior. Mr. Brooks has sent me about a dozen specimens (all red) from Mount Forest.

A study of all the available specimens of *Evotomys gapperi* from northern localities in eastern North America convinces me that the animal is dichromatic, and that it assumes independently of age, sex, or season a red pelage, *E. gapperi*, or a brown pelage, *E. 'fuscodorsalis.'* Throughout the southern part of the animal's range the red phase dominates to the nearly complete exclusion of the brown. The brown phase becomes conspicuous in the lower edge of the Hudsonian zone (Trousers Lake, N. B., Lake Edward, Quebec, the north shore of Lake Superior), and at the northernmost point from which I have seen specimens (Hamilton Inlet, Labrador) it greatly outnumbers the red.

The reasons for considering *Evotomys 'fuscodorsalis'* the brown phase of *E. gapperi* instead of a distinct species as at first supposed may be briefly summarized as follows: (1) typical examples of the two 'species' differ in color only, and show perfect agreement in size, proportions, and in cranial and dental characters; (2) individuals representing each type of coloration live together in the same runways; (3) a perfect series of intermediates connects the two extremes.

These facts admit of only two interpretations, that *Evotomys gapperi* is a dichromatic species, the red phase of which (*gapperi*) occurs throughout the animal's range, while the brown phase (*'fuscodorsalis'*) is dominant at the north, but rare or absent at the south; or that *E. gapperi* and *E. 'fuscodorsalis'* are distinct species which so far as known differ from each other in color only, which live together, have precisely similar habits, and hybridize freely. The first alternative is much the more reasonable, as it is in harmony with the facts already known in the case of some other dichromatic mammals. While typical specimens in red and brown pelage are very unlike in appearance, it is impossible to find any differences in size or proportions. Some specimens of *Evotomys gapperi* have a total length of from 140 mm. to 160 mm., but in the vast majority this measurement falls between 120 mm. and 140 mm. Only about two dozen specimens of *E. fuscodorsalis* are at present known from the region south of Hamilton Inlet, and, as might be expected, most of these are under 140 mm. in length. Mr. Allen has, however, recorded one that measures: total length, 152; tail vertebrae, 46; hind foot, 20.5; thus reaching well toward the maximum of *E. gapperi*. The average of fourteen specimens from New Brunswick given by Mr. Allen is: total length, 133 (127–140); tail vertebrae, 38 (35–41); hind foot, 20 (19–20.5). The five specimens from the north shore of Lake Superior average: total length, 133.8; tail

MEASUREMENTS OF ADULT SPECIMENS OF EVOTOMYS GAPPERI FROM THE NORTH SHORE OF LAKE SUPERIOR.

Evotomys gapperi.

LOCALITY.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
Nepigon, Ontario.	4166	♂	138	35	19	14
" "	4169	♂	123	32	18.4	12.4
" "	4170	♂	135	35	19	13.6
" "	4176	♂	134	34	18.4	13.6
" "	4177	♂	144	41	20	14
" "	4181	♂	130	35	19	13.8
" "	4183	♂	126	33	19	13.4
" "	4168	♀	136	38	20	15
" "	4171	♀	132	38	19.6	13
" "	4173	♀	130	32	19	13
" "	4179	♀	152	40	20	15
" "	4180	♀	135	38	19	14
" "	4186	♀	133	35	19	13.4
" "	4187	♀	130	34	19	14
" "	4188	♀	135	34	19	14
Peninsula Harbor, Ont.	4196	♀	144	37	19	16

Evotomys 'fuscodorsalis.'

LOCALITY.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
Nepigon, Ontario.	4211	♂	132	33	19	12
" "	4212	♀	132	38	19	14
" "	4213	♀	135	36	19	14
Peninsula Harbor, Ont.	4214	♂	138	30	19	14
" " "	4215	♂	132	35	18	16

vertebrae, 34.4; hind foot, 18.8; ear from meatus, 14. Ten specimens in red pelage from the north shore of Lake Superior average: total length, 135.4; tail vertebrae, 36.4; hind foot, 19.3; ear from meatus, 13.8.

No cranial or dental characters were claimed for *Evotomys* '*fuscodorsalis*' by the original describer, and I am unable to find any in the large series of skulls that I have examined. Skulls and teeth of individuals of approximately the same age are so exactly similar that it is impossible to say, without examining the labels, which belong with red skins and which with brown.

The peculiar appearance of *Evotomys* '*fuscodorsalis*' due to the entire lack of red is even more noticeable in freshly killed specimens than in skins. So much is this the case that when I first trapped the brown animals I was convinced of their specific distinctness. Careful comparison of fresh specimens, however, showed that in all external characters, except color, the red and brown individuals were exactly alike. It also showed, what is not always so apparent in dried skins, that, however different the actual color of red and brown specimens may be, the color pattern is exactly similar in the two.

Wherever *Evotomys* '*fuscodorsalis*' has been found, *E. gapperi* has also been taken, and the two are invariably trapped in the same crevices and runways. At Nepigon and Peninsula Harbor it happened that I caught the brown phase in heavy woods only and the red phase in deep woods and comparatively open places indifferently. Since the proportion of red to brown at these localities is probably as great as forty to one, the fact that the former was found in the greater variety of situations does not indicate that it prefers a different habitat.

The chain of intermediates between the most extreme red and brown specimens of this species[1] is so complete in the series collected by Mr. Goldthwaite at Hamilton Inlet, Labrador, that it is impossible to draw any line between the two phases. In the Lake Superior specimens the intergradation is almost as perfect. These and others from Quebec and New Brunswick vary so much among themselves that several are worth detailed description.

♂ ad. (No. 4215, collection of Gerrit S. Miller, Jr., Peninsula Harbor, Ontario, September 29, 1896); dorsal stripe, sharply

[1] While the Hamilton Inlet series is clearly *Evotomys gapperi* it is probably not referable to the typical subspecies.

defined and extending from a little in front of ears nearly to base of tail, very dark blackish seal-brown with a few scattered grayish hairs (most numerous across the shoulders); sides very pale wood-brown slightly tinged with olive and sparsely sprinkled with blackish hairs; belly dirty yellowish white.

♂ ad. (No. 4214, Peninsula Harbor, Ontario, September 27, 1896); similar to No. 4215 but sides more strongly tinged with olive and much more heavily sprinkled with blackish hairs.

These two specimens represent the extreme phase of '*fuscodorsalis*.' They have darker backs and more sharply contrasted paler sides than in the type.

♀ ad. (No. 4212, Nepigon, Ontario, September 12, 1896); dorsal stripe less sharply defined than in Nos. 4214 and 4215, sepia slightly mixed with gray; sides as in No. 4215 but more strongly tinged with olive, especially along edge of dorsal stripe.

This specimen closely resembles a topotype, and four skins from Lake Edward, Quebec. It may be considered as representing the typical phase of '*fuscodorsalis*.' The typical phase is connected with the extreme dark phase by intermediates of which No. 4211, ♂ ad. Nepigon, Ontario, September 11, 1896, is a fair representative. Two specimens in my collection and many in the Bangs collection connect the typical phase of '*fuscodorsalis*' with *gapperi*. The two intermediate Ontario skins are colored as follows: —

♀ ad. (No. 4213, Nepigon, Ontario, September 17, 1896); dorsal stripe blackish seal-brown as in the darkest '*fuscodorsalis*,' but slightly intermixed with rufous; sides pale rufous becoming darker and richer along border of dorsal stripe.

♂ (No. 4205, Peninsula Harbor, October 11, 1896); much like a dull-colored immature specimen of *gapperi*, but with a faintly indicated brownish dorsal stripe; sides and back both distinctly suffused with rufous.

While No. 4213 might be considered merely an abnormal example of '*fuscodorsalis*,' No. 4205 is so perfectly intermediate between this and *gapperi* that I am unable to decide to which it should be referred.

PHENACOMYS LATIMANUS Merriam.

At Peninsula Harbor I took seven specimens of the vole which Dr. C. Hart Merriam described a few years ago as a new species under the name *Phenacomys latimanus*. The species has hitherto been known from the type specimen only, collected at Fort Chimo, Ungava, Labrador.

My first specimen was caught under the roots of a young spruce in a small Sphagnum bog inhabited by *Evotomys gapperi*, *Synaptomys fatuus*, *Microtus pennsylvanicus fontigenus*, *Sorex personatus*, *S. albibarbis*, and *Blarina brevicauda*. This accident led me to believe that the animal was a bog lover, and accordingly I lost much time in unsuccessful attempts to trap more in similar places. Quite accidentally I discovered that Phenacomys prefers a very different habitat. One morning while crossing a high upland barren which at first sight appeared to be wholly without mammalian inhabitants, I saw a small mouse dart from a dense mat of stunted blueberry bushes, cross an open space, and disappear in a hole beneath the small mound left by a rotting stump. By digging I found that the tunnel into which the mouse had run descended rather gradually, until at a distance of about two feet from the entrance it terminated some ten inches below the surface in a small chamber apparently ready for a winter nest but at this time empty except for the inhabitant — an adult Phenacomys. Numerous collections of half eaten blueberries concealed in hollows and crevices under roots and decaying logs near by showed that some small rodent had joined forces with the bears in harvesting the berry crop on this lonely 'prairie.' Berries were so abundant and the mice so well fed that trapping proved almost a failure, and after a week's work I had secured only a few Peromyscus and one more Phenacomys. Afterward I found Phenacomys inhabiting the ruined log huts of a former camp of Italian workmen on the barren plain south of Peninsula Harbor. Here I caught four more and saw a fifth which escaped in spite of the efforts of two dogs and five men.

The favorite food of *Phenacomys latimanus* appears to be the berries of different species of Vaccinium and the leaves and twigs of *Arctostaphylos uvaursi*. I found large quantities of the latter cut and stored under small stumps and pieces of sheet iron near the abandoned camp. These mice also eat twigs of young paper birch and other shrubs, and the succulent parts of the stems of *Potentilla tridentata*.

I have compared the Lake Superior specimens with the type of *Phenacomys latimanus*. They agree closely in all characters except color. Since the type was preserved in alcohol before it was skinned, its peculiar reddish coloration is doubtless abnormal. The color of adult individuals from Lake Superior is as follows: dorsal surface pale, yellowish, cinnamon-brown, clearer and more tinged with reddish on muzzle and face, the region from eyes to tail strongly darkened with blackish hairs, these most numerous on back, but not enough so to produce a distinct darker dorsal area; feet and whole ventral surface pale whitish gray, the throat and belly slightly darkened by the plumbeous bases of the hairs; no distinct line of demarcation on sides; tail distinctly bicolor, the dark brown dorsal stripe occupying less than one half the circumference of the tail; ears closely furred with fine short hairs not different in color from the surrounding parts, but small area just behind ear slightly paler; whiskers reaching about to tips of ears, mixed dark brown and silvery gray.

Body Measurements of Phenacomys latimanus from Ontario.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
Peninsula Harbor, Ontario.	4216	♂	124	27.6	18	14
" " "	4217	♀	125	28	18	13
" " "	4218	♂	120	27	18	12.6
" " "	4219	♂	132	29	18	14
" " "	4220	♂	138	33	19	13
" " "	4221	♀	150	38	18	13
" " "	4222	♂	124	27	18	13

Cranial Measurements of Phenacomys latimanus from Ontario.

Number.	4216	4219	4220	4222	4217	4221
Sex and age.	♂ ad.	♂ ad.	♂ ad.	♂ ad.	♀ ad.	♀ old
Basilar length.	21	22.4	22.6	21	22	23
Basilar length of Hensel.	19.8	21	21	19.6	20.4	21.4
Zygomatic breadth.	13	13	13.6	13	13	14.2
Mastoid breadth.	11	11.4	12	11	11.6	11
Interorbital constriction.	3.4	3.2	3.4	3.6	3 6	3.4
Length of nasals.	7.8	7.4	7	6.6	6.6	7
Incisor to molar (alveoli)	6	6.8	6.6	6	6.2	7.2
Incisor to postpalatal notch.	10.8	11.8	12	11.4	11.6	11.8
Basioccipital to front of interparietal.	7	6.8	6.8	7	7	7
Greatest length of mandible.	14	14.6	14.4	14	14	15
Length of mandibular molar series (alveoli)	6	6	6	6	6	5.8
Length of maxillary molar series (alveoli)	6	6.4	6.6	6.2	6	6

The variation in color is inconsiderable. It is chiefly found in the exact tone of the ground color, which may be more red or more gray than in the specimens described, and in the amount of shading of the back caused by the dark-tipped hairs. The exact extent of the rufous on the face is also variable.

The ears are usually thickly furred, but in one specimen (No. 4219, ♂ ad., Oct. 15,) they are less densely haired than usual, while in a very old female (No. 4221), taken on October 18, they are naked except for a few scattered hairs.

In the female just mentioned there are eight mammae, four pectoral and four inguinal.

The skull of *Phenacomys latimanus* never develops distinct interorbital ridges, even in extreme old age. It is in general characterized by weakness and lack of angularity.

The enamel pattern is peculiar in the form of the front loop of the first lower molar. This loop is so deeply cut by the re-entrant angle on the inner side that it has the form of a hook with the concavity turned inward and is thus very different in form from the terminal loop of the back upper tooth.

PEROMYSCUS LEUCOPUS NOVEBORACENSIS (Fischer).

1829. *Mus sylvaticus* δ. *Noveboracensis* Fischer, Synopsis Mammalium, p. 318.

1830. *Cricetus myoides* Gapper, Zool. Journ., vol. 5, p. 204, pl. 10.

1897. *Peromyscus leucopus myodes* Rhoads, Proc. Acad. Nat. Sci. Phila., p. 27.

I did not find the common northern white-footed mouse at North Bay or on the north shore of Lake Superior.

Mr. Brooks writes me that it is abundant at Milton and Mount Forest.

Mentioned by Gapper as occurring in the region between York and Lake Simcoe.

I have already recorded this species from Sutton, just south of Lake Simcoe.[1]

Mr. S. N. Rhoads has pointed out the characters which separate the northern and southern forms of the eastern white-footed mouse. To the former he applies Gapper's name *myoides*. Fischer's *Mus sylvaticus* δ. *Noveboracensis* refers undoubtedly to the same animal and as *noveboracensis* antedates *myoides* it must be adopted.

[1] Proc. Biolog. Soc. Washington, June 20, 1893, vol. 8, p. 60.

PEROMYSCUS CANADENSIS CANADENSIS Miller.

Common everywhere in the forests about North Bay.

Found by Mr. Brooks in damp evergreen woods and along creek bottoms at Mount Forest.

It can no longer be doubted that *Peromyscus canadensis* is specifically distinct from *P. leucopus*. Specimens of eastern white-footed mice in the flesh can always be referred without question to one species or the other. Supposed intermediates are probably in most cases short-tailed specimens of *P. canadensis* whose characters have been obscured by faulty taxidermy.

The range of the species west of the Great Lakes is not yet known, but in eastern North America it is about co-extensive with the wooded parts of the Hudsonian and Canadian zones. It penetrates the Transition zone in some localities where extensive tracts of cold, damp woodland give it the surroundings that it requires. The typical form, *Peromyscus canadensis canadensis*, is apparently confined to the Canadian and Transition zones. In the Hudsonian zone occur a second and third subspecies, *P. canadensis abietorum* Bangs[1] in New Brunswick and Quebec and *P. canadensis umbrinus* Miller on the north shore of Lake Superior.

PEROMYSCUS CANADENSIS UMBRINUS Miller.

New subspecies (Type, ♀ ad. No. 4054, collection of Gerrit S. Miller, Jr., Peninsula Harbor, Ontario, October 1, 1896); smaller than *Peromyscus canadensis canadensis* but similar in proportions, ground color yellower than in the typical form, and dark shading, especially on back and face, much more conspicuous.

Color. — Type: general color of back and sides light yellowish wood-brown, brightest and purest on cheeks, dullest and grayest on occiput and neck, everywhere strongly suffused with black, the dark shading most noticeable along middle of back, but not forming a dark dorsal stripe; conspicuous patch at base of whiskers and narrow ring around eye black; ears thinly clothed with short hairs, these nearly black except along rims of ears where they are whitish; tail well haired and sharply bicolor, black dorsally, white ventrally; belly, throat, and backs of all four feet white; body fur, except on chin, deep plumbeous at base, this color showing through the white of the belly very slightly.

[1] Proc. Biolog. Soc. Washington, Mar. 9, 1896, vol. 10, p. 49.

Size. — Average of five adult males from Nepigon: total length, 175; tail vertebrae, 88.2; hind foot, 19.7; ear from meatus, 17.6. Average of eight adult females from Nepigon: total length, 171.9; tail vertebrae, 84.9; hind foot, 19.2; ear from meatus, 17.6. Average of eleven adult males from Peninsula Harbor: total length, 176.4; tail vertebrae, 87.1; hind foot, 20.5; ear from meatus, 18. Average of eight adult females from Peninsula Harbor: total length, 171.9; tail vertebrae, 84.9; hind foot, 19.2; ear from meatus, 17.6. The detailed measurements of these specimens are given in the following table: —

Measurements of Peromyscus canadensis umbrinus.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
Nepigon, Ontario.	4039	♂	182	91	20	18.4
" "	4043	♂	178	91	21	18.4
" "	4044	♂	172	86	19	17.4
" "	4047	♂	181	91	19	17
" "	4048	♂	162	82	19.4	17
Peninsula Harbor, Ont.	4052	♂	171	82	20.4	18.4
" " "	4055	♂	180	90	19	18.6
" " "	4056	♂	187	95	21	18
" " "	4057	♂	180	88	20	18
" " "	4058	♂	183	93	21	19
" " "	4062	♂	170	80	20	18
" " "	4065	♂	176	88	21	18
" " "	4067	♂	165	82	20	17.4
" " "	4068	♂	180	90	21	18
" " "	4073	♂	166	81	20	18
" " "	4075	♂	183	89	22	17.6
Nepigon, Ontario.	4037	♀	180	93	19.4	19
" "	4038	♀	165	81	20	17
" "	4040	♀	183	90	20	17.6
" "	4041	♀	172	86	20	17.4
" "	4045	♀	162	79	19.8	18
" "	4046	♀	175	88	19.6	17
" "	4049	♀	170	82	20	17.6
" "	4050	♀	168	82	19.8	17.4
Peninsula Harbor, Ont.	4054	♀	177	90	20	18[1]
" " "	4059	♀	170	83	21	18
" " "	4061	♀	170	86	21	18
" " "	4066	♀	176	87	21	18
" " "	4069	♀	173	86	21	19
" " "	4070	♀	160	76	21	19
" " "	4076	♀	185	90	20	18
" " "	4080	♀	170	83	20	17

[1] Type.

Peromyscus canadensis canadensis is a larger animal than *P. c. umbrinus*. Ten adult male topotypes of the former average: total length, 191.5; tail vertebrae, 98.1; hind foot, 21.2; ear from meatus, 18.2. Ten adult female topotypes average: total length, 183.3; tail vertebrae, 92.3; hind foot, 20.9; ear from meatus, 18.4. Detailed measurements of 100 specimens of the typical form are given in the original description.[1]

Skull and teeth. — In cranial and dental characters *Peromyscus canadensis umbrinus* agrees closely with *P. canadensis canadensis*. Both skull and teeth are slightly smaller than in the typical subspecies, but the differences are no greater than might be anticipated from the relative sizes of the animals. The skull of *Peromyscus canadensis umbrinus* is distinguished from that of *P. texensis arcticus* by its more slender form, lighter and longer rostrum, and less abruptly flaring zygomata.

General remarks. — In color and external appearance *Peromyscus canadensis umbrinus* resembles *P. texensis arcticus* more closely than it does *P. canadensis canadensis*. It is easily separated from any of the forms of *texensis*, however, by its proportionally longer tail and differently shaped skull. From *P. leucopus* it differs in proportions and color, but is apparently the form of *canadensis* most closely resembling *leucopus*. As compared with autumnal specimens of *P. canadensis canadensis*, *P. canadensis umbrinus* differs in darker tail and ears, darker face markings, slightly darker and richer ground color of back, and conspicuously greater darkening of back resulting from admixture of black-tipped hairs. As a rule the belly in *umbrinus* appears to be less snowy white than in *canadensis*, as the plumbeous under fur shows through more distinctly on the surface.

Mus musculus Linn.

The house mouse is common at North Bay, but does not occur at Peninsula Harbor or Nepigon.

Mr. Brooks found it abundant at Mount Forest and Milton.

In 1830 Gapper wrote of this animal: "Very common all over the country [between York and Lake Simcoe]. A great many are frozen to death in the barns, where the native mice live in perfect security."

[1] Proc. Biolog. Soc. Washington, 1893, vol. 8, p. 67–69.

Mus decumanus Pall.

The house rat was introduced through northern Nipissing and southern Algoma at the time of construction of the Canadian Pacific railroad, along the line of which it is now irregularly distributed. I saw no rats at North Bay or Peninsula Harbor, but found them abundant at Nepigon. They are said to occur at Heron Bay, a few miles south of Peninsula Harbor.

Common at Mount Forest and Milton (Brooks).

Gapper wrote in 1830 that the house rat was then "found only in the warehouses near Lake Ontario."

Castor canadensis Kuhl.

At North Bay the beaver is locally common, and I saw a mounted specimen that had been killed near the town. At Nepigon they are said to be common, and at Peninsula Harbor I saw abundant signs of their work on the bank of a stream a few miles north of the station.

In 1830 Gapper wrote that the beaver is "now very rare [in the region between York and Lake Simcoe], though their old embankments are still to be seen on most streams."

Arctomys monax monax (Linn.).

Mr. Brooks found the woodchuck abundant at Milton and Mount Forest.

Not uncommon in the region between York and Lake Simcoe (Gapper).

Two melanistic adults taken by Mr. Brooks at Mount Forest and now in the Bangs collection are clearly referable to the typical subspecies, a form whose northern limit probably coincides very nearly with the upper edge of the Transition zone. These specimens were not measured in the flesh, but their long tails (130 mm.) distinguish them from the form inhabiting the north shore of Lake Superior.

Arctomys monax melanopus (Kuhl)?

At North Bay woodchucks are said to be common, but during the summer of 1896 they were so scarce that I saw none.

The woodchuck is common at Nepigon and Peninsula Harbor, but I was so unfortunate as to secure no adults. On the north shore of Lake Superior the animal hibernates at the end of September or beginning of October. Shortly after the latter date I found several recently used burrows near Peninsula Harbor, but traps set in them yielded only a few stray rabbits. At Nepigon I was told that the Indian name is wenusk.

It is with great hesitation that I refer the three woodchucks taken at Nepigon to the form to which Mr. S. N. Rhoads has recently applied the name *melanopus* Kuhl.[1] These specimens represent a race which is distinct from true *monax*, but which appears to be characterized by small size, short ears and tail, and small, weak skull. The Nepigon specimens may be described as follows: —

Color. — (♂ *juv.* No. 4014, collection of Gerrit S. Miller, Jr., Nepigon, Ontario, September 24, 1896); fur of back, throat, and most of ventral surface deep plumbeous at base; hairs on back of two kinds, those of the soft short under fur (about 20 mm. long) with only two distinct color bands, the basal half plumbeous and the terminal half yellowish cinnamon (some of the hairs forming the under fur have indistinct dark tips), those of the longer coarser outer fur (about 35 mm.) plumbeous at base, then successively yellowish, cinnamon, black, dirty white, and black,[2] producing a grizzled mixture very hard to describe; whitish element in mixture most noticeable on shoulders and sides of neck, least conspicuous on rump and buttocks; feet, hands, ankles, and wrists black; tail dark brown slightly sprinkled, especially near edge and tip, with russet; ears dirty whitish, dark brown at tips; muzzle, lips, and chin whitish; throat, chest, belly, front legs, and inner side of hind legs bright clear russet, palest on throat, clearest and brightest on chest and front legs, the dark bases of the hairs forming a distinct median line broadest across mid ventral region; cheeks and sides of head distinctly paler and yellower than surrounding parts; top of head very dark glossy brown.

The other two specimens are melanistic, one clear black throughout except for the white muzzle and lips, the other with the black of the feet extended up the legs, and the rump, buttocks, middle of back, and middle of neck entirely unsprinkled with whitish. In this specimen the fur otherwise retains its normal color.

[1] Proc. Acad. Nat. Sci. Phila., February, 1897, p. 30.

[2] The width of the bands varies in different regions. In a hair 33 mm. long from the middle of the back the plumbeous basal band occupies 13 mm., the russet band 6 mm., the first black band 10 mm., the dirty white band 2 mm., and the terminal black band 2 mm.

Size. — The three specimens measure as follows: —

No.	Sex.	Age.	Total length.	Tail vertebrae.	Hind foot.	Ear.
4012	♂	juv.	460	95	70	26
4013	♀	juv.	470	100	75	28
4014	♂	juv.	465	103	70	28

I have found great difficulty in obtaining specimens of *Arctomys monax monax* of the right age to make a fair basis for comparison with the form occurring on the north shore of Lake Superior. My specimens of the latter are all young of the year, which have not yet shed the milk premolars, yet the condition of the bones and sutures in the skull shows that they are not very immature. A young female taken at Wareham, Mass., on August 11, 1894, and evidently younger than any of the Nepigon specimens measures: total length, 504; tail vertebrae, 138; hind foot, 80; ear, 34. A young male taken at the same locality on August 7, 1893, and very much younger than the last measures: total length, 479; tail vertebrae, 112; hind foot, 74.5; ear, 30.5.

Skull and teeth. — The fact that all three specimens of Arctomys from Nepigon are immature makes any comparison of cranial characters between this form and the typical subspecies a matter of difficulty and uncertainty. I have, however, found the skulls of eight specimens with which a fair comparison can be made. The Lake Superior skulls are evidently the oldest of the lot, though none of the eleven have shed their milk premolars. In spite of their greater age they are slightly smaller than the others, and the rostral portions of the skulls are uniformly shorter, narrower, and less deep. Until adults of the two races can be compared, it is impossible to state with certainty what the true differential cranial characters ares I can find no differences in the teeth. The following table show. the extent of the differences in size of these skulls.

Cranial Measurements of Arctomys.

Locality	Nepigon, Ont.	Nepigon, Ont.	Nepigon, Ont.	Fredericksburg, Va.	Elizabethtown, N. Y.	Elizabethtown, N. Y.	Peterboro, N. Y.	Wareham, Mass.	Wareham, Mass.	East Hartford, Conn.	Racine, Wis.
Number	4012[1]	4013[1]	4014[1]	35651[2]	1905[2]	1910[2]	4476[1]	1004[3]	1740[3]	121[4]	1679[2]
Sex	♂	♀	♂	♀	♂	♂	♂	♂	♀		——
Basilar length	64.8	67	67.6	75.5	72	74	73	69	71	75	69
Basilar length of Hensel	61	64	64	71.5	68	71	69	66	66.6	71.6	66
Occipito-nasal length	69	72	72	81	80	80	77	75	75	82	77
Zygomatic breadth	48	48	49	55	54	50	51.4	48.8	49.8	53	52
Mastoid breadth	34	36	35	41	39.5	36.5	39	37	37	39.6	39
Breadth across postorbital processes	33	31.4	34	35	——	37.4	36	31	35	35	——
Least frontal breadth between orbits	18.6	18	19	21	20	21.4	21.4	18	18.6	20	19
Greatest length of nasals	24.4	29	29.6	33	31.5	33	32	30	31.4	32	31.5
Greatest breadth of nasals	11.4	11	11.6	15.5	14	14	14	13.6	13	14	13.5
Diastema	17.6	19	19	23	21.5	21	21.4	20	19	21.8	19
Incisor to postpalatal notch	35	38	37	44	41	42	42	39	39	43	41
Depth of rostrum at posterior edge of incisive foramina	14	15	15.4	17.5	16	16	18	16	16.4	18	15.5
Distance between molar series anteriorly	13.8	15	13.6	15	16	13	15	15	15	14	16.5
Distance between molar series posteriorly	10	10	10.6	12	13	11	11.8	10.4	11.8	11.8	12.5
Length of maxillary tooth row (alveoli)	18	18	18	20	19.5	20	20	19.8	19	19	21
Greatest length of mandible	52	55	55	61.5	60	——	59	56	57	59	57
Length of mandibular tooth row (alveoli)	18	18	18	21	20	——	20	20	19	19	21

[1] Collection of G. S. Miller, Jr.
[2] Collection U. S. National Museum.
[3] Collection of E. A. and O. Bangs.
[4] Collection of C. F. Batchelder.

Tamias striatus lysteri (Rich.).

The common eastern chipmunk is abundant at North Bay.

Abundant at Milton and Mount Forest (Brooks).

Very common between York and Lake Simcoe (Gapper).

The type of this race came from Penetang on Georgian Bay.

The North Bay specimens are typical *lysteri* and differ from those taken at Nepigon in smaller size and more yellowish color of the back and sides.

Measurements of Tamias striatus lysteri from Ontario.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	3985	♀	246	93	34	18.4
" " "	3986	♀	254	95	36	19
" " "	3987	♀	255	100	35	19
" " "	3988	♂	234	95	34	18
" " "	3989	♂	256	97	35.6	19.4

Tamias striatus griseus Mearns.

The large gray form of the eastern chipmunk is extremely numerous at Nepigon and at Peninsula Harbor.

While the five specimens taken are not extreme *griseus*, they approach this form more closely than they do *lysteri*. The dorsal stripes do not extend so far back as in typical *griseus*, and the rump averages redder than in specimens from Fort Snelling, Minn. In general appearance they are most like a series of intermediates between *lysteri* and true *striatus* collected by Dr. Mearns at Highland Falls, N. Y., but in size they agree with *griseus*.

Measurements of Tamias striatus griseus from Ontario.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
Nepigon, Ontario.	3990	♀	230[1]	72[1]	37	20
" "	3991	♀	272	118	36	21
" "	3992	♂	280	111	37	20
" "	3993	♀	265	114	37	19

[1] Tail imperfect.

Tamias quadrivittatus neglectus J. A. Allen.

The two species of Tamias which occur in Ontario are recognized as distinct by the inhabitants, who call *T. striatus* the 'big chipmunk' and *T. quadrivittatus* the 'little chipmunk.' The latter is rare and local at North Bay but excessively abundant on the north shore of Lake Superior.

It was not found by Brooks or Gapper in the southern part of the Province.

Although it is universally distributed outside of thick woods at Nepigon and Peninsula, the little chipmunk shows a marked preference for open rocky hillsides, while the big chipmunk prefers the edge of the forests, where stumps and logs furnish it a more congenial shelter. At North Bay the smaller species occurred on the rocky hill north of the town, and I was unable to find it elsewhere, while the larger animal was everywhere, among rocks, in partly cleared fields, in gardens, about outbuildings, and in fresh 'brulies.'

Tamias quadrivittatus is quicker and more graceful in its movements than *T. striatus*, and its notes are easily distinguished from those of its larger relative by their greater shrillness. While *T. striatus* on the north shore of Lake Superior hibernates near the end of September, immediately after the first heavy frosts, *T. quadrivittatus* remains active much later — probably until the snow cuts off its food supply. The small chipmunk was actively running about in the light snow during the second week of October, 1896, although the temperature during the day averaged about 15° F. On October 23, I found an adult female in a nest built of feathers and soft vegetable fibers at the end of a tunnel under a clump of bearberry. The tunnel was about two feet long and terminated a foot or more beneath the surface in a chamber about the size of a cocoanut. This chamber was completely filled by the nest, which contained, in addition to its occupant, a small store of seeds of various weeds and wild fruits. The small chipmunks enter traps with perfect freedom. The smallest sized 'cyclones' and 'Schuylers' are strong enough to kill them.

North Bay is the most easterly point at which any form of *Tamias quadrivittatus* has yet been found.

The series of this chipmunk which I collected on the north shore of Lake Superior shows very little individual variation. They agree perfectly both in color and size with the type, taken on Lake Superior by the Agassiz expedition, and with a large series from the north peninsula of Michigan in the Bangs collection.

MEASUREMENTS OF TAMIAS QUADRIVITTATUS NEGLECTUS FROM ONTARIO.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	3960	♀	208	85	31	17
Nepigon, "	3964	♀	215	96	31	16
Peninsula Harbor, "	3970	♀	230	96	32	16
" " "	3972	♀	218	90	32	16
" " "	3976	♀	220	90	32	17
" " "	3977	♀	217	90	31	16
" " "	3979	♀	221	97	32	16
" " "	3980	♀	224	100	33	16
" " "	3981	♀	216	95	32	18
" " "	3982	♀	212	90	31	16
" " "	3983	♀	211	91	32	16
Nepigon, "	3961	♂	220	98	33	16
" "	3962	♂	222	91	32.6	16
" "	3963	♂	220	95	32	17
" "	3965	♂	213	91	31	16
" "	3966	♂	215	98	32	16
" "	3967	♂	206	88	31	16.6
" "	3968	♂	222	95	32	17
" "	3969	♂	225	92	33	17.4
Peninsula Harbor, "	3971	♂	214	91	31	16
" " "	3973	♂	220	91	32	17
" " "	3974	♂	215	89	31	17
" " "	3975	♂	215	98	32	17
" " "	3978	♂	213	92	32	17
" " "	3984	♂	213	95	32	17

SCIURUS HUDSONICUS Erxl.

The red squirrel is abundant at North Bay, Peninsula Harbor, and Nepigon.

Abundant at Milton and Mount Forest (Brooks).

Mentioned by Gapper as occurring in the region between York and Lake Simcoe.

Mr. Outram Bangs, who has examined my Ontario squirrels, tells me that those from the north shore of Lake Superior are typical examples of the subspecies *hudsonicus*, but that those from North

Bay show the first indication of intergradation toward *loquax*, the subspecies that undoubtedly inhabits the whole southern portion of the Province.[1]

MEASUREMENTS OF SCIURUS HUDSONICUS HUDSONICUS FROM ONTARIO.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	3995	♀	316	117	47	24.4
" " "	3997	♀	300	128	48	24
" " "	3998	♂	321	125	47	26
" " "	3999	♂	313	118	48	23
" " "	4000	♂	307	133	46	25
Nepigon, "	4001	♀	317	122	45	26
Peninsula Harbor, "	4002	♀	290	110	44	25
" " "	4006	♀	310	125	48	25
" " "	4007	♀	300	118	44	23
" " "	4011	♀	240[2]	58[2]	49	24
" " "	4003	♂	315	138	46	25
" " "	4004	♂	310	120	47	23
" " "	4005	♂	300	118	44	23
" " "	4009	♂	270[2]	90[2]	46	25
" " "	4010	♂	310	125	47	25

SCIURUS CAROLINENSIS LEUCOTIS Gapper.

The gray squirrel does not occur at North Bay. I did not find the animal on the north shore of Lake Superior, but reports reached me that it had been taken near Port Arthur.

" At Mount Forest this squirrel used to be common, but was very scarce during the six years preceding 1892, when it began to get more numerous again. Fairly common in 1894. Only one gray specimen observed, and this had a considerable admixture of black. Generally common at Milton, some years abundant. Black form predominating about 10 to 1 " (Brooks).

In 1830 Gapper recorded the black phase as the more common in the region between York and Lake Simcoe. He considered the black and gray phases as two distinct species, and described the latter as new under the name *Sciurus leucotis*.

[1] For a revision of the squirrels of eastern North America see Bangs, Proc. Biolog. Soc. Washington, Dec. 28, 1896, vol. 10, p. 145–167.

[2] Tail imperfect.

Sciuropterus sabrinus (Shaw).

Flying squirrels are said to be common at North Bay, but I was unable to secure any. At Nepigon I took one specimen.

Rare at Mount Forest and Milton (Brooks).

Gapper mentions '*Pteromys volucella*' among the squirrels which he found in the region between York and Lake Simcoe. This animal was probably *Sciuropterus volans*, a species which undoubtedly occurs throughout the Transition zone in Ontario.

Sorex albibarbis (Cope).

The marsh shrew is rare at North Bay, but tolerably common at Peninsula Harbor. I did not find it at Nepigon.

This shrew is always found in or near thick woods and in the wettest situations, generally near the bank of a stream. At Peninsula Harbor I trapped several in vole runways at the edge of a wet caribou meadow.

Measurements of Sorex albibarbis from Ontario.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	3902	♀	154	70	20	8.2
" " "	3904	♀	164	77	21	9
" " "	3905	♀	157	70	20	9
" " "	3903	♂	155	74	19.4	9
Peninsula Harbor, "	3906	♂	151	65	21	10
" " "	3908	♂	162	72	19.6	9
" " "	3909	♂	154	69	19	9
" " "	3910	♂	171	82	20.6	9.4
" " "	3912	♂	158	71	20.4	9
" " "	3914	♂	160	71	20	9
" " "	3915	♂	155	70	20.4	8
" " "	3907	♀	160	73	20	9
" " "	3911	♀	160	74	20	8

Sorex richardsoni Bachman.

I caught two Richardson's shrews at Peninsula Harbor, one in an open Sphagnum bog, the other in a dense spruce thicket.

Both specimens are in a very dull pelage closely resembling the summer coat of the European *Sorex araneus*.

So far as I know this species has not been taken elsewhere in Ontario.

Sorex fumeus Miller.

The smoky shrew is apparently uncommon at North Bay, as I was unable to secure more than one specimen. I did not find the animal on the north shore of Lake Superior.

"Scarce at Mount Forest; met with in wet evergreen woods only. Not found at Milton" (Brooks).

Not mentioned by Gapper.

Sorex personatus I. Geoff. St. Hilaire.

The masked shrew is common everywhere at North Bay except in the clearings. It is excessively abundant at both Peninsula Harbor and Nepigon.

Common at Mount Forest and tolerably common at Milton (Brooks).

Mentioned by Gapper under the name *Sorex forsteri*.

While the specimens taken by Mr. Brooks at Mount Forest are true *S. personatus*, those from North Bay differ slightly from the typical form, and those from the north shore of Lake Superior are almost different enough to warrant separation as a distinct subspecies. The characters by which these specimens differ from the subspecies *personatus* are in the direction of the large, dark, Alaskan subspecies *streatori*[1] and not in the least toward the small, pale, plains form sometimes recognized as the subspecies *haydeni*. Until the geographic range and individual variations of *Sorex personatus streatori* are better known than at present, I prefer to let the Lake Superior specimens stand as *Sorex personatus*, without attempting to refer them to their proper subspecies. It is almost certain, however, that they cannot be considered *S. personatus personatus*. In color the Lake Superior shrews do not differ appreciably from typical *S. personatus* of the Transition zone in the eastern United States, but in size they are much larger. Eight specimens from Nepigon and Peninsula Harbor average: total length, 105; tail vertebrae, 44.2; hind foot, 12. Five specimens of *S. personatus personatus* from Tuckerton, N. J., average: total length, 98.6; tail vertebrae, 40.6; hind foot, 12.8. Eight of the same subspecies from Montauk Point, N. Y., average: total length, 98.3; tail vertebrae, 38; hind foot, 12.1. Eight specimens

[1] Merriam, North Amer. Fauna, No. 10, p. 62–63.

of *S. personatus streatori* from Yakutat, Alaska, the type locality, average: total length, 106.6; tail vertebrae, 45.6; hind foot, 12.7. Fifteen of the same subspecies from Sitka average: total length, 108.1; tail vertebrae, 46.9; hind foot, 13.4.[1] As fourteen specimens of *Sorex personatus* collected by Mr. Outram Bangs at Lake Edward, Quebec, are nearly as large as those from Lake Superior,[2] it seems probable that *Sorex personatus personatus* is replaced by a larger subspecies wherever the range of the species enters the Hudsonian zone.

In a female taken at North Bay on August 27, and in another taken at Peninsula Harbor on October 12, the mammae are well developed. The uterus of the North Bay specimen contained two large embryos. In each of these females there are six mammae, two abdominal and four inguinal.

MEASUREMENTS OF SOREX PERSONATUS FROM ONTARIO.

Locality.		Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay,	Ontario.	3920	♂	105	41	12	7
" "	"	3921	♂	106	40	12.4	7.6
" "	"	3926	♂	103	42	12.8	7
" "	"	3927	♂	98	40	11.4	8
" "	"	3922	♀	105	42	12.4	7.4
" "	"	3923	♀	103	42	12.4	8
" "	"	3924	♀	100	40.6	12	6.4
" "	"	3925	♀	111	43	12.8	7.4
" "	"	3928	♀	100	39.4	12.4	7.6
" "	"	3929	♀	103	41.6	12	7
Nepigon,	"	3930	♀	105	44	12	7.6
"	"	3931	♂	104	43	12	7.8
"	"	3932	♂	103	43	12	7.8
"	"	3933	♂	105	43	12	8
Peninsula Harbor,	"	3934	♂	105	45	12	7
" "	"	3935	♂	97	38	12	8
" "	"	3937	♂	105	46	12.6	7.8
" "	"	3936	♀	113	46	12	8

[1] The mean measurements of *S. p. personatus* and *S. p. streatori* are taken from North Amer. Fauna, No. 10, p. 63.

[2] The Lake Edward specimens average: total length, 104.3; tail vertebrae, 42.7; hind foot, 11.9.

Sorex hoyi Baird.

Hoy's shrew is tolerably common at North Bay. I secured only one at Peninsula Harbor.

Neither Brooks nor Gapper mentions this shrew.

Hoy's shrew avoids bogs and heavy woods. At North Bay I invariably found it in dry clearings and gardens. Several fell into pitfalls dug in a garden, and others entered traps set beneath stumps in a meadow. The one taken at Peninsula Harbor was found by a dog under the rotting trunk of a small tree in an open upland 'prairie.'

A female taken at North Bay on August 22 has only four mammae, all inguinal. In this character it differs from *Sorex personatus* and agrees with *Blarina brevicauda*. A reduction in the number of mammae is probably characteristic of the subgenus Microsorex.

Measurements of Sorex hoyi from Ontario.

Locality.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	3916	♂	88	29	10	6
" " "	3919	♂	92	33	10	6.4
" " "	3917	♀	95	31	9.6	6.8
" " "	3918	♀	91	32	9.8	6
Peninsula Harbor, "	4307	♂	92	35	10.4	6.8

Blarina brevicauda (Say).

The short-tailed shrew is abundant at North Bay, Peninsula Harbor, and Nepigon.

Common at Mount Forest (Brooks).

Gapper described this shrew as a new species under the name *Sorex talpoides* from the region between York and Lake Simcoe.

At North Bay I caught one alive in a dry pitfall. The animal showed no sign of fear, but sprang savagely at my hand whenever I reached toward him. He gave every indication of good vision by dodging or attacking small objects tossed at him. He also evinced great acuteness of hearing, as the slightest noise caused him to start and assume a defensive attitude. During the ten minutes that I teased him before setting him free he kept up a continuous bat-like squeaking. At times, when especially enraged, he stood on his hind legs, resting his front feet as high as possible on the side of the pitfall, and vented his anger in a sound much resembling a red squirrel's chatter greatly reduced in volume and proportionally increased in intensity. While doing this he invariably threw back his muzzle so as to expose to the fullest extent his formidable incisors.

Although the northern range of *Blarina brevicauda* has been supposed to be limited by the southern edge of the Canadian zone,[1] the abundance of the species on the north shore of Lake Superior shows that it must be considerably extended. I have nowhere seen *Blarina brevicauda* more abundant and destructive than at Peninsula Harbor, and the fact that it occurs there in equal abundance in all situations from the deepest spruce woods to the most barren 'prairies' is sufficient indication that its presence is not dependent on some specially favorable local condition.

A female taken at North Bay on August 25 has four mammae, all inguinal.

MEASUREMENTS OF BLARINA BREVICAUDA FROM ONTARIO.

Locality.		Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.
North Bay,	Ontario	3882	♀	123	26	15
" "	"	3883	♀	122	24	15.4
" "	"	3887	♀	125	27	15.4
" "	"	3888	♀	127	27.6	15
" "	"	3889	♀	118	24	15
" "	"	3891	♀	110	25	15
" "	"	3884	♂	123	24.6	15
" "	"	3885	♂	120	26	14
" "	"	3886	♂	121	26	15
" "	"	3890	♂	130	26	15.6
" "	"	3892	♂	125	26	15
Nepigon,	"	3893	♀	120	24	15.4
"	"	3897	♀	124	25	15
"	"	3894	♂	130	27	16
"	"	3895	♂	130	27.6	15
Peninsula Harbor,	"	3898	♀	130	30	16
" "	"	3899	♀	125	26	16
" "	"	3900	♀	125	30	16.6
" "	"	3901	♂	130	29	17

[1] Dr. C. Hart Merriam in his revision of the genus (North Amer. Fauna, No. 10, p. 11) defines the range of *Blarina brevicauda brevicauda* as follows: "Upper Austral and Transition zones, * * * * penetrating a short distance into lower edge of boreal."

While the short-tailed shrew of Ontario like that of the eastern United States is slightly different from true *Blarina brevicauda*, the type of which came from Nebraska, it is not sufficiently so to require recognition as a distinct subspecies.[1]

Condylura cristata Linn.

Moles are said to occur at North Bay, but I saw none. At Nepigon a star-nosed mole was brought me which had been killed in a field at the Hudson Bay Company's post. The hills and ridges made by this animal were very numerous in the damp ground between the railroad and the lake at Peninsula Harbor. I secured no fresh specimens here, but took the remains of one from the stomach of a rough-legged hawk killed early in October.

"Tolerably common at Mount Forest. Once observed about six miles north of Milton in a cedar swamp" (Brooks).

Not mentioned by Gapper.

The specimen from Nepigon measures: total length, 200; tail vertebrae, 80; hind foot, 28. It is an adult male.

Vespertilio subulatus Say.[2]

At North Bay I shot five of these bats as they flew along the roadways through the woods at dusk. One evening I saw several feeding among the tops of some tall birches to the twigs of which they would cling for an instant while picking off their prey.

I have a specimen taken by Mr. Brooks at Mount Forest. Mr. Brooks reports the species common at both Mount Forest and Milton.

Vespertilio lucifugus Le Conte.

Mr. Charles Bullard who accompanied me to North Bay caught a specimen of this bat on the platform of the railroad station at Gravenhurst on the evening of August 16. Many others were seen. On August 11 I shot one at North Bay in the woods near Mr. Besserer's clearing.

[1] See Merriam, North Amer. Fauna, No. 10, p. 12.

[2] For the two species of Vespertilio known to occur in Ontario I adopt provisionally the names used by Dr. H. Allen in his first Monograph of North American bats (1864). The names of the other bats are those used by Dr. Allen in his second Monograph (1893).

Adelonycteris fuscus (Beauv.).

"The brown bat is rare at Mount Forest" (Brooks).

There is a specimen of this bat in the U. S. Nat. Mus. (Dept. of Agric. Collection) taken at Toronto.

Lasionycteris noctivagans (Le Conte).

Not common at Mount Forest (Brooks).

Atalapha cinerea (Beauv.).

Mr. Brooks once found a dead hoary bat at Milton.

Mentioned by Gapper in his list of the mammals of Upper Canada.

Atalapha noveboracensis (Erxl.).

I shot two red bats at North Bay during the latter part of August.

Cariacus virginianus (Bodd.).

Deer are very numerous at North Bay, where I saw many heads and antlers.

"At Mount Forest almost exterminated some years ago but now increasing in numbers. All killed off at Milton many years ago" (Brooks).

Mentioned by Gapper in 1830 among the mammals occurring in the region between York and Lake Simcoe.

Alce americanus Jardine.

Moose are locally common about North Bay, where I saw a number of antlers and mounted heads. On the north shore of Lake Superior I was told that the moose is occasionally found, but as a rare straggler only.

Rangifer caribou Aud. & Bach.

Caribou are very abundant on the north shore of Lake Superior, where they replace the deer and moose of the Canadian zone. I saw heads, antlers, and jaws of caribou at White River, Peninsula Harbor, Schreiber, and Nepigon.

A wet pasture among the hills a mile or more northeast of Peninsula Harbor is a favorite feeding ground of these animals. Their fresh foot prints, resembling cattle tracks, were to be found every morning, but I only once saw one of the animals. The pale color of this caribou's sides and buttocks made him a conspicuous object as he trotted leisurely about the edge of the marsh and among the stunted spruces and tamaracks with which it is bordered.

PROCYON LOTOR (Linn.).

The raccoon is tolerably common at Mount Forest and rather more numerous at Milton (Brooks).

Mentioned by Gapper as occurring in the region between York and Lake Simcoe.

Mr. William McKirdy of Nepigon told me that a few years ago a raccoon was killed by some Indians near Lake Nepigon and brought to the Hudson Bay Company's post. Neither Indians nor traders ever had seen the animal in the region before, and to most of the former it was entirely unknown.

URSUS AMERICANUS Pallas.

The black bear is locally common at North Bay, where I saw a mounted specimen. On the north shore of Lake Superior it is said to be abundant. Bear signs were very numerous at Peninsula Harbor on the blueberry covered upland 'prairies' and on the rocky hills back from the lake shore.

"The black bear still occurs at Mount Forest" (Brooks).

Recorded by Gapper in 1830 from the region between York and Lake Simcoe.

LUTRA HUDSONICA Lacépède.

Otters are not common at North Bay, though they are taken in considerable numbers at various points about the shore of Lake Nipissing. Near Peninsula Harbor and Nepigon they are numerous, and I saw several skins taken by Indians at Lake Nepigon.

Scarce at Mount Forest and very rare at Milton (Brooks).

Mentioned by Gapper in 1830 among the mammals of Upper Canada.

MEPHITIS MEPHITICA (Shaw).

Skunks are common at North Bay, Peninsula Harbor, and Nepigon. I also obtained a specimen killed near the mouth of the Little Pic River.

Scarce at Mount Forest; tolerably common at Milton (Brooks).

Mentioned by Gapper in 1830, but not on his own authority.

The skunks which I collected at North Bay and on the north shore of Lake Superior have been recorded by Mr. Outram Bangs as typical examples of the northern subspecies.[1] Individuals varying toward the *Mephitis mephitica scrutator* probably occur in extreme southern Ontario.

The adult skunks taken at North Bay are all infected by the parasite that disfigures the frontal region of the skulls of a large proportion of specimens of North American Mustelidae. I submitted one of the North Bay skulls with the parasites preserved in formalin *in situ* to Dr. W. McM. Woodworth, who identified the worms as *Filaroides mustelarum*, a viviparous nematode hitherto recorded from Europe only, where it has been found in various species of Putorius and Mustela.[2]

Mustela americana Turton.

The marten is common at North Bay, Peninsula Harbor, and Nepigon.

At Nepigon a trapper told me that the martens, wherever they occur in sufficient numbers, so terrorize the red squirrels by constant persecution that the noisy rodents, learning that silence is their best protection, stop chattering. Hence an abundance of silent squirrels is — according to my informant at least — a certain indication that marten fur is plenty.

Mustela pennanti Erxl.

Fisher occur in small numbers at North Bay, Peninsula Harbor, and Nepigon. At North Bay I saw a mounted specimen.

Gapper mentions one taken somewhere between York and Lake Simcoe about the year 1830.

Putorius vison (Schreber).

The mink is abundant at North Bay, Peninsula Harbor, and Nepigon.

Common at Mount Forest and Milton (Brooks).

Mentioned by Gapper as occurring in the region between York and Lake Simcoe.

[1] Proc. Biolog. Soc. Washington, Dec., 1896, vol. 10, p. 160.

[2] Amer. Nat., March, 1897, vol. 31, p. 234-235.

A very large adult male taken at Peninsula Harbor on October 8, 1896, measures: total length, 610; tail vertebrae, 200; hind foot, 65; ear from meatus, 25; greatest length of skull, 70. This specimen probably represents about the maximum size attained by the typical subspecies.

I caught this mink in a steel trap baited with mice and set at the corner of a boat house on the shore of the harbor. His track as he approached the trap could be traced for fully an eighth of a mile along the sandy beach. He had followed the water's edge closely most of the way but occasionally had made short excursions up the beach in search of prey. On one of these side expeditions he had captured a shrew (*Sorex personatus*) which had also left its track in the sand. The tracks of the two animals showed that the shrew was not killed until he had led his enemy a sharply zigzag chase. The mink left the tail and hind quarters of the shrew lying on the sand, and continued his way directly to my trap.

PUTORIUS CICOGNANI CICOGNANI (Bonap.).

Bonaparte's weasel is common at North Bay, Peninsula Harbor, and Nepigon.

Not common at Mount Forest and Milton (Brooks).

Mentioned by Gapper under the name *Putorius erminea*.

MEASUREMENTS OF PUTORIUS CICOGNANI CICOGNANI FROM ONTARIO.

LOCALITY.	Number.	Sex.	Total length.	Tail vertebrae.	Hind foot.	Ear from meatus.
North Bay, Ontario.	3951	♂ juv.	295	75	38	18
" " "	3952	♂	321	97	39	20
" " "	3953	♀	330	88	42	21
Nepigon, "	3954	♀	325	97	41	21
Peninsula Harbor, "	3955	♂	260	62	30	15.4

PUTORIUS CICOGNANI RICHARDSONI (Bonap.).

Mr. Bangs records a specimen of *Putorius cicognani* more closely resembling the large northern form than the typical subspecies, from Fort Albany, Ontario.[1]

[1] Proc. Biolog. Soc. Washington, Feb., 1896, vol. 10, pp. 18, 21.

Putorius longicauda spadix Bangs.

A tanned skin of a weasel given me by Mr. L. W. Besserer of North Bay has been identified by Mr. Outram Bangs as the dark eastern race of *Putorius longicauda*, a species not hitherto recorded from any point east of Minnesota. Mr. Besserer trapped this specimen on the bank of the Chippewa Creek, a few miles north of North Bay, and at once recognized it as a very different animal from any others he had ever seen.

Mr. Brooks writes that he saw weasels very much larger than *P. cicognani* at Milton. It is doubtful whether these were *P. longicauda* or *P. noveboracensis*, but I am inclined to think they were the latter.

Putorius rixosus Bangs.

Mr. Bangs has recorded two least weasels taken at Moose Factory.[1]

At Nepigon and Peninsula Harbor I was told of the occurrence of a very small weasel that turns entirely white in winter.

Vulpes pennsylvanicus (Boddaert).

The red fox is common at North Bay, Peninsula Harbor, and Nepigon.

Common at Milton and Mount Forest (Brooks).

Recorded by Gapper from the region between York and Lake Simcoe.

Canis nubilus Say.

Wolves are probably found throughout the less inhabited parts of Ontario. I saw none, but heard numerous trustworthy reports of the animal's occurrence in the country a few miles north of Lake Nipissing and on the north shore of Lake Superior.

In 1830 Gapper recorded *Canis 'griseus'* on his own authority from the region between York and Lake Simcoe.

Lynx ruffus (Güldenstädt).

"Wild cats still occur in large cedar swamps at Mount Forest" (Brooks).

Note. — Both Canada lynx and panther are doubtless to be found in Ontario, but I have no positive evidence of the occurrence of either. Various species of seals and cetaceans probably reach the northern border of Ontario on James Bay.

[1] Proc. Biolog. Soc. Washington, 1896, vol. 10, p. 22.

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PROCEEDINGS OF THE ANNUAL MEETING, MAY 5, 1897.

BOSTON:

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June, 1897.

No. 2.— *Proceedings of the Annual Meeting, May* 5, 1897.

REPORT OF THE CURATOR, ALPHEUS HYATT.

Owing to the sickness of a member of his family, the Curator was obliged to be absent from the last annual meeting, his report having been read by Prof. H. W. Haynes, who kindly consented to appear for him. During this absence, which lasted about six weeks, the Curator called at the great seaside laboratory of Professor Dohrn at Naples, and selected a suite of preparations in alcohol for which that establishment is famous. The perfection of the preparations is such that the natural colors and forms even of delicate animals like jelly fishes are preserved, and they are far more satisfactory than models or artificial preparations. The Society owes this collection to the generosity of Miss H. O. Cruft.

The Gulick collection of shells was first alluded to in the report of May 7, 1890. Since that time, the Curator has spent a large part of his available time in working upon this collection. The importance of solving the problem presented by these land snails cannot be over-estimated. They illustrate more perfectly than any known group of living or extinct animals the modes of evolution of organic beings. Evolution as an obviously rational hypothesis applied to the history of organisms is generally admitted, but series of animals so closely and undeniably connected that they can be used as demonstrations of the laws of divergent evolution are so rare that only a half dozen have been so far published, and none of these approach in perfection the Achatinellinae of the Hawaiian Islands. The most complete representation of these interesting and beautiful shells was collected by Rev. J. T. Gulick, a missionary to these islands, and from him the fullest suite of specimens in his possession, except his own reserved collection, was purchased by the Society in 1890. This collection has been thoroughly worked over by the Curator, and every species and variety and their connection with others carefully and fully re-described. This statement of the facts, by far the most important part of this piece of scientific work, is now rapidly nearing completion. In order to obtain the means to continue this investigation, which requires a large amount of clerical work, the Curator gave two lectures, one in the hall of the Society and the other in Cambridge, and the proceeds were sufficient to meet the expenses for a time.

The Museum has this year been visited on days when the public is not admitted by 17 teachers and 476 pupils, representing 18 schools.

Teaching in the Museum.

This department still continues to be active, but is entirely dependent upon the generosity of the same lady who has heretofore supported it. The following talks and courses have been given by Mr. A. W. Grabau. In September short talks upon various subjects were given in the Museum, the attendance usually numbering from ten to twenty persons. Beginning with October and continuing through November, a course of nine lectures on the elementary principles of organic evolution was given on Saturdays at 11 o'clock. The course attracted attention, and the lectures were frequently reported in the newspapers. The average attendance at each lecture was about eighty persons, the number not infrequently reaching one hundred. This course has done more than any other to attract public attention to this department of our work. On Wednesdays during October and November a course of eight lectures on the great ice age and its work was given at 11 o'clock. The average attendance at these was about thirty. Altogether this has been the most successful season for this department. The one thing necessary to give it wider usefulness is advertisement. The short notices in the papers are too slight to become widely known, and many persons who would be glad to hear the lectures do not know of their existence.

Lecturing in the Museum was resumed on the first Saturday in April, 1897, but no regular course was begun until the 17th of that month.

On Wednesdays at 11 o'clock lectures on the surface of the earth, its rocks, soil, and scenery are given; attendance at these averages about thirty persons.

Dynamical Zoology.

The Curator has expended considerable time in preparing labels for this department which will be put in place next year. The difficulties in the way of progress in this department consist in the amount of time demanded by every step, even the labeling of the preparations already in place being very difficult. The absence of means sufficient to purchase the necessary preparations, and the need of building up others piece by piece occasion loss of time and wearisome delays that cannot be avoided.

Synoptic Collection.

A large amount of work has been done on this collection this year as in the past by Miss J. M. Arms, and the following is an account in detail of her work.

The palaeozoic corals have been studied, and representative species for nine genera have been selected. A number of fossils have also been selected from the lot purchased of Mr. Greene. The development and geologic history of crinoids have been studied, and thirty-three illustrations and a number of specimens selected to represent the genera, and about forty-five pages of text written.

The asterioids, ophiurioids, and holothurioids have been worked upon, and illustrative figures selected. Clypeasteroids and spatangoids have been studied and some preparations made, and fifty pages of the text of the Guide on Echinozoa have been written. Pteropoda have been revised in connection with new materials received, and the text of the corresponding part of the Guide revised.

A very valuable preparation of a fossil trilobite, Triarthrus beckii, showing the antennae, and two restorations of the same species, showing all the appendages, have been added. These were sent to the Curator by Dr. Charles E. Beecher, and represent the remarkable discoveries and equally remarkable work of that distinguished palaeontologist.

This department has also received a series of representative marine forms purchased from the marine zoological laboratory at Naples and mentioned in the first part of this report. These consist of 86 specimens in alcohol, and represent the more important marine types of the Mediterranean. Dry preparations of one hundred and fifty-three specimens of vertebrates and some invertebrates have been mounted for this collection. Miss Martin has also made a hundred colored drawings to illustrate the work done by Miss Arms.

Botany.

The work in this department still continues to progress under the patronage of Mr. John Cummings. Miss Carter reports as follows: —

Progress has been made in the systematic arrangement of duplicates, which will be completed another year. The labeling of the Lowell collection with special labels has been carried on during the year and is nearly finished. The additions have been mounted and distributed in their proper places.

Accessions during the year were as follows: Miss C. H. Clarke, 3 specimens, New England Algae; also a copy of Farlow's Marine Algae for herbarium use. Mr. F. S. Collins, 160 specimens, New England Algae. Prof. W. O. Crosby, 240 specimens, French cryptogams, belonging to herbarium of the late Fred. Pech. Miss Harriet E. Freeman, 18 specimens, plants from British Columbia and Yellowstone Park. Nine specimens of southern plants have been received by exchange with Biltmore Herbarium, N. C., and 263 specimens of lichens from the Cummings, Williams, and Seymour collection of North American lichens by purchase.

Twenty-seven persons have been permitted to consult the herbarium under supervision of Miss Carter.

Geology.

The work on the Geology of the Boston Basin and on the collections has been progressing and a number of important additions have been made by purchase during the past year, but owing to the unfortunate sickness of Professor Crosby no report can be made until the next annual meeting.

Palaeontology.

A very valuable series of palaeozoic fossils, mostly corals, have been added by purchase from Mr. G. K. Greene. This department needs considerable special work, and will, it is hoped, receive its proper share of attention next year. We have on hand a number of important fossils that would make valuable additions to our exhibition collections, and this whole department needs revision. A suite of fossil fishes from the Green River region has been purchased from Mr. G. B. Frazar.

Miss Martin has made a catalogue of the fossils stored in the trays under exhibition cases in the palaeontology room, and one can now find any species stored in these trays.

Mollusca.

The Curator outside of his work on Dynamical Zoology and routine duties has spent all this time upon the Achatinellinae of the Hawaiian Islands, noticed on the first page of this report.

Miss Martin has finished the catalogue of the shells under the exhibition cases in the Mollusca room, the gallery adjoining, and the fish room, and one can now find any species stored in these trays. The same assistant has also spent some time in reviewing odd lots of shells and picking out material for exhibition.

Mrs. Flint has numbered and catalogued a valuable collection of English coast shells purchased from Sowerby, and a small collection of Achatinellinae purchased from Mr. Baldwin, and has also been more or less occupied in sorting and arranging duplicate shells.

Insecta.

This important and perishable collection is under the charge of our Secretary, Mr. Henshaw, and is reported as in safe condition by him.

Mammals and Birds.

Mr. Charles F. Batchelder has spent considerable time in working upon these two departments, but his efforts have been necessarily of a preparatory and miscellaneous nature and cannot be reported upon in detail.

A number of the smaller mammals of the Boston Museum collection have been remounted. A large and very costly case has been completed, in which the giraffe and some other large mammals have been stored. A valuable specimen of the sloth bear, Melursus labiatus, an Armadillo, and several very young lion cubs have been given by the proprietors of the "Zoo."

The Nuttall Ornithological Club, through the kind intercession of Mr. Batchelder, has offered to make for the Society a collection of the nests and eggs of birds breeding in New England, to be exhibited in connection with the New England collection. Miss Martin has catalogued a number of eggs and nests of birds lately received. Cans have been made for six of the large trays under bird cases in Gallery R, and these have been fitted in place by Mr. Coles.

Remarks.

A large amount of work is done every year that is not usually reported upon. This consists of the inspection and poisoning of dry specimens, birds, mammals, and all perishable dry preparations, of which there are a large number, the inspection of all bottled specimens and renewal of alcohol when needed, the revision of the laboratory collection of specimens and diagrams, and the remounting of miscellaneous specimens among these and in the Museum.

Laboratory.

The room of this department has been used as in previous years by the classes from the Boston University and three classes of the Teachers' School of Science. Miss Martin has done considerable work in rearranging and mounting specimens, and painting diagrams for use in the lectures given to these classes.

Teachers' School of Science.

The special course for the pupils of the Normal School has this year been carried on by Professor Barton at his own expense, the funds for the course not having been continued. The class consisted of eighteen persons.

A course of eight lectures on the study of animal life has been given by Mr. A. W. Grabau on Saturdays, at 10 A. M.; the average attendance at these was about thirty persons. A course on the animals of the shores of New England has been begun by Mr. Grabau and is in progress. The attendance at these lectures, which take place at 11 o'clock on Saturdays, varies from forty to seventy-five persons. Two field classes have been begun and are now being carried on by means of excursions to the seashore for the collection and study of marine animals. The attendance was so large that it has been found necessary to divide this class and have an excursion on Wednesday afternoons in addition to those on Saturdays. A class in laboratory work, also conducted by Mr. Grabau and directly connected with these field excursions, is held on Saturdays at 9 o'clock, with an attendance of about twenty persons. These courses have been developed out of the efforts of a Boston lady to furnish the public with better guidance in the Museum, and are a great and welcome addition to the public usefulness both of our Museum and of the Teachers' School of Science.

Lowell Free Courses.

The field course in geology, begun in the spring of 1896, was the last series of ten lessons in a three years' course. The more distant points visited were Haverhill, Mount Holyoke, and Wachuset. The two former occupied one day each, and the last three days. The average attendance at these lessons was twenty-seven. In the autumn of 1896 a new field course was begun, and a series of ten lessons given. The more distant points visited were Marblehead, the region about Mount Greylock, and Hoosac tunnel. The last trip occupied two days and was extraordinarily successful, the attendance being 89. The average attendance at these lessons was 73.4. The spring course for 1897 was begun, April 24, with an attendance of 35 persons.

The regular laboratory course in geology began the first Saturday in December and finished April 10. Fifteen lectures and exercises were given, and the subject of petrology was finished, this being the third year in a four years' course. The attendance at these classes is larger than upon any other subject. The class numbered 139, the average attendance was 100. The usual examinations have been held, and the results as in previous years were satisfactory.

Dr. Robert W. Greenleaf gave a series of lessons upon "The principles of classification of flowering plants," beginning November 7, 1896, and ending March 13, 1897. The topics were as follows: (1) Fundamental characters involved in the relative positions of leaf and stem, plan of the flower, embryonic conditions, etc.; (2) Environmental characters; color of flower, stem, and leaf in relation to surroundings, etc. It should be remembered that these lessons, like all others in the Teachers' School of Science, are strictly objective, dealing with plants themselves, which the pupils observe, study, and draw in the laboratory under the direction of the lecturer.

With this in mind, one understands fully the significance of the following remark. Dr. Greenleaf finds that, in trying to accommodate themselves to the use of this objective method, a considerable proportion of his class, although obliged to teach botany in the public schools, showed an obvious want of the necessary capacity to make or assimilate facts of observation. He in consequence of this experience comments justly upon the cut and dried nature of a system that obliges any one to undertake the work of teaching subjects for which he or she has no natural capacity.

There were forty-nine members in this class, and the average attendance was thirty-six. The usual examinations were held, and results were satisfactory as on former occasions.

The Curator gave the second series of lessons in his course dealing with the Echinozoa, Vermes, and Crustacea. This series began the first Saturday in November, and ended March 27, making sixteen lessons of two hours each. The number of tickets issued was thirty-six, and the average attendance was twenty. The usual examinations were held with results as satisfactory as in former years.

REPORT OF THE SECRETARY AND LIBRARIAN, SAMUEL HENSHAW.

Membership.

Twenty-two Corporate members have been elected by the Council during the past year; eight, Thomas T. Bouvé, Caleb D. Bradlee, Frederick G. Frothingham, Caleb W. Loring, Jacob Norton, Oliver W. Peabody, George F. Waters, and George W. Wales, have died, five have resigned, and three have forfeited their membership for non-payment of dues. One Honorary member, Auguste Daubrée, and six Corresponding members, Edward D. Cope, G. Brown Goode, Juan Gundlach, Ferdinand von Müller, Joseph Prestwich, and Josiah Dwight Whitney, have died.

The membership of the Society corrected to May 5, 1897, consists of 12 Honorary, 139 Corresponding, and 363 Corporate members, a total of 514.

The general meeting held, December 2, 1896, was commemorative of Thomas Tracy Bouvé, who died at Hingham, June 3, 1896. Mr. Bouvé was a member of the Society for more than sixty-two years. His disinterested devotion and activity in behalf of the Society connects his name indissolubly with our history and endears his memory as a cherished association.

The names of the members elected and the dates of their election are as follows: —

Francis Noyes Balch. Dec. 16, 1896.
Edward E. Bancroft. Dec. 16, 1896.
W. S. Beekman. Apr. 21, 1897.
Walter G. Chase. Apr. 21, 1897.
Miss Clara E. Cummings. Dec. 16, 1896.
George C. Curtis. Apr. 21, 1897.
Ulric Dahlgren. Feb. 17, 1897.
George A. Dorsey. Feb. 17, 1897.
Justus W. Folsom. Dec. 16, 1896.
Mrs. Mary L. Hammatt. Apr. 21, 1897.
Walter E. Hobbs. Oct. 21, 1896.
John G. Hubbard. Feb. 17, 1897.
James Arnold Lowell. Oct. 21, 1896.
John Murdoch. Dec. 16, 1896.
James E. Peabody. Oct. 21, 1896.
William Z. Ripley. Dec. 16, 1896.
John H. Sears. Oct. 21, 1896.
Mrs. Mary L. Seavey. Oct. 21, 1896.
W. Porter Truesdell. Apr. 21, 1897.
Miss Mary L. Ware. Dec. 16, 1896.
Samuel M. Weld. Dec. 16, 1896.
J. Edmund Woodman. Feb. 17, 1897.

Meetings.

Fourteen regular meetings have been held with a total attendance of 1,138, an average of 81 *plus* to a meeting; the total last year was 1,339, the average 95 *plus*.

The largest attendance at any one meeting was 280, the smallest 28; the largest last year was 400, the smallest 13.

Thirty communications have been made by twenty-five persons.

Eight papers have been presented by title.

The meetings, attendance, and communications presented have been as follows: —

May 6, 1896. Annual meeting. Forty persons present.

Reports of the Curator, Secretary, Librarian, Treasurer, and Trustees.

Prof. Charles S. Minot. On the principles of the construction of microtomes.

May 20, 1896. General meeting. Seventy-four persons present.

Prof. E. S. Morse. Man as a Tertiary mammal.

Dr. G. A. Dorsey. On the photograph and skeleton of a native Australian.

November 4, 1896. General meeting. One hundred and seventeen persons present.

Prof. George L. Goodale. The reclaiming of deserts.

Mr. S. H. Scudder. List of exotic Orthoptera described by S. H. Scudder, 1868–1879, with a revision of their nomenclature. (By title.)

Mr. G. S. Miller, Jr. Notes on the mammals of Ontario. (By title.)

Dr. Garry de N. Hough. A monograph of North American Muscidae. (By title.)

Dr. Garry de N. Hough. A monograph of North American Sarcophagidae. (By title.)

November 18, 1896. General meeting. Two hundred and eighty persons present.

Prof. G. H. Barton. Observations on the inland ice and the glaciers proceeding from it in the Umanak District, Greenland.

Prof. Alfred E. Burton. The topographical features of the Umanak District, Greenland.

December 2, 1896. General meeting. Forty-eight persons present. Memorial of Thomas Tracy Bouvé.

Mr. Charles J. Sprague and Dr. James C. White. The early services of Mr. Bouvé to the Society.

Prof. Alpheus Hyatt. Mr. Bouvé's work in the Society since 1870.

Prof. W. O. Crosby. Mr. Bouvé's work in geology and mineralogy.

Dr. A. P. Chadbourne. A study of the feather colors and the process of color changes in the mature feather. (By title.)

December 16, 1896. General meeting. Twenty-eight persons present.

Prof. F. W. Putnam. Statement concerning some recent discoveries at Trenton, N. J., bearing upon the early presence of man in the Delaware Valley.

Prof. G. Frederick Wright. The extent of preglacial erosion in the United States, and its bearing on the question of the length and date of the glacial period.

January 6, 1897. General meeting. Eighty persons present.

Mr. A. W. Grabau. The sand plains of Truro, Wellfleet, and Eastham.

Prof. N. S. Shaler. Remarks on Mr. Grabau's paper.

Mr. J. B. Woodworth. Remarks on Mr. Grabau's paper.

Prof. W. M. Davis. Remarks on Mr. Grabau's paper.

Prof. W. M. Davis. A geographical classification of costal plains.

January 20, 1897. General meeting. Forty-three persons present.

Prof. W. O. Crosby. The great fault and accompanying sandstone dikes of Ute Pass, Colorado.

February 3, 1897. General meeting. One hundred and six persons present.

Mr. William C. Bates. Venezuela and British Guiana; their natural history, scenery, and people.

February 17, 1897. General meeting. Seventy-three persons present.

Prof. N. S. Shaler. Subterranean water of southeastern New England.

Dr. C. R. Eastman. On some Devonian fish-beds of North America.

March 3, 1897. General meeting. Sixty-five persons present.

Mr. T. A. Jaggar, Jr. Experimental study of mountain building.

Mr. J. B. Woodworth. Geology of the Gay Head Cliff.

Mr. Theodore G. White. Petrography of the Blue Hills complex. (By title.)

March 17, 1897. General meeting. Ninety-three persons present.

Mr. Frank Russell. An account of a naturalist's voyage down the Mackenzie.

April 7, 1897. General meeting. Thirty-two persons present.

Report of the Nominating Committee.

Prof. J. Eliot Wolff. The occurrence of tourmalins at Mt. Mica, Paris, Me.

Dr. C. B. Davenport. The rôle of water in growth.

Dr. C. R. Eastman. The characters of Macropetalichthys. (By title.)

April 21, 1897. General meeting. Fifty-nine persons present.

Mr. Herbert Lyon Jones. Some biological adaptations of our seaside plants.

Prof. W. M. Davis and Mr. George C. Curtis. A new series of geographical models. (By title.)

Publications.

Twelve papers, completing volume 27, and one paper, the first of volume 28, of the Proceedings have been issued during the year.

The large number of plates, twenty-six, illustrating volume 27 is noteworthy and is the result of publishing two papers in co-operation with the Museum of comparative zoology.

The separate publication and prompt distribution of each paper has proved satisfactory to our contributors and our exchanges.

Library.

The additions to the library reported last year were larger than any previously recorded, and this year they exceed by 119 the number reported a year ago.

The total 3,656 is made up as follows: —

	8vo.	4to.	Folio.	Total.
Volumes	362	114		476
Parts	2,033	363	8	2,404
Pamphlets	681	37	14	732
Maps				44
Total	3,076	514	22	3,656

The library contains 23,538 volumes, 1,299 incomplete (including current) volumes, and 11,573 pamphlets.

New exchanges have been arranged with twenty-four institutions as follows: K. k. naturhistorisches Hofmuseum, Wien; Museu Paulista, São Paulo, Brazil; Institute of Jamaica, Kingston; Université de Lyon, Lyon; Bibliothèque de la faculté des sciences, Marseille; Naturwissenschaftlicher verein, Elberfeld; Botaniske forening, Kjobenhavn; Museo de La Plata, La Plata; Musei di zoologia ed anatomia comparata, Torino; Westfälischer provinzial-verein für wissenschaft und kunst, Münster; Roemer-museum, Hildesheim; Société d'étude des sciences naturelles, Beziers; Naturforschende gesellschaft, Leipzig; Deutscher wissenschaftlicher verein, Santiago; Académie des sciences, Cracovie; Société d'horticulture du Doubs, Besançon; Società Romana per gli studi zoologici, Rome; Società di naturalisti, Napoli; Denison scientific association, Denison university, Granville; Botanical survey of Minnesota, Minneapolis; Texas academy of science, Austin; Oberlin college, Oberlin; Liverpool literary and philosophical society, Liverpool; K. k. mineralogische gesellschaft, St. Petersburg.

The Society now exchanges its publications with 416 scientific institutions and periodicals.

By purchase we have added seven serials: Anatomische hefte; Revista trimestral micrografica; Archives d'anatomie microscopique; Proceedings entomological society of Washington; Journal New York entomological society; Memoirs Torrey botanical club; Palaeontographia Italica.

Eight hundred and twenty-eight books have been borrowed by 123 persons; 154 volumes have been borrowed for use in the building, and the library has been consulted 373 times.

Eight hundred and five volumes have been bound in 356 covers; 200 pamphlets have been bound.

Five years ago we began indexing the papers published in serials. This work is laborious and the progress necessarily slow; the cards issued by the International bibliographical institute will, however, relieve most of the work on current volumes and allow us to devote our efforts to earlier volumes.

The total indexed is 70 serials, 1,017 volumes.

The list of 9 serials, 226 volumes, indexed this year is as follows:—

Anatomische hefte.	5 vols.
Berlin. K. akademie der wissenschaften; physikalische abhandlungen.	40 vols.
Copenhague. Académie royale des sciences; Mémoires.	31 vols.
Linnean society of London; Transactions.	39 vols.
Palaeontographia Italica.	2 vols.
Paris. Muséum d'histoire naturelle; Annales; Archives; Nouvelles archives.	56 vols.
Revista trimestral micrografica.	1 vol.
St. Pétersbourg. Académie des sciences: Mémoires, ser. 7 and 8.	39 vols.
Wien. K. k. geologische reichsanstalt; Abhandlungen.	13 vols.

Two sides of the basement room are fitted with shelves providing for about 4,000 volumes. This has cost $121.

In the annual report for May, 1894, I gave a list of the journals and serial publications received by the Society. The list soon to be issued by the Boston Public Library will show not only those taken currently by the Society but also by the libraries of Boston and vicinity. It will not, however, include discontinued serials, and as these are numerous and important I append to this report a list of those on our shelves.

A gift of $250 for the library from Miss H. O. Cruft was most timely, as it enabled us not only to purchase some recently published books but also to increase the number of volumes bound during the year.

Walker Prizes.

The subjects selected by the Walker Prize Committee for the annual award were: —

(1). A study of glacial, fluviatile, or lacustrine phenomena associated with the closing stages of the glacial period.

(2). Original investigations in regard to the chalazal impregnation of any North American species of Angiosperms.

(3). An experimental investigation in cytology.

(4). A contribution to our knowledge of the morphology of the Bacteria.

Only two essays, both on the geological subject, have been received, and Professor Sedgwick, the chairman of the Committee, in accordance with the rules of the Council, has informed me that the Committee award a prize of one hundred dollars ($100) to the author of the essay on modified drift of Cape Cod, inscribed "9492," and a second prize of fifty dollars ($50) to the author of the essay on the Pleistocene history of the Nashua Valley, inscribed "Quinepoxet."

The subjects announced for the award in May, 1898, are: —

(1). A cytological study of the sexual reproduction in Mucoraceae or Peronosporaceae.

(2). A contribution to our knowledge of color-vision, especially the evolution of color-vision.

(3). A contribution to our knowledge of cell-division.

(4). A study of the chemical and physical relations of any group of closely related mineral species.

(5). A geological study (including the mineralogy and economic geology) of any mineral deposit in the United States.

APPENDIX A.

ADDITIONAL LIST OF JOURNALS AND OF THE PUBLICATIONS OF SOCIETIES, SURVEYS, ETC., RECEIVED BY THE BOSTON SOCIETY OF NATURAL HISTORY.[1]

Anatomische hefte.
Annals of British geology.
Annuaire géologique universel.
Appalachian mountain club: Appalachia.
Arcachon. Société scientifique et Station zoologique: Travaux des laboratoires
Archives d'anatomie microscopique.
Australian museum, Sydney: Memoirs.
Bibliotheca zoologica.
Biologische untersuchungen.
Boston. Department of parks: Annual report.
Boston public library: Monthly bulletin.
Bruxelles. Société belge de géologie, de paléontologie et d'hydrologie: Bulletin.
 Société entomologique de Belgique: Mémoires.
Chicago academy of sciences: Bulletin.
Clermont-Ferrand. Académie des sciences, belles-lettres et arts: Mémoires.
Colorado college scientific society: Colorado college studies.
Columbia college: Memoirs of the department of botany.
Contributions to science.
Denison university: Bulletin of the scientific laboratories.
Entomologische nachrichten.
Field Columbian museum: Publications.
Glacialists' magazine.
Hamburg. Naturwissenschaftlicher verein: Verhandlungen.
Harvard university. Bussey institution: Bulletin.
Hildesheim. Roemer-museum: Mittheilungen.
Institute of Jamaica, Kingston: Journal.
Iowa. Agricultural college experiment station: Bulletin.
Johns Hopkins university: Memoirs from the biological laboratory.
Kentucky. Agricultural experiment station of the state college: Bulletin.
Kjobenhavn. Nordiske oldskrift-selskab: Mémoires.
Klagenfurt. Naturhistorisches landesmuseum von Kärnten: Carinthia.
La Plata. Museo de La Plata: Anales: paleontológia Argentina; seccion antropológica; secc. geológica y mineralógica; secc. zoológica. Revista.
Leland Stanford Junior university: Publications, geology and paleontology.

[1] The main list is published in the Annual report, May 2, 1894, Proceedings, vol. 26, p. 294–308.

Lyon. Université de Lyon : Annales.
Madras government museum : Bulletin.
Madrid. Sociedad geográfica : Revista de geografía colonial y mercantil.
Maine. Agricultural experiment station : Annual report.
Marseille. Faculté des sciences : Annales.
Maryland. State weather service : Biennial report.
Massachusetts. Board of metropolitan park commissioners : Report.
Mexico. Instituto geológico de Mexico : Boletin.
Michigan. Geological survey. Reports.
Middelburg. Zeeuwsch genootschap der wetenschappen: Verslag van het verhandelde in de algemeene vergadering.
Milano. Museo civico and Società italiana di scienze naturali : Memorie.
Minerva.
Minnesota. Botanical survey : Bulletin.
Minnesota. Geological and natural history survey : Report of the state zoologist.
Minnesota academy of natural sciences : Occasional papers.
Museums association : Report of proceedings.
Napoli. Società di naturalisti : Bollettino.
National academy of sciences : Biographical memoirs.
National geographic society : National geographic magazine.
Natural history society of New Brunswick : Occasional papers.
New Hampshire. New Hampshire college agricultural experiment station : Bulletin.
New Jersey. Agricultural college experiment station : Annual report. Bulletin.
New York entomological society : Journal.
Nuttall ornithological club : Memoirs.
Ohio academy of science : Annual report.
Oxford university department of zoology.
Palaeontographia italica.
Paris. Muséum d'histoire naturelle : Bulletin.
Peabody museum of American archaeology and ethnology, Cambridge : Memoirs.
Prag. Bohemian academy for arts, science and literature : Bulletin international.
Deutscher naturwiss.-medicinischer verein für Böhmen, Lotos : Abhandlungen.
Queensland. Geological survey : Bulletin.
Revista trimestral micrografica.
Revue générale de botanique.
Royal Scottish geographical society : Scottish geographical magazine.
Royal society of Queensland : Proceedings.
St. Pétersbourg. Académie des sciences : Annuaire du Muséum.
San Paulo. Commissão geographica e geologica : Boletim.
Sao Paulo. Museu Paulista : Revista.
Scottish microscopical society : Proceedings.
Seismological journal.
Texas academy of science : Transactions.
Trinidad field naturalists' club : Journal.
University of Illinois : Biennial report of the biological experiment station.

University of Pennsylvania: Contributions from the zoological laboratory.
University of Wisconsin: Bulletin, science series.
Vermont. State agricultural experiment station: Annual report. Bulletin.
Wien. Naturwissenchaftlicher verein an der universität: Mittheilungen.
Zoological society of Tokyo: Zoological magazine.
Zoologist.

APPENDIX B.

LIST OF DISCONTINUED SERIAL PUBLICATIONS IN THE LIBRARY OF THE BOSTON SOCIETY OF NATURAL HISTORY.

Academy of natural sciences of Philadelphia. Proceedings of the mineralogical and geological section, 1879–81.
Academy of science of St. Louis. Contributions to the archaeology of Missouri by the archaeological section, 1880.
Albany institute. Proceedings, 1870–74.
American association for the advancement of science. Memoirs, 1875.
American entomologist, 1868–80.
American journal of conchology, 1865–72.
American journal of otology, 1879–82.
American monthly magazine and critical review, 1817–18.
American quarterly journal of agriculture and science, 1845–47.
American quarterly microscopical journal, 1878–79.
American society of microscopists. Proceedings, 1880–85.
American sportsman, 1873–75.
Amiens. — Académie des sciences, agriculture, commerce, belles-lettres et arts du dép. de la Somme. Mémoires, 1837–73.
Amoenitates academicae, 1749–60.
Amsterdam. — K. akademie van wetenschappen. Processen-verbaal van de gewone vergaderingen, afd. natuurkunde, 1865–84.
Amsterdam. — K. zoologisch genootschap, Natura artis magistra. Nederlandsch tijdschrift voor de dierkunde, 1863–84.
Annals of anatomy and physiology, 1850–53.
Annals of botany, 1805–1806.
Annals of philosophy, or Magazine of chemistry, etc., 1813–20.
Annals of phrenology, 1834–35.
Annals of science, 1852–54.
Annual of scientific discovery, or Year-book of facts in science and art, 1850–60, 62, 69.
Ansbach. — Historischer verein in Mittelfranken. Jahresbericht, 1859–74.
Anthropological society of London. Anthropological review and journal of the society, 1864–69.

Archiv für anatomie, physiologie und wissenschaftliche medicin, 1848–50, 53–56.
Archiv für anatomie und physiologie, 1826–30, 32.
Archiv für zoologie und zootomie, 1800–1806.
Archives de botanique, 1833.
Around the world, 1893–95.
Association of American geologists and naturalists. Reports of the meetings, 1843–45.
Atlantic journal and friend of knowledge, 1832–33.
Batavia. — K. natuurkundige vereeniging in Nederlandsch Indië. Verhandelingen, 1856–60.
Beiträge zur gesammten natur- und heilwissenschaft, 1836–39.
Beiträge zur wissenschaftlichen botanik, 1858–68.
Bergen. — Bergens museum. Aarsberetning, 1883–91. Urda, 1834–47.
Bergen. — Sondre Bergenhus amtsformandskab. Forhandlinger, 1866–70.
Berlin. — Akklimatisation-verein. Zeitschrift für akklimatisation, 1863–72.
Berlin. — Berlinische gesellschaft naturforschender freunde. Schriften, 1780–94.
Berlin. — Gesellschaft naturforschender freunde. Mittheilungen aus den verhandlungen, 1836–38.
Berlin. — K. preussische akademie der wissenschaften. Bericht über die zur bekanntmachung geeigneten verhandlungen, 1849–55. Monatsberichte, 1856–81.
Berlin. — Meteorologisches institut. Uebersicht der witterung im nordlichen Deutschlands, 1855–58.
Berlin. — Verein zur beförderung des gartenbaues in d. k. preuss. staaten. Monatsschrift, 1873–81. Verhandlungen, 1853–59. Wochenschrift für gartnerei und pflanzenkunde, 1860–72. *With* Gesellschaft der gartenfreunde: Garten-zeitung, 1882–85.
Blankenburg. — Naturwissenschaftlicher verein des Harzes. Berichte, 1840–62.
Bologna. — Accademia delle scienze dell' istituto. Rendiconti delle sessioni, 1838–79.
Bonn. — Verein von alterthumsfreunden im Rheinlande. Jahrbücher, 1843–70.
Bordeaux. — Société linnéenne. Bulletin d'histoire naturelle, 1826–29.
Boston journal of philosophy and the arts, 1824–26.
Boston society of natural history. Boston journal of natural history, 1837–63.
Botanical bulletin, 1875–76.
Botanical magazine, 1787–1812.
Botanical miscellany, 1830–33.
Botanical society of Canada. Annals, 1861–62.
Breslau. — Schlesische gesellschaft für vaterländische kultur. Abhandlungen, abtheil. f. naturwissenschaft und medicin; phil.-hist. abtheil., 1861–74.
Brooklyn entomological society. Bulletin, 1878–85. Entomologica Americana, 1885–90.
Buenos Ayres. — Sociedad zoológica Argentina. Periodico zoológico, 1874–81.
Calcutta journal of natural history, 1840–44.
Canadian institute. Canadian journal of industry, science and art, 1858–78. Proceedings, 1879–90.

Chicago academy of sciences. Proceedings, 1866.
Christiania. — K. norske Frederiks universitet. Aarsberetning, 1866–77. Universitets programm, 1851–86.
Cincinnati quarterly journal of science, 1874–75.
Cincinnati society of natural history. Proceedings, 1876.
Cleveland academy of natural science. Proceedings, 1845–59.
Companion to the Botanical magazine, 1835–36.
Conchologist's exchange, 1886–88.
Connecticut academy of arts and sciences. Memoirs, 1810.
Correspondenzblatt für sammler von insecten, insbesondere von schmetterlinge, 1860–61.
Danzig. — Naturforschende gesellschaft. Versuche und abhandlungen, 1747–56.
Dessau. — Naturhistorischer verein für Anhalt. Verhandlungen, 1842–70.
Deutsches archiv für die physiologie, 1815–23.
Dorpat. — Gelehrte estnische gesellschaft. Schriften, 1863–69.
Dresden. — Actien-verein für den zoologischen garten. Geschäftsbericht des verwaltungsrathes, 1861–65.
Dresden. — Gesellschaft Isis. Allgemeine deutsche naturhistorische zeitung, 1846–47.
Dresden. — Oekonomische gesellschaft im königreich Sachsen. Jahrbücher für volks- und landwirthschaft, 1868–72.
Dublin quarterly journal of science, 1861–66.
Edinburgh journal of science, 1824–32.
Edinburgh new philosophical journal, 1839–60.
Edinburgh philosophical journal, 1819–23.
Elliott society of natural history. Journal, 1859.
Emden naturforschende gesellschaft. Darstellung der verrichtungen und des zustandes, 1824–34. Geschichtliche darstellung der verhandlungen, 1823. Kleine schriften, 1855–79.
Entomological magazine, 1833–38.
Entomological society of Philadelphia. The practical entomologist, 1865–67. Proceedings, 1861–67.
Entomologist's weekly intelligencer, 1856–61.
Epping forest and county of Essex naturalists' field club. Transactions, 1880–82.
Essex institute. Proceedings, 1848–70.
Field naturalist, 1833–34.
Frankfurt a. M. — Neue zoologische gesellschaft. Bericht des verwaltungsrates, 1876–88.
Frankfurt a. O. — Naturwissenschaftlicher verein. Monatliche mittheilungen, 1884–91.
Freiburg im Breisgau. — Naturforschende gesellschaft. Berichte über die verhandlungen, 1855–85.
Gardener's magazine and register of rural and domestic improvement, 1835–43.
Gent. — Natuurwetenschappelijk genootschap. Natura, 1883–84.
Geological society of Dublin. Journal, 1833–62.
Geological society of London. Proceedings, 1834–45. Transactions, 1811–56.
Geological society of Pennsylvania. Transactions, 1834–35.

Gera. — Gesellschaft von freunden der naturwissenschaften. Verhandlungen, 1858–72.

(Gesellschaft der) deutschen naturforscher und ärzte. Amtlicher bericht über die versammlung, 1828–77.

's Gravenhage. — Nederlandsche entomologische vereeniging. Handelingen, 1854–57. Verslag van de algemeene vergadering, 1858–67.

Graz. — Verein der ärzte in Steiermark. Jahresbericht, 1863–67. Sitzungsberichte, 1867–74.

Great Britain. Geological survey and museum of practical geology. Memoirs, 1846–48.

Habana. — R. sociedad economica. Memorias de la sociedad y anales de fomento, 1862–66.

Halle. — Deutscher Humboldt-verein. Die natur, 1883–84.

Halle. — Naturwissenschaftlicher verein für Sachsen und Thüringen. Abhandlungen, 1860–61. Jahresbericht, 1850–53.

Hamburg. — Naturhistorisches museum. Bericht des deirektor, 1883–87.

Hamburg. — Naturwissenschaftlicher verein. Uebersicht der ämter-vertheilung und wissenschaftlichen thätigkeit, 1865–74.

Hamburg. — Zoologische gesellschaft. Bericht der verwaltungsrathes, 1862–65.

Hannover. — Verein zur gründung eines naturhistorischen museums. Jahresbericht, 1850–51.

Hawaiian club. Papers, 1868.

Helsingfors. — Finska läkare sällskapet. Handlingar, 1841–65. Notisblad for läkare och pharmaceuter: bihang till Handlingar, 1849–65.

Helsingfors. — Finska vetenskaps societeten. Bidrag till Finlands naturkännedom, etnografi och statistik, 1857–64.

Helsingfors. — Observatoire magnétique et météorologique. Observations, 1850–73.

Helsingfors. — Societas scientiarum Fennicae. Observations météorologiques, 1873–80.

Hermannstadt. — Siebenbürgisch-sächsischer landwirthschaftlicher verein. Die ernteergebnisse auf dem königsboden, 1878.

's Hertogenbosch. — Provinciaal genootschap van kunsten en wetenschappen in Nord-Brabant. Handelingen, 1852–83.

Hollandische beiträge zu den anatomischen und physiologischen wissenschaften, 1848.

Hooker's Journal of botany and Kew garden miscellany, 1849–54.

Horticultural register and gardener's magazine, 1835–39.

Illinois agricultural society. Transactions with proceedings of the county societies, 1853–57.

Illinois state microscopical society. The lens, 1872–73.

India. Geological survey. Annual report, 1858–67.

Innsbruck. — Ferdinandeum. Jahresbericht des verwaltungs-ausschusses, 1834–63. Neue zeitschrift, 1835–44.

Institut: journal des sociétés et travaux scientifiques de la France et de l'étranger, 1833–39.

International congress of geologists. Proceedings, 1881–91.

Jahrbücher der insectenkunde, mit besonderer rücksicht auf die sammlung in K. mus. zu Berlin, 1834.

Japan. Geological survey. Reports of progress, 1877-79.
Journal de géologie, 1830-31.
Journal de micrographie, 1877-92.
Journal de zoologie, 1872-77.
Journal für die liebhaber der entomologie, 1790.
Journal of applied science, 1870-82.
Journal of botany, 1834-42.
Journal of the Indian archipelago and eastern Asia, 1847-49.
Journal of travel and natural history, 1868-69.
Kansas. Geological survey. Report, 1866.
Kansas university. Observer of nature, 1874-76.
Kentucky. Geological survey. Report, 1856-61.
Kiel. — Verein nordlich der Elbe zur verbreitung naturwissenschaftlicher kenntnisse. Mittheilungen, 1857-69.
Kiel universität. Schriften, 1856-82.
Kirtland society of natural sciences. Papers, 1874.
Kjobenhavn. — K. danske videnskabernes selskab. Collectanea meteorologica, 1829-76.
Kjobenhavn. — K. nordisk oldskrift-selskab. Antiquarisk tidsskrift, 1843-63.
Kronstadt. — Society of naval physicians. Protocols of the session 1863-65, 1869-71.
Leeds philosophical and literary society. Transactions, 1837.
Leiden. — Academia Lugduno-Batava. Annales, 1816-75.
Lille. — Société des sciences, de l'agriculture et des arts. Mémoires, 1851-80.
Literary and philosophical society of New York. Transactions, 1815.
London geological journal and record of discoveries in British and foreign palaeontology, 1846-47.
London journal of botany, 1842-48.
London physiological journal, 1843-44.
Lüneburg. — Naturwissenschaftlicher verein für das fürstenthum Lüneburg. Jahresbericht, 1852-64.
Luxembourg. — Société des sciences naturelles du grand-duché de Luxembourg. 1853-69.
Lyceum of natural history, N. Y. Annals, 1824-76.
Lyon. — Société d'études scientifiques. Bulletin, 1874-80.
Madrid. — R. academia de ciencias. Resumen de las actas, 1849-63.
Magasin de zoologie, 1831-45.
Magazin der entomologie, 1813-21.
Magazin für das neueste aus der physik und naturgeschichte, 1783-1806.
Magazin für die liebhaber der entomologie, and Neues mag., 1778-87.
Magazin für insektenkunde, 1801-1807.
Magazine of horticulture, botany, and improvement in rural affairs, 1835-58.
Magazine of natural history and journal of zoology, etc., 1829-40.
Magazine of zoology and botany, 1837-38.
Maine. Commission of fisheries. Report, 1867-75, 1879-81.
Malakozoologische blätter, 1854-65.
Manchester, Engl., scientific students' association. Report, 1862-89.
Mans, Le. — Société d'agriculture, sciences et arts de la Sarthe. Mémoires, 1855.

Massachusetts. Agricultural survey. Report on the agriculture of Massachusetts, 1838-41.
Massachusetts. Commissioners of fisheries. Report, 1867–78, 1882–88.
Massachusetts. Geological survey. Reports.
Massachusetts. State board of agriculture. Annual report on the injurious and beneficial insects of Massachusetts, 1871-72.
Massachusetts society for promoting agriculture. Massachusetts agricultural repository and journal, 1793–1832.
Mende. — Société d'agriculture, commerce, sciences et arts. Mémoires, 1829–49.
Meseritz. — K. realschule. Programm, 1850, 1851, 1853–67.
Michigan. — Annual report of the state geologist, 1839–42.
Microscopic journal and structural record, 1841–42.
Middelburg. — Zeeuwsch genootschap der wetenschappen. Zelandia illustrata, 1866–85.
Milano. — R. istituto lombardo di scienze, lettere ed arti. Atti, 1860–63.
Milano. — Società italiana di scienze naturali. Memorie, 1865–71.
Mining magazine and journal of geology, 1859–61.
Missouri. State board of agriculture. Annual report on the noxious, beneficial and other insects of Missouri, 1869–81.
Modena. — Società dei naturalisti. Annuario, 1875–82. Atti, rendiconti, 1883–87.
Monthly microscopical journal, 1869–77.
Moscou. — Imperial Moscou society of rural economy. Russian rural economy, 1869–73.
Moscou. — Société impériale des amis d'histoire naturelle. Bulletin, 1865–81.
München. — K. bayerische akademie der wissenschaften. Gelehrte anzeigen, 1835–60. Sitzungsberichte, 1860–70.
Napoli. — R. accademia delle scienze. Memorie, 1857. Rendiconti, 1856–57. Rendiconto, 1852–55.
Napoli. — Zoologische station. Jahresbericht, 1876.
National academy of sciences. Annual, 1863–67.
National microscopical congress. Proceedings, 1878.
Natural history review, including proceedings of Irish natural history societies, 1854–65.
Natural history society of Hartford. Transactions, 1836.
Natural history society of Montreal. Annual report, 1829–63. Canadian naturalist and geologist and proceedings of the society, 1856–83. Proceedings at the annual meeting, 1864–78.
Natural history society of Northumberland, Durham and Newcastle-upon-Tyne. Transactions, 1831–38.
Naturalist, 1831.
Naturen, 1883-84.
Naturforscher, 1774–1804.
Naturhistorischer verein von Wisconsin. Jahresbericht, 1868-82.
Naturhistorisk tidsskrift, 1837–84.
New Brunswick. Geological survey. Report, 1839–41.
New Hampshire. Geological survey. Annual reports, 1841–73.
New York. Agricultural experiment station. Annual report, 1884–87.

New York entomological club. Papilio, 1881–84.
New York state agricultural society. Transactions, 1844–68.
New York. State survey. Annual report, 1879–82. Reports, 1837–41.
Newfoundland. Geological survey. Reports.
Niederländisches archiv für zoologie, 1871–82.
Nordamerikanischer monatsbericht für natur- und heilkunde, 1851–52.
Nordisk universitets-tidskrift, 1854–64.
North Carolina. Geological survey. Reports.
Nuttall ornithological club. Bulletin, 1876–83.
Odessa. — Imperial society of rural economy of southern Russia. Leaves, 1833–36, 38–40. Memoirs, 1841–76.
Odessa. — Odessa society of history and antiquities. Memoirs, 1844–63.
Ohio. Geological survey. Reports.
Ottawa field naturalists' club. Transactions, 1880–87.
Padova. — Imp. reg. accademia di scienze, lettere ed arti. Revista periodica dei lavori, 1851–64.
Palaeontographica, 1851–70.
Palaeontographical society, 1856–83.
Paris. — Académie des sciences. Histoire, avec les mémoires de mathématique et de physique, tirés des registres, 1699–1731.
Paris. — École des mines. Atlas du mineur et du métallurgiste, 1839–42.
Paris. — Institut de France. Mémoires : sciences mathématiques et physiques, 1798–1804. Mémoires : sciences morales et politiques, 1798–1804.
Paris. — Institut historique. Journal, 1834–40.
Paris. — Muséum d'histoire naturelle. Annales, 1802–27. Archives, 1839–61. Mémoires, 1815–32. Rapports annuels, 1878–80.
Paris. — Société Cuviérienne. Revue zoologique, 1841, 1843–48.
Paris. — Société d'histoire naturelle. Mémoires, 1823–34.
Paris. — Société des études historiques. Revue, 1884–88.
Paris. — Société nationale d' acclimatation de France. Bulletin, 1865–88.
Peabody museum of Yale college. Memoirs, 1880.
Philadelphia medical and physical journal, 1805–1809.
Pisa. — Accademia Valdarnese del Poggio. Memorie Valdarnese, 1835–55.
Popular science review, 1869–73
Portland society of natural history. Journal, 1864.
Poughkeepsie, N. Y., society of natural science. Proceedings, 1878–80.
Providence Franklin society. Proceedings, 1846–47.
Psychological society of Great Britain. Papers, 1875–76.
Puy, Le. — Société d'agriculture, sciences, arts et commerce. Annales, 1865–82.
Record of American entomology, 1868–71.
Recueil zoologique suisse, 1883–92.
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REPORT OF THE TREASURER, EDWARD T. BOUVÉ.

Annual Statement, May 1, 1897. Boston Society of Natural History.

To balance from April 30, 1896	$ 148.38
To cash received from income General Fund	5,140.66
“ “ “ “ “ Walker Fund	1,799.47
“ “ “ “ “ J. W. Randall Fund	250.00
“ “ “ “ “ H. F. Wolcott Fund	383.11
“ “ “ “ “ Entomological Fund	28.84
“ “ “ “ “ Special Museum Fund	88.00
“ “ “ “ “ C. L. Flint Fund	235 11
“ “ “ “ “ Bulfinch St. Estate Fund	1,061.88
“ “ “ “ “ S. P. Pratt Fund	656.98
“ “ “ “ “ Walker Grand Prize Fund	108.21
“ “ “ “ Boston University	2,500.00
“ “ “ “ Massachusetts Inst. Technology	200.00
“ “ “ “ Admission Fees	85.00
“ “ “ “ Annual Assessments	1,160.00
“ “ “ “ Museum Fees	197.24
“ “ “ “ Donation Miss Cruft	500.00
“ “ “ “ “ Miss Hovey	50.00
“ “ “ “ “ Mr. Gaffield	10.00
“ “ “ “ Sale of Publications	445.56
Total,	$15,048.44

By loss on sale $37.50 C. & W. M. Scrip sold	$ 18.07
“ cash paid on account of Repairs	323.55
“ “ “ “ “ “ Fuel	190.00
“ “ “ “ “ “ Gas	42.50
“ “ “ “ “ “ Insurance	160.00
“ “ “ “ “ “ General Expense	822.66
“ “ “ “ “ “ Salaries and Wages	8,068.50
“ “ “ “ “ “ Laboratory	49.57
“ “ “ “ “ “ Museum	964.43
“ “ “ “ “ “ Library	1,177.55
“ “ “ “ “ “ Publications	1,340.14
“ “ “ “ “ “ Walker Prizes	110.00
“ “ “ “ “ “ “ Prize and Special Expense Fund	75.61
By cash paid Trustees for Sinking Fund	469.25
“ “ “ “ “ Insurance Sinking Fund	440.00
“ “ “ “ Income Special Museum Fund	88.00
“ “ “ “ “ Walker Grand Prize Fund	108.21
“ “ “ “ Balance	600.40
Total,	$15,048.44

To cash received from Augustus Lowell, Trustee for the Teachers' School of Science	$2,450.00
To cash received from Interest on Deposit	11.46
Balance from April 30, 1896	538.80
Total,	$3,000.26

By cash paid on account of Lectures and Supplies	$2,631.68
Balance to new account	368.58
Total,	$3,000.26

The reports of the Trustees were read; also the report of the Auditing Committee.

On opening the envelopes accompanying the Walker Prize essays, Mr. Myron L. Fuller was announced as the author of the paper, "Modified drift of Cape Cod," to whom a prize of $100.00 was awarded, and Mr. W. O. Crosby, the author of the essay on the Pleistocene history of the Nashua Valley, to whom a prize of $50.00 was awarded.

It was voted to proceed to the election of officers for 1897–98. Messrs. W. A. Jeffries and C. R. Eastman were appointed to collect and count the votes. They reported the election of

PRESIDENT,

CHARLES SEDGWICK MINOT.

VICE-PRESIDENTS,

NATHANIEL S. SHALER. CHARLES P. BOWDITCH.
EDWARD S. MORSE.

CURATOR,

ALPHEUS HYATT.

SECRETARY,

SAMUEL HENSHAW.

TREASURER,

EDWARD T. BOUVÉ.

LIBRARIAN,

SAMUEL HENSHAW.

COUNCILLORS FOR THREE YEARS,

Samuel L. Abbot.
William S. Bryant.
William M. Davis.
Henry W. Haynes.
Miss Catharine I. Ireland.
Benjamin Joy Jeffries.
Nathaniel T. Kidder.
William H. Niles.

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William H. Niles.

COUNCILLORS FOR TWO YEARS,

Edward A. Bangs.
William Brewster.
Miss Cora H. Clarke.
William G. Farlow.
Robert T. Jackson.
George H. Parker.
A. Lawrence Rotch.
William T. Sedgwick.

COUNCILLORS FOR ONE YEAR,

Hermon C. Bumpus.
Charles B. Davenport.
William A. Jeffries.
George G. Kennedy.
Augustus Lowell.
Miss Susannah Minns.
Thomas A. Watson.
Samuel Wells.

COUNCILLORS *ex-officiis*,

John Cummings.
George L. Goodale.
Frederick W. Putnam.
Samuel H. Scudder.

Proceedings of the Boston Society of Natural History.
VOL. 28, NO. 3,
p. 73–84.

THE RÔLE OF WATER IN GROWTH.

BY C. B. DAVENPORT.

BOSTON:
PRINTED FOR THE SOCIETY.
JUNE, 1897.

No. 3.— *The Rôle of Water in Growth.*[1]

By C. B. Davenport.

In this paper it is proposed, first, to consider the definition of growth in organisms; next, to analyze the processes of growth; then, to show what an important part water plays in growth and the significance of this fact for the developmental process in general; and, finally, to discuss the bearing of the new facts brought forward upon previously formulated laws of growth.

Organic growth I shall define as increase in volume. It has been variously defined by others. Thus Huxley has called growth "increase in size," which is essentially the same definition. Sachs defines growth as an increase in volume intimately bound up with change of form ("eine mit Gestaltveränderung innig verknüpfte Volumenzunahme"), and he illustrates the definition by the example of the growth of a sprout from its beginning to its completed form. In this case two phenomena are distinguishable: first, increase in volume, and, secondly, the filling out of the details of form. As Sachs says, these phenomena taken together are generally denominated "development," and it seems to me decidedly advantageous to retain this term with its usual signification and to distinguish the two component processes by the terms growth and differentiation.

Pfeffer's definition differs still more widely from mine. He defines growth as change in form in the protoplasmic body ("die gestaltliche Aenderung im Protoplasmakörper"), and he goes on to say that increments of volume and mass are not proper criteria of growth. Pfeffer illustrates this statement by the following example: A plant stem or a cell membrane can be permanently elongated by extension beyond the limits of elasticity, without the volume necessarily increasing, and he apparently means to include such an artificial deformation in his definition of growth. "And," he continues, "under certain circumstances a diminution of volume of a plant segment can indeed occur as a result of growth, when, for example, the elasticity of the wall is increased by growth and water is pressed from the cell until equilibrium is restored"; I doubt,

[1] Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy at Harvard College, E. L. Mark, Director, No. 80.

however, if Pfeffer would say that in this case the cell, as a whole, had grown, but if he would, then his definition is a wide departure from ordinary usage.

Vines offers a definition intermediate between that of Sachs and that of Pfeffer. "By growth," he says, "we mean permanent change of form, accompanied usually by increase in bulk." But then he goes on to say, "Nor does an increase even of the organized structures of an organ, that is of the protoplasm and the cell wall, necessarily imply that it is growing. Thus, an increase of the cell wall may take place without any perceptible enlargement of the cell, as, for instance, when a cell wall thickens." But since the thickening of the cell wall is a "permanent change of form," it should be considered by the author a growth process, were not increase in size of the cell, after all, in the author's mind, the most important criterion of its growth. Finally, Frank finds no other criterion for growth than an increase of volume (dependent, however, upon the increase of a particular substance).

Thus, with these different plant physiologists we find the word growth bearing the ideas of increase of volume and of differentiation, then of differentiation alone, and, finally, of increase of volume alone. Returning now to the definition proposed above, we see that growth as mere increase of volume is to be distinguished from development, from differentiation, even from increase in mass, although the latter may often serve as a convenient measure of growth.

In analyzing the processes of growth in organisms we must recognize at the outset that organisms are composed of living matter and formed substance, and that growth may therefore result from the increase in volume of either of these. The living matter in turn is composed of two principal substances: the plasma and the chylema or cell sap; so growth may be due to the increase of either of these substances, — may result either from assimilation, or more strictly from the excess of the constructive over the excretory processes of the plasma, or from the taking in of water.

Other writers have analyzed the process of growth in very diverse ways. I cite a few of their conclusions. Huxley says, "growth is the result of a process of molecular intussusception." According to N. J. C. Müller, "all phenomena of growth depend, in last analysis, upon this, that the molecule of the solid substance is introduced into the region of growth." Frank understands by growth that increase of volume which consists of the apposition or intussusception of new solid molecules of similar matter ("welche auf der An- oder Einlagerung neuer fester Molecule gleichartigen Stoffes beruhen"). These definitions include what I regard as only half of the process of growth.

On the other hand Bütschli has recognized that growth is, in part, due to increase of the chylema, and Driesch distinguishes two kinds of cell growth: (1) passive growth, due to imbibition of water, and (2) active growth, resulting from assimilation. This classification agrees with the one I have proposed, but I think the term passive growth very inapt, since the imbibition of water is as truly an active process as any other vital activity.

Of the three factors involved in growth — increase of formed substance, of plasma, and of chylema — the part played by the last seems to me to have been underestimated. Plant physiologists have been in the best position to acquire the facts. They have recognized in the tip of the plant three growth regions. At the extreme tip of the stem (or radicle) is the region of rapid cell division but comparatively slow growth; next below is the zone exhibiting the Grand Period of growth; and still below is the zone of histological differentiation (Fig. 1). In the first zone growth of plasma is occurring; in the second zone growth of the chylema is chiefly taking place; in the third zone, there is growth of formed substance. The immense

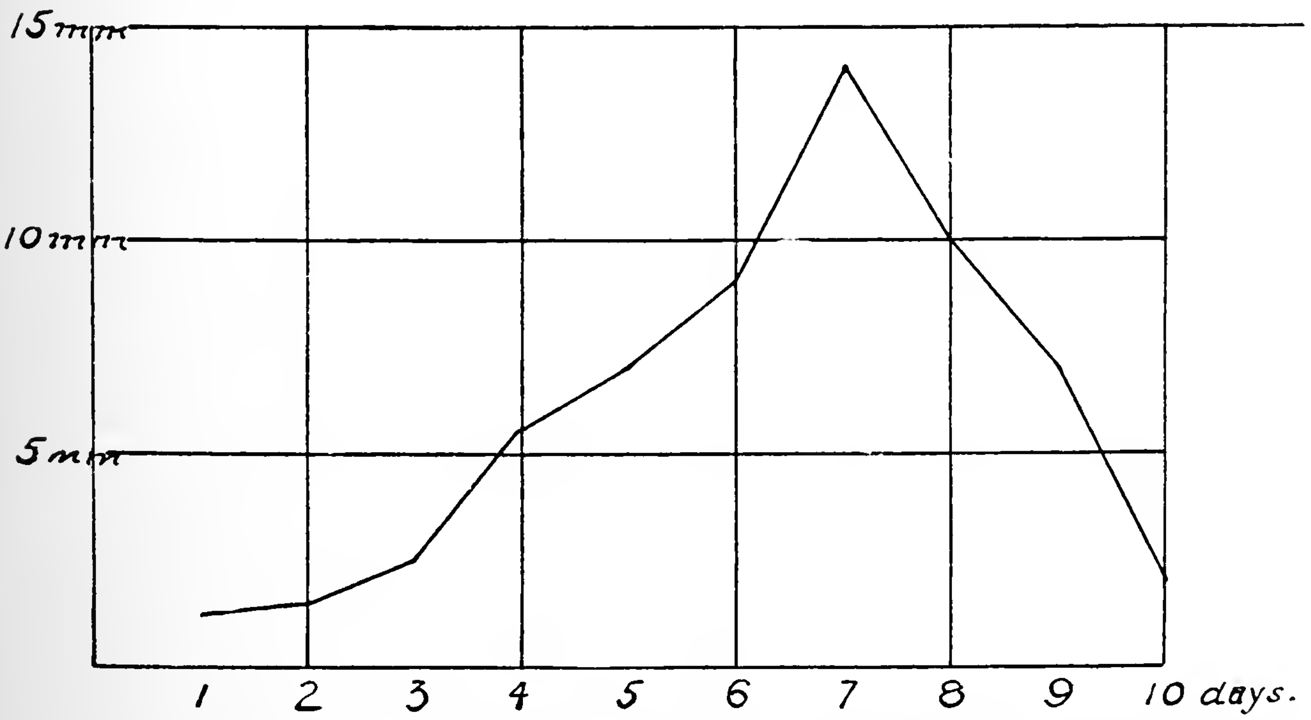

Fig. 1. Curve of daily growth in length of a disc, originally 1 mm. long, and taken immediately behind the vegetation point of a radicle of Phaseolus. It comes to occupy in successive days the three zones referred to in the text. From SACHS, Lectures on Plant Physiology.

preponderance of the growth of the second period (7 days) is an index to the preponderating influence in growth of the imbibition of water.

An analysis of the substance of the stem at different levels below the tip reveals the same thing — a sudden increase in the amount of water from 73% at the tip to 88% at the first internode (II), reaching a maximum at 93% in the second internode (III), then falling slightly (92.7) to the fifth internode (VI, Fig. 2). The

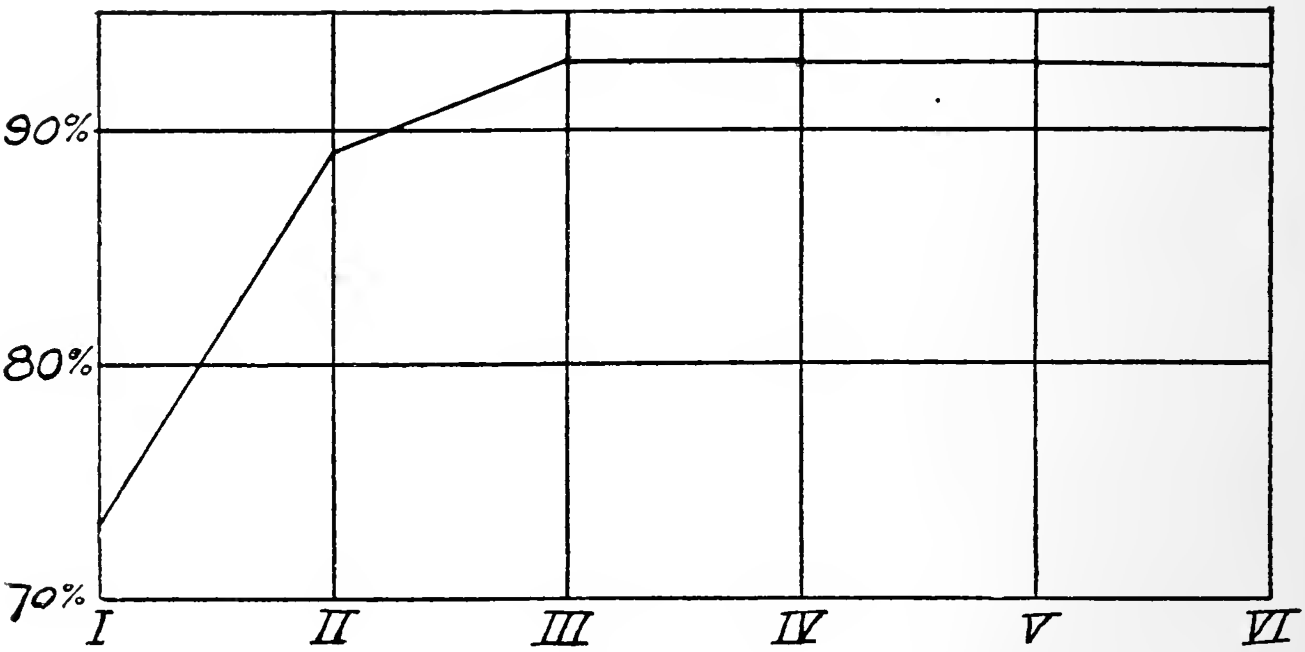

Fig. 2. Curve showing the percentage of water in successive internodes of Heterocention, from the tip to the fifth. After KRAUS, Festschr. naturf. Ges. Halle, 1879.

experiments and observations upon which these conclusions rest thus agree in assigning the chief rôle to water in the growth of plants.

With animals experiments on this point were lacking. It seemed to me, therefore, a worthy thing to determine whether animals followed the same law in respect to the preponderating importance of water in growth. Accordingly I set to work to determine the percentage of water in the body of developing tadpoles at different stages. Eggs and embryos were weighed at various ages after removing superficial water. Then they were kept in a desiccator from which air had been pumped and which contained a layer of sulphuric acid to absorb moisture. After repeated weighings a condition was found in which the drying mass lost no more water (constant weight). The total diminution in weight indicated the mass or volume of free water contained in the organism at the beginning of the experiment. Numerous weighings were made during two seasons upon

Amblystoma, toads, and frogs. All series showed the same thing; the most complete series is that given in the following table: —

EMBRYOS OF FROGS. 1895.

Date.	Days after hatching.	Avg. wt. mg.	Wt. of dry substance. mg.	Wt. of water. mg.	% of water.
May 2.	1	1.83	.80	1.03	56
" 3.	2	2.00	.83	1.17	59
" 6.	5	3.43	.80	2.63	77
" 8.	7	5.05	.54	4.51	89
" 10.	9	10.40	.72	9.68	93
" 15.	14	23.52	1.16	22.36	96
June 10.	41	101.0	9.9	91.1	90
July 23.	84	1989.9	247.9	1742.0	88

These results are graphically represented in Fig. 3. The curve and table show that, exactly as in plants, there is a period of slow

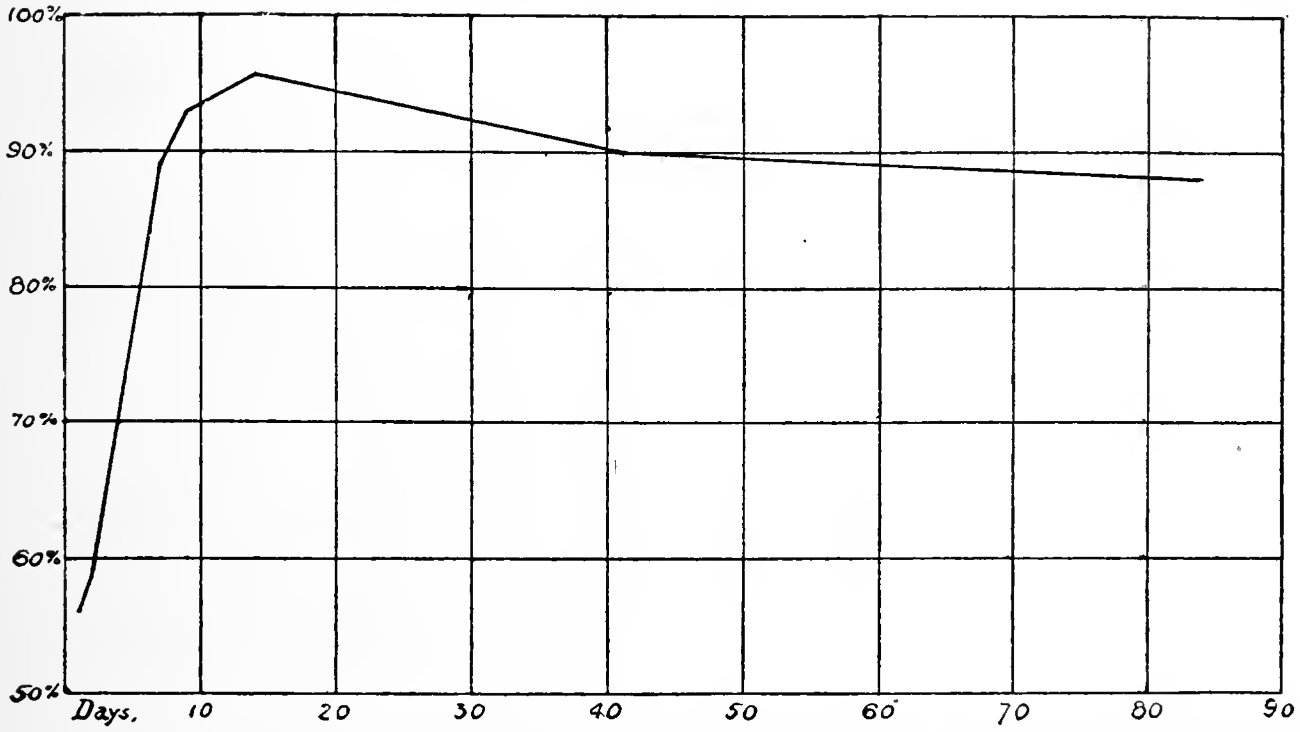

Fig. 3. Graphic representation of last column of Table, showing percentage of water in frog embryos from 1 to 84 days after hatching. Compare with Fig. 2.

growth accompanied by abundant cell division — the earliest stages of the egg. Then follows, after the first few hours, a period of rapid growth due almost exclusively to imbibed water, during which the percentage of water rises from 56 to 96; lastly comes the period of histological differentiation and deposition of formed substance, during which the amount of dry substance increases enormously, so that the percentage of water falls to 88 and below. But the *growth* is due chiefly to imbibed water.

Now what light do these results throw upon the process of development? As we have seen, development consists of the growth of the organism as a whole and the differentiation of its parts. But one important factor out of the many which are to be found in differentiation is the unequal growth of the different parts of the body. This is very clearly seen in the development of the frog.

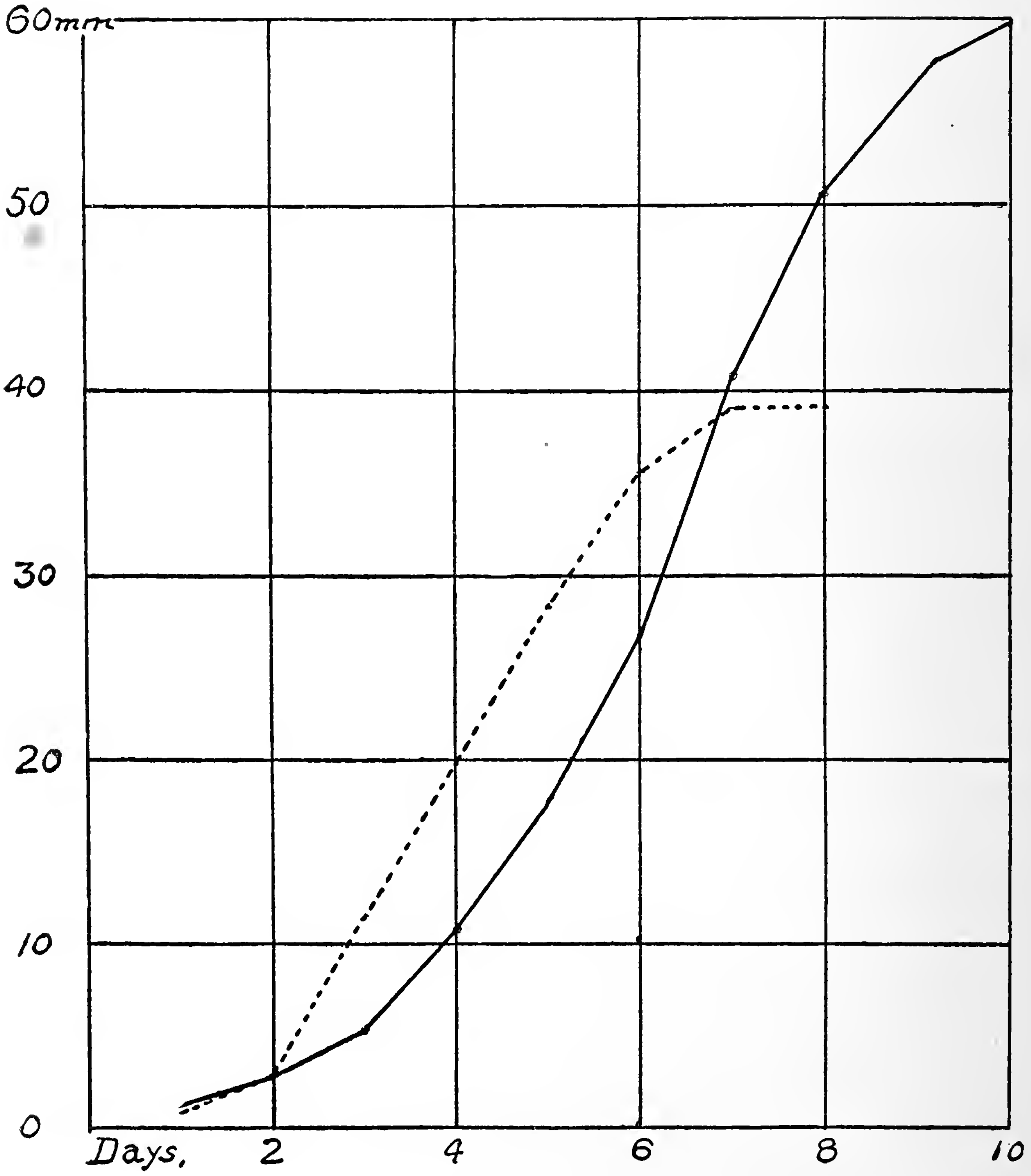

Fig. 4. Curves of growth of Phaseolus multiflorus (continuous line) and Vicia faba (broken line). The ordinates represent actual lengths attained on the respective days by a bit of stem originally 1 mm. long. After SACHS, Lectures on Plant Physiology.

The originally spherical body — the egg — does not merely grow to a larger sphere but it grows faster in one axis than in the others and so becomes elongated; its trunk grows in cross-section faster than its tail; from the side of the gill-bars rapid growth occurs forming the gills; at four points on the side of the body excessive growth takes place in skin, musculature, and mesenchyma, resulting in limbs. Meanwhile the amount of dry substance in the embryo remains constant; we have to conclude, therefore, that all these local growths are due to local imbibition of water. The question, What determines excessive local growths? resolves itself into this, What determines excessive local imbibition of water? What determines that water shall be taken in especially where the limbs bud out, or the gill filaments arise? The problem of differential growth —

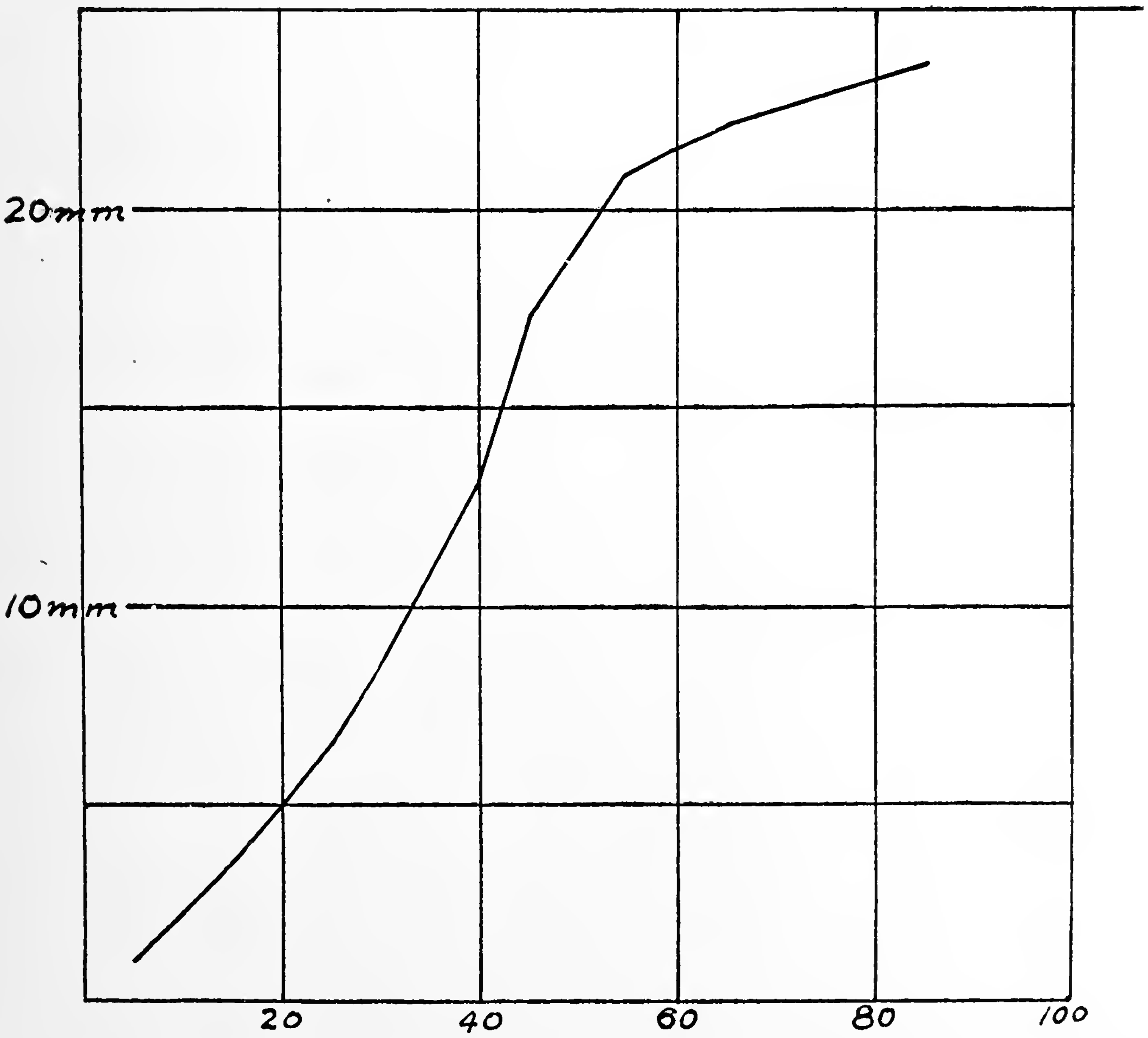

Fig. 5. Curve of length of shell of Lymnaea stagnalis at intervals from hatching up to 85 days. From SEMPER Animal Life, p. 163.

which is one of the most important of the processes in early development — is the problem of differential imbibition of water.

This conclusion seems to me of importance for morphogenesis, for it enables us to state certain elements of the problem in simpler terms. Differential growth occurs because at the appropriate time the germinating organ gains that chemical condition which invests it with the imbibitory property.

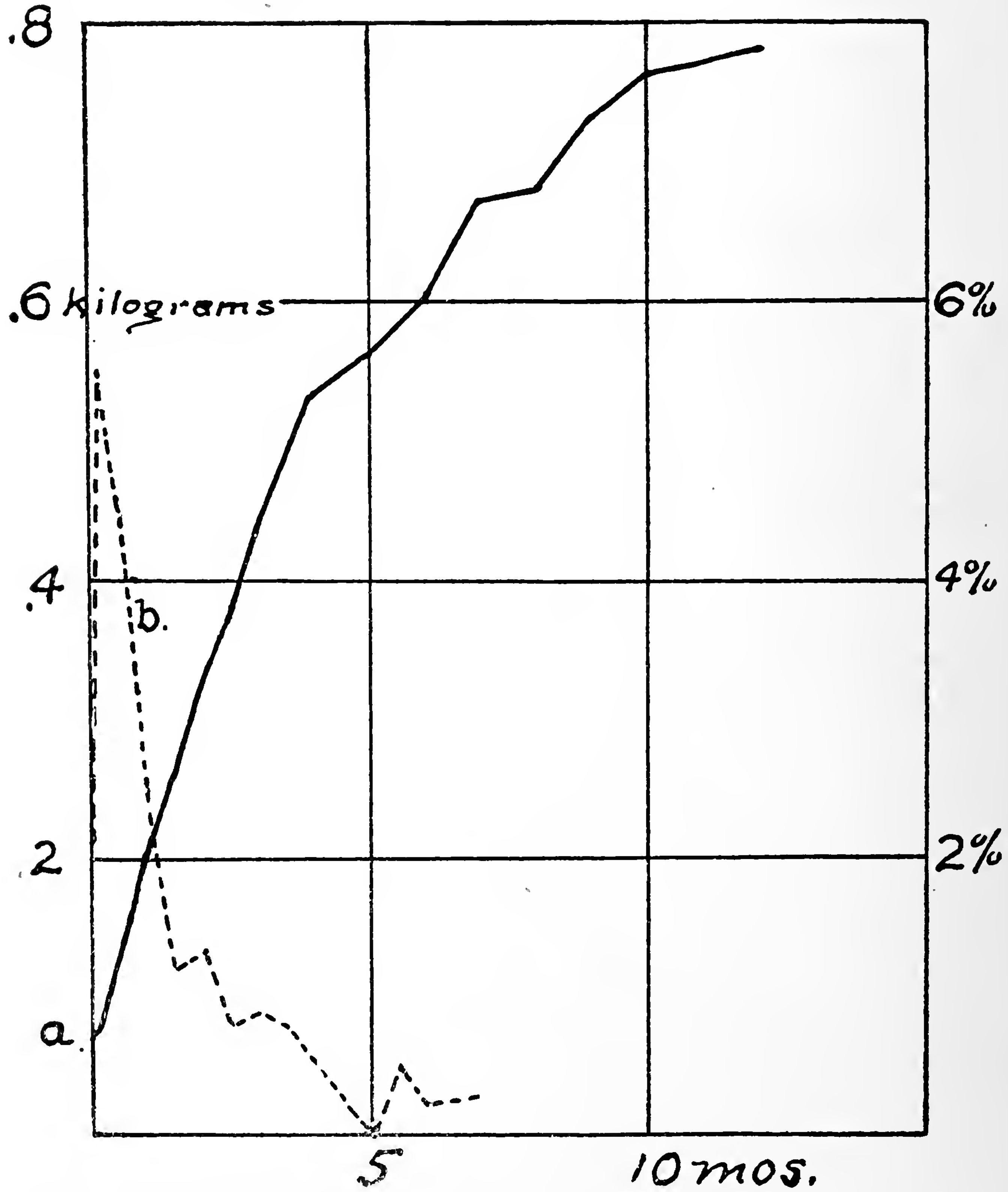

Fig. 6. The continuous line (a) represents the weights in fractions of a kilogram attained by guinea pigs from birth until 12 months old. The broken line (b) represents the daily percentage increments (%'s at the right) of the same guinea pigs up to 7 months. After MINOT, Journal of Physiology, 1891, vol. 12.

The fact that water plays so important a part in the development of organisms has an important bearing upon the interpretation of curves of growth. These curves, whether made for animals or plants, have a decided resemblance (Figs. 4, 5, 6a). They are all constructed on this plan: the abscissae indicate times or ages; the ordinates, the absolute size (weight or volume) at a given time. The ordinates do not show, therefore, the growth or increment in the strict sense of the word. In order to show this increment we might transform our curve of frog growth into another, in which the ordinates are proportional to the absolute daily increment (Fig. 7). This curve is seen to be, within the limits of the series, a rapidly ascending one.

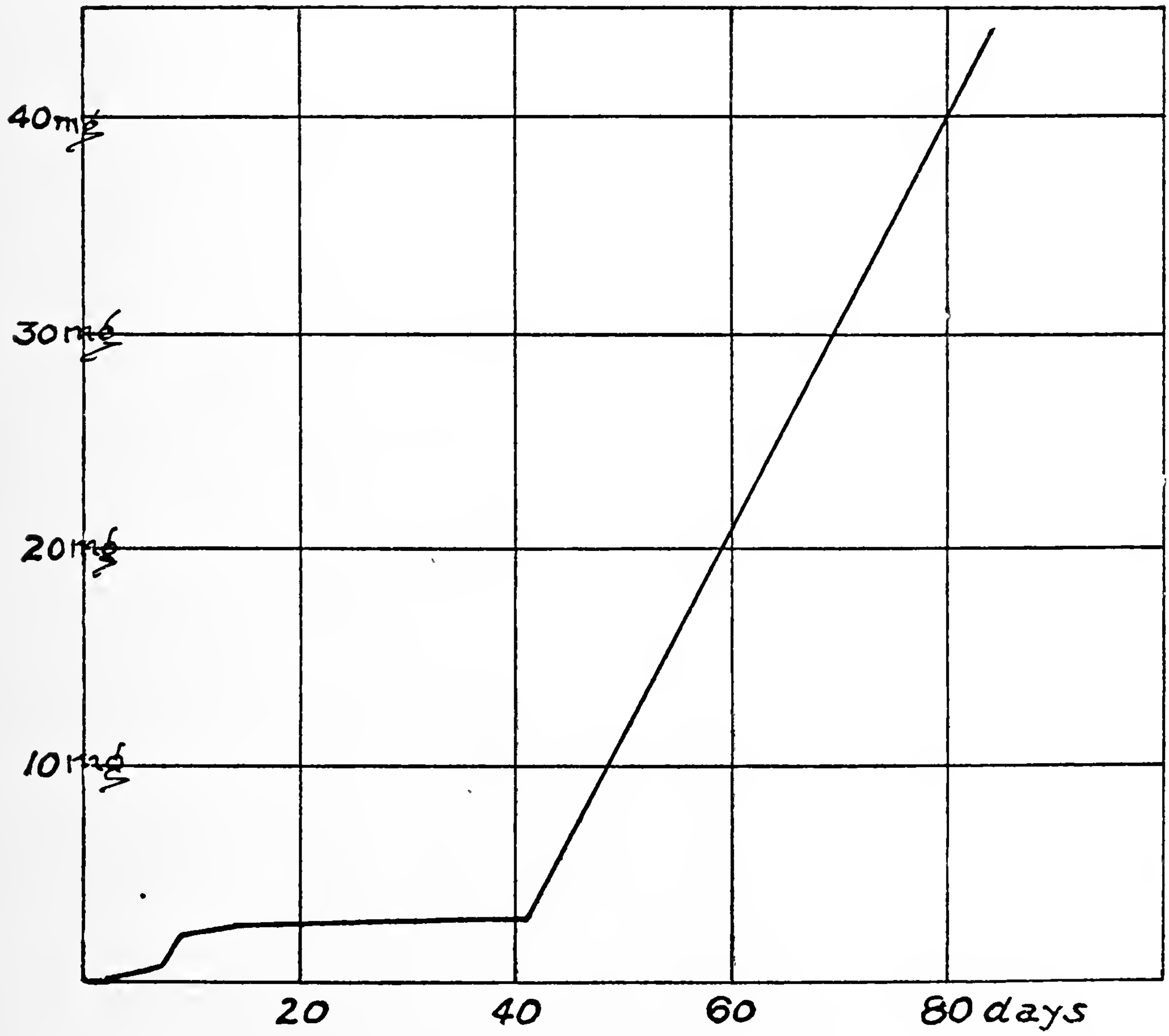

Fig. 7. Curve of daily absolute increments in weight (in milligrams) of tadpoles of from 1 to 80 days after hatching.

Professor Minot has, however, suggested that such a curve as this does not give a true insight into the vigor of growth at the different ages, for, he says, "the increase in weight depends on two factors, first upon the amount of body substance or, in other words, of growing material present at a given time; second, upon the rapidity with which that amount increases itself. Hence for a given period the rate of growth may be expressed as the fraction of weight added during that period," — in percentage increments. A curve of "percentage daily increments" for the frog is given in Fig. 8a.

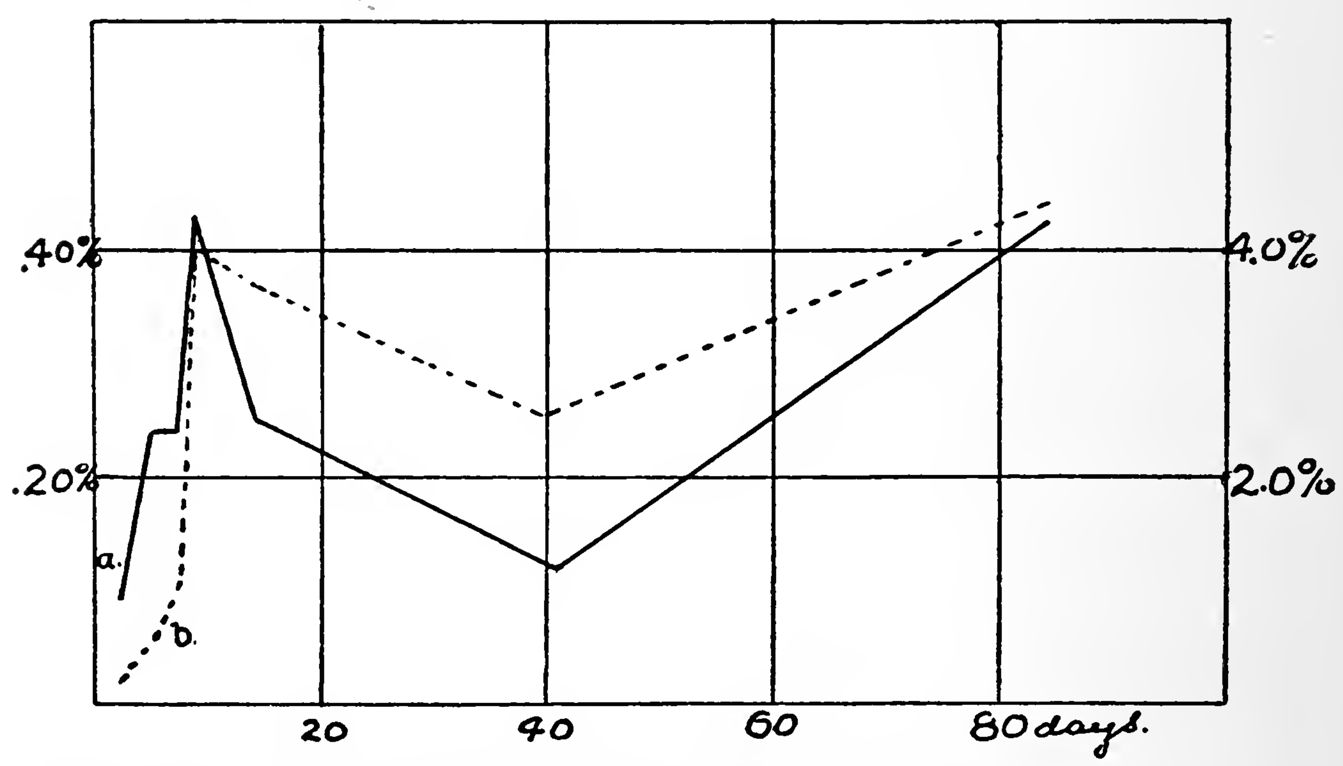

Fig. 8. Continuous line (a) represents the daily percentage increments, based on whole weight of tadpoles; broken line (b) represents daily percentage increments based on dry weight of tadpoles.

This curve is irregular; it is certainly not rapidly ascending like Fig. 7. In studying his guinea pigs, Minot found that the curve of percentage daily increments was a rapidly descending one, (Fig. 6b), and he was led to suggest that there is a "certain impulse given at the time of impregnation which gradually fades out, so that from the beginning of the new growth there occurs a diminution in the rate of growth." The question arises, do the results obtained from embryo frogs confirm this hypothesis?

In the first place our results indicate that the curve of percentage daily increments is of little significance for the frog and probably for organisms in general, on account of the fact that one assumption on which it rests is not justified. In the sentence quoted, Minot says, "the increase in weight depends . . . upon the amount of body substance or, in other words, of growing material present at a given time." An error seems to me to lie herein that not all the body substance is growing substance — *e. g.*, the water does not reproduce itself.

If then the increase of the body does not necessarily mean increase of the growing substance, there is no good reason for expressing the growth of any day in terms of the fraction of the initial weight which has been added during the day. If today all of the body substance is growing, an increase of 10 % will not mean so high a rate of growth as an increment of 10 % in a body half of which is water. If we assume for the moment, in our ignorance of what part of the body is growable, that the dry substance is all capable of reproducing itself (and that is an overestimate), we get a somewhat different curve of percentage increments, as in Fig. 8b. The curve rises on the whole, but would have risen more rapidly if we had used only that fraction of dry substance which is growing. Here then we find no loss in the rate of growth of the growing substance, and in so far a lack of confirmation of Minot's generalization.

One reason for the lack of agreement between the curve of percentage increments of the frog embryos and that of the guinea pig is due to the fact, that in our study of tadpoles we have been dealing with the beginnings of development, while in the guinea pigs, taken from birth on, we do not have the earliest stages. Doubtless a time will come in the life of the frog when it will not increase its weight a milligram a day; it will have ceased to grow. But are we justified in ascribing this cessation of growth to a gradual fading out of the growth force given by impregnation? We get some light upon this question when we go to plants and consider again the tip of the epicotyl. Here the growing tissue just behind the tip soon ceases to grow, while it undergoes histological differentiation. Is this cessation of growth due to the fading out of a growth force — due to the remoteness of impregnation? It is clear that this explanation is unsatisfactory, for the protoplasm at the very tip of the epicotyl continues to grow during, it may be, years. There is no evidence that it ever loses its capacity for growth. It may go on developing for centuries, as we see in trees. It may go on growing far beyond the ordinary life of a tree. Thus, as we all know, there is in Cambridge an elm "under which Washington took command of the American army, July 4, 1775," and some cuttings have been made from this tree, which are growing quite as well as young trees that have presumably been derived from protoplasm more recently impregnated. We see here, after the lapse of perhaps two centuries, no loss in the power of growth.

I would suggest that the reason why the animal ceases at last to grow is the same as the reason why the differentiated tissue below the tip of the epicotyl ceases to grow — not because there is a necessary limit to growth force at a certain distance from impregnation, but because it is advantageous to the species that the individual should cease to grow at this point. If it is not advantageous for it to cease to grow, it may go on for centuries like the tip of the plant.

To sum up, then, my studies lead me to recognize a general parallelism between the developmental processes occurring at the tip of a twig and in the animal embryo. In both there is first a period of rapid cell division with slow growth; next, a grand period of growth in which the general form of the embryo is acquired, the Anlagen of the organs are established, and the organism increases rapidly in size by imbibition of water; and, lastly, a period in which histological differentiation is carried on while the absolute growth increments cease to increase. Finally, the fact that increase in body substance is so largely due to a non-growing substance — water — diminishes the value of the percentage increment curve of growth.

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THE HARVARD GEOGRAPHICAL MODELS.

By William Morris Davis.

WITH A NOTE ON THE CONSTRUCTION OF THE MODELS.

by G. C. Curtis.

With Four Plates.

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No. 4 — *The Harvard Geographical Models.*

By William Morris Davis.

The use of models or reliefs in teaching geography has been frequently advocated but seldom put systematically into practice. It is not to be doubted that the representation of the manifold forms of the land can be better understood from good models than from any other means, short of actual exploration; but good models are so few and so expensive that they have no place in our general school system. The models here illustrated and described have been designed and constructed in the hope of eventually making the use of such aids much more common than it is now.

Geographical models are of various classes. The models made of sand, pulp, clay, etc., by young scholars belong in the series and certainly have an element of value; but it is to be questioned whether much of the time employed in making such models could not be better employed in studying better models. Actual modeling by school children need not be carried further than actual mapping; both can be best introduced in order to make it clear that models and maps may be used to represent parts of the earth's surface; but it is undesirable to carry work in this direction so far that school children become makers rather than students of maps and models. When good models are as plentiful and as cheap as good maps are today, the time spent on modeling may be reduced to the small measure now properly allotted to mapping.

Models of actual places made by geographical experts, or constructed by artisans on the basis of surveys by geographical experts, may be divided into two groups according as they are of large or small scale. Small scale models are at their best when they include some natural division of moderate size, such as a state; of these we may mention the superb model of California constructed by W. D. Johnson and exhibited at one end of the California building in the World's Fair at Chicago, 1893; the models of various states constructed by E. E. Howell, of Washington; the model of Italy by Pomba, on a true curved terrestrial surface. According to their accuracy of construction and to the moderation in their vertical exaggeration, these have a greater or less value. Good models of this class are certainly extremely useful. On an intermediate scale, areas as great as the United States are attempted; but with this decrease of scale, there is nearly always an increase of vertical exaggeration. Yet Howell's models of the United States on a curved surface are certainly very instructive. Even entire continents, such as those made for Butler's Geography by Mindeleff, have much value when delicately treated; but their very delicacy makes them so crowded with detail that their use in elementary teaching is lessened. But when the scale is so small that the model embraces the whole earth, the necessary exaggeration of the vertical element is so great as to make them of questionable value. They forcibly impress so much that is erroneous, in the matter of proportional dimensions, that it is doubtful whether they do not teach more error than truth.

Large scale reliefs, in the neighborhood of an inch to a mile, may exhibit much detail of form, sufficient to give real physiographic expression. Exaggeration may here be very small, or even zero. Some of the finest models of this class include the more popularly visited parts of the Alps, and are to be seen in various European museums. They are elaborately wrought, with much artistic effect in form and color. Their cost is forbidding. The most accurate models of this kind known to me are those constructed by the Geographical Service of the French Army, for military purposes. One of this series, exhibited at the World's Fair, and afterwards presented to the Geographical Laboratory of Harvard University, is on a scale of 1:20,000, horizontal and vertical. The relief is mechanically constructed with remarkable accuracy according to detailed surveys; and the colored contoured maps, cut into small rectangles, are then most skilfully pasted on the relief without tearing, and so nicely that every contour line falls into a horizontal plane. These models are not "on the market." D. Locchi of Turin has recently made an excellent model of the terminal moraines south of Lake Garda for the Italian Military School, copies of which are for sale, price about 300 lire ($60.00).

Few models of large scale have been made in this country. Among the best are those by Harden, prepared some years ago for the Second Geological Survey of Pennsylvania, and those of certain Appalachian districts, prepared by Howell. A photographic reproduction of an example of the latter may be seen in the National

Geographic Magazine for 1894, illustrating a part of the southern Appalachians.

A third class of models includes those intended to represent ideal type forms rather than actual places. The best of these are found in a set of four, constructed by Prof. A. Heim, of Zurich, and duplicated for sale originally by Wurster and Co., now succeeded by J. Meier of the same city. Their price is about $20 without duty. They represent a high mountain district with snow fields and glaciers; an Alpine torrent; a volcanic island; and a cliff and dune coast. A number of these have been imported into this country by various colleges and are found of great service in teaching; but they have as yet made little or no impression on the schools. These four models are all independent of each other; each one tells its own story. Additions to the series from Professor Heim's expert hand would be warmly welcomed by geographers.

The models here figured fall into the same class as Heim's, inasmuch as they are ideal type forms; but they stand in systematic sequence, and thus illustrate not only individual forms, but the relationship of different forms, and the principles of geographical evolution, a study which has been greatly advanced in recent years. I presume that others have designed models in series of this kind; but if so, they have not come to my notice. My own first considerable effort in this direction was in 1887, on the occasion of a series of lectures on physical geography in the Teachers' School of Science, supported by the Lowell fund, and conducted under the auspices of the Boston Society of Natural History. The original clay models were constructed partly by myself, partly by Mr. J. H. Emerton, of Boston; and copies of all of them were made in paper by Mr. Emerton. They represented several series of land forms; for example, the valley of a degrading or eroding stream, with steep side slopes and narrow floor; the same district after a period of aggrading action, as a result of which the valley has been filled to a considerable depth, producing a broad flood plain; the same district after the river has resumed its degrading action, sweeping away part of the valley filling, and producing terraces and locally superposed falls, such as abound in New England to-day. Another group included five members, three in regular sequence and the other two in side branches. The first showed a plateau in an adolescent stage of dissection, the second in a mature stage, the third in an old stage. The fourth included a bay or drowned valley, produced by partial submergence of the second; and the fifth exhibited the old denuded plateau, or peneplain, revived into new youth by elevation. A few sets of these models were made by Mr. Emerton and sold to schools and colleges, but they are now "out of print." The set in my own laboratory has been in active use for ten years past. Selections from it have travelled as far as Philadelphia, Baltimore, and Washington to illustrate lectures; some have been sent to Boston, Brooklyn, and Chicago for exhibition; a number of them have accompanied me to teachers' meetings in different parts of New England. It is natural, therefore, that they show signs of wear. They have been used with especial acceptance in my summer course in physiography for two years past; many teachers inquiring whether copies of them could be had, and declaring their emphatic belief that with such aids it would be easy to teach many facts and principles that now seem too difficult for the pupils of secondary schools. That such is the case has been my feeling for some years, and hence I have greatly desired to revise the models in various respects. A new edition should be constructed with greater care, and adapted particularly to such a course in physiography as may, I trust before long, be accepted among the alternative subjects for admission to college.

It has been by good fortune possible to undertake this revision during the past year. A considerable fund for the expenses of the work was contributed by a number of ladies and gentlemen of Boston, whose names would be familiar from their frequent association with educational or philanthropic undertakings. Of these, I must mention in particular Miss Marian C. Jackson, without whose kind interest in my plans, the measure of success thus far attained would have been impossible. During the winter of 1895–96, Mr. G. C. Curtis, then a fourth-year student in the Lawrence Scientific School, devoted part of his time to designing and constructing a model of composite topography, and thus gained good preparation for the desired work. Through the past winter, he has been engaged, under my constant supervision, in constructing the first numbers of a series of models in wax, and copying them in plaster. Some account of his method is appended to this paper. We have finally had the expert assistance of Mr. John L. Gardner, 2d, in photographing the uncolored plaster casts, as here reproduced in four plates, the fourth containing two oblique views of the third model. In their final form, they will be simply colored to bring out their natural divisions more distinctly than is possible in a monotint.

The models are 24 by 18 inches in horizontal dimensions, and their greatest relief measures about two inches above their sea level. Their scale may be taken as about an inch to a mile, and this will hold good for vertical as well as for horizontal measures. It is true that the slopes are strong in the mountainous area; but while perhaps unusual in nature, they are not impossible. As here shown on reduced scale, some of the detail of form is lost; but when enlarged by lantern projection on a screen, it is all clearly portrayed, and the effect is very striking.

In the construction of these ideal models, a guiding principle has been constantly borne in mind. *A rational explanation must be given for every element of form.* It is not necessary here to go elaborately into the many discussions that Mr. Curtis and I have held on the arrangement of ridges and valleys, peaks and passes, snow fields and glaciers, doabs and straths, headlands and deltas. Suffice it to say that close scrutiny has been given to every particular, and that we believe the models to be substantially natural. Nearly every element of form has been justified by examination of photographs and large scale maps; and the combination of these elements has been argued out so as to be reasonable and possible, although not actual. Instead of describing the models, the following paragraphs illustrate their teaching value by giving such an account of them as might be spoken by a teacher in a secondary school, while pointing to the models before a class of young scholars.

First Model. *Mountains bordering on the sea.* Here the foot hills of a mountain range descend directly to the sea shore. Extensive snow fields are seen in the cold climate of the higher summits, supplying glaciers that creep down and melt away in milder temperatures of the valleys. Streams fed by the glaciers and by many side branches on the valley slopes run rapidly down to their mouths at the sea shore.

The rocks on the ridges weather slowly, and the waste is quickly washed down the steep slopes into the valleys, and carried along by the streams to the sea. The waves beat on the headlands, cutting cliffs in their front. The larger rivers build deltas at their mouths, and here only is the sea bordered by low land. The depth and number of the valleys show that already much land waste has been carried into the sea. There it has been spread out by waves and currents. The sounding line shows the sea bottom to be much smoother than the land, deepening gradually for many miles off shore. The dredge brings up gravel, sand, and mud, the texture of the sediments being finer as the distance from the land and the depth of the water increase. Very little of these land-derived sediments is found more than one or two hundred miles off shore. All this means that, while the land has been dissected and roughened by the action of weather and streams, the sea floor has been smoothed over by layers of sediment furnished by the wasting lands.

A rugged land like this can seldom support a large population. It is chiefly in the valleys that strips of flat land, suitable for easy occupation, can be found; and these are often exposed to the danger of floods from the torrential streams which rise suddenly over their banks after a heavy rain or thaw. Most of the scanty population is ordinarily gathered in villages near the mouths of streams or rivers; the rest live scattered over the lower hills near the shore, crowded in the narrow inner valleys, or spread over the smoother and more accessible uplands. Movement is difficult, except along the valleys. It is not easy to reach the interior country beyond the mountains, for the passes are high and rugged, often crossing over snowfields and glaciers. In moving parallel to the shore line from one valley village to another, the traveller must climb over the intervening ridges, where notches determine the place of paths and roads. No roads can follow immediately along the bold sea shore, for most of the cliffs are washed to their base at every tide.

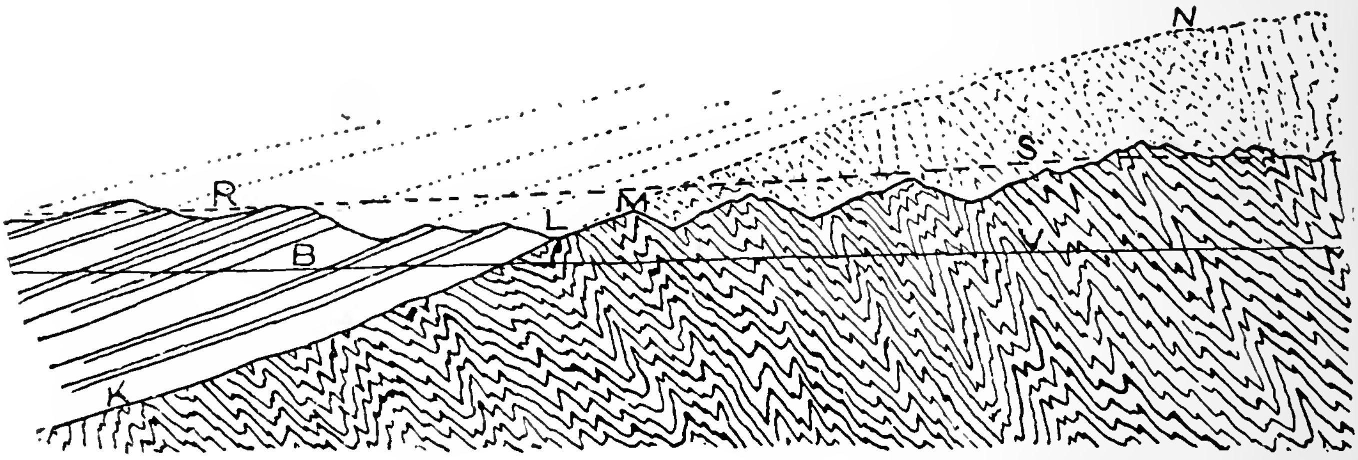
Protected harbors are rare on such a coast; the best ones are found in slight re-entrants between headlands, or in the mouths of the larger rivers. The ridges, cut off by sea cliffs, afford no landing place; the boldest of them may be crowned with lighthouses, to warn the mariner from the rocky stacks and skerries, remnants of the headlands near the shore not yet consumed by the waves.

Certain parts of the coast of California may be compared to the type here described. The Sierra Santa Lucia, south of Monterey, descends boldly to the sea; its slope is hardly inhabited for seventy miles. North of San Francisco, a less severe type of form prevails; the mountains there are not so bold, and more space is offered for settlement near the sea.

The Mediterranean coast, from Nice past Genoa to Spezia, is a famous example of this class, more densely populated than is usual. The mountains rise rapidly from the water's edge. Streams run like torrents to their very mouths. Little villages nestle in the slight re-entrants of the coast; their boats are poorly sheltered during on-shore storms. The harbor of Genoa is enclosed by an artificial breakwater for the protection of shipping. A railroad, following this rugged shore, is compelled to tunnel through many headlands. No highway runs along the shore east of Genoa; westward from that city, it has been only with great difficulty and at great expense that the famous Cornici road connecting France and Italy has been constructed over or around the headlands.

The northeastern coast of Spain about Barcelona offers an excellent illustration of the same kind. Mountain spurs descend to the sea. Villages are generally placed at river mouths between the spurs, but harbors are few and poor. Communication with the inner valleys is easily led along the larger streams, but movement along the coast is impeded by very hilly roads. Many suggestive comparisons, easily appreciated by young scholars may thus be drawn between the ideal model and certain parts of the real world.

Older scholars may study the model as an example of a frequently repeated geological structure and a well-adjusted drainage system. Here the employment of a technical terminology is almost essential. Good practice may be had in drawing structural sections and in sketching surface forms. The mountainous area is easily seen to be divisible into two districts of unlike structure; an area of massive or crystalline rocks without manifest foliation on the right, and an area of stratified rocks in monoclinal attitude on the left. It is clear that the latter rest unconformably on the former, as shown in the accompanying section. Several chapters of geological history are thus disclosed, all contributing their share to the existing geographical form. A little exercise of the imagination may picture the older rocks long denuded in ancient times, and then submerged to receive the unconformable cover of the newer strata. Before submergence, the older rocks must have been reduced to a surface of moderate relief, a peneplain, KL, as is shown by examining the line of contract, L, between the older and younger series. This line is comparatively regular; and hence the surface on which the overlying strata rest was a comparatively smooth peneplain before they were deposited. The lowest members of the stratified series do not extend all along the contact line, but occupy only the northern part of it; later and later layers overlap upon the contact line southward. From this it must be argued that the depression of the peneplain was progressive, and that the depression began in the north and extended southward. The great thickness of the stratified series, aggregating about 15,000 feet within the limits of the model, suggests a long continued period of depression and deposition, so often encountered when the ancient history of the earth is deciphered.



Uplift from this period of depression and deposition was unequal, being greater in the northeast than in the west and southwest; thus the tilted attitude of the strata was produced. The former greater extension of the stratified series eastward over the crystallines may be inferred from the manifest truncation of the strata to-day. A great part of the denudation by which the present form has been produced must be referred to a cycle previous to that in which the existing valleys have been carved; for in this way the general sky-line of the region can be explained best, as it obliquely bevels across the older and younger rocks. A rough peneplain, RS, may have then been carved, making a distinct angle with the peneplain of much earlier date, KN; the earlier peneplain being buried in the west, KL, and worn away in the east, MN; a part of it, LM, being stripped and made visible where the crystalline rocks run under the stratified series. Like many another fossil, this ancient land surface has been preserved by burial and is now revealed by weathering. As in many another case the weathering has injured the fossil while revealing it, for it is less perfect now than when it was buried.

The later peneplain, RS, is now uplifted in the north and depressed in the south, where the land runs under the present sea. In this attitude it has been strongly dissected with reference to the existing baselevel, BV; thus the valleys and shore line of to-day have been carved.

During the preceding and present cycles of denudation, there have been many adjustments of streams to structures, and several more adjustments are imminent. The original uplift by which the stratified series was given its dip to the west and southwest may be assumed to have initiated an extensive system of consequent drainage in those directions. To-day, many of the streams flow along the strike of the strata, following valleys that have been worn in their weaker members, and few streams run down the dip of the monocline. Part of this change may be ascribed to the first cycle; but a considerable extension of the change should be referred to the present cycle, in which the south-flowing streams have been greatly aided in extending their headwaters by the southward tilting given to the region when its present attitude was assumed. The chief river of the model is thus seen to follow a subsequent course along the basal members of the stratified series. A little further headward extension of its drainage area will enable it to divert the upper waters of the large river that now flows westward near the northern side of the model; the course of this river is about down the dip of the monocline from the older to the newer rocks, and its origin is therefore presumably consequent on the uplift at the beginning of the previous cycle. The lower beheaded part of a once larger consequent river may be seen near the middle of the western border. Its former headwaters are represented by certain small streams on the older rocks, now diverted to the service of the master subsequent river. Several other streams flowing southwest on the older rocks near the center of the model also represent the headwaters of a river that once escaped across the stratified rocks. They originated on the former inland extension of the stratified rocks and flowed down their dip to the sea. Now they have become superposed on the older rock series, and their former lower trunk is completely lost, owing to the successful depredations of the various subsequent streams by which the monoclinal valleys are drained.

All this would be clearer if the successive chapters in the development of the region were represented by appropriate models, and eventually this may be done; but as the present series is designed primarily for school use, it is limited to the exposition of relatively simple problems.

Various other features of the model might be discussed if time and space permitted. The graded lower courses of the streams, in contrast to their torrential headwaters; the ungraded outcrop faces of the monoclinal ridges, in contrast to their graded back slopes; the retreating shore line where the sea is actively cutting cliffs, in contrast to the advancing shore line where the main river is building forward its delta. A slight and slow depression of the region may be inferred from the breadth of the flood plain in the main valley. All these matters of detail may serve as the basis of observation, description, and explanation. When accompanied by illustrations, through maps or photographs showing actual examples of similar features, the model may be made the basis of effective teaching.

On all mountainous coasts, where the streams are actively at work washing the waste of the land into the sea, and the waves are vigorously cutting back the headlands, the sea floor must receive abundant supply of sediments. Judging by the depth of the valleys and the height of the shore cliffs in the first model, these processes must have been going on for ages. The sea floor near the shore must be strewn over with heavy sheets of land waste. With this introduction, the second model may be presented to a class of young geographers.

SECOND MODEL.[1] *Narrow coastal plain between mountains and sea.* This model exhibits a region where the piedmont hills descend abruptly to a smooth lowland, and the lowland or coastal plain slopes very gently to the sea. Soundings show that the inclination of the lowland is continued in the slowly deepening sea floor. The conditions of life may here be much more favorable than in the previous example, provided the climate is fitting and the soil fertile. A large population may gather on the lowland, enjoying the contrast between the mountains in the background and the sea in front.

The plain is divided into many similar parts by the shallow valleys of streams that flow across it from the mountains to the sea. Each division of the plain may be called a *doab;* that is, a two-river space (*doab*, a term of Hindu origin, meaning "two rivers"). The surface of a doab is so smooth and nearly level that a great part of the rainfall enters the pervious soil instead of running off in surface streams, as is the habit in the steep ravines and valleys among the

[1] In order to gain room for the coastal plain in this model, the higher mountains in the back country of the first model are cut off and the sea front is extended. The modeled area is, as it were, brought forward.

hard-rock hills of the back country. The rivers on the plain are not separated by definite divides; a great part of the interstream surface is really undivided; and in this respect the drainage of the immature plain is very unlike that of the maturely dissected mountains, where sharp crested ridges divide the rainfall very definitely between the streams in the neighboring valleys. The implication often made in text-books, that the basins of adjoining rivers are always distinctly divided, is thus seen to be incorrect. As the lateral ravines gnaw further headward into the doabs, a better definition of the divides will be given, but much work must be done before that time arrives.

Where a river swings to one side of its valley floor or *strath*, and flows against the valley side, it undercuts the slope and lays bare the structure of the plain. It is thus seen to consist of layers or strata of gravel, sand, and clay for the most part. The smooth plains of the doabs are merely the surface of the uppermost of these strata. The pebbles in the gravels often resemble the harder rocks of the hilly or mountainous back country; the clays often contain shells, similar to those found in the neighboring sea.

The rainfall that sinks beneath the surface is known as ground water. It moves slowly through the gravelly and sandy layers beneath the doab plains towards the sea or towards the valleys. It emerges in springs at the base of the valley sides, in the river channels, on the shore, or even off shore on the sea bottom. Ordinary wells on the doabs encounter the ground water at a moderate depth; artesian wells near the shore find it at a greater depth, and fresh water may thus be obtained even on the offshore sand reefs.

The little side ravines by which the margin of the doabs is more or less fringed also occasionally disclose the bedded or stratified structure of the plain. There is very little land waste washed from the flat upland of the doabs, but the steep side slopes of the ravines and the edges of the larger valleys suffer rapid loss by the creeping, slipping, and washing of the loose sediments there exposed. It is manifest, from the amount of waste that the side streams carry in wet weather, that the ravines are continually encroaching at heads and sides on the low upland. Years ago, the ravines were smaller than they are now; ages ago, the ravines did not exist; in still earlier time, even the main valleys had not been cut out. All the material that once filled the ravines, as well as that which occupied the larger valleys between the doabs, has been carried away by the streams. Some of it may be seen in small deltas at the river mouths, the rest is spread over the sea floor. In the future, the doabs will be more dissected by ravines and valleys; in the past, they were less dissected. Before any valleys were cut, the doabs were all united in a continuous coastal plain. When all this has been made clear, no one can doubt that the coastal plain was once a smooth sea bottom, and that this region was then like the sea-skirted mountains of the first model. Since then, the relative level of land and sea has been altered, part of the even sea bottom is now revealed to form the coastal plain, and the valleys have been cut in the plain by the streams.

As soon as this simple relation is recognized, the background of hills and mountains is seen to be the *oldland*, from whose waste the strata of the coastal plain were built. The inner boundary of the plain is the oldland shore; and the former sea cliffs may be discovered along the margin of the hills. The cliffs are no longer clean swept at the base by waves; they are now cluttered with waste fallen from their faces. The streams from the oldland no longer mouthe at the oldland shore, but extend their courses across the coastal plain, guided by its gentle slope; for this reason, they may be called *extended streams*. As their direction is consequent upon the slope of the plain, they may also be called *consequent streams*. Some small streams may rise on the plain, and flow by short direct courses to the sea; these are *original consequent streams*, in contrast to the consequent extensions of the streams that head on the oldland. The latter are the larger; some of them, draining a large extent of oldland, may be the master rivers of the district.

As the region now stands relatively higher than before, the rivers all tend to cut down their valleys to the new level of the sea at their mouths. This controlling base of their action is called the *baselevel* of the region. As long as the land stands in its present position, continually wasting under the destructive attack of the atmosphere, the surface will be worn lower and lower, closer and closer to baselevel. In the coastal plain shown in the model, a good beginning of this great task is accomplished along the line of the streams, but the interstream doabs are as yet hardly touched. The general process of wasting by which the land is worn down, and deeper and deeper structures laid bare, is called *denudation*. It varies with structure, slope, and climate; an inch in from one to ten centuries may be taken as a rough value, averaged for large areas. Thus a simple introduction is given to the essential idea of the *geographical cycle*, the long time-interval necessary for the complete wearing down of a land mass to baselevel.

Where the extended rivers cut down their valleys across the plain, they disclose part of the foundation on which the sands and gravels lie for a little distance outside of the oldland shore. The foundation is seen to be nothing more than an extension of the oldland, whose surface pitches seaward at a somewhat steeper angle than the slant of the coastal plain. The strata of the plain are thus seen to constitute a wedge-shaped mass (shown in section on the side of the model), with the thin edge of the wedge at the oldland shore and thence thickening seaward.

While the rivers flow upon the resistant rocks of the oldland foundation just outside of the former shore line, they find the work of deepening their valleys much more difficult than when they reach the weak strata of the plain, further down stream. Hence there will be, for a certain period in the history of the plain, a relatively strong descent of each river as it passes from the oldland rocks to those of the plain, and this strong descent will cause rapids or falls. A line drawn through the rapids of all the extended streams may be called the fall-line: it lies near and about parallel to the oldland shore. It is important as marking the head of navigation in the larger rivers, and as furnishing waterpower for manufacturing industries.

Taking advantage of the permission given by the relative uplift of the land to cut deeper than before, the streams of the oldland are all entrenching themselves in their former valley floors. This change is as yet hardly noticeable in the small streams and in the headwaters of the larger ones, but it is plainly apparent in the lower courses of the master rivers, where distinct terraces show the remnants of the former flood plains. The terraces often serve as excellent sites for villages and roads, out of reach of floods.

Simply in order to introduce a greater variety of form in the second model, a small volcano and several lava flows have been built up on the oldland near the old shore line. The crater of the chief cone has a little crater within it, and a subordinate cone has been formed on the flank of the larger one. The lava flows radiate from the chief cone, following the slopes of the land before them. One flow obstructs a valley, and a lake fills the basin behind it. The lake outlet is turned across a ridge, where it is actively cutting a gorge by which the lake will be soon drained. Inasmuch as one of the lava flows runs into a little valley on the coastal plain, it is manifest that at least that part of the volcanic accident took place after the plain had been elevated and dissected.

A simple system of describing land forms may be illustrated by means of this elementary example. The existing forms of the coastal plain may be treated as dependent, first, on the form of the plain as it rose from the sea; and, secondly, on such modifications as it has suffered since then under the action of weather and water. The term *initial* may be applied to the original form, or to so much of it as is still visible on the doabs. The term *sequential* may be applied to the forms that follow from the action of the various processes of weathering and washing on the initial form. In this case, the smooth doabs still preserve the initial form of the plain with insignificant change; the broad valley floors or *straths* of the master streams, and the narrow valleys of the minor streams, and the little lateral ravines of the wet weather streams are all sequential forms. Ultimately, when the doabs are worn down flat, close to sea level, the *final* form will be reached. Evidently, the final form will be attained much sooner on the weak strata of the coastal plain, than in the resistant rocks of the oldland mountains. The cycle of the latter is much longer than the cycle of the former.

The surface of the doabs is everywhere so much alike in form and quality that villages are located here and there without system. Roads run in straight lines for long distances, because they meet no obstacles; but they generally follow ravines in passing from doab down to strath. The neighborhood of a master river commonly attracts the greatest population of the region. Its strath is generally fertile, but is exposed to danger from floods. The river comes from an extensive system of confluent valleys among the oldland hills and mountains, and may lead tribute from mines and quarries, forests and upland pastures, to the city near the sea. The city serves as the market place for the agricultural products of the plain, although these are sometimes not of the best; for where the surface is sandy, it may be hardly worth tilling; it may then be left to such forest growth as it will bear, or it may serve for grazing.

The city is the local center of trade and of commerce from over sea, for only through the large river mouth can sea-going vessels of some size find safe harborage. Near the land the sea is very shallow. Sand reefs or beaches are formed a little distance off shore, built of sands washed in from the sea floor by waves chiefly in time of storms. The reefs bear barren sand dunes, blown up from the beach by on-shore winds. Between reef and mainland there are quiet lagoons, shallow and marshy. Here and there, the tides maintain a passage or inlet through the reef; villages spring up on the mainland near by, whence fishermen may go out in small boats to the shallow sea. The ways of living on the rugged oldland and the smooth coastal plain are almost as unlike as their form.

Inquiry is naturally excited as to the manner in which the sea bottom was raised, or the sea waters withdrawn, to lay bare the coastal plain. It is well enough in teaching elementary geography to be frank about this, and say directly that no one really knows exactly how such changes are brought about. Some interesting theories have been suggested to account for the observed facts, but they are not yet proved beyond doubt, and their discussion belongs to geology. There is no reason to believe that volcanic action has any essential control of or connection with elevation; many coastal plains have no volcanoes near them. But the main facts remain: the relative level of land and sea have changed, and part of the former sea floor has been converted into a coastal plain; and this not long ago, as the earth reckons time, for the doabs are as yet but little fringed by the ravines that the side streams are gnawing back from the transverse consequent valleys. The shallow valleys of the larger extended rivers appear to have been cut down almost as fast as the weak strata of the plain were laid bare.

The dimensions of oldlands and of coastal plains vary greatly in different parts of the world where these forms occur in the simple relation here described. The oldland may be of more moderate relief and of much more habitable quality than in the model here figured. Its margin may be more irregular, the salients having been more cliffed and the re-entrants more delta'd in the time before the coastal plain was born. The plain may be of small length and breadth, or it may stretch hundreds of miles along a continental margin and add a considerable measure to the continental width; but if of large dimensions, it is likely to have a more complicated history and a greater variety of features than those here represented. The altitude of the inner part of the plain may be several hundred feet, so that valleys of a considerable depth are cut into it, and these may come to be serious obstacles in the way of movement along the plain. As the dimensions vary in one way or another, the conditions and opportunities for human occupation vary with them.

The eastern coast of Mexico in the neighborhood of Vera Cruz is bordered by a low coastal plain about fifty miles wide, back of which the mountains rise rather abruptly. The plain is called the "tierra caliente," or hot country; it is sandy and relatively infertile. Its broad surface is very flat, but it is here and there incised by the streams that flow out from the mountains. The railroad from the coast to the interior has an easy grade to the former shore line at the base of the oldland, but then rapidly ascends the flank of the mountains. The coast has no good harbors. Large vessels cannot approach close to the land, but must anchor off shore and transfer their cargo to lighters, unless extensive artificial docks and wharves are constructed. The rough handling incident to this method of discharging cargo has caused much injury to imported goods, even to the point of inducing one of our consuls to urge that manufacturers in the United States should on this account use great care in packing their wares exported to Mexico.

In the Mexican war (1847), when the fortified port of Vera Cruz was captured, the Mexicans found no other place for resistance on the smooth coastal plain, and therefore fell back to the hilly border of the oldland. Here they entrenched themselves on a spur, called Cerro Gordo, between two ravines that had been deepened by the streams from the mountains after the region was uplifted and the plain revealed. Although well defended, the spur was successfully assaulted by the American army under General Scott in the most decisive battle of the war.

The highlands of the Deccan in the peninsula of India are bordered on the east by a gently sloping plain, not more than fifty miles wide. It consists of bedded gravels, sands, and clays, containing marine or brackish-water shells. Large rivers, the Godavari and Kistna, draining great areas of the interior highlands, have extended their courses across the plain and built projecting deltas at its front.

The accessible descriptions of these coastal plains in Mexico and India are so brief that nothing is said about many significant features whose existence may be strongly suspected. No mention is made of sea cliffs and river falls along the old shore line; yet it can hardly be thought that these characteristic physiographic elements are altogether wanting in nature. The relative breadth of the straths and the doabs, the local relief of the doabs above the straths, and the degree of dissection of the doab borders are so briefly or imperfectly described that no accurate mental picture of the plains can be constructed. No sufficient account is given of the manifold relations that must exist between the form of the plains and the distribution and occupation of the people. It may be fairly contended that if a traveller in those regions were familiar with a type example of a coastal plain, such as the second model exhibits, his attention to many physiographic features would be awakened where it now slumbers, his observation would be immediately directed to critical localities, and his records would be very intelligible and satisfying to his readers.

Third model. *A mountainous region descending to an irregular shore line.* In marked contrast to the comparatively even shore lines of the first and second models, the land here borders very irregularly on the sea. The ridges advance in promontories. Outstanding islands are seen beyond the ends of some of the headlands. Long branching bays enter between the ridges, penetrating far inland and terminating in rather acute points. There is a systematic relation between land form and shore outline. Every valley descends into a re-entrant of the shore line; the larger the valley, the longer the re-entrant. The ridges that separate the valleys also serve to divide the bays.

The irregular outline of the land cannot be explained by the action of present processes. The headlands are wasting where the strong outer waves are cutting cliffs at their ends. Some of the coves receive the waste from the cliffs in the form of concave beaches. The bays are filling at their heads where the streams are building deltas. The continuation of these processes would reduce the shore line to comparative simplicity of outline. Indeed, in some earlier period than the present, the shore line must have been somewhat more irregular than it now is. Before the cliffs were cut, the headlands were longer and sharper than today. Before the concave beaches were swung between the headlands, the coves were deeper than now. Before the deltas were built, the bays were longer and more acutely pointed. From this more irregular outline, the shore is really becoming smoother by the action of existing processes.

It is moreover manifest that the land cannot have stood long, as the earth counts time, in its present position; for if so, the headlands would have been more cut back by the waves, and the bays would have been more filled by delta growth. A great deal more time must have been spent in wearing the valleys between the ridges than has been spent in building the little deltas. Thus it becomes clear that the land has had a much longer history than is recorded by the cliff cutting and the delta building; and that by some other processes than those of today was the original irregular shore line produced.

A simple and sufficient explanation of both these conclusions may be found by assuming that the valleys were eroded while the region as a whole stood higher than today, like the first model; and that then a relatively uniform movement of depression occurred, whereby the sea advanced upon the lower lands. It necessarily entered furthest into the main valleys, and by drowning them produced the branching bays between the advancing headlands. This explanation fits the case so perfectly that there can be no doubt about it. Since the movement of depression occurred, a relatively brief period of time has elapsed; for, as has been already said, the deltas are small and the sea cliffs are low. When more time has elapsed, the headlands may be cut far back and the deltas built far forward; and then the shore line will be much simpler than now.

The lessons taught by comparing the second and third models with the first are among the most important that the young geographer can learn. In the first place they give him a rational introduction to the fact that the lands rise and fall with respect to the sea, and that in consequence of these changes, the face of the earth alters its expression. The subject may become scientific not only in its content, but in its treatment. Indeed, long before the deliberate advance of the description and explanation here suggested, any intelligent school boy or girl, looking at the first and third models, would have seen that the latter was derived from the former by partial submergence followed by slight changes of the shore line. It is remarkable that an explanation so simple and sufficient as this should have been so long making its way into the school room. Yet it is only in recent years that teachers have taught that bays like the Chesapeake, or firths like that of the Clyde, are merely "drowned valleys." The difficulty has not been in the lack of intelligence on the part of the scholars. Their natural powers have been long retarded by basing geography on artificial, empirical definitions, instead of on observation and rational explanation.

An interesting consequence of the depression by which the first model is converted into the third is seen in the dismemberment of the chief river system in the original mountainous region, and the survival of only the head streams, each of which appears as an independent river system in the partly-drowned mountains. Streams thus separated from the main river to which they once belonged may be called betrunked. They are very common in many parts of the world. All the rivers that now flow independently into Narragansett bay, or into the Baltic sea, are betrunked rivers; they once joined a trunk river whose drowned valley now forms the bay or sea.

Just as the explanatory treatment of the dissected coastal plain suggested a general method for the description of land forms, so the rational view of the uplifted or partly-drowned regions leads to a natural way of describing shore lines. Their outline depends, first, on the form of the crust (land surface or sea bottom) upon which the sea came to edge at the time of the last movement of elevation or depression; and, secondly, on the amount of change suffered in the original outline by the action of streams and waves. Thus the smooth sea bottom of the first model, uplifted to form a coastal plain in the second model, had a very simple initial shore line; and the initial shore line has suffered small sequential changes in the way of delta and sand-reef building, whereby the existing littoral features of the second model are produced. The initial outline of the third model was very irregular, because the uneven land of the first model, with strongly eroded valleys and minutely carved ravines, was depressed, so that the sea rose upon the flanks of the ridges, entering far between them and following every sinuosity in their contour. Since then, sequential changes of appropriate order have been introduced in small amount. It is serviceable as well as interesting to describe actual shore lines in this way; and by means of the type forms represented on the three models much actual description may be accomplished.

The terminology here suggested, initial, sequential, etc., is of relatively small importance, although I believe it to be of the same order of convenience as that which suggests the use of such terms as cube, cylinder, and sphere, in the kindergarten, after the things thus named are familiar by sight. Any teacher who desires to do so may of course introduce other terms, or dispense with terms altogether; but the facts which the terms represent cannot be dispensed with, if the verity of nature is to be presented to school children. Indeed, if children were allowed to base their study on models, supplemented by pictures and maps and descriptions of actual forms, I believe that they would soon invent for themselves a paraphrastic terminology, so simple and manifest are the facts of form and process. To withhold such geographical explanations as are summarized by systematic terms, or to replace them by empirical definitions, is to retard the progress of school children in one of the most universal subjects of study, and to blunt rather than to sharpen their intelligence. A teacher who is easy minded on these matters, and who has an adequate supply of illustrative material, can give scholars an appreciation of the real facts of nature far beyond anything that has ever been attained by text-book recitations.

It is immaterial whether the explanation of the land and sea forms is given before or after the relation of these forms to their occupation by man. The questions asked by a class of bright scholars are probably better guides to the order of presentation than any predetermined plan. If the relation of the branching bays to a system of partly submerged valleys is noticed by one of the class, let the explanation by relative depression be introduced at once. The cause of depression is as unknown as the cause of elevation in the second model; but the facts of depression and elevation are patent in both examples. If a question is asked about harbors, the conditions of life may at once be taken up. In either case, familiarity with the first topic that is considered will aid in the discussion of the second.

On this half-drowned coast, the most noticeable matter in the relation of earth and man is the shelter given by the promontories to the bay heads, or by the islands to the coves back of them. In such a region the art of navigation is naturally developed. The outlying islands tempt exploration. The sheltered harbors promote the use of small boats, which in the course of time are constructed on larger and larger scale. Coastwise voyages of much greater length than from the mainland to neighboring islands are then attempted, and at last comes the bold navigator who sails forth on the open sea, leaving the land far out of sight behind him. Where harborage is found, settlements spring up; thus villages come to lie near that point in a valley floor where the advancing sea halted. Hundreds of examples might be given of settlements thus located. The promontories are less attractive for occupation than the ridges of the first model; for they are now bordered by the sea on either side, and thus somewhat isolated from the rest of the region: connection with the interior must be made by following the crest line, or along side-hill roads, difficult of construction and maintenance. The islands are still more out of the way; easily reached across the quiet inner waters; storm beaten and almost unapproachable on the outer side; allowing the development of only isolated communities at the best. The mountains in the background are a little more approachable than in the first model, for on account of standing at a less height, their climate has been somewhat tempered, and the snow fields and glaciers have therefore been a little reduced in area.

Southwest Ireland and northwest Spain offer typical illustrations of half-drowned valleys on a mountainous coast. It is coming to be the practice among European geographers to give the Spanish name, *ria*, to a branching bay thus formed, *fiord* being reserved for arms of the sea whose inner waters are deeper than those at their mouth. In Spain, the rias of Vigo, Pontevedra, Arosa, Muros and Noya, and Corcubion lie south of Cape Finisterre; the rias of Camariñas, Corme and Lago, Coruña, Ares, Ferrol, and Cedeira follow to Cape Ortegal; and others lie further east. Most of these bays are named after towns on sheltered harbors on their sides or near their heads. The dangers of the headlands between them are well known to navigators. Crossing to Ireland, Long Island, Dunmanus, Bantry, Kenmare, Ballinskellig, and Dingle bays lie between bold mountainous headlands. The headlands are cut back into formidable cliffs, and fronted by stacks and skelligs. The bay heads are continued by delta-like plains, filled in by the rivers. There are the settlements, while the mountains are sparsely occupied.

The leading features of the geography of Greece may be briefly expressed by describing it as a mountainous land, which has stood up to its knees in the Mediterranean long enough to have delta plains of considerable size built in the bay heads between the promontories. Thereupon follows a great part of the individuality of various communities which early occupied the lowlands enclosed between adjacent ranges and fronting on the sea; a theme which historians have often emphasized, although without giving much meaning to its fundamental features. The harborful coastline of northwestern Europe is, also, an illustration of a half-submerged topography. The sheltered waters of the numerous *viks*, or bays, developed a sea-faring people who impressed themselves most forcibly on early European history. The vik-ings, or bay people, were sea-kings through the growth of habits fostered by their geographical surroundings, but not through etymology.

In our own country, we have numerous examples of drowned valleys, but none which so closely resemble the type form of the third model as do the rias on the mountainous coast of northwestern Spain. The ragged coast of Maine was not a mountainous country, but a dissected old-mountain peneplain, before its valleys were drowned by partial submergence. Moreover, a well-defined coastal plain of clayey and sandy strata containing marine shells occupies much of its littoral belt, and this proves that the region has today partly recovered from a greater submergence of a somewhat earlier time. The greater submergence allowed the sea to rise about three hundred feet above its present level, the shore line then being about as irregular as now. This submergence lasted long enough for the long arms of the sea to receive a considerable accumulation of sands and clays, by which the inequality of their floor was much reduced. The elevation by which the sand and clay deposits are in part revealed still allowed the sea to occupy various valleys between projecting headlands and outstanding islands; hence the irregular shore line of today. The elevation occurred only long enough ago to permit the extended streams to cut narrow valleys in the plain. In the typical coastal plain of the second model, the old and the new shore lines are comparatively straight and lie nearly parallel to each other. The coastal plain of Maine is a most irregular patchwork, without regularity of inner or outer margin. It penetrates far inland between rocky hills and ridges that were once promontories; it wraps around rocky knobs that were once islands. So open is the suggestion of the rocky ledges which often rise through the flat clay fields, that the farmers (who have often had a turn at sea-faring) call them "reefs." The discontinuity of the plain is so great that it is seldom recognized in geographical descriptions. Yet once seen and appreciated as a coastal plain formed along a ragged instead of along a smooth coast, its essential peculiarities may be easily apprehended. Among these peculiarities, none is more marked than the irregular distribution of falls on the extended streams of to-day. Normally, the falls should be found only where the streams leave the oldland rocks at the inner margin of the plain; in Maine falls occur in the coastal plain wherever the streams happen to incise their channels upon a buried rocky spur or knob. It is for this reason that so many falls occur there close to the sea, while the inner margin of the coastal plain is thirty or more miles inland. Thus starting with an example that seems to correspond, as far as drowned valleys are concerned, with the third model, we are led to consider the effects of elevation, in which the second model is our aid.

These complications in so familiar a region as the coast of Maine suggest the importance of adding new models to the small series here described, and thus systematically developing the most varied topography from the simplest elementary examples. It is therefore proposed to construct a successor to the third model which shall represent the same district after the lapse of a considerable period of time, during which the ridges shall have been perceptibly worn down to fainter relief, and the large stream to the north of the main range shall have been captured by the headwaters of the south-flowing stream that lies on the contact between the older and younger rock series. At the same time the deltas will have greatly advanced, filling in most of the bays. A number of independent streams in the third model will thus be engrafted upon a single trunk again; but this trunk may not run precisely above the course of its ancestor in the first model. While all this is going on, the waves will have consumed the outer islands, and the headlands will be much worn back. Sand reefs will be spread along certain parts of the shore, tangent to the cliffs from which much of their supply is derived; and some of the bays will be thus enclosed. The inner islands will be tied to the mainland, either by forward growth of the delta plain, or by backward growth of sand reefs. The area of easily occupied lowland will be greatly increased; a large and flourishing population might settle on such a plain. Still another model might represent the mountain peaks and ridges reduced by long continued denudation to a peneplain, above which a few monadnocks might stand as the last witnesses of the vanished highlands. This would then serve to explain the ancient peneplain worn on the older rocks of the first model before the newer strata were deposited.

Similarly, the second model should be followed by another in which additional elevation has broadened the coastal plain, and further volcanic action has complicated the group of cones and flows. With greater elevation and age of the coastal plain, it would be possible to introduce the development of thoroughly dissected doabs; and by drowning these forms, the type of Chesapeake Bay and of the Potomac estuary would be illustrated. Another succession from the young coastal plain would show a *cuesta*, or longitudinal flat ridge, with gentle outlooking slope and relatively steep inface, enclosing an inner lowland; this group of features being known on the coastal plain of Alabama. Associated with these features, there would be certain systematic re-arrangements of drainage, such as characterizes regions of this kind.

When these complications are expressed only in words, they are relatively difficult to follow; but when expressed in a series of models, in which successive stages are not separated by too great intervals, the development of various land forms would be very easy even for young scholars to understand. Thus aided in gaining an appreciation of the facts of geographical form, it would be a relatively simple matter to exhibit the way in which man takes advantage of these forms in his manner of life. It does not seem too much to say that the general introduction of systematic geographical models in elementary teaching would revolutionize the condition of geography in the schools. By the addition of more complex forms, the models would form the nucleus of a museum of systematic geography, in which land forms would be classified according to structure and development. Such a museum promises to be as useful for the future progress of scientific geography as systematic collections of animals and plants have been for the past progress of zoology and botany.

Note on the Construction of the Models. By G. C. Curtis. As a preliminary step to the construction of the models here described, shaded maps were drawn with some care, in order to be sure that a genetic sequence of typical forms should be secured. This is regarded as an essential, for otherwise it would be hardly possible to provide in the first member of the series the proper antecedents of all the forms developed in the later members. The drawings were based on a careful study of appropriate maps and photographs, so that their design might be essentially true to nature; but further than this, no forms were introduced for which a reasonable physiographic explanation could not be given. Only in this way can arbitrary and impossible combinations of form be avoided. It is true, that, in the later construction of the models, the specifications of the drawings were departed from in a number of particulars; yet the guiding principles according to which the drawings were designed were followed throughout. The models are, therefore, of the same order of verity as a picture of a human face would be, if designed as a type by an artist familiar with the essential combination of human features. The series of drawings goes further than the models now constructed; but it is hoped that the later forms, already prepared on the maps, may eventually be reproduced in relief also.

When the drawings had reached an acceptable stage of detail, they were reproduced in modeling wax, a specially prepared form of beeswax, procured of Messrs. Wadsworth and Howland, Boston. This proved to be a very satisfactory material for modeling. It is easily worked, is susceptible of taking much detail of form, and retains its form unchanged for months at a time. Being free from moisture, it does not cause the modeling board to warp. By slight warming, it becomes plastic, so that it can be roughly shaped almost as easily as moist clay. The blocked-out ridges, made by hand, were then carefully carved, for the most part with steel tools, into more detailed expression; photographs selected from the Gardner collection, and plates in various geological reports being a constant guide in this part of the undertaking.

After the first model was completed, several plaster negatives were taken from it in the ordinary manner. The fiorded coast of the third model was then produced by planing down the sea level in one of the negatives. Upon a positive from this modified negative, the headland cliffs were cut and bayhead deltas added, a slight modification was made in the land slopes, and the glaciers were somewhat curtailed, on account of the depression of the region and the consequent tempering of the mountain climate. The positive, thus altered, served as the original for negatives and casts in turn.

The coastal plain was built forward on the original wax model, by adding a new sea level in the foreground, and reducing the wax forming the former sea level to the inclined surface of the plain. The valleys of the extended streams were then carved in the plain, and a corresponding development of terraces in the valley floors among the mountains was given. The volcano and its lava flows were built up in an essentially accidental relation to the pre-existent topography. The negative from this enlarged model was then cut off at the landward end, so as to reduce its length to the same measure as that of the others.

In all the models, the production of a perfect sea surface has been a matter of no little difficulty. In the first model, the sea was first scraped as smooth as possible with a steel straight-edge, and then planed true on the plaster negative. The sea of the fiorded coast was made by planing the plaster negative, as stated above; the chief difficulty here was to reduce the different parts of the negative uniformly, and to stop with a true plane surface when the desired irregularity of shore line was reached. In the sea bordering the coastal plain, the wax was scraped down and the negative planed off, as in the first model.

The construction of these models is a form of creative work, the labor of modeling being similar to that of the sculptor's work in clay. The modeler must understand, not only the geographic history of the region which he depicts, but must grasp the essentials of form which characterize such a territory and topography. The work differs essentially from the modeling of mapped localities, which is a mechanical process of reduplication in three dimensions. The differences of the two arts might be compared with those of the photographer and the landscape artist.

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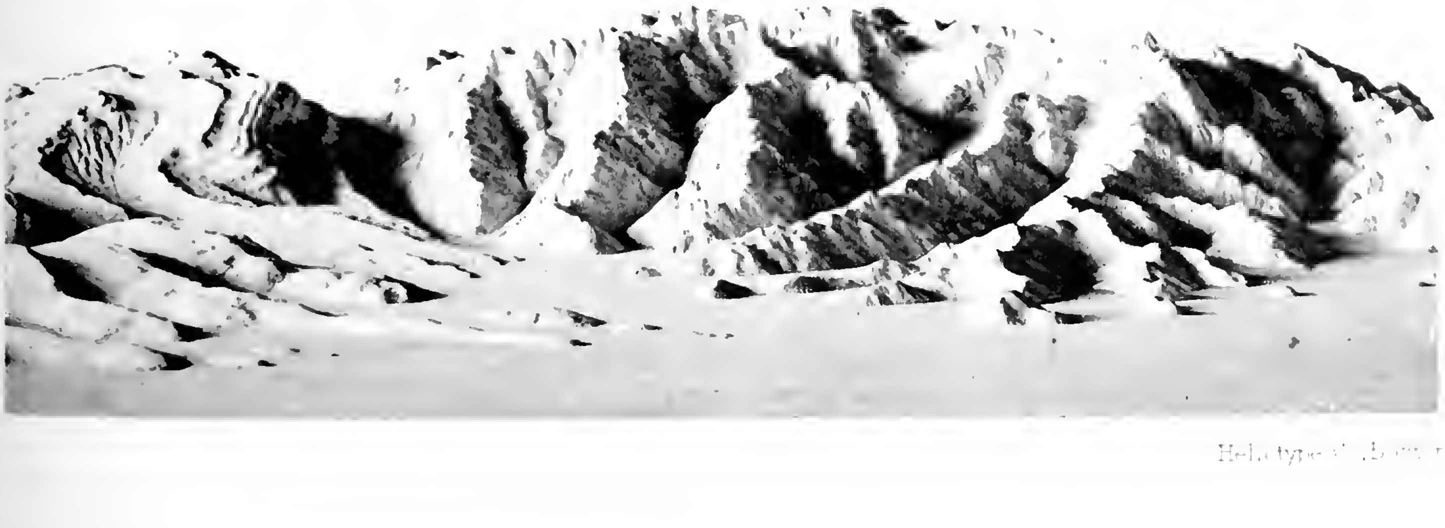

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CLYMENE PRODUCTA SP. NOV.

By Margaret Lewis.

With Two Plates.

BOSTON:
PRINTED FOR THE SOCIETY.
August, 1897.

No. 5.— *Clymene producta sp. nov.*[1]

By Margaret Lewis.

The worm which I am about to describe was discovered in the summer of 1895, at Cotuit, Mass., in a sand-flat of one of the tributaries of Vineyard Sound. I have found no mention of it by any of the writers on marine annelids and believe it has not been previously described. It shows so strong a similarity to members of the family Maldanidae, that I have no hesitancy in placing it with them, although, so far as I can learn, it contains a very much larger number of segments than any of the known Maldanids which have been described.

This annelid constructs a tube of coarse sand, similar to that of Axiothea torquata, a species with which it was found associated. Its distribution, however, seems much more limited than that of A. torquata, as I have found it in only one locality, although I have examined sand-flats in many parts of Vineyard Sound.

I have never succeeded in securing an entire, unbroken worm; but by putting together portions of worms and by a comparison of several such, I conclude that the animal consists of about seventy segments. I have had more than sixty segments in one piece. Some of my incomplete specimens measure twelve inches in length.

This Maldanid is divided into three regions, distinguished by the size and shape of the segments: — first, the thorax, consisting of four segments, if we count as one the fused buccal and cephalic segments; secondly, the middle region or abdomen, consisting of five segments; and, thirdly, the tail, comprising the rest of the worm and consisting of about sixty segments.

In the thorax the three segments following the buccal segment are larger at the anterior end and taper gradually toward the posterior end. The buccal segment is without setae; it is obliquely truncated (Pl. 1, Figs. 3, 4) at an angle much sharper than in Axiothea torquata (Pl. 1, Fig. 2). In dorsal aspect (Fig. 3) it shows a cephalic plate with median dorsal ridge placed between two narrow ciliated grooves. This median ridge ends in front in a thumb-

[1] Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy at Harvard College, under the direction of E. L. Mark, No. 81.

like process, which is longer than that of A. torquata (Fig. 2). The dorsal and lateral margins of the head are prolonged into a thin rim, which shows three small notches (Pl. 1, Fig. 3), a median dorsal one and a pair of much smaller ones so situated as to divide each lateral half rim into two unequal portions, a posterior dorsal third, and an anterior ventral two thirds. A large number of ocelli, more than a hundred, are found on the anterior ventral surface of this first segment, just in front of the mouth (Pl. 1, Figs. 4, 5). They show a somewhat V-shaped arrangement, and in preserved specimens have the appearance of very small brownish black dots, visible only with the aid of a lens.

In the remaining thoracic segments there are setae, which are borne near the anterior end of the segment (Pl. 1, Fig. 1).

The abdominal segments, five in number, show a nearly uniform diameter throughout their length. The setae of the first four are placed near the posterior end of the anterior third of the segment (Pl. 1, Fig. 1). The first two abdominal segments are of about equal length; the third is slightly longer than the second; the fourth is longer than the third, and is followed by a segment which is much shorter than any of the other four. In this short abdominal segment the setae are placed at the middle of the segment. The boundary line between this and the first segment of the tail is very inconspicuous.

The collar, which is formed by the forward prolongation of the anterior margin of the first abdominal segment, is not well marked.

With the beginning of the third portion of the body there is an abrupt change in the position of the parapodia. Throughout the tail region these are borne very near the posterior ends of the segments. Behind the fifth segment of the tail there is a continual decrease in the length of the segments, until the posterior end of the animal is reached. The worm is easily broken in this third region; this, no doubt, accounts for the difficulty of getting entire specimens.

The preanal segment (Pl. 1, Fig. 6) is very short and destitute of both setae and uncini. The anal segment is surrounded by a circle of papillae much as in A. torquata; but in A. torquata the three segments in front of the anal segment are destitute of setae.

The dorsal setae (Pl. 2, Figs. 16, 17) are long and slender, of capillary fineness, and become very abundant in the abdomen and anterior segments of the tail. There are two forms, both of which show much variation in size. In both forms the setae taper very gradually and uniformly to a sharp point. In the simpler form (Pl. **2**, Fig. 16) the seta is entirely smooth; in the other (Pl. **2**, Fig. 17) it is provided with bipinnately arranged spinous hairs, which give it a plumose appearance when seen under the microscope.

The ventral setae are uncini (Pl. **2**, Figs. 13, 14, 10, 11) and show a marked difference of form in the case of the thoracic and the remaining segments. In the thorax there are only two (Pl. **2**, Figs. 13, 14) in each parapodium, and one of these is not evident upon superficial examination, because it is not protruded beyond the surface of the segment. They are rather short and stout, and the free end terminates in a single slightly curved, rather blunt process. The less evident one (Pl. **2**, Fig. 13) scarcely projects beyond the surface of the body. It differs from the other especially in the form of the inner end, which is very blunt.

The abdomen has a large number of uncini in each ventral ramus. Beginning with 16–18 in the first abdominal segment, the number rapidly increases, so that in the fifth abdominal segment there are 37–40 in each ventral ramus. These uncini (Pl. **2**, Figs. 10, 12) end sometimes in four, sometimes in five hooks; the foremost of these hooks is the largest, the others are successively smaller. Each uncinus bears a tuft of bristles at the base of the largest hook. The uncini from the abdominal segments (Pl. **2**, Fig. 10) are curved less than those (Pl. **2**, Figs. 11, 18) from the first segments of the tail region; otherwise they resemble them closely.

As a whole, the worm is of a pinkish flesh color. There is a conspicuous bright red band around the posterior portion of each of the five segments of the abdomen. The most anterior of these bands is very narrow, but they increase successively in width until the fourth abdominal segment is reached, in which the red band occupies about two thirds of the segment (Pl. **1**, Fig. 8). In preserved specimens the anterior portions of these banded segments are of a dull whitish color. The posterior portion of the fifth abdominal segment, the ninth segment of the worm, has a red band of a less pronounced character than the four preceding it.

There are three pairs of nephridial openings, one pair each in segments eight, nine, and ten. They are ventral and a little posterior to the row of uncini (Pl. **1**, Fig 8). Corresponding with these openings there are, as I find by dissection, three pairs of nephridia.

In attempting to classify this worm, we find no characteristics which would exclude it from the family of the Maldanidae (Maldaniae Savigny, '20) as emended by Grube ('68), except the number of segments, which Grube makes never greater than twenty-seven. In all other respects the worm would belong in this family. It contains, however, probably more than seventy segments.

Malmgren ('65) in establishing the genera of the family lays great stress upon the number of segments, both the total number and the number of setigerous segments, and he breaks up the genus Clymene of Savigny into several genera depending upon these characters. If we should follow Malmgren, it would be necessary to establish for this worm a new genus.

De Saint Joseph ('94) in his recent extensive work goes over the whole ground of the classification of Maldanidae and, disregarding entirely the number of segments, — the total number in the body as well as the number of the preanal segments, — bases his distinction of genera upon the following characteristics: —

1. Form of head. 2. Form of anal segment. 3. Form of ventral uncini. 4. Presence of acicular setae replacing the uncini in a certain number of anterior setigerous segments. 5. Absence of either acicular or hooked setae from a certain number of anterior setigerous segments.

Saint Joseph regards this, the fifth point, as an invariable characteristic of all species. By this revision he reduces the whole number of genera in the family Maldanidae to twelve.

Accepting Saint Joseph's basis of classification, which seems to me the most accurate and reliable one yet published, there is nothing to exclude this worm from the genus Clymene Savigny as defined by Saint Joseph. On account of the length of the worm, which is greater than that of any other member of the genus which I have found described, I propose for it the name *Clymene producta.*

In view of Saint Joseph's classification, there seems to be no reason whatever for retaining the genus Clymenella established by Verrill ('73). For Verrill has given no truly generic characters which would separate Clymenella from the genus Axiothea of Malmgren ('65). Saint Joseph therefore places Clymenella torquata Verrill in the genus Axiothea Mgn., basing his conclusion upon the fourth of the generic characteristics given above — ventral setae with hooks being found in the anterior setigerous segments, as well as in all the other setigerous segments.

I would call attention to the fact that Verrill's ('73, p. 607–608) brief description of the genus Clymenella is at fault in one important particular. It is not the anterior margin of the fourth setigerous segment that is prolonged as he states into a thin membranous collar. The collar arises near the middle, not at the anterior margin, of the segment; it is prolonged in front of the anterior margin, from which, however, it is entirely free.

As the presence of ventral hooked setae in the thoracic segments establishes, according to Saint Joseph, the character of this genus, and as Verrill gives no figure of these, I have given a figure (Pl. **2**, Fig. 9) of an uncinus from the thoracic region of this worm.

The name, Clymene torquatus, Leidy ('55) it is thus seen should be changed to Axiothea torquata.

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PLATE 1.

Fig. 1. Anterior segments of Clymene producta, showing general characteristics. × 2.

Fig. 2. Dorsal-oblique view of the head of Axiothea torquata. × 10. For comparison with Clymene producta.

Fig. 3. Dorsal-oblique view of the head of Clymene producta. × 10.

Fig. 4. Lateral view of the head of Clymene producta. × 10.

Fig. 5. Ventral view of the head of Clymene producta, showing position and arrangement of ocelli. × 10.

Fig. 6. Posterior segments of Clymene producta, showing presence of setae in all except the last preanal segment. × 6.

Fig. 7. Posterior segments of Axiothea torquata, showing absence of setae from the three preanal segments. × 10.

Fig. 8. Ventral aspect of the eighth segment of Clymene producta, showing the nephridial pores.

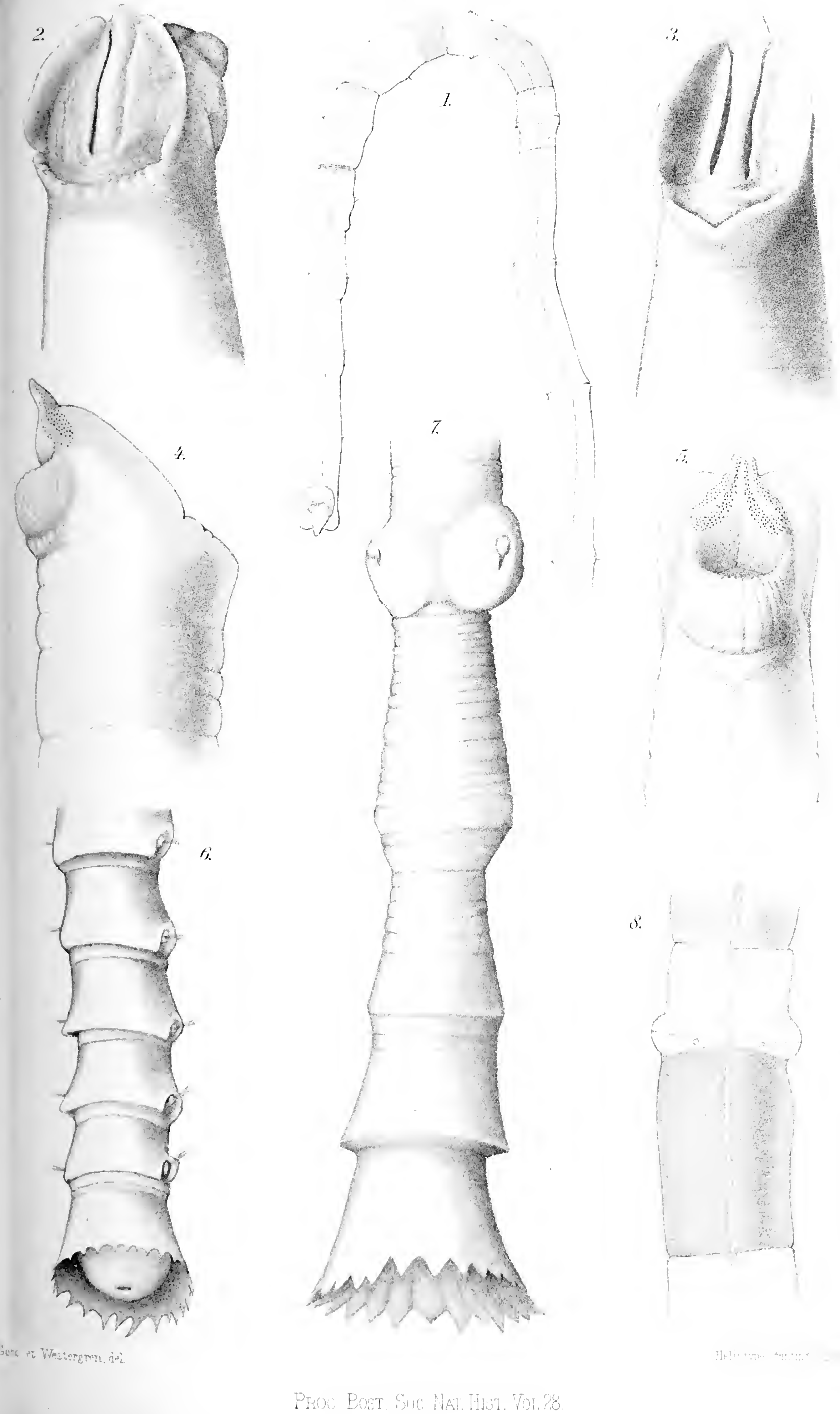

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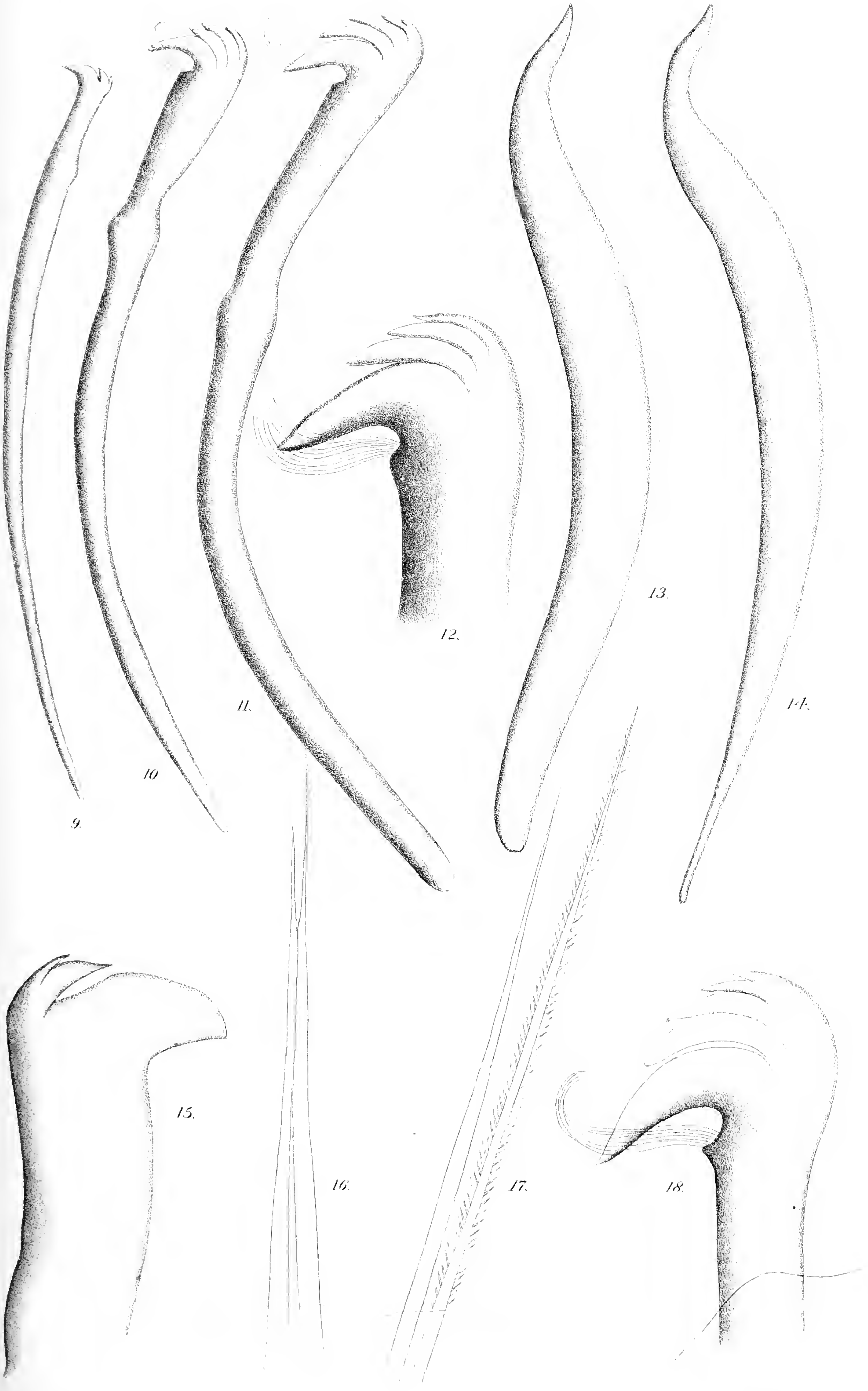
PLATE 2.

Fig. 9. Uncinus from thoracic segment of Axiothea torquata. × 155.
Fig. 10. Uncinus from anterior abdominal segment of Clymene producta, showing four hooks. × 405.
Fig. 11. Uncinus from anterior tail segment of Clymene producta, showing five hooks. × 405.
Fig. 12. Exposed portion of the uncinus shown in figure 10, more enlarged. × 750.
Fig. 13. First form of uncinus from thoracic segment of Clymene producta, showing blunt inner end. × 120.
Fig. 14. Second form of uncinus from thoracic segment of Clymene producta, showing tapering inner end. × 120.
Fig. 15. Exposed portion of uncinus from thoracic segment of Axiothea torquata. × 750.
Fig. 16. First form of capillary setae from Clymene producta. × 750.
Fig. 17. Second form of capillary setae from Clymene producta. × 750.
Fig. 18. Exposed portion of uncinus shown in fig. 11. × 750.



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A CONTRIBUTION TO THE PETROGRAPHY OF THE BOSTON BASIN.

BY THEODORE G. WHITE.

WITH FIVE PLATES.

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No. 6. — *A Contribution to the Petrography of the Boston Basin.*

By Theodore G. White.

CONTENTS.

INTRODUCTION.

Through the kindness of Prof. W. O. Crosby, who for many years has been making a study of the geology of the Boston Basin, the writer has been privileged to avail himself of Professor Crosby's results, and with him to visit the leading localities sufficiently to gain a general knowledge of the field relations of the rocks within the area, and to collect material for petrologic work. The geologic area, which Professor Crosby has designated the *Blue Hills Complex*, includes portions of the towns of Milton, Quincy, Braintree, and Weymouth, taking in the famous quarry district and the Blue Hills Reservation. The field is an excellent one for the petrologist, as nearly all the rocks, except those on the very surface, are in fresh condition.

CLASSIFICATION.

FIELD RELATIONS AND TERMINOLOGY.

The rocks found within the above-defined area may be grouped as follows: —

1. SEDIMENTARY ROCKS: —
   - Cambrian slates and limestone.
   - Newer slates.
   - Conglomerate.
2. GRANITOID[1] (PLUTONIC) ROCKS with hypidiomorphic granular texture, resulting from subterranean cooling: —
   - Diorite and dioritic granite: Extreme basic type.
   - Biotite granite (Granitite) } Normal types.
   - Hornblende granite } Normal types.
   - Hornblende granitite: Zonal acidic type.
3. PORPHYRITIC AND FELSITIC (EFFUSIVE) ROCKS, with textures which resulted from surface cooling, or from the devitrification of glassy rocks.
   - A. *Acidic.*
     Aporhyolite: (Quartz porphyry, felsite): Extreme acidic type.
     - Texture: —
       - Porphyritic.
       - Fluidally banded.
       - Brecciated.
   - B. *Basic:* —
     - Melaphyr.
4. DIKES of diabase, gabbro, etc., cutting each of the above.
5. GRANITE DIKES.

The above classification seems to represent in a general way the succession in age of formation of the rocks involved. However, in the case of the igneous rocks, as will be brought out later, there is in the Blue Hills a complete series of gradations from the typical hornblendic Quincy granite to the most jaspery fluidal aporhyolite. Throughout the present paper an effort has been made to simplify the use of terms in accordance with recent English usage, rather than to adopt the age distinctions employed by German petrographers. For this reason the name *aporhyolite* (*apo*, altered, and *rhyolite*, from the Greek "to flow") has been used in general in

[1] The classification of rocks here employed is modified from that of Adams ('91), Sears ('94), Bascom ('93, '96), Harker ('95), and Kemp ('96).

the present paper for all the rocks of porphyritic or vitrophyric texture in which quartz and the alkali feldspars predominate, and in which flow texture is ordinarily apparent in the microscopic sections; thus avoiding the terms felsite, quartz porphyry, etc., which might indicate age distinction.

Professor Crosby's conclusions ('95)[1] based on the field relations are, that "at the time of its eruption the granite must have been deeply buried beneath the Cambrian slates, in which it formed large dome-shaped masses or batholites; and the most abundant and characteristic type of felsite occurs chiefly or exclusively as a contact-zone between the granite and slate. The felsite occurring in this way is a highly crystalline quartz porphyry, which passes downward by an insensible gradation into the granite. In walking over the main range of the Blue Hills, from the Great Blue Hill to Rattlesnake Hill and Pine Hill, we find that this quartz porphyry is the prevailing and almost the only surface rock. * * * But on closer examination we observe that wherever erosion has cut most deeply on the flanks or summits of the hills the granite is exposed beneath, with a perfect gradation, as already noted, between the two rocks. * * * That is, each hill is a dome-shaped batholite of granite, with a veneering or outer layer of intensely hard and resisting quartz porphyry. * * * During the formation of the batholites, and while the interior portions were still in a molten condition, fissures were, in some instances, formed in the outer shells, through which, as previously stated, considerable volumes of molten rock were extravasated, forming by rapid cooling and subsequent devitrification dikes and sheets of compact and banded felsite."

This compact jaspery type extends from Wampatuck Hill along the south side of Rattlesnake Hill to the eastern base of Pine Hill.

In the field the porphyritic areas are only distinguishable by the fact that their feldspar phenocrysts weather more prominently than those in the granite and stand in relief on the surface.

In hand specimens, however, the rocks are often nearly identical, so far as the unaided eye can distinguish. Jackson ('71) notes that there is an insensible passage from the syenite (old name of the Quincy granites) to the greenstone porphyry, while Wadsworth ('82), treating of the contact of the granites with the Cambrian slates along Hayward Creek, observes that the granite there has lost its distinctive characters, being changed to a spherulitic quartz

[1] Compare the earlier accounts by Crosby ('80, p. 90–91, and '89, p. 5).

porphyry. The passage of felsite into syenite has been noted in Canada by Bailey ('79, p. 3 D D).

The transitions bear a strong resemblance to those shown in the stages of zones 7 and 6 (*i. e.* the hornblendic granite and the biotitic granite porphyry) from the classic locality at Willey Notch in the White Mountains (Hawes, '81), where the granite became a quartz porphyry, with the same conspicuously weathering feldspars in a dark ground mass, near the contact.

While there is no evidence of a line of contact between the granite and quartz porphyry type, we do find near the quarries on Pine Hill, and also near the summit of Wampatuck Hill, an irregular line of abrupt demarcation between the porphyritic and the fluidal aporhyolite; the same being traceable for a long distance. This apparently indicates that the latter was a flow at subsequent time, especially as the general weathering of the fluidal lines follows a direction in general parallel to the contact. The distinction, however, is no more marked than has been known to occur in New Brunswick and elsewhere in superficial portions of the same flow. In the building up of the batholite from a magma of undifferentiated composition that portion of the molten magma which failed to reach the surface naturally cooled very slowly, giving an opportunity for all its component minerals to crystallize out separately; but as various crystals interfered with each other's growth, only those first formed could approximately attain their normal crystalline outlines. Therefore a holocrystalline or *granitic* texture was the result (Pl. **1**, Figs. 2 and 3). The outer portion of the magma, which was thrust to the surface before more than a few of its components had had time to crystallize, became suddenly chilled, giving rise to the *porphyritic* type of rocks (Pl. **1**, Fig. 4), which would in composition most nearly represent the original proportion of the constituents in the undifferentiated magma, and which, as proved by chemical analysis, would therefore occupy the position of a mean in composition, between the more highly differentiated extremes of the granite and the (devitrified) fluidal rhyolites. The remaining mineralizers of the surface crust in part formed a ground mass like the granite texture on a small scale, termed a *micro-granitic* ground mass, or else formed an *amorphous glass* which in these old rocks has undergone a subsequent change through the process of *devitrification.* For these devitrified rhyolites Dr. Bascom proposes the term *aporhyolite*, employed in this paper. The devitrification process casued a rearrangement of the constituents to form a new series of secondary minerals. Particles of the unaltered glass sometimes remain; at other times it has only partly altered and hence gives a "dusty" appearance. The crystals which had time to assume their crystalline forms, in these rocks usually the quartz and feldspars, remain in this more or less altered ground mass. Professor Iddings ('89) has proposed the convenient term *phenocrysts* (or preferably *phanerocrysts*) for the porphyritic crystals. Finally came the type of rhyolites having the *fluidal* or fluxional arrangement of the ground mass (Pl. **1**, Fig. 5). These erupted through the porphyritic shell, from the molten interior, where they left behind the basic granite, which had slowly crystallized beneath and thus separated out, while the relatively acid residuum of the magma poured forth on the surface. This latter type, as indicated by the analyses, is the most acid of the series of rocks in this district, — that is to say, the percentage of silica is relatively highest; therefore, as the magma was not readily fusible, in flowing over the surface it quickly chilled, yielding few or no conspicuous phenocrysts, and being thus frozen as they flowed they maintained their flow lines and ropy character, forming a glass which later suffered devitrification. The devitrification in portions of the flow has given rise to a *granophyric* texture, like short dark-colored bristles arranged radially about the feldspar phenocrysts, in banks like axiolites or as rosettes. The thin sections often show these bands beautifully, flowing closely around the included phenocrysts as seen in Pl. **1**, Fig. 5; Pl. **2**, Fig. 6; and Pl. **5**, Fig. 15. In various portions of the great volcanic ejectment of the Blue Hills we may trace almost every phase of the results of magma cooling under varying conditions, with their transition stages,[1] the variations illustrating very beautifully Professor Iddings's idea of consanguinity in rock magmas. The various stages in this separation of the more acidic and the more basic portions of the magma constitute the various rock types described in this paper, starting with the more nearly neutral phases of the granites, which on gross analysis would probably run approximately from 65 % to 70 % in silica, and passing thence to the most basic type, — the diorites, on the one hand, giving perhaps as low as 55 % of silica, and to the most acid type, the fluidal aporhyolites, on the other,

[1] For discussion of the causes of crystallization and relations of portions of a cooling magma see Iddings ('89 and '92).

For discussion of varieties of texture and descriptive terms applied to them see Bascom ('96).

which may afford as high as 73 % to 79 % of silica. The various mineral compounds capable of forming from the percentages of elements present in different portions of the magma are found in the rock types of the several localities, and from a series of gross analyses of the rock types, such as we hope may some day be afforded, these component minerals may be computed. Rarely is an area found where a better opportunity is afforded for the chemical study of magmatic differentiation than that which the petrographic study of the Blue Hills area suggests.

The field relations of the various batholitic zones composed of the rocks described in this paper have been carefully worked out by Professor Crosby, and hence receive no further discussion here.[1]

SEDIMENTARY ROCKS.

Slates and Limestone. — The Cambrian slate of the Hayward Creek *Paradoxides* locality[2] is of a greenish gray color, somewhat siliceous, heavily bedded, and uniformly fine-grained. Grains of pyrite are diffused through it, as well as through the dikes that pierce it. Microscopically it is of very fine texture and mottled in color; the mottlings being grouped about particles of menaccanite. Discoloration by iron oxides is frequent.

The slates of Weymouth Fore River and Mill Cove are banded with thin purplish or chocolate streaks and contain nodules or cavities of irregular forms and sizes, usually conforming to the direction of the bedding planes. These cavities are coated or filled with alternate yellow or greenish, and dark green or brown layers; frequently, in the larger ones with earthy matter in the center (Pl. 2 Fig. 9). They seem to be due to alteration, near the granite contact, of original calcareous segregations or claystones in the slate, before lithification of the slate. Further away from the

[1] S. Godon ('09) classed the rhyolites as

"Simple Petrosilex { Flinty Petrosilex
Sonorous "
Jasper "
Novacular " }
Porphyritic Petrosilex."

He remarks upon "the transition of feldsparoid to petrosilex and porphyritic petrosilex" in the Blue Hills. See also Crosby ('80, p. 91) and Hitchcock ('41, p. 665.)

[2] See Rogers ('56), Ordway ('61), and Hunt ('72).

granite these are found undecomposed and effervesce freely with acid.

Most peculiar phenomena of rifting also occur along the walls of these cavities, as though they had been regions of special shrinkage and distortion. The same tendency is observed in thin sections, in the formation of minute rifts. In the Mill Cove area, limestone belts occur through the slates with accompanying epidotic, serpentinous or chloritic alteration products usually showing slickensides along the contacts. The microscope adds little information regarding these phenomena, as the products formed are so opaque, decomposed, and earthy that only dust of varying degrees of translucency is apparent, with scattered grains of quartz, chlorite, epidote, and limonite. The contact limestone evinces very thorough baking. Sears ('91) describes the same limestone from this locality and from near Cape Ann.

The slate itself closely resembles that of the coast of Maine, as noted by Professor Shaler ('89). The slate of Eldridge Hill is very nearly the same as in the Paradoxides quarry, except that the dark grains are more scattered and the mottling is not so marked.

The slate adjacent to the granite in the North Common Hill quarries is of considerably coarser texture and is less uniform. Microscopically it shows the compact texture which the German petrographers designate as "hornfels," or hornstone.

The feldspar grains of this rock are often elongated in lath-shaped forms, intermingled with large flakes of partially altered and frayed-out biotite, some brown fibrous alteration product, and grains of magnetite. Single large-sized fragments of milky feldspars, partially colored by iron, are present throughout.

In the same quarry, adjacent to the latter, is another type of hornfels of dusty, cryptocrystalline appearance. It contains abundant pink garnets, with very fresh and sharp outlines, varying from minute size up to one eighth of an inch. Tourmaline occurs in cavities throughout the hornfels in dark brown crystals. The rock is doubtless much baked as a consequence of its limited area in the midst of such a vast intrusion of igneous rock.

In most of the localities the slates show microscopically only a fine dust of quartz, feldspar, iron ores, and dark silicates, sometimes with larger frayed or indefinite scales of chlorite of various shades of color and degrees of alteration. There is nothing in the microscopic characters on which to base any correlation of the slates or distinguish the older from the newer.

Conglomerate.— At two points in the area covered I have had the opportunity to examine the conglomerate. The first is in the locality north of the North Common Hill quarries. Wadsworth ('82, p. 132) and Crosby ('80) have both spoken of the rock as composed of debris of the Quincy granite. The rock is variable in character. On the south it is a compact conglomerate of angular to partially rounded granite pebbles, up to several centimeters in diameter, in a gray subcrystalline ground mass. Weathered surface slabs show well-rounded pebbles. The rock is in general considerably sheared and is especially so on the north in the cut of the Old Colony R. R. where certain portions look almost like a slate. In the latter cut, north of Black's Creek, the planes of the included calcite crystals show shearing notably. The pebbles here are of quite small size.

From the field relations and from the rounded character of the pebbles seen in the hand specimen, we must conclude that the rock is a sedimentary conglomerate, yet in thin sections the ground mass cementing these pebbles is exceedingly like that of a volcanic tuff, as seen in Pl. **2**, Fig. 7. It consists largely of rather large lath-shaped plagioclases and short stubby hornblende crystals with scattered grains of magnetite. Plagioclases of various sizes and irregular forms are packed into this ground mass. The feldspar is chiefly decayed, and does not show twinning. A handsome zonal structure is seen in some cases. Quartz is in small grains, scattered among the feldspar. Fractured grains of epidote occur through the sections. Many of the smaller pebbles at least are of fine-grained porphyry.

Unless the rock is in reality a true volcanic which has in some way enveloped rounded pebbles, we have a case of a conglomerate surprisingly metamorphosed and recrystallized in the presence of the neighboring igneous rocks. It should, however, be observed that rounded pebbles show only in weathered blocks; in hand specimens of fresh material the imbedded pebbles seem to have a more angular section (Pl. **4**, Fig. 13).

The conglomerate of Hough's Neck, as Professor Crosby clearly demonstrates, is of two ages of deposition, one underlying, the other overlying, the interbedded sheet of melaphyr. The lower conglomerate somewhat resembles the one above mentioned, but is not of nearly so fine a texture. Much crushing has evidently taken place, and the result in this section is unsatisfactory. The upper conglomerate is a much coarser rock, often containing large included masses of the melaphyr, whereas the lower contains none, and is interbedded with seams of brown fine-grained sandstone. From the complex character of the upper conglomerate and the extensive masses of older rocks, chiefly igneous, and many of them crystalline, the field characters, rather than the microscopal slide, must be relied on in description.

GRANITOID ROCKS.

Plutonic Rocks with hypidiomorphic granular ground mass, without phenocrysts.

Although variable in detailed characters, the granites of the area considered may be divided both by microscopic and macroscopic characters into four types, viz: —

Type 1: Dioritic, medium coarse granite, often with segregations of diorite and becoming diorite proper in the extreme phase of basic differentiation.

Type 2: Biotite granite (Granitite). An even-textured rock with fairly equal proportions of quartz, feldspar, and biotite; presumably forming, with Type 3, the normal phase of the magma.

Type 3: Typical Quincy coarse hornblende granite, which shades into the porphyritic series of rocks (Aporhyolites).

Type 4: Hornblende granitite, presumably forming a contact zone over Type 3. A fine-grained, evenly crystalline granite, principally feldspathic.

Type 1. Dioritic Granite. — Texture medium coarse and usually associated with inclusions or segregations of diorite. It occurs in a limited area near the contact with the Braintree argillites and also on Mt. Pleasant, Weymouth, and about South Weymouth, as well as in the vicinity of the Whitman Pond diorite area noted later on. It is similar to the granite of Sullivan, Maine; light colored with grains of various dark green silicates scattered through it. Microscopically its texture is thoroughly granitic. The feldspars are of both kinds. Plagioclase is always present and is the chief one; sometimes also seemingly microcline. Zonal decomposition of the feldspar is evident in some instances. Frequently microperthitic intergrowth is shown, with jagged edges.

Quartz occurs in considerable quantities. Mica is chiefly biotite of a brown color often bleached in places to pale green by incipient decay due to loss of the Mg molecule of the biotite. The biotite is idiomorphic when alone and not broken by strains. When with hornblende the borders are irregular, probably due to resorption into the magma and recrystallization as hornblende. The biotite contains various minerals between its leaves. The most prominent of these are rutiles regularly crossed at angles of 60° according to the sagenite law of DeSaussure.[1] In some cases these crystals are very fine and close. Small crystals of apatite occur also in the leaves of biotite, showing the perfect hexagonal cross section.

Hornblende is very pleochroic and has the prismatic cleavage strongly developed, with a lighter green chloritic alteration which is scarcely pleochroic.

Magnetite is plentiful and some ilmenite occurs, with limonite alteration in the cracks. The magnetite crystals are often surrounded and intergrown with fresh hornblende and some biotite.

Near the slate contact the granite is finer grained and dark colored. The contact of the slate and granite in the railroad cut near Weymouth station exhibits the peripheral phases of crushed granite, with decomposed pyrite and chlorite, and dust in the highly polarizing quartz. These are probably largely the result of faulting that has subsequently taken place along the original igneous contact. The granite as it approaches the slate becomes felsitic, and is a heavy greenish or reddish rock, in its extreme phase being a compact felsite (not like the aporhyolites however) without phenocrysts, and under the microscope presenting only a dusty and iron-stained appearance.

The included diorite is of a green color, in pieces from several inches up to some feet in diameter, and varies in texture from very compact and uniform to coarsely crystalline. Microscopically the feldspars appear to be chiefly plagioclase, the remainder being decomposed orthoclase.

Epidote, evidently an alteration of hornblende, occurs in the feldspar.

Mica has changed chiefly to chlorite with limonite discoloration.

The amphibole is a green hornblende occurring as interlocking crystals with a yellowish alteration. The secondary hornblende is uralitic, with pale yellow and green pleochroism and a higher extinction than in the brown portion.

[1] See G. H. Williams ('83, p. 617) on similar rutiles interposed in the mica of a porphyritic diorite from the Black Forest (near Tryberg), Germany; also Iddings ('89, Figs. 56 and 58).

Apatite abounds in long prismatic crystals with hexagonal section.

Pyrite is scattered through the section.

The rock varies greatly in texture and degree of alteration in different portions. The plagioclase is clear when fresh, but most of it has become milky. The alteration products are not definitely determinable. Chlorite from the neighboring bisilicates has soaked in and given further alteration to epidote, forming a "greenstone."

Neither macroscopically nor microscopically is any definite demarcation between the diorite and the including granite perceptible; the diorite seems simply to develop wherever the orthoclase of the granite diminishes, and the chloritic products lend a green color to such masses. Similar variation is noted in New Brunswick by Matthew ('94).

Diorite.— The greatest development of the diorite itself, however, is seen at Whitman Pond. The granite adjacent to the mass of unmixed diorite partakes of the dioritic character and is well exposed in a small quarry on the east side of Whitman Pond. The rock here is a dioritic granite or grano-diorite with a considerable proportion of both orthoclase and quartz. The hornblende is largely uralitic, having light green and yellow pleochroism and frequently associated particles of magnetite. The hornblende seems to have largely replaced any original biotite. A few small crystals of zircon and apatite were noted.

The diorite itself is of a rather strongly basic character, of a dark green color and quite coarsely crystalline. It contains well-twinned plagioclase feldspars and, unlike the adjacent granite, is entirely quartzless. A secondary, greatly strained and bent hornblende occurs all through the rock and is its most prominent feature. There is also an original brown hornblende, which in most cases, however, is so bleached that it is easily mistaken for a variety of pyroxene. Crystallized apatite occurs, also epidote scattered through the rock.

As previously noted, the dioritic granite is a feature especially characteristic of the contact zone. The lamprophyric types, rich in lime, magnesia, and iron, would naturally tend to form peripheral zones on the great granitic batholites, until finally as here found the entire mass attains the composition of diorite, according to Pirsson's ('95) rule that the "highly differentiated magma of one locality may be the common type or main one at some other center." This fact is well exhibited in the development of dikes in the grantie, as well as bosses, along the shore near Marblehead, Mass.

TYPE 2. BIOTITIC GRANITE (GRANITITE).—The second type of granite is found wholly south of the Blue Hill Complex, as determined by Professor Crosby, in the south parts of Weymouth and Braintree, in Randolph, etc.

It is a light-colored granite of medium coarse texture, and, as the hand specimen shows, is rich in quartz, white, light gray or sometimes greenish feldspar, and scattered fragments of biotite of considerable size. Rarely a little hornblende is seen. The three constituents seem to be remarkably evenly distributed in quantity throughout the mass of the rock. Occasionally segregations of a few centimeters in diameter occur, in which the minute grains of biotite are especially abundant, imparting a darker color to these patches. This type of granite is quite representative of what German petrographers denote as *Granitite.* Under the microscope the feldspar proves to be both monoclinic and triclinic. The former frequently exhibits microperthic intergrowths and granopheric rims, and is occasionally twinned according to the Carlsbad law. The plagioclase shows handsome zonal twinning according to both the albite and pericline laws. The biotite is in brown scales and is idiomorphic in nearly all cases, sometimes appears to have been strained and frayed on the edges. In the quartz this straining is often quite marked, and the grains seem to have been twisted even though they lie closely packed in the interstices of the plagioclase. Between the larger mineral fragments a fine micrograhitic structure is apparent. The rock seems to be free of accessory minerals, with the exception of a few magnetite grains.

TYPE 3. HORNBLENDE GRANITE.—The typical Quincy granite of the quarries, often referred to as "syenite" by Hitchcock ('41, p. 668) and Hunt ('75, p. 188),[1] occurs throughout the quarries of West Quincy and thence southwesterly along the northern border of the Blue Hills area, where it merges into the succeeding types of porphyritic development.[2]

Macroscopically it is a coarse holocrystalline aggregate of white or bluish orthoclase and smoky quartz; these forming the bulk of the rock; with dark green or black hornblende having marked prismatic cleavage, which in places is altered to a lighter green chlorite. The

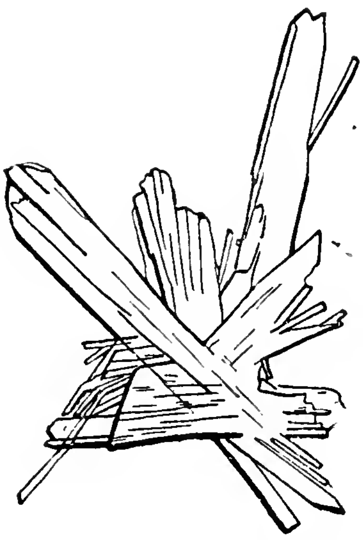
[1] See also Godon ('09, p. 137), Dana, J. F., and Dana, S. L. ('18, p. 205), Smock ('90, p. 231 Shaw ('60, p. 353), and Bayley ('88, p. 207, 295).

[2] Dodge ('83, p. 65-71) claims that there are two granites in the Quincy district, but gives no evidence .

orthoclase crystals often attain a length of 12 mm. and predominate, their abundance constituting the leading character of the rock; while the proportion of quartz varies, the dark silicates being least abundant. According to Merrill ('89, p. 409; also '84, p. 10), the Quincy granite also contains a very brittle variety of pyroxene, in addition to the hornblende, which tends to break out as the stone weathers so that a polished surface in time becomes pitted. This is not, however, uniformly the case with the stone now quarried. In many of the sections examined no pyroxene was present. Dr. Merrill has kindly permitted me to examine the original slides prepared for the Tenth Census and now in the U. S. National Museum. One fragment in these sections, at least, seems to be pyroxene, while there are various dark brownish and greenish associated minerals, which Dr. Hawes, who originally determined the slides, regarded as products of alteration of the pyroxene. In other slides examined, however, unaltered pyroxene occurs.

Microscopically the rock presents a typically granitic texture, without differentiation of ground mass and phenocrysts. The feldspar is practically all orthoclase with possibly a little plagioclase. It is for the most part simply twinned, according to the Carlsbad law, and is little altered. Microperthitic texture due to intergrowth of orthoclase and albite is prominent, and often takes place in a striking manner at an angle of 65½ degrees with the cleavages. It sometimes also assumes a "shoe-peg texture" like that often seen in melilite. Occasional inclusions of minute crystals of indeterminable minerals are noticeable in the feldspar. They are probably of hornblende. The fluid inclusions noted by Wadsworth ('78, p. 310) in the Rockport granites, which are in many respects similar, are not apparent. Rarely lines of weakness are noticeable, which develop the "rift" of the rock (Tarr, '91, p. 267).

Amphibole is much the more abundant dark silicate. It is usually a hornblende, apparently of a rich soda variety, as the analyses of the rock also indicate, in densely opaque masses. On the edges, however, these masses are, in the thinnest sections, seen to be composed of many fine rod-like needles felted together and fringed with projecting needles. Often the center of the mass does not seem to be so high in soda as the edges. A similar case has been figured by Cross ('90, p. 359) in the case of certain pyroxenic growths. The needles are also seen in bundles or rosettes of blue or black acicular crystals among the feldspars, arranged in a manner similar to the tourmaline in luxullianite or as single prismatic crystals contained in the feldspar, lying either parallel to the *c* axis or obliquely to the twinning plane. A drawing of a particularly characteristic group of these crystals is shown below taken from slide 25,609 of the series prepared for the Tenth Census and kindly loaned by the U. S. National Museum through Prof. Geo. P. Merrill. Professor Merrill writes, "the beautiful blue acicular crystals (sec. 25,616) were never determined by me, and I find no certain reference to them in Hawes's notes, although on section 25,609 he had written in pencil '*Draw*,' as though he had worked it out mentally but not committed himself in writing."



Crystals of glaucophane.

The needles show the greatest absorption very nearly parallel to the longitudinal axis. More rarely they give an appearance of absorption at right angles, so as to be easily mistaken for tourmaline, which the form and occurrence strongly suggest. The edges of the larger needles are often blue, seemingly indicating a soda amphibole, at least as a growth surrounding the original needles. They show high refraction; and as the arrangement of the needles in the fluidal rhyolites, in which they also occur, agrees with the fluxional arrangement, they evidently crystallized in an early stage of the magma. Separate needles when inclosed in the plagioclase form an angle of about 19° with the striations of the inclosing feldspar.

The writer at first thought these crystals to be riebeckite, a soda amphibole intermediate between aegirine and pyroxene; which latter as Rosenbusch says ('92, Vol. 1 p. 566) it strikingly resembles. Riebeckite occurs in a similar manner in the granite of the island of Socotra (Sauer, '88). Bonney ('73, p. 283) at Socotra mistook the mineral for tourmaline pseudomorph after hornblende, but Sauer thinks it is at least in part, an alteration of the feldspar. Harker ('88) describes black to bluish crystals agreeing very nearly with these as a blue hornblende, from granites and felsites at Mynydd Mawr, near Snowdon, Wales, which he afterwards identified as riebeckite.

Careful determinations with the gypsum plate, on a number of sections of the Quincy mineral, in order to determine the position of its axes of elasticity, seem to indicate an optically positive mineral. The test is rendered difficult by the minute size of most of the crystals and the interference of the polarization colors of the usually inclosing feldspar. These results determined the needles to be glaucophane, and it is interesting to note that the same conclusion was reached by Dr. M. E. Wadsworth ('83, No. 71), although no mention elsewhere has been made of the abundant occurrence of this interesting mineral in the Quincy granite.

The hornblende granite of Geising in Saxony is very similar in both macroscopic and microscopic appearance, although the hornblendic needles are shorter. It also resembles the granite of Mts. Adam and Eve, Orange Co., N. Y. (Kemp and Hollick, '94, p. 641), but the latter has more quartz. In the Orange County locality the rock is said occasionally to approach quartz porphyry in texture. The feldspar is mostly much strained and broken.

Quartz varies from colorless to the smoky variety and is very closely mixed with the feldspar, although less plentiful. Hair-like needles, too minute for determination, are occasionally met with in the quartz.

Biotite occurs sparingly as brown flakes scattered through both quartz and feldspar.[1]

In portions of the granite local segregations of various mineralizers occur in small quantity. These are especially noticed in the neighborhood of contacts. Fluorite is thus found in beautiful, bluish purple, partly crystallized masses of microscopic dimensions, intermingled with altered pyroxene. Aegirine occurs sparingly, in long, bright green shreds. Zircon forms doubly terminated crystals. Danalite has been reported by Dr. Wadsworth ('78, p. 310), but Dr. Wadsworth, to whom I am indebted for a cordial response to inquiries, writes that the mineral was reported from field observations and not from thin sections.

In many places, notably at the small quarry on Rattlesnake Hill, segregated patches of darker color are observable in the granite. These vary in size from a few inches up to several feet in diameter, and are usually roughly oval in form. They are of a dark bluish gray color, are much finer grained than the remainder of the rock, and are formed by concentration of the dark silicates, very much in the same way as the diorite of type 1, above. In most cases it shows more conspicuous quartz, in rounded grains of larger size than the other minerals, either white or smoky. It is accompanied

[1] Cooke ('67, p. 222) has shown the black mica of the Cape Ann granites to be lepidomelane.

by a few large feldspars. Although the outline of the patches is fairly defined, yet there is perfect gradation without line of separation at the juncture of the rocks; hence they are clearly segregations and not inclusions. A very similar example is figured by J. Arthur Phillips ('80). There is no indication of spheroidal or concentric structure often observed in such segregations. Similar differentiations in the granite of Mt. Ktaadn, Maine, are noted by Hamlin ('81, p. 212). Some of these had their outlines sharply defined, and others merged gradually into the inclosing granite. They are finer grained, darker colored and commonly deep gray. Such variations are likewise recorded in New Brunswick by Matthew ('94, p. 191) and in Maine by Merrill ('83, p. 137). They are probably due simply to an abnormal arrangement of the minerals constituting the granite, the orthoclase decreasing and dark silicates increasing as the rock becomes finer, while the quartz particles alone retain their dimensions. In the Wasatch Range in Utah tunnels showed that these segregated nests did not extend deeply into the rock, so that they may represent the first step in transition from the normal deep-seated hornblendic granite to the more rapidly cooled surface porphyries, later described, which these dark patches closely resemble.

Microscopically they present the same minerals as the including rock, although they are packed together in smaller pieces, producing a finer-grained granitic texture. If anything a little more plagioclase is noticeable. Some of the quartz occurs in large-sized grains. Hornblende needles occur as normally, while the dark green silicates both mica and hornblende and their alteration products, are much more abundant than in the mass of the granite.

Further south, in Pine Hill, Braintree, the granite assumes a reddish or pinkish color, resembling the hornblende granites of Mt. Desert Island, Me. (Hitchcock, '63, p. 271, Shaler, '89, Davis, '94, p. 46), and at Iron Mountain, Mo. (Pumpelly, '73, p. 5, '92, p. 220, and Nason, '92). In both these localities the granite occurs associated with like porphyries. This variety is known among the quarrymen as the Braintree granite. The feldspars are crystals up to 1 or 1.5 mm. long and twinned. The reddish color is no doubt due to a partial oxidation of the iron, not only in the dark silicates but also in the peroxidation of the iron to which the feldspar of the unaltered gray granite owes its color; the gray granite, in the case of the Echo quarry on Payne's Hill, being found only in the deepest part of the quarry. In some parts of the red granite the basic segregations are completely chloritized and although of small size are very numerous. Larger segregated patches, as in the case of the gray granite tend to the porphyritic texture. Smoky quartz, which is about half as large a proportion of the rock as is the feldspar is packed into the interspaces. Less dark silicate is present than in the gray granite. Microscopically the rock shows a coarse granitic texture — chiefly of orthoclase and quartz with a little plagioclase. There is hardly any dark silicate, but greenish particles of some alteration product, probably epidote. The feldspars are fractured and milky white, seldom showing twinning.

Small octahedral magnetites occur in streaks between the feldspars; and also a red limonite alteration product, to which the color of the rock is probably due. Similar dust-like particles of magnetite occur in the Iron Mountain rock referred to.

Upon theside of Rattlesnake Hill, the granite, as it approaches the aporhyolite, becomes finer and begins to assume the porphyritic texture. Macroscopically it is gray, coarsely crystalline, apparently composed almost exclusively of closely packed feldspar crystals, with brilliant tabular faces up to 8 mm. in size, with a very little dark silicate filling the spaces, and with no apparent ground mass. The quartz is not visible.

Microscopically it exhibits a microgranitic texture, partly confused by the crushing effects which the rock has undergone, which renders it difficult to get a straight extinction in the irregularly formed and often uncertainly defined phenocrysts.

Orthoclase is the principal feldspar and is rarely twinned. The edges of the phenocrysts are usually corroded. The quartz strikingly shows the effects of crushing and strain, with frequent embayments. Hornblende and tourmaline each occur as pale apple-green interlacing needles in both quartz and orthoclase, chiefly the latter. Hornblende also forms duller green, pleochroic aggregates. Hematite occurs in scattered blood-red grains. Calcite is sparingly present. The resorbing of edges of the phenocrysts and the fractured ground mass seems to indicate the first transition to the porphyritic phase described later.

Type 4. Hornblendic Granitite. — The fourth granitic type Professor Crosby considers to represent the contact zone of the normal hornblendic granite just described. It occurs in East Braintree and eastern Quincy along the west bank of Weymouth Fore River, as a rule in the vicinity of the slate.

It is of a fine-grained texture, and composed largely of white or pink feldspar, usually of fine rectangularly crystalline form, with scattered grains of dark silicate and very little quartz. In North Weymouth, and in Quincy, west of the railroad between West Quincy and East Milton, the rock is considerably decomposed and the dark silicates are more in evidence. Similar granites occur along Long Island Sound in the vicinity of Niantic and New London, Conn., and also at Laurium in Greece.

Unlike the biotitic type of granite previously described, this granite shows no plagioclase, but the numerous rectangularly idiomorphic grains are of monoclinic feldspar. This feldspar is shown in most instances to be shot through with innumerable acicular crystals of the blue hornblende already described in the normal hornblendic granite, to which this granite type is so closely related. The needles gathered into compact clusters also form masses by themselves among the other minerals. The biotite in small brown flakes is quite abundantly scattered through the rock, often lying directly adjacent to the hornblende masses. The feldspar shows no twinning. As already stated the quartz is present only in small quantity, and is of the smoky variety. No accessory minerals were observed.

The rock is, then, a hornblende-biotite-granite, or, to be briefer, a *hornblende granitite.*

PORPHYRITIC AND FELSITIC ROCKS.

Porphyritic Aporhyolite. — Where the latter type of hornblendic-granitite is lacking, the normal (Quincy) hornblendic granite, passes, without visible change in the field, into a rock which under the microscope exhibits a microgranitic ground mass without granophyric texture, composed of a finely crystalline aggregate of monoclinic feldspar, quartz, and unaltered dark green or ultramarine-blue hornblende. The latter makes up about one fourth the mass of the rock. A few grains of hematite are also present. Occasional larger grains of feldspar exhibit a microperthitic texture.

The phenocrysts consist of a monoclinic feldspar and quartz, the former predominating. The feldspars vary up to 5 or 6 mm. in length, and are very regular in outline, the faces *M*, *P*, and *X* being chiefly developed. Twinning according to the Carlsbad law is conspicuous.

Minute crystals of the feldspars frequently occur included in the larger crystals. Hornblende, in the same variety referred to under granite, in slender bluish transparent needles, extinguishing in the direction of elongation, occurs in both the ground mass and the feldspar phenocrysts, but presents no definite arrangement. The quartz phenocrysts are less plentiful than the feldspars, and are irregular in outline and without inclusions.

At several points in the West Quincy quarry district a handsome black rock appears, in "association with a light gray granite." This black "granite" is very similar to the red (Braintree) hornblendic granite, except that the coarsely crystalline and brilliantly faced feldspar is perfectly black instead of pink. The quartz is chiefly white. The texture, in thin section proves to be strongly porphyritic, — a ground mass of quartz and small feldspars and hematite scales, having large quartzes and feldspars packed into it. Tourmaline occurs in bunches of blunt needles, as does also hornblende, — the latter also in ultramarine or brownish aggregates. The dark color of the feldspar, which is monoclinic, proves in this section to be due to innumerable minute needle-like hornblende crystals which traverse it.

As we pass down hill into the valley between Rattlesnake and Wampatuck Hills, the rock grows dark gray to nearly black, that being the characteristic color of the feldspar, — the crystals of which, up to 1 cm. in length, form the mass of the rock, as before. A little white quartz, but no ground mass, is observable. Under the microscope it shows a handsome porphyritic texture, — a finely microgranitic ground mass, — the phenocrysts large and cleanly outlined and making up three fourths of the rock. Orthoclase, twinned on the Carlsbad law, or showing peripheral zonal phases, in crystals up to 3–5 mm. in diameter prevails. Plagioclase is less abundant and is allotriomorphic. It shows the effects of strains and gives undulatory extinction. Pyroxene forms much-cracked allotriomorphic masses of bright green color, pleochroic from brown to green. Sillimanite forms handsome, long, transparent crystals showing the characteristic transverse cracking. Hornblende as usual occurs in fine needles throughout. It also occurs in irregular translucent flakes or uralitic, probably from alteration of biotite, and giving a light green to yellow pleochroism. Magnetite or menaccanite in

[1] I have not visited the locality; the words are from Professor Crosby's label upon the specimen.

irregular grains occurs sparingly, associated with the dark silicates. Passing over the crest of Wampatuck Hill to the most easterly of "The Broken Hills," the typical "bluish quartz porphyry" appears without trace of flow structure. Macroscopically there is a compact grayish blue ground mass with numerous irregularly arranged, well-banded phenocrysts of flesh-colored orthoclase, from one or two up to five mm. in length, with more or less equally abundant glassy smoky quartz grains scattered among them. Miss Bascom ('96, Plate 7,) figures a specimen from the South Mountain, Penn., locality, identical, except in color, with specimens from Pine Hill.

Microscopically, this ground mass is granophyric and largely isotropic with characteristic interlacing lath-shaped feldspars, arranged in fluidal texture following the outlines of the phenocrysts; in part, also, it is glassy. Into this ground mass are packed large quartz and feldspar phenocrysts. The quartz is idiomorphic and not fractured; it shows beautiful embayments of the ground mass. The boundaries are sharply outlined, and the hexagonal sections are frequently prominent. Some sections show marked distortion.

The feldspar is practically all monoclinic and is microperthitic in nearly all cases, showing a very thorough interpenetration. In some cases the feldspars have so many inclusions as to appear like those of a gabbro or anorthosite (Smyth, '95, p. 272).

The feldspar is usually in rectangular crystals, having rounded corners with outlines more or less exactly defined, and in some phases once twinned. A little triclinic feldspar occurs in a few sections. Hornblende forms irregularly rounded and fractured grains and particles scattered through the rock, as well as occurring plentifully in needles through the ground mass and scattered parallel to the margins in the large feldspars. A variety of decomposed dark silicates also appears both in the ground mass and in the feldspars, especially along the edges of the feldspars. Magnetite and a limonite decomposition product occur sparingly. Hematite forms red specks in some slides. Titanite in transparent crystals is abundant in some sections. Sillimanite in long crystals is also present. In places the rock is brecciated with black fragments of 1 cm. to several cm. in diameter, which are clearly outlined, but inseparable from the porphyry. Although so distinct in the field, and in fineness of texture in the section, the components are the same as those of the ground mass of the remainder of the rock. It is apparently without phenocrysts, but approaches in places a microgranitic texture.

Lines and grains of decomposed limonite are scattered through it. The hornblendes as a rule are more chunky and are rounded.

FLUIDAL APORHYOLITE. — The fluidal aporhyolite first appears in contact with the presumably earlier flow of porphyritic aporhyolite, near the summit of Wampatuck Hill. In the field it is a compact, jaspery, purplish black rock with brilliant flesh-colored feldspars, showing chiefly the face *OP*, in crystals up to 3 or 5 mm. long, scattered through it. It also shows in places a very little smoky quartz in fine grains, and occasionally bundles of needles of yellowish tourmaline. The weathered surfaces show the contorted flow structure, giving that peculiar wavy, or often knotted appearance so common in blast furnace slags and modern volcanics. Dr. Wadsworth[1] first called attention to this fluidal structure, so long mistaken for remains of sedimentary origin in these felsites and porphyries of the Boston Basin, as the strongest evidence in favor of their eruptive origin.[2] It is caused by the flowing movements of the molten magma, or ancient lavas, the slight inequalities in the composition of which, or the presence of iron oxides, crystallites, or solid particles render the structure prominent only after weathering, or in thin sections (Iddings, '87). By polarized light the base is found to be completely devitrified, giving rise to the so-called microfelsitic base. The flow texture of the rock, followed by its sudden chilling, probably arose from the magma being so siliceous. In the subsequent devitrification, the silicates crystallized out, leaving the residual silica in the form of quartz occupying the interspaces. Thin sections reveal a well-marked fluidal texture of the ground mass, even where the rock, *en masse*, does not. The particles either assume lenticular outlines as they flow around the phenocrysts, or else they form narrow chains of spherulites. It is noticeable that these rocks are all of a purplish black color, rendered gray with black lines in thin sections. Rocks of precisely this character occur on the Cranberry Islands, Vinal Haven, Eastport, Lubec, and elsewhere on the coast of Maine (Shaler, '89, Williams, '94, Bayley, '95, and Smith, '95 and '96); as well as in New Brunswick, (Matthew, '94 and '95). As Professor Williams ('94) has pointed out,

[1] In Whitney and Wadsworth ('84, p. 429); see also Wadsworth ('79), Diller ('80 and '81, p. 169), and Hyatt ('76). The felsites are the rocks classed since Godon's ('09) time as petrosilex.

[2] It is worth noting that, as early as 1822, Dr. Thomas Cooper wrote ('22, p. 239): "No person accustomed to volcanic specimens can look at the porphyries from the neighborhood of Boston * * * and doubt their volcanic origin."

these rocks form a belt down the Atlantic coast from Newfoundland to Georgia. In this portion of the Blue Hills the ground mass of the rock in small patches is microgranitic, with quartz and feldspars, but for the most part it presents a granophyric texture forming rosettes or parallel bands of fine hair-like fibers or needles, usually surrounding the feldspars. As suggested by Miss Bascom ('93, p. 817) in the case of the volcanics of South Mountain, Penn., this appearance may represent the intermediate stage between the spherulitic and completely micropoikilitic [1] crystallization, caused by the breaking up of the radiating spherulitic fibers in the process of devitrification. Such is the "flexuose structure" of Rosenbusch ('92, p. 380). The needles of these rosettes or surrounding bands seem to be partly of feldspar, but chiefly dark silicates; the latter frequently tending to form darker margins about the feldspar phenocrysts. Particles of the dark silicates, or else of one of the iron ores, too minute for identification, are also scattered through the rock. Phenocrysts are not abundant.

Quartz is usually with well-marked crystal outlines, but is also corroded and sometimes with inclusions. In some of the sections the quartz shows cracks and undulatory extinction due to movement of the magma after the quartz crystallized.

Orthoclase, on the whole, seems to be quite as abundant as quartz in the phenocrysts. Usually it presents sharply defined, rectangular crystals of rather low polarization colors, and but little altered. Strains and microperthitic intergrowth are noticeable, frequent twinning on the Carlsbad law, and minute, perfectly formed feldspar crystals of similar form intergrown in the larger ones, with the same orientation. The cracks are filled usually with the microgranitic type of ground mass.

Grains of a decomposition product, yellowish in the center with dark opaque rims, are present. Rutile in tiny brilliantly polarizing needles with very perfect terminations is scattered through the ground mass of some of the sections, — particularly those approaching the microgranitic ground mass.

Zircon occurs in small amounts.

Hematite forms a few blood-red grains.

Biotite appears sparingly but usually as an alteration product bleached by departure of the magnesia molecule. Some of the dark-

[1] The term micropoikilitic (Williams, '93, p. 176) is applied to those minerals which have a pronounced mottled appearance under the microscope, caused by numerous inclusions of different orientation.

colored spherulites above referred to may have arisen from the alteration of biotite with the dark staining of iron ores.

Haworth ('91, p. 5, Pl. 4) figures almost identical flow texture in quartz porphyries from Missouri.

On the summit of Pine Hill the banded texture appears. The rock is a devitrified glass with more or less contorted bands of darker jaspery aporhyolite with few pink feldspar phenocrysts interbanded with lithoidal felsite of a reddish color. The latter is a fine breccia of fragments less than 4 mm. in diameter. The two kinds of texture are arranged in alternating bands as shown on weathered surfaces. This *banding* differs from the ordinary flow texture in having the lines almost free from undulations. Sometimes the layers are very thin and close together, as would be the case around the edge of a lava sheet where the liquid flow had extended to the margins of previously formed flows. No character of rhyolites is more marked in many places than this banded texture. Devitrification in many cases has considerably destroyed these lines, leaving in some of the layers the spheroidal globules. The general color of the rock is reddish black, the alternating finer bands being nearly black. Rocks of very similar texture occur at South Mountain, Penn., as described by G. H. Williams ('94) and F. Bascom ('96). Microscopically the composition and texture of these banded aporhyolites do not differ materially from the other fluidal aporhyolites already described.

Upon Pine Hill there also occurs, near the most westerly quarry, porphyritic aporhyolite with a jaspery ground mass, the feldspars up to 1.5 cm. diameter, with the *OP* face prominent, flesh-colored, and weathering rather conspicuously. Carlsbad twinning is often shown. Smoky quartz forms particles up to 3–7 mm. in diameter. It is very fresh and glassy. Except for its black instead of red color, this rock resembles the quartz porphyries of the Lake Superior Copper District (Irving, '83, and Van Hise, '92). It varies to a much more compact gray felsitic rock with a true devitrified glassy base and some tendency to flow structure, having a lithoidal, conchoidal fracture. The phenocrysts are then small and hardly distinguishable.

Upon the most westerly of the Broken Hills there occurs an irregular two-foot band of a handsome bluish green rock with a very uniformly crystalline feldspathic texture, without distinction of ground mass and phenocrysts, through which are distributed small brilliant grains of smoky quartz, and which is brecciated with larger, fractured white feldspathic fragments of well-marked outlines, 1.5 cm. or more in diameter, giving in the field somewhat the appearance of an ash-bed rock. Upon weathered surfaces it exhibits a coarse fluidal texture. Under high magnification it shows an extremely fine microgranitic ground mass composed of minute lath-shaped feldspars, regularly bounded quartz grains, various green, altered silicates, rectangular magnetite particles, and scattered hematites. The phenocrysts, which make up perhaps a third of the rock, are also small, mostly under 2 mm. long. Quartz is the most abundant; it seems to be younger than the feldspar, crystals of which are included in its own well-marked crystals. The feldspar crystals are not so perfect as in the types previously described, but show handsome Carlsbad twins and contain hornblende needles. Biotite occurs throughout. It is of various shades from pale green to ultramarine. Flow texture in the arrangement of the ground mass is apparent, although not strongly marked.

Melaphyr. — The melaphyr upon Hough's Neck has been petrographically treated of by Professor Wolff ('82), hence detailed mention of it here is unnecessary. Professor Wolff has shown that its true character is that of an altered basalt. In fact, except in regard to its amygdules, most of the rock is clearly a diabase or olivine-free basalt; the olivine being very rarely evident. For the most part it is compactly or imperfectly crystalline and rather soft. Its color varies, according to the condition of the iron oxide, from dull grayish green to dull reddish or purplish tints, — the former tint being characteristic of the base of the Hough's Neck flow, the latter of the top of the flow. The same variation has been noted by Professor Crosby ('94, p. 242) in the case of the Huit's Cove area in Hingham. In the brown melaphyr at the top of the Hough's Neck flow, amygdules are conspicuous. They consist chiefly of calcite, which is readily cleavable and has been very frequently removed on the surface, through solution by acidic infiltrations, leaving the original steam cavities intact. Epidote and quartz also occur, as well as chlorite and feldspars, as secondary fillings of these cavities. Rarely the superficial amygdules are feldspathic and in the interior epidotic, or composed of the ferruginous chloritic alteration product, delessite. Whatever the interior of the amygdule, there is invariably a brownish lining of some decomposition product, coating the walls of the amygdule. The amygdules in the surface of the flow are much more abundant than in the base, and the lath-shaped feldspars in the ground mass are much larger. Other minerals of the ground mass are magnetite, chlorite, and epidote; with red hematite grains, kaolin, and other earthy decomposition products. The lath-shaped feldspars often show a tendency to flow texture.

The melaphyr at the top of the flow, along the irregular contact, is of a slaty character, both the amygdules and the microscopic texture of the base showing the effects of a shearing action in many cases, while the larger feldspars show bendings.

In the purple portion the olivine has almost entirely been replaced by a green product, but the olivine appears in the fresher greenish gray base of the flow, as shattered grains, with dark rims and brilliant polarization. Doubtless some of the apparent amygdules of fibrous chlorite and serpentine are pseudomorphs after olivine, in the process of alteration. The interior of one of these shattered masses also shows a gray tint, polarizing brilliantly, and probably, as Professor Wolff has suggested, indicating an alteration to talc. Feldspar in lath-shaped crystals is scattered through the sections (Pl. 5, Fig. 15). Neighboring crystals forming an angle with each other often have the included space filled by augite, which has generally altered to a green or greenish brown chloritic substance, sometimes traversed by red stains along the cracks. The feldspar was doubtless originally plagioclase, but its form is often entirely obliterated, or else it is changed to a monoclinic feldspar, probably orthoclase. Others are converted into pale green chlorite. Magnetite is in grains like fine dust, usually in connection with the epidote. It is most abundant in the purplish portion of the rock. Apatite is of frequent occurrence. Epidote is in irregular grains disseminated through the ground mass, especially in the greenish portion of the rock. Microscopic veins of epidote also traverse the rock.

At the base of the flow the rock almost wholly lacks amygdules and seems to be a true basalt. The base of the flow strongly resembles the melaphyrs of the hanging wall of the copper mines in the upper Michigan peninsula described by Irving ('83, p. 62.)[1] It contains none of the calcite or feldspathic amygdules, but shows large round amygdules nearly 1 cm. in diameter, of a brownish

[1] Compare Pumpelly ('80, p. 31); also on metasomatic development, p. 274, etc.

black uncertain decomposition product. The fillings of the cavities evidently do not arise from segregation, as they are barely attached to the walls of the cavities, and it is almost impossible to grind a section of the rock without detaching them. They seem rather to result from mineralizers in the cavities of the rock. They vary from microscopic size up to nearly a centimeter in diameter and are scattered through the rock without particular arrangement. Various writers (Shaler, '79, Benton, '81, Davis, '81, Wadsworth, '83, p. 10, and Merrill, '86, p. 439, and '93) have described similar melaphyrs from Brighton and Nantasket.

DIKES.

The dike rocks are for the most part diabases too much altered for satisfactory determination. Similar diabase dikes have been described from other portions of the Boston Basin (Merrill, '93, p. 38–44), from many points along the coast of New Brunswick, (Matthew, '95), and Maine (Shaler, '89, and Kemp, '90), about Cape Ann (Shaler, '89), at Nahant (Lane, '89), in Essex Co., Mass. (Sears, '94, p. 130), in the great Somerville dike (Hobbs, '88), as well as along Lake Champlain (Kemp and Marsters, '91 and '93, and White, '94, p. 229).

From the field relations Professor Crosby concludes that the diabase dikes are of three sets in regard to age. On petrographic evidence, however, there is no means of separating them, all the more decomposed diabases appearing very nearly identical.

For the purpose of proving the age distinction, if possible, a few typical dike rocks were collected whose relative age was evident in the field. In many slides the alteration is so complete that only a dusty aggregate of chloritic products, kaolinized feldspar, leucoxene, ferruginous discoloration, and some of the unaltered quartz is shown. They are soft when weathered, but very compact, of a dark green to black color. In many cases no particles of fresh augite remain, and the chloritic alteration product obscures everything.

Dikes in the slate. Two dikes cut the Paradoxides slate in the Hayward Creek locality. They are of dark gray decomposed diabase, the augite mostly changed to feebly pleochroic chlorite,— the so-called "viridite" of various writers,— giving the rock a green color. The orthoclase is pinkish and shows traces of altered lath-shaped crystals. Pyrite is present in microscopical crystals. Much ilmenite occurs in elongated fragments, and is slightly altered along the edges to the white decomposition product, leucoxene. Garnets of light color occur scattered through the rock, together with a very little quartz.

A dike 15 feet wide occurs on the side of Eldridge Hill. It is of similar rock, but more decomposed, the ground mass being chiefly converted into an indefinite brown or black mass of specks with abundant and only slightly altered ilmenite in long shreds and irregular aggregates, and with considerable of the chloritic alteration product.

A dike two and a half feet wide cuts the slate at Mill Cove. It is of a dark green color, with darker markings, which present an oily appearance to the naked eye. Its microscopic characters are so altered as to make specialized determination impossible. This is also the case with the two dikes near by at Mill Cove Dam.

An extensive dike 300 feet wide cuts the slate on Quincy Avenue, opposite the brick store, adjacent to a similar small dike. The ground mass is composed of dirty brown alteration masses, in which are imbedded lath-shaped feldspars which give an extinction angle of about 7°. Bending of the crystals and flow structure are observable. Triangular magnetite crystals are present, and a little ilmenite somewhat altered to leucoxene.

A large primary dike occurs south of Pine Tree Brook in the Blue Hill Reservation. It seems to be a strongly gabbroitic development of the diabase, containing in portions conspicuous shreds of feldspar. The augite passes into hornblende on the margins, with a central core of unaltered augite or pyroxene. Magnetite crystals are abundant.

Dikes older than the granite. Near the target of the shooting range in the Blue Hill Reservation is a large dike, cut by and hence older than the granite. It proved in section to be a coarse diabase with uralitized green hornblende, resulting from chloritic decomposition, and a fresher leek-green hornblende, twinned feldspars with tendency to ophitic texture, and small secondary feldspar rods. Some magnetite was also present.

A similar primary dike, also in the Reservation, occurs east of Pine Tree Brook, near Walnut Ave. This is also a diabase, but of very fine-grained ground mass, and with striking rod-shaped crystals. The chlorite is slight in amount, but considerable magnetite is present.

Dikes newer than the granite. A large diabase dike occurs on Mt. Pleasant, containing a handsome rose-colored augite that appears like garnet except for its low refraction. The rock is much chloritized, the chlorite extending all through the feldspar. Many minute quartz veins ramify through the rock.

An especially fresh and handsome dike rock (Pl. **2**, Fig. 8), forming a dike 35 feet wide, occurs on Pine Hill. It shows strikingly the ophitic texture. The plagioclases are in lath-shaped forms, sometimes fibrous, and of a greenish color. The interspaces are filled by masses of a handsome pink augite. Iron ore is abundant, chiefly in grains of irregular outline, hence presumably ilmenite. Many small needles of some mineral not definitely determined are visible without polarized light. It approaches the augite porphyrite of Predotzo in appearance.

A dike five and one half feet wide, of dark color, and similar to the above dikes, cuts the granite on a private way leading south from Broad Street, near Vine Street, in Weymouth. It is rich in pyrite and shows considerable effects of crushing. A dike from fifty to sixty feet wide runs between the granite and slate and the conglomerate on the west side of North Common Street. The dike runs with the stratification of the slate and is almost a gabbro. A pink decomposition product occurs throughout it.

GRANITE DIKES.

A granite dike three inches wide cuts both the slates and the primary dikes in the locality east of Randolph Avenue, near Pine Tree Brook already referred to. The microscope shows it to be of decayed minute grains with granophyric texture, and pegmatitic growths interpenetrating the feldspar and quartz. (Plate **5**, Fig. 14.)

Another granite dike, similar in character, was noted between Common Street and the North Common Hill quarries, not far from the corner of Adams Street. The dike is from fifty to sixty feet wide.

CONTACT PHENOMENA.

The contacts between the granite and slate are remarkably distinct, and even in the thinnest sections the sharply defined line of contact is evident. The dark particles of the slate tend to collect rather more abundantly along the contact line, while the granite for a few millimeters is a trifle finer grained. The contact metamorphism often noted is not shown, however. Contacts are especially well shown in the sections from North Common Hill quarries (Pl. 1, Fig. 1). A few sections show bits of the slate included in the granite, near the contact.

In the North Common Hill quarries there is on the contact with the granite a very compact dense hornfels, so baked that pieces emit a metallic sound when struck with a hammer, and the zone appears almost like a dike.

The contact of the Paradoxides slate and felsite in the Hayward creek locality has been so much altered that the felsite has assumed somewhat the appearance of a gneiss, as described by Shaler ('71). In other cases the felsite, which is a contact phase of the granite, according to Wadsworth ('82) has along this juncture with the slate lost all its distinctive granitic characters and "been transformed into a spherulitic quartz porphyry along the contact."

SUMMARY.

From the foregoing it will be seen that there is in the district treated a complex series of rocks which have been intruded through the Cambrian and later slates and conglomerates. The conglomerate occurring near the North Common Hill quarries in Quincy, although containing rounded pebbles, which indicate its sedimentary character, nevertheless microscopically resembles a volcanic tuff, since it seems to have lath-shaped plagioclases in the ground mass. There are many evidences of crushing here as well as in the conglomerate on Hough's Neck. In the upper conglomerate of the latter locality many fragments of the various neighboring volcanics are contained.

Four granites, besides the diorite, are described; but the hornblendic granitite is omitted from this summary: — The dioritic granite occurring on Mount Pleasant and near Whitman Pond, as a phase near the contact in which patches of diorite of various sizes have segregated out in the granite, until finally the diorite itself assumes prominence, as the prevailing type in the vicinity of Whitman Pond, as the peripheral phase of the collected dark silicates of the great intrusion of the complex.

The biotitic granite is of limited occurrence, of a white or pink color, resembling those on Long Island Sound, and is very finely crystalline. The hornblendic granite of Quincy has a typical granitic texture, the feldspar being chiefly orthoclase. The most striking feature is the occurrence of numerous blue acicular crystals of glaucophane. Segregated patches of dark silicates, resembling those of the Maine granite, occur in places. By imperceptible gradations the latter granite, in the Blue Hills Reservation, passes into a porphyritic aporhyolite, with well-developed flow structures in the ground mass; or in which, in some cases, the ground mass is micrographitic.

The porphyritic type seems to represent the normal composition of the magma which formed the batholites, having been the outer crust in cooling. The granite has crystallized within this crust and the fluidal aporhyolite is a later ejectment through the crust, subsequent to the differentiation of the magma.

This later aporhyolite shows all the types of compact, jaspery, fluidal, and coarsely banded texture, seen elsewhere along the Atlantic coast, and is always entirely devitrified. Spherulitic texture is rare and only minutely developed, and the beds of volcanic tuff, ashes, and breccias, often found overlying on the Maine and New Brunswick coasts, are lacking.

Melaphyr forms the great flow on Hough's Neck which Wolff has already described as a dike, but which on account of its relations to the conglomerates seems rather to be a tilted sheet. The upper part of the flow is filled with amygdules. In the base of the flow these are lacking and the rock becomes a true basalt. Olivine is rarely evident, and much of the rock is now a diabase.

The dikes, although plainly of different ages, are nearly all diabases, differing little in microscopic appearance and usually much decomposed. There is in some a strong gabbroitic development. One dike, newer in age than the granite, contained a rose-colored augite, resembling garnet except for its low refraction.

Granite dikes occur cutting the slates. The great points of interest are the relation of the various rocks to one another and the transitions noted in the phases of the conglomerate, — the passage of granites into true porphyries and subsequent fluidal aporhyolites, — and the development of peripheral phases of diorite.

My thanks are due to Prof. W. O. Crosby for enabling me, under his guidance and that of Mr. Thos. A. Watson, of Weymouth, to visit, in a few days, the most noteworthy exposures, contacts, and outcrops illustrating stages of transition among the rocks of the Blue Hills, which he has spent years in searching out and mapping, and for his valued criticisms in the prosecution of the research. My thanks are also due to Prof. J. F. Kemp of Columbia University for many valuable suggestions in the course of this petrographic study.

With the increasing interest recently developed in the petrographic examination of these Pre-cambrian volcanics, especially of the Atlantic coast, it is to be hoped that in a few years we shall be able to correlate them, and more fully to determine their most interesting relations, than is possible with the limited published results now at our disposal.

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	Slide.
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" " " " " " " " .	E 2
" " " " " " " " .	C 4
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"	17436
"	17436a
"	26585
"	26585a
"	25607
"	25607a
"	25607b
"	25610
"	25610a
"	25610b
"	26584
"	25617
"	25617a
"	25606
" Field & Wild's quarry, blue granite	25616
" Same locality	25616a
Quincy, North Common Hill	25608
" " " "	25608a
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" " " " "	E 4
" " " " "	E 5
" " " " "	E 6
" " " " "	E 7
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	Slide.
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PLATE 1.

Fig. 1. Contact between slate (on the left) and granite (on the right), showing sharp demarcation and slight contact zone. North Common Hill. Slide C 14, × 81.

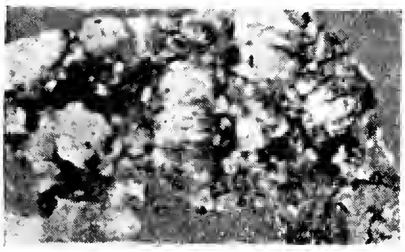
Fig. 2. Coarse granitic texture. Hornblende granite. Rattlesnake Hill. Slide 72a, × 4.

Fig. 3. Fine granitic texture. Hornblende granitite. Weymouth Fore River. Slide C 2, × 4.

Fig. 4. Porphyritic texture. Porphyritic aporhyolite. Near Wampatuck Hill. Slide C 10, × 4.

Fig. 5. Aporhyolite showing orthoclase crystals and flow texture. Summit of Wampatuck Hill. Slide 78, × 4.

2



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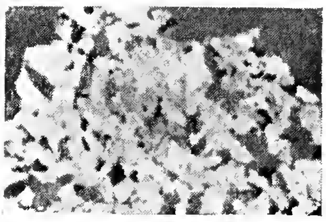

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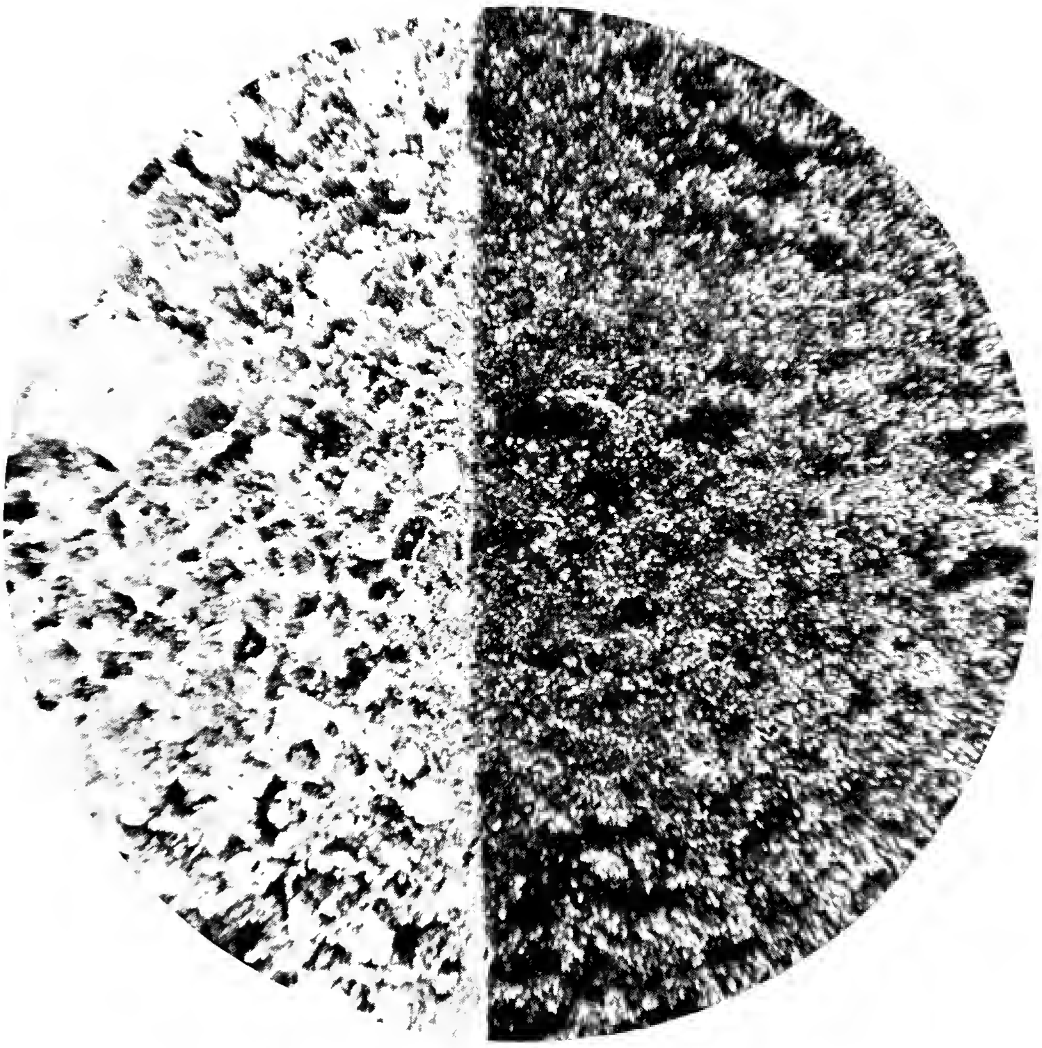

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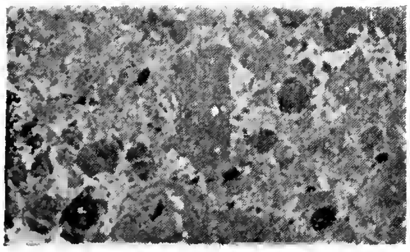

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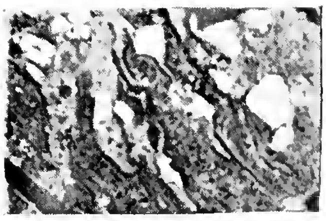

PLATE 2.

Fig. 6. Fluidal texture. Aporhyolite. Summit of Wampatuck Hill. (See Pl. **1**, Fig. 5.) Slide 78, × 144.

Fig. 7. Conglomerate. Near North Common Hill quarries. (See Plate **4**, Fig. 13.) Slide 204, × 4.

Fig. 8. Ophitic texture. Diabase, showing lath-shaped feldspars. Dike on Pine Hill. Slide 203, × 4.

Fig. 9. Opaque rings of alteration products, lining cavities in slate. Cut transverse to structure. Mill Cove. Slide C 15, × 4.

6

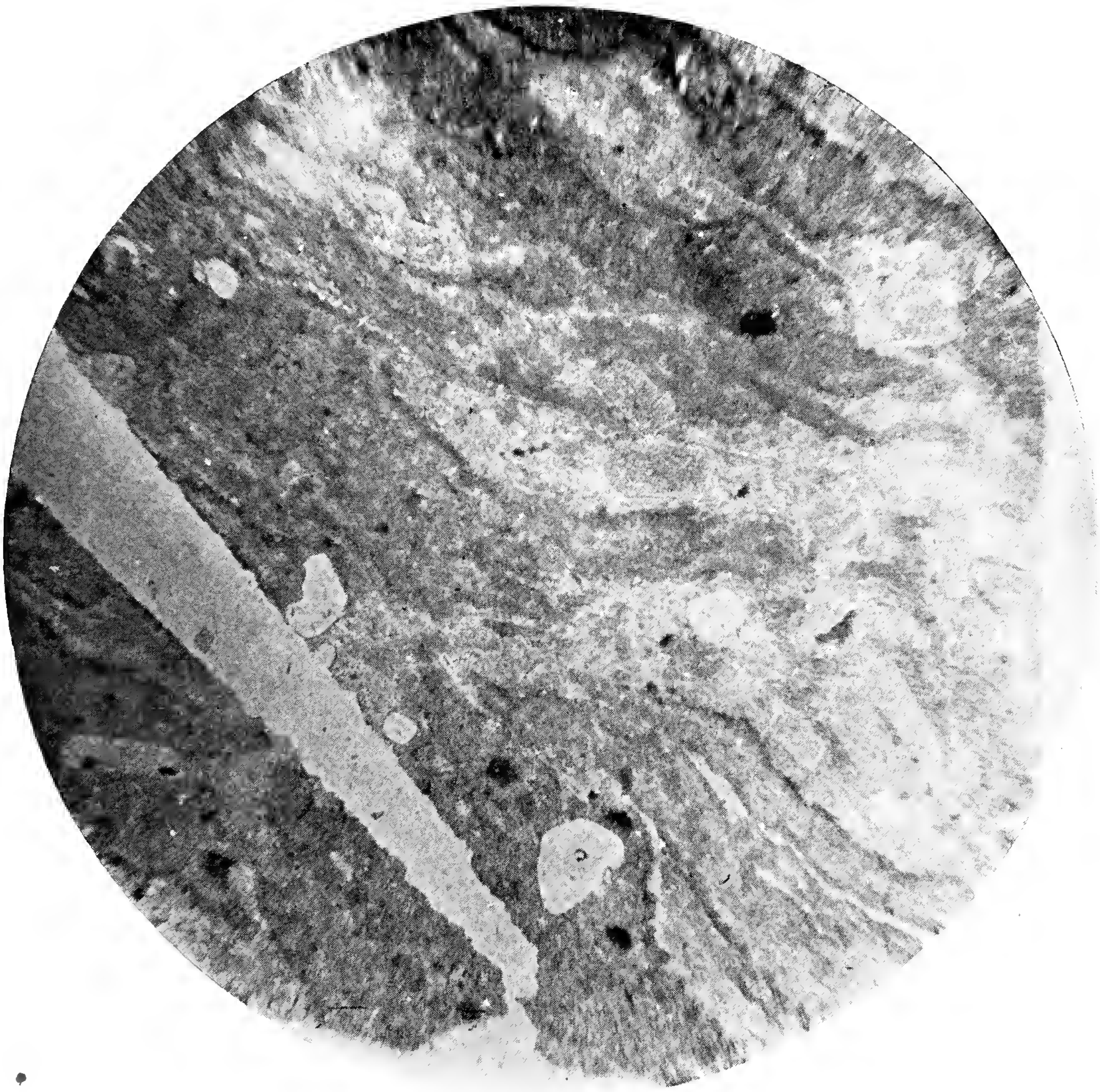

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PLATE 3.

Fig. 10. Glaucophane crystals. From 10th census slide 25,609 of hornblende granite of Hardwick quarry, Quincy, × 144.

Fig. 11. Hornblende granite, Rattlesnake Hill, showing Carlsbad twin, containing several glaucophane crystals. Slide 72a, × 144.

10

11

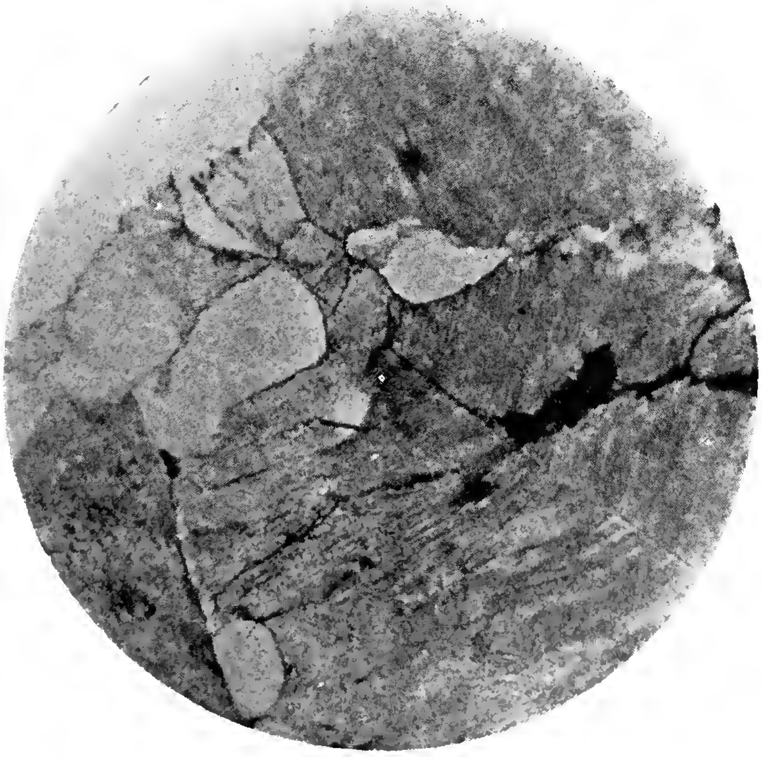
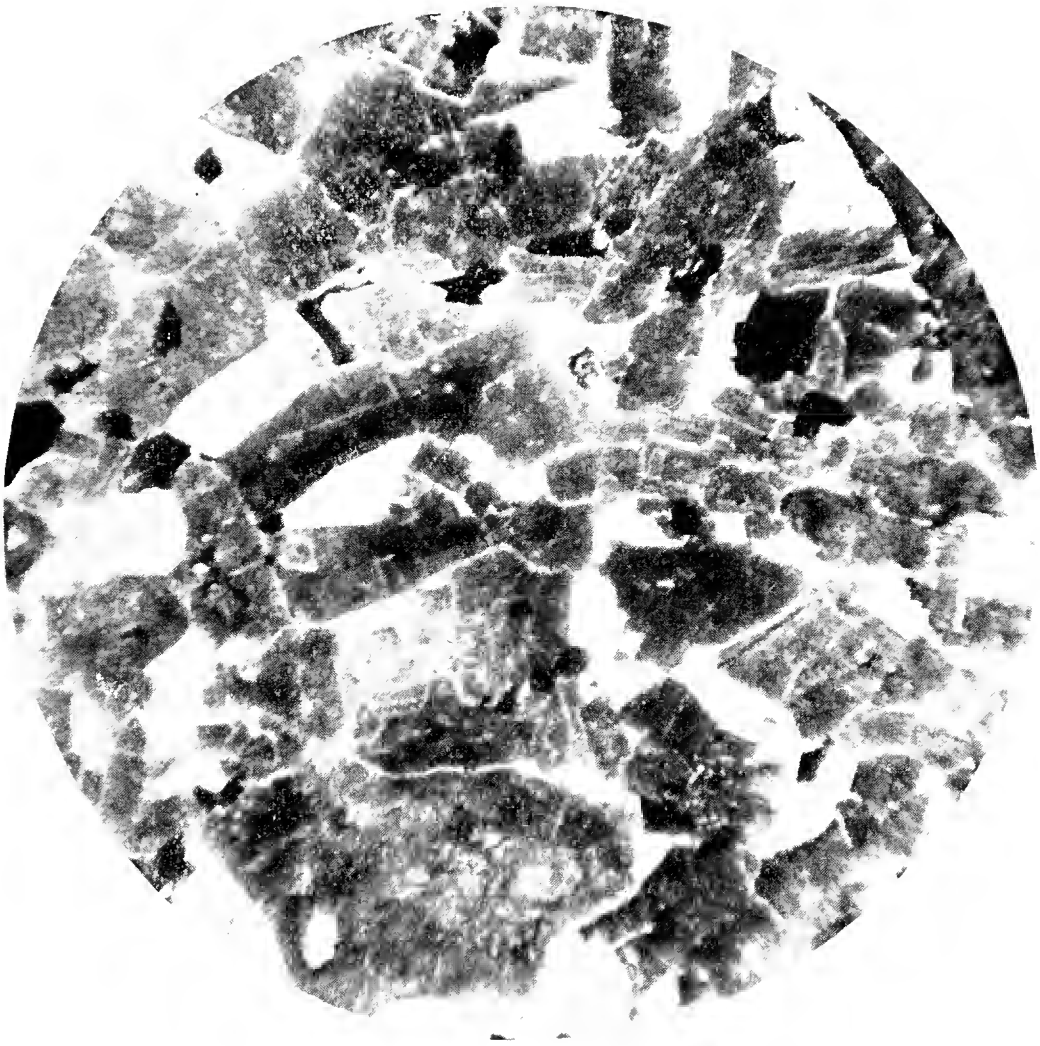


PLATE 4.

Fig. 12. Hornblende granitite. Weymouth Fore River. Slide 87, $\times$ 144.
Fig. 13. Conglomerate. Near North Common Hill quarries, Quincy, Mass. Slide 212, $\times$ 144.

12



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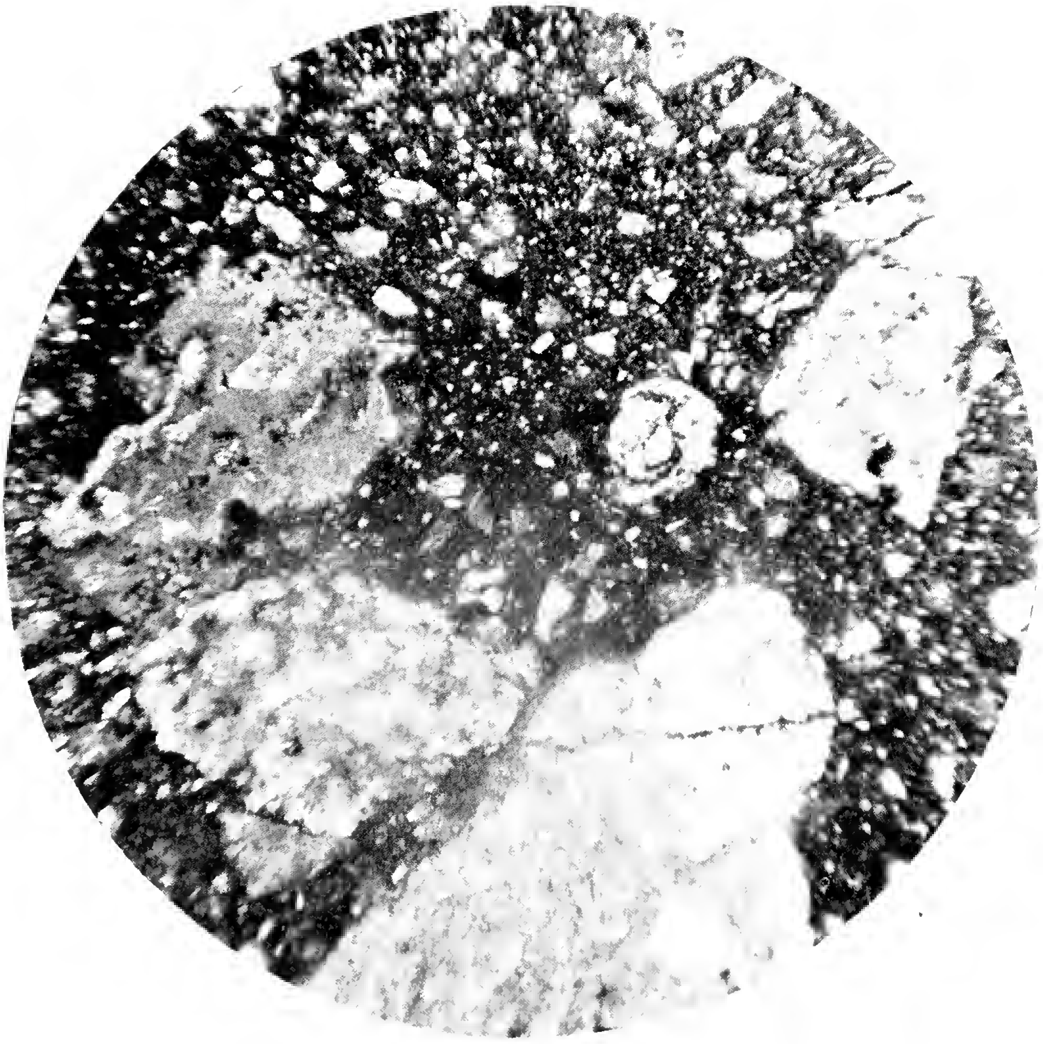

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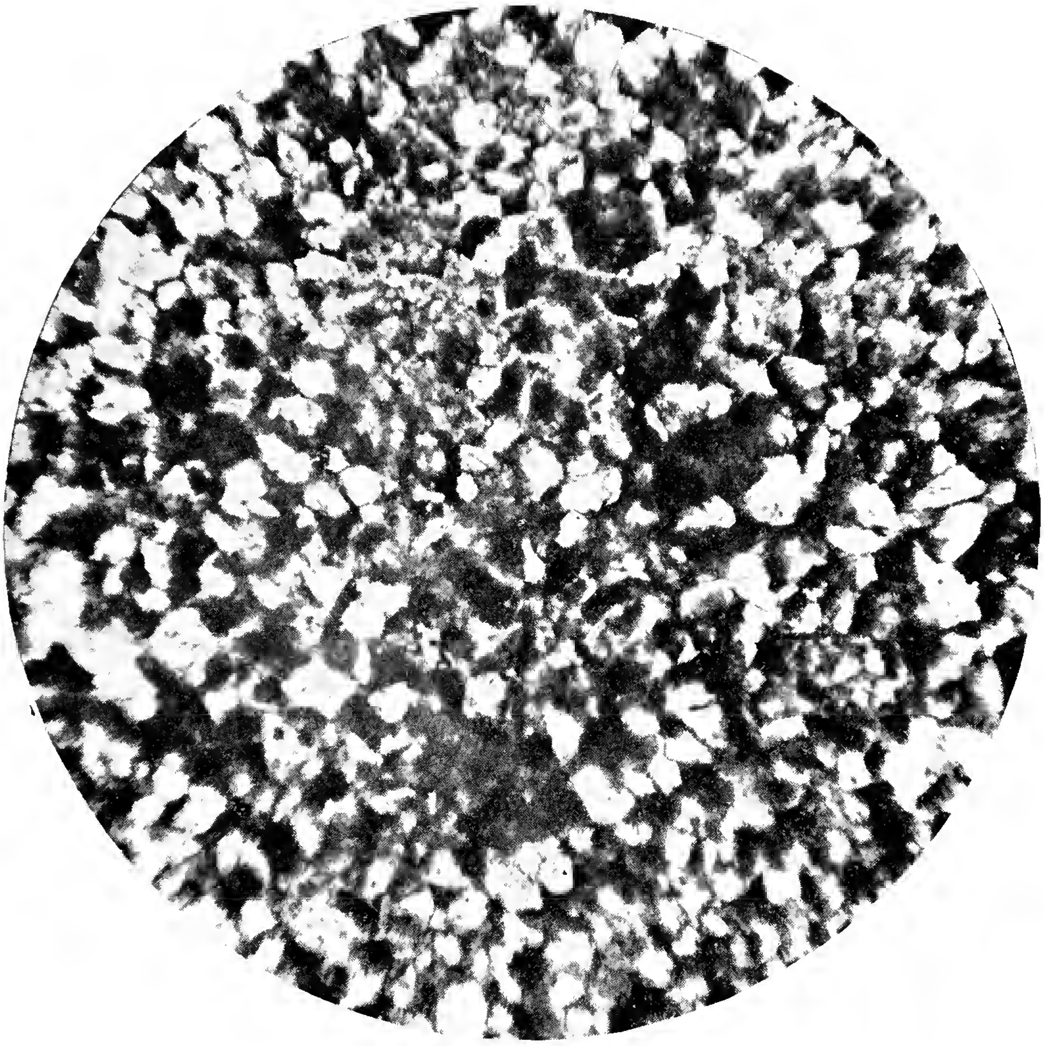
PLATE 5.

Fig. 14. Fine granite vein. Blue Hills Reservation near Pine Tree Brook. Slide 219, × 144.

Fig. 15. Melaphyr from top of flow, showing arrangement of lath-shaped feldspars. Hough's Neck. Slide 201, × 144.

14



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THE LAND MAMMALS OF PENINSULAR FLORIDA AND THE COAST REGION OF GEORGIA.

By Outram Bangs.

BOSTON:
PRINTED FOR THE SOCIETY.
March, 1898.

No. 7. — *The Land Mammals of Peninsular Florida and the Coast Region of Georgia.*

By Outram Bangs.

The present paper is intended to include all the land mammals that occur in the region between the Savannah River and Cape Sable, including the Sea Islands of Georgia and the islands of eastern Florida, but it does not cover Florida west of the Suwannee River. The list of Chiroptera has been kindly prepared for publication in this paper by Mr. Gerrit S. Miller, Jr., and is published exactly as it came from his pen; all the other work is wholly my own. Seventy-three forms are recognized as inhabitants of the region treated, seventeen of which are described as new.

In all probability this number is nearly complete, as the region has now been pretty thoroughly worked. Some unlooked-for forms may of course turn up, and it is possible that some of the Sea Islands, upon which Mr. Brown was unable to collect, may hold insular forms. One hears all kinds of strange stories in Florida of wonderful beasts that have been seen and even killed there. Tales of jaguars and ocelots have often been published, and are told by many of the hunters. If these animals really occur in Florida, it is strange that specimens have never found their way into collections, although many efforts to get them have been made. Still better evidence against the occurrence of the jaguar or the ocelot in Florida is that given by Mr. Cory, who says that the Indians know them not.

Among other things I have heard of a Bassariscus being killed in the everglades, and a "gray gopher" on one of the interior prairies. The "gray gopher" I had a chance to run to earth, and it turned out to be a gray squirrel (*Sciurus carolinensis*), with a broken, stumpy tail, that was surprised and shot while attempting to cross a treeless prairie by the man who told me the story. It was mounted, and I traveled some miles to see it, because my informant had come to Florida from Minnesota and assured me that he knew a gray gopher (meaning *Spermophilus franklini*). The Bassariscus rests on the authority of W. F. McCormick of Cocoanut Grove, Florida, who is well informed, and who told me he had shot the animal himself.

Peninsular Florida and the Coast Region of Georgia.
Type Localities Marked ●

History. — The first list of the mammals of Florida, that of J. A. Allen, "Mammals and winter birds of East Florida" (Bull. Mus. comp. zool., 1871), mentions thirty-five species. Few of the forms peculiar to Florida were recognized, and the list is interesting now merely as a matter of history.

This was followed in 1872 by C. J. Maynard's "Catalogue of the mammals of Florida, with notes on their habits, distribution, etc." (Bull. Essex inst., vol. 4), with thirty-six species. Practically the same list was published by Mr. Maynard in 1883 (Jour. Bost. zool. soc., vol. 2), still with but thirty-six species. In these three lists the manatee, and in Mr. Maynard's lists the porpoise, were included.

In 1894 Samuel N. Rhoads published (Proc. Acad. nat. sci. Phila.) a partial list of the mammals found in the region about Tarpon Springs, Florida. This is entitled, "Contributions to the mammalogy of Florida," and mentioned twenty-two forms, two of which were described as new.

On November 30, 1894, Frank M. Chapman's "Remarks on certain land mammals from Florida with a list of the species known to occur in the state" (Bull. Amer. mus. nat. hist., vol. 6) appeared in which the author recognized fifty-three forms. This valuable list, with much that is excellent, was published before many of the forms peculiar to the region had been named, and is already antiquated.

In the next list, by Charles B. Cory in his book, "Hunting and fishing in Florida" (Boston, 1896), fifty-two forms including the manatee are given.

In the interval between the appearance of Mr. Chapman's and Mr. Cory's lists, several new forms had been described from Florida. Mr. Cory has, however, overlooked these, and gives but two names, the manatee and the Florida puma, described as new, not in Chapman's list. Much of Mr. Cory's matter is of interest, however, especially that which refers to the larger mammals with which he has had experience in life.

Besides these lists, various forms of Mammalia peculiar to Florida have been described in monographic reviews or in separate papers.

COMPARATIVE TABLE OF NAMES USED FOR LAND MAMMALS

	Names used in present paper.	Allen, 1871.	Maynard, 1872.
1.	Didelphis virginiana pigra	D. virginiana	D. virginiana
2.	Lepus palustris	L. palustris	L. palustris
3.	L. p. paludicola	....	....
4.	L. sylvaticus	L. sylvaticus	L. sylvaticus
5.	L. s. floridanus	....	....
6.	Geomys tuza	....	....
7.	G. floridanus	G. pineti	G. pineti
8.	G. f. austrinus	....	....
9.	G. colonus	....	....
10.	G. cumberlandius	....	....
11.	Microtus pinetorum	Arvicola pinetorum	A. pinetorum
12.	M. alleni	....	....
13.	Neotoma floridana	N. floridana	N. floridana
14.	N. f. rubida	....	....
15.	Reithrodontomys lecontii	....	....
16.	R. l. dickinsoni	....	....
17.	Oryzomys palustris	Hesperomys palustris (in part)	H. palustris (in part)
18.	O. p. natator	Hesperomys palustris (in part)	H. palustris (in part)
19.	O. p. coloratus	....	....
20.	Sigmodon hispidus	S. hispidus	S. hispidus
21.	S. h. littoralis	....	....
22.	S. h. spadicipygus	....	....
23.	Peromyscus floridanus	....	....
24.	P. gossypinus	Hesperomys leucopus et gossypinus	H. leucopus
25.	P. g. palmarius	....	....
26.	P. anastasae	....	....
27.	P. insulanus	....	....
28.	P. nuttalii	Hesperomys aureolus	H. aureolus
29.	P. niveiventris	....	....
30.	P. phasma	....	....
31.	P. subgriseus	....	....
32.	P. s. rhoadsi	....	....
33.	P. s. arenarius	....	....
34.	Mus musculus	....	....
35.	M. decumanus	M. decumanus	M. decumanus
36.	M. rattus	....	....
37.	M. r. alexandrinus	....	M. tectorum
38.	Sciurus niger	S. niger	S. niger
39.	S. carolinensis	S. carolinensis	S. carolinensis
40.	S. c. extimus	....	....
41.	Sciuropterus volans	....	....
42.	S. v. querceti	....	....
43.	Blarina brevicauda carolinensis	....	....
44.	B. b. peninsulae	....	....
45.	B. parva	....	....

OF PENINSULAR FLORIDA AND THE COAST REGION OF GEORGIA.

Maynard, 1883.	Rhoads, 1894.	Chapman, 1894.	Cory, 1896.
D. virginiana	....	D. marsupialis virginiana	D. marsupialis virginiana
L. palustris	....	L. palustris	L. palustris
....	....	L. p. paludicola	L. p. paludicola
L. sylvaticus	....	L. sylvaticus	L. sylvaticus
....	....	L. s. floridanus	L. s. floridanus
....	....	....	....
G. pineti	....	G. tuza	G. tuza
....	G. tuza	....	....
....	....	....	....
....	....	....	....
A. pinetorum	....	A. pinetorum	A. pinetorum
....	....	A. alleni	Neofiber alleni
N. floridana	....	N. floridana	N. floridana
....	....	....	....
....	....	R. humilis	R. humilis
....	R. humilis	....	....
H. palustris (in part)	....	....	....
H. palustris (in part)	O. p. natator	O. palustris natator	O. palustris natator
....		....	....
S. hispidus	S. h. littoralis	S. hispidus	S. hispidus
....	....	S. h. littoralis	S. h. littoralis
....	....	....	....
....	....	Sitomys floridanus	S. floridanus
H. leucopus	Sitomys americanus gossypinus	S. americanus gossypinus	S. americanus gossypinus
....	....	....	....
....	....	....	....
....	....	....	....
H. aureolus	....	Sitomys aureolus	S. aureolus
....	....	S. niveiventris	S. niveiventris
....	....	....	....
....	....	S. n. subgriseus	S. n. subgriseus
....	Sitomys niveiventris subgriseus	....	....
....	....	....	....
....	M. musculus	M. musculus	M. musculus
M. decumanus	M. decumanus	M. decumanus	M. decumanus
....	....	M. rattus	M. rattus
M. tectorum	M. alexandrinus	M. alexandrinus	M. alexandrinus
S. niger	S. niger	S. niger	S. niger
S. carolinensis	S. carolinensis	S. carolinensis	S. carolinensis
....	....	....	....
....	....	S. volucella	S. volucella
....	S. volucella	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

COMPARATIVE TABLE OF NAMES USED FOR LAND MAMMALS

	Names used in present paper.	Allen, 1871.	Maynard, 1872.
46.	B. floridana	B. brevicauda	B. brevicauda et talpoides
47.	Scalops aquaticus australis	S. aquaticus	S. aquaticus
48.	S. anastasae	....	....
49.	Artibeus perspicillatus	Megadermatidae, sp. ?	A. perspiccilalune
50.	Corynorhinus macrotis	C. macrotis	C. macrotis
51.	Myotis lucifugus	....	....
52.	Lasionycteris noctivagans	....	....
53.	Pipistrellus subflavus	Scotophilus georgianus	S. georgianus
54.	Vespertilio fuscus	Scotophilus fuscus	S. fuscus
55.	Lasiurus borealis	....	....
56.	L. b. seminolus	L. noveboracensis	L. noveboracensis
57.	L. cinereus	....	....
58.	Dasypterus intermedius	....	....
59.	Nycticeius humeralis	N. crepuscularis	N. crepuscularis
60.	Nyctinomus cynocephalus	N. nasutus	N. nasutus
61.	Cariacus osceola	C. virginianus	C. virginianus
62.	Procyon lotor elucus	P. lotor	P. lotor
63.	Ursus floridanus	U. arctos	U. americanus
64.	Mephitis elongata	M. mephitica	M. mephitica
65.	Spilogale ambarvalis	Mephitis bicolor	M. bicolor
66.	Lutra hudsonica vaga	L. canadensis	L. canadensis
67.	Putorius vison lutreocephalus	P. lutreolus	P. lutreolus
68.	P. lutensis	....	....
69.	P. peninsulae	....	....
70.	Urocyon cineroargenteus floridanus	Vulpes virginianus	V. virginianus
71.	Canis ater	C. lupus	C. lupus
72.	Lynx ruffus floridanus	L. rufus	L. rufus
73.	Felis concolor floridana	F. concolor	F. concolor

OF PENINSULAR FLORIDA AND THE COAST REGION OF GEORGIA.

Maynard, 1883.	Rhoads, 1894.	Chapman, 1894.	Cory, 1896.
B. brevicauda et talpoides	....	{ B. brevicauda carolinensis	B. brevicauda carolinensis
....	....	B. cinerea	B. cinerea
....	....	B. exilipes }	B. exilipes
S. aquaticus	S. parvus	S. aquaticus australis	S. aquaticus australis
....	....	....	....
A. perspicillalune	....	A. carpolegus	A. carpolegus
C. macrotis	....	C. macrotis	C. macrotis
....	Vespertilio gryphus	V. gryphus	V. gryphus
....	....	....	....
S. georgianus	Vesperugo carolinensis	V. carolinensis	V. carolinensis
S. fuscus	Adelonycteris fuscus	A. fuscus	A. fuscus
....	....	....	....
L. noveboracensis	Atalapha borealis pfeifferi	A. borealis	A. borealis
....	....	Atalapha cinerea	A. cinerea
....	....	D. intermedius	D. intermedius
N. crepuscularis	N. humeralis	N. humeralis	N. humeralis
N. nasutus	N. brasiliensis	N. brasiliensis	N. brasiliensis
C. virginianus		C. virginianus	C. virginianus
P. lotor	P. lotor	P. lotor	P. lotor
U. americanus	....	U. americanus	U. americanus
M. mephitica	....	M. mephitica	M. mephitica
M. bicolor	....	S. putorius	S. putorius
L. canadensis	L. hudsonica	L. canadensis	L. canadensis
P. lutreolus	....	Lutreola vison	Lutreola vison
....	....	....	....
....	P. peninsulae	{ P. erminea P. peninsulae }	P. ermina peninsulae
V. virginianus	....	Urocyon cinereoargenteus	U. cinereoargenteus
C. lupus	....	C. lupus griseoalbus	C. lupus griseoalbus
L. rufus	....	L. rufus floridanus	L. rufus floridanus
F. concolor	....	F. concolor	F. concolor floridana

Itinerary. — In the last three years I have made three collecting trips in Florida and Georgia. On the first of these I spent all my time, from January 30 to March 9, 1895, at Oak Lodge, on the east peninsula, opposite Micco, Brevard County, Florida, collecting four hundred and fifty-five mammals. All but a few of these were taken in the immediate vicinity of Oak Lodge. A small number, comparatively, were collected at Micco on the opposite side of the Indian River. This large collection contained enormous series of the commoner species, which have proved of great value as showing the range of individual variation at one place, and of variations with age, etc.

In 1896, I went to St. Mary's, Georgia, and spent the time from March 9 to April 19 collecting in the immediate vicinity of that quaint old city, my principal object being to find out how far north the Florida forms extended. In this I was partly successful, although I soon saw that a more extended tour along the coast of northern Florida and Georgia was necessary. While at St. Mary's, I did some collecting both on Cumberland Island, and at Rose Bluff on the Florida side of the St. Mary's River. The smaller mammals were scarce in this region and collecting was very laborious, and I made but one hundred and fifty-seven skins.

In the winter of 1897, I made a more extended trip in Florida, spending less time at any one place and visiting many different localities. The first two weeks (February 4 to 17) I spent at Point Matanzas, collecting at Carterville on the main land across the Matanzas River, on Point Matanzas, and on Anastasia Island — to the mammalogist one of the most interesting spots in Florida. Three mammals, a mole and two white-footed mice, that I took there prove to be insular species confined to Anastasia Island. At Carterville I collected, among other things, a large series of Geomys that can be considered topotypes of *G. floridanus.* I then went to Oak Lodge again, remaining only a few days. And then to Eau Gallie, where I stopped a week, devoting most of my time to trapping Geomys from the large colony there; this colony of *G. floridanus* is probably the southernmost of any size existing. From Eau Gallie I proceeded to Gainesville, where I stayed from March 20 to April 6, principally for the purpose of getting topotypes of the species described by Chapman, namely, the Florida mole, the old-field mouse, Chapman's rice-field mouse, and the big-eared Florida deer mouse, all of which I secured.

Besides these trips that I have made myself, I have had several collectors in Florida and Georgia. The most important trip was that undertaken last winter by Mr. W. W. Brown, Jr., who collected from the middle of December, 1896, to the end of May, 1897, covering the ground from the Savannah River to New Berlin and Burnside Beach, Florida. He visited all the Sea Islands, but to my disappointment was unable to work on four of the largest of these. All the Sea Islands are now held either by private individuals or by clubs as game preserves, and are strictly and rather jealously guarded. On Sapolo, Wolf, St. Simon's, and Jeckle Islands, Mr. Brown was refused permission to collect. On Skiddaway, Ossabaw, St. Catherine's, and Cumberland Islands, he was courteously treated and allowed to carry on his work. On the main land he made collections at the following localities in Georgia: Hursman's Lake (Savannah River), Pinetucky, Adam, Montgomery, Barrington, Doctortown, and Sterling. The last part of his time was spent in the vicinity of Jacksonville, Florida, principally with a view of securing series of the wood rat and the cotton rat, the types of these two species being supposed to have come from that region. Mr. Brown took large series of both these animals. His collection of over a thousand specimens is of great importance in the present work and has enabled me to map out the range of nearly all the Florida forms and determine where they either merge into their austral representatives or overlap their ranges. The bear, deer, and lynx are the only species Mr. Brown did not take that I was particularly anxious for, as it leaves the northern limit of these three animals still in doubt.

In the late winter and early spring of 1895, Mr. C. L. Brownell collected for me at the following places in southern Florida: Jupiter Inlet, Miami, Cape Sable, Flamingo, and Key West. When the coral rock formation is reached small mammals decrease both in numbers and in number of species, and Mr. Brownell's collection, though containing two new forms peculiar to southern Florida (*Oryzomys palustris coloratus* and *Sigmodon hispidus spadicipygus*), was small. At Cape Sable and Flamingo, he took of the smaller mammals but three species, namely, *Peromyscus gossypinus palmarius*, *Oryzomys palustris coloratus*, and *Sigmodon hispidus spadicipygus*. While at Key West he could find nothing but the two imported species of Mus, *Mus rattus alexandrinus* and *Mus musculus*.

Another collection of considerable importance is that made by F. L. Small in Citrus County, Florida. Mr. Small resided here for nearly a year and in that time made an extensive collection of the mammals. All his skins were divided between the collections of Gerrit S. Miller, Jr., and E. A. and O. Bangs, and have already formed the basis of considerable work on the Mammalia of Florida.

Besides these large collections from Florida and Georgia, I have received from time to time specimens from different hunters and collectors, and a small lot of skins from W. A. Dickinson taken in the vicinity of Tarpon Springs, Florida.

Physical Geography and Distribution of Mammalian Life.— The coastal strip of Georgia and northern, central, and southwestern Florida agrees very closely in general formation, and also in faunal and floral characters. The general character of the country is flat and monotonous with a light sandy soil and interminable forests of pine, — the "flat woods" or "piny woods" as they are called. In this forest the trees grow far apart, and in the higher parts the white sand is only partially concealed by an undergrowth of scrub palmetto. In the lower and moister places, sphagnum, reeds, and some grasses cover the ground, and a great variety of flowering plants enlivens the monotony of the scene. Scattered everywhere through the flat woods are little cypress ponds, and occasionally the forest gradually opens out into extensive tracts of treeless "prairie." Few small mammals live in the piny woods, the fox squirrel, the mole, the salamander, the cotton rat, and the cotton-tail rabbit being its principal inhabitants.

Along the margins of streams and in the so-called hummock land, the growth is very different from that of the flat woods, and the big magnolia, black gum, live oak, water oak, bald cypress, and, near the coast, cabbage palmetto form heavy forests. The rich soil is overgrown by shrubs and climbing vines, which twisting from branch to branch bind the whole into a dense tangle. In such places the gray squirrel, the cotton mouse, the rice-field mouse, the wood rat, and the marsh rabbit live.

In places through the great pine barrens the ground rises into higher ridges of white sand where black-jack oak (*Quercus nigra*) and turkey oak (*Q. catesbaei*) to a great extent replace the pine. The young of these two trees often make little clumps of scrubby growth, and usually there are patches of scrub palmetto scattered about, but the bare white sand shines through everywhere, looking from a distance as if the ground were covered with snow. Such places are known as "black-jack ridges" and are, in my experience, the sole abode of one of the most remarkable mammals of Florida, the big-eared Florida deer mouse.

The whole coast of Georgia and northeastern Florida south to the Matanzas River is one continuous stretch of salt-tide marsh interlaced by deep creeks, and now and then broken by a sandy beach where some higher point of land meets the deep water. In these vast salt marshes live marsh rabbits, cotton rats, rice-field mice, and the salt-marsh mink; while enormous numbers of raccoon visit them nightly in search of crabs and fish, wearing beaten paths from the upland down over the marsh.

Along the Georgia coast stretches the series of islands, many of them of considerable size, known as the Sea Islands. The Sea Islands are, according to geologists, of comparatively modern date, and are merely portions of the mainland separated by miles of salt marsh and creek; yet Cumberland Island has two mammals peculiar to it, a "salamander" and a white-footed mouse, and some of the other islands have forms which in the course of time will probably become differentiated into island species. The mole on Ossabaw Island is already slightly different from that of the mainland opposite, as is also the gray squirrel on Cumberland Island. The cotton rat upon Ossabaw Island is very pallid, and has a strong tendency to have pale cinnamon under parts. Were it not for the great local variation in color presented by this species, I should feel tempted to recognize this form by name. Anastasia Island lies directly opposite the City of St. Augustine, and is by far more interesting than any of the Sea Islands; it has three insular species, two mice (*Peromyscus anastasae* and *P. phasma*) and one mole (*Scalops anastasae*). It may be that Anastasia Island is older than the Sea Islands, and the forms insulated upon it have had more time to change; or, perhaps, its open sand hills with an abundance of food, but offering scanty protection to the mammals inhabiting them, have caused a rapid modification in the direction of protective coloration. This, while it is very probably the case with the mice, could, however, hardly apply to the mole. Anastasia Island is about fifteen miles long, and is separated from the mainland by the Matanzas River. At each end of the island a deep inlet, through which the tide runs like a mill race, connects the river with the ocean. The island is made up of a long series of sand hills with many salt flats between. There are but few trees, the growth being for the most part low bushes that mass themselves into almost impenetrable thickets in the more sheltered valleys between the sand hills. The exposed sand hills are clothed with a scattered growth of sea oats (*Uniola paniculata*), the seeds of which afford abundant food for the small mammals, that fairly swarm over the island. In no place have I seen small mammals so abundant as on Anastasia Island. Besides the three insular species peculiar to it, the cotton rat lives there, literally by the thousand, and even such a marsh-loving animal as the rice-field mouse can not resist its fascinations, and I caught several on the barren sand hills.

South of the Matanzas River there begins a long sandy beach, probably the most beautiful in the world, extending for a distance of over 350 miles to Lake Worth. In several places it is interrupted by deep inlets that connect the Indian River and the ocean. Back of the beach rise low sand hills, covered with saw palmetto, sea oats, and sea grape, the only known abiding place of the little Florida beach mouse. The small Florida striped skunk is extremely abundant here also, although very rare or entirely wanting in other parts of Florida. Along this entire stretch between the Indian River and the ocean, known as the east peninsula, all the smaller Florida mammals, such as the Florida cotton mouse, Chapman's rice-field mouse, Chapman's cotton rat, the Florida short-tailed shrew, etc., are much more abundant than elsewhere. Back of the east peninsula, running parallel to it and separating it from the main peninsula, is the Indian River. The river shores are fringed by mangrove, and on each side tideless salt savannahs separate the upland from the river. On these savannahs in great numbers live the Florida water rat and the Florida marsh rabbit.

The whole of the central and western parts of the Florida peninsula is much the same as northern Florida and eastern Georgia; the country is rather more rolling, however, and one often sees extensive tracts of ground covered with broom grass, hickory, and deciduous oak, that are more suggestive of the Carolinas. There are a few mammals whose range in Florida is apparently confined to the western part of the peninsula, and that do not occur in eastern Florida. The old-field mouse and little-harvest mouse are good examples of such, and the salamander of the west side of the peninsula is subspecifically different from that of the east side, as is also the cotton rat.

Southern or tropical Florida is a region apparently poorly adapted to the needs of most mammals, being principally coral or limestone rock, and vast submerged swamps of cypress and mangrove and endless saw grass marshes. The burrowing mammals, such as moles and salamanders, can not live there, and all smaller mammals, excepting the south Florida cotton rat, the south Florida rice-field mouse, the Florida cotton mouse, and the everglade gray squirrel, are rare. There is a decided difference in the flora of this region from that of northern and central Florida, as shown by the presence of such trees as the royal palm, mahogany, and many other tropical plants, while the manatee and crocodile attest to the tropical element in the fauna.

Faunal Areas. — Two faunal areas come within the scope of the present paper. 1. The Lower Austral Zone, which includes eastern Georgia and the whole of Florida south to about half way down the peninsula.

2. The Tropical Zone (perhaps better subtropical) which according to Dr. Merriam (Nat. geog. mag., 1894, vol. 6) covers the lower half of the peninsula from Tampa Bay on the west and Cape Canaveral on the east. See also, a very important paper by E. A. Schwarz, entitled, "The insect fauna of semitropical Florida with special regard to Coleoptera" (Entom. Amer., Dec., 1888, p. 165–175), where the author discusses at length the tropical element of southern Florida.

A few species conform very well to these two faunal areas and have lower austral and tropical (or subtropical) subspecies. Among these are the cotton-tail rabbit, the marsh rabbit, the flying squirrel, the gray squirrel, and the cotton mouse.

On the whole, however, the mammalian fauna of Florida does not conform very closely to the faunal divisions, for which two causes can be assigned: —

1st. The long peninsulation of Florida, which in itself would have a tendency to change the forms living far down upon it, just as being confined to an island does.

2d. The extreme localization of many of the smaller species and their special adaptation to certain habitats.

For instance, the little beach mouse, with a highly developed protective coloration, lives only along the beaches and sand hills of the east peninsula, and the big-eared Florida deer mouse is only found in the black-jack ridges. Neither of these species respects the division between lower austral and tropical areas, but occurs in both areas alike wherever the country is suitable.

Some species have three subspecies within the limit of the two zones, the rice-field mouse, the cotton rat, and the old-field mouse being examples; while the large mammals that roam over the whole area alike have in every instance a subspecies, the range of which is not limited by the tropical zone of south Florida, but that occupies the whole of the Florida peninsula and extends north certainly to southern Georgia. The two Florida short-tailed shrews are as indifferent to local surroundings as are the larger mammals, and have about the same range, covering the whole Florida peninsula and southeastern Georgia, while the range of the Florida mole extends still farther north, certainly to the Savannah River. These forms can properly be called "Floridan" and probably have their origin rather in the peninsulation of their habitat than from the effect of the laws of temperature control.

List of Species and Subspecies with Type Localities.

Name.	Type Locality.
Didelphis virginiana pigra Bangs	Oak Lodge, Fla.
Lepus palustris Bach.	Eastern S. Carolina.
L. p. paludicola (Miller and Bangs)	Fort Island, Citrus Co., Fla.
L. sylvaticus Bach.	Austral Zone, eastern U. S.
L. s. floridanus Allen	Micco, Fla.
Geomys tuza (Ord)	Near Augusta, Geo.
G. floridanus (Aud. and Bach.)	St. Augustine, Fla.
G. f. austrinus Bangs	Belleair, Hillsboro Co., Fla.
G. colonus Bangs	St. Mary's, Geo.
G. cumberlandius Bangs	Cumberland Isl., Geo.
Microtus pinetorum (Leconte)	Eastern Georgia.
M. alleni (True)	Georgiana, Fla.
Neotoma floridana (Ord)	St. John's River, Fla.
N. f. rubida Bangs	Gibson, La.
Reithrodontomys lecontii (Aud. and Bach.)	Riceboro, Geo.
R. l. dickinsoni (Rhoads)	Willow Oak, Pasco Co., Fla.
Oryzomys palustris (Harlan)	South Carolina.
O. p. natator Chapman	Gainesville, Fla.
O. p. coloratus Bangs	Cape Sable, Fla.
Sigmodon hispidus Say and Ord	St. John's River, Fla.
S. h. littoralis Chapman	Oak Lodge, Fla.
S. h. spadicipygus Bangs	Cape Sable, Fla.

Name.	Type Locality.
Peromyscus floridanus (Chapman)	Gainesville, Fla.
P. gossypinus (Leconte)	Riceboro, Geo.
P. g. palmarius Bangs	Oak Lodge, Fla.
P. anastasae Bangs	Anastasia Island, Fla.
P. insulanus Bangs	Cumberland Island, Geo.
P. nuttalii (Harlan)	Norfolk, Va.
P. niveiventris (Chapman)	Oak Lodge, Fla.
P. phasma Bangs	Anastasia Island, Fla.
P. subgriseus (Chapman)	Gainesville, Fla.
P. s. rhoadsi Bangs	Head of Anclote River, Hillsboro Co., Fla.
P. s. arenarius Bangs	Hursmans Lake, near Bascom, Geo.
Mus musculus Linné [1]	
M. decumanus Pallas [1]	
M. rattus Linné [1]	
M. r. alexandrinus (Geoff.) [1]	
Sciurus niger Linné	Southern S. Carolina.
S. carolinensis Gmel.	Carolina.
S. c. extimus Bangs	Miami, Fla.
Sciuropterus volans (Linné)	North America.
S. v. querceti Bangs	Citronelle, Fla.
Blarina brevicauda carolinensis (Bach.)	Eastern S. Carolina.
B. b. peninsulae (Merriam)	Miami River, Fla.
B. parva (Say)	Near Blair, Nebraska.
B. floridana Merriam	Chester Shoal, 14m. n. of Cape Canaveral, Fla.
Scalopus aquaticus australis Chapman	Gainesville, Fla.
S. anastasae Bangs	Anastasia Island, Fla.
Artibeus perspicillatus (Linné)	Jamaica.
Corynorhinus macrotis (Leconte)	Riceboro, Geo.
Myotis lucifugus (Leconte)	Riceboro, Geo.
Lasionycteris noctivagans (Leconte)	Eastern U. S.
Pipistrellus subflavus (F. Cuvier)	Eastern U. S. (probably Geo.).
Vespertilio fuscus Beauvois	Philadelphia, Pa.
Lasiurus borealis (Müller)	New York.
L. b. seminolus (Rhoads)	Tarpon Springs, Fla.
L. cinereus (Beauvois)	Philadelphia, Pa.
Dasypterus intermedius H. Allen	Matamoras, Tamaulipas, Mex.
Nycticeius humeralis Rafinesque	Kentucky.
Nyctinomus cynocephalus (Leconte)	(None given.)
Cariacus osceola Bangs	Citronelle, Fla.
Procyon lotor elucus Bangs	Oak Lodge, Fla.
Ursus floridanus Merriam	Key Biscayne, Fla.
Mephitis elongata Bangs	Micco, Fla.
Spilogale ambarvalis Bangs	Oak Lodge, Fla.
Lutra hudsonica vaga Bangs	Micco, Fla.
Putorius vison lutreocephalus (Harlan)	Maryland.

[1] Introduced.

Name.	Type Locality.
P. lutensis Bangs	Opposite Matanzas Inlet, Fla.
P. peninsulae Rhoads	Hudson's, Pasco Co., Fla.
Urocyon cinereoargenteus floridanus Rhoads	Tarpon Springs, Fla.
Canis ater (Richardson)	North America.
Lynx ruffus floridanus (Raf.)	Florida.
Felis concolor floridana Cory	Region north of Lake Okeechobee and east of Kissimmee River, Fla.

Didelphis virginiana pigra subsp. nov.

Type from Oak Lodge, on the east peninsula, opposite Micco, Brevard County, Florida, ♀ young adult, No. 3,500, collection of E. A. and O. Bangs. Collected, Jan. 31, 1896, by O. Bangs.

General characters. Similar to *D. virginiana typica* but smaller, with a much longer and more slender tail and smaller feet.

Color. Same as in *D. virginiana typica.* The type: under fur long white, tipped with brownish black, except on the legs and arms, where it is black throughout, and on the head, throat, and median line along the under parts, where it is white throughout; region around the legs brownish black; many long white hairs scattered over the back, sides, and under parts and loosely overlying the under fur. Tail nearly naked, black basally then grayish flesh color. Feet and hands black; toes and fingers white; ears thin and naked, black with, in life, white tips.

Flesh measurements of Didelphis virginiana pigra.

Locality.	No.	Sex and age.	Total length.	Tail vert.	Hind foot.
Fla. Oak Lodge	3,500	(Type) ♀ yg. ad.	762	330	66
Fla. Eau Gallie	7,223	♀ yg. ad.	734	304	63
Fla. Citronelle	2,492	♀ old ad.	805	349	69
Fla. Deer Creek	2,493	♂ yg. ad.	757	325	—
Fla. New Berlin	6,530	♀ ad.	875	390	69
Fla. New Berlin	6,528	♀ ad.	922	402	72
Fla. New Berlin	6,529	♀ ad.	793	340	70
Ga. St. Mary's	5,042	♀ ad.	836	318	74
Ga. St. Mary's	5,041	♀ ad.	745	313	62
Ga. Sterling	6,417	♀ old ad.	865	345	68
Ga. Barrington	6,422	♂ ad.	830	375	68
Ga. Montgomery	6,299	♀ old ad.	785	340	67

Cranial characters. Skull similar to that of *D. virginiana typica* but smaller.

Skull. The type: basal length, 97.4; zygomatic breadth, 57.2; interorbital constriction, 20; greatest constriction behind postorbital processes, 10.8; greatest length of single half of mandible, 83.

General remarks. The opposum is subject to a great range of individual variation in size, but the difference in proportion between the two races is constant.

D. virginiana pigra is extremely abundant throughout Florida and extends up the whole coastal strip of Georgia, probably passing into true *virginiana* somewhere in the Carolinas. It is very similar to true *virginiana* in general appearance, from which its smaller size, much longer and more slender tail, and smaller hind foot distinguish it. I have specimens from many places in Florida and Georgia.

Lepus (Limnolagus) palustris palustris Bachman.

Lepus palustris Bachman, Jour. Acad. nat. sci. Phila., 1837, p. 194, 336.

Type locality. Eastern South Carolina.

The large Carolina marsh rabbit is common all over eastern Georgia, including the Sea Islands, and begins to grade towards the Florida form in northern Florida. Specimens from St. Mary's, Georgia, are clearly referable to *L. palustris typicus*, having the long rostrum and narrow nasals of that form, but in their smaller size and shorter ears approach *L. paludicola*. Specimens from Gainesville, Florida, and Anastasia Island are about alike and are intermediate between the two races.

The marsh rabbit is most abundant in the salt marshes of the coast, where it occurs in great numbers, but is very common also in fresh-water swamps and marshes, and in hummocks. In marshes it makes beaten runways along which it occasionally darts with astonishing rapidity. It takes to the water readily and swims well, the ears and top of the head alone showing above water, with the fore feet splashing in front. Seeing one swimming thus for the first time no one would think that it was a rabbit.

Mr. Brown took the marsh rabbit on all the Sea Islands that he collected on. On St. Catherine's Island they were rare, and he got but one specimen, a not quite fully grown female, No. 6,173. This specimen is peculiar; the fur is very long and silky, and of a light yellowish color. It would be strange to find an island form of an animal so aquatic in its habits, and I am inclined to consider the St. Catherine's specimen abnormal, until I see more material. Mr. Brown also collected a series at each place where he stopped along the Georgia coast, and I took specimens at St. Mary's and at Gainesville and Anastasia Island, those from the last two places being not typical.

Lepus (Limnolagus) palustris paludicola (Miller and Bangs).

Lepus paludicola Miller and Bangs, Proc. Biol. soc. Wash., 1894, p. 105.

Lepus palustris paludicola Chapman, Bull. Amer. mus. nat. hist., 1894, vol. 6, p. 340.

Type locality. Fort Island, near Crystal River, Citrus County, Florida.

The Florida marsh rabbit is abundant all over southern Florida, living in marshes, swamps, and the heavier hummocks. On the savannahs of the Indian River I have seen it in greater numbers than elsewhere.

L. paludicola is easily distinguished from *L. palustris typicus* by its smaller size, shorter ear, and strong cranial differences. The two intergrade in northern Florida. Melanistic individuals are not rare. I took one at Micco that is pure blue-black all over. I have specimens from Citrus County, Oak Lodge, Micco, and Flamingo, Florida.

Lepus (Sylvilagus) sylvaticus sylvaticus Bachman.

Lepus sylvaticus Bachman, Jour. Acad. nat. sci. Phila., 1837, p. 403.

Type locality. North America. Restricted by the splitting off of subspecies to the Austral Zone of eastern North America.

The cotton tail is very common in all suitable country south to about the middle of the Florida peninsula, where it gradually shades into the smaller dark form of southern Florida. True *sylvaticus* extends south down the east peninsula without change beyond the range of *floridanus* on the main peninsula; thus at Oak Lodge on the east peninsula true *sylvaticus* is abundant, and lives around the edges of the cultivated fields and among the saw palmetto of the upper beach, while at Micco, on the main peninsula opposite, *floridanus* is the form found, it being in fact the type locality of that subspecies.

I have many specimens from a number of localities in Georgia and northern Florida.

Lepus (Sylvilagus) sylvaticus floridanus Allen.

Lepus sylvaticus floridanus Allen, Bull. Amer. mus. nat. hist., 1890–91, p. 160.

Type locality. Micco, Brevard County, Florida.

The south Florida cotton tail is found all over southern Florida, from a little north of Micco at least to Miami (except on the east peninsula). I have never been able to ascertain definitely whether it is found in the everglades or not. Miami is the southernmost point I have specimens from.

Ten fully grown topotypes (partly measured by W. L. Gibson, partly by myself) give the following average measurements: total length, 410; tail vertebrae, 47.5; hind foot, 86. Maximum size, that of largest individual in above average, No. 3,436, total length: 429; tail vertebrae, 58; hind foot, 89.

Geomys tuza tuza (Ord).

Mus tuza Ord, Guthries geog. 2d Amer. ed., 1815, vol. 2, p. 292.

Geomys pinetis Raf. Amer. mo. mag., Nov., 1817, vol. 2, no. 1, p. 45.

Geomys tuza Merriam, N. Amer. fauna, 1895, no. 8, p. 113.

Type locality. Pine Barrens near Augusta, Georgia.

The Georgia "salamander"[1] occurs in immense colonies scattered through the pine woods of eastern Georgia, from the Savannah River south at least to Sterling and west to western Georgia, where it begins to merge into *G. tuza mobilensis*.[2]

[1] I use the name "salamander" for all the species of Geomys of the *tuza* group, not only on account of its appropriateness, but also because it is the only name used for them in the region in which they occur.

[2] *Geomys tuza mobilensis* Merriam, type locality Mobile Bay, Alabama, does not properly come within the scope of the present paper. It is a small, dark form with wide frontals and a sagittal crest. It occupies western Georgia, western Florida, and the coast region of Alabama.

When Dr. Merriam wrote his monographic revision of the pocket gophers (Geomyidae), he had comparatively few specimens from Florida and Georgia. I have made particular efforts to fill this want of material and now have a series of nearly 300 specimens of Geomys from eastern Georgia and Florida. This ample material has enabled me to distinguish three additional forms from this region.

None of the forms of the *tuza* group show any tendency to melanism, so common among some of the other species of Geomys. In my large series from Georgia and Florida there is not a single individual that is even slightly melanistic.

Mr. Brown collected twenty-six specimens of *G. tuza tuza* at Hursman's Lake (Savannah River); forty-three at Adam; four at Pinetucky; eleven at Doctortown; and twenty at Sterling, Georgia.

He saw colonies along the line of the Georgia Central R. R. between Augusta and Savannah at Allen, Bennocks, McBean, Thomas, Munnerlyn, Perkins Station, Lawtonville, Millen, Scarboro, Rocky Ford, Ogeechee, Dover, Cameron, Halcyon Dale, Guyton, Marlow, and Maldrim, the last colony being about fifty miles from Savannah.

Geomys floridanus floridanus (Aud. and Bach.).

Pseudostoma floridana Audubon and Bachman, Quad. N. Amer., 1854, vol. 3, p. 242–245.

Geomys tuza floridanus Merriam, N. Amer. fauna, 1895, no. 8, p. 115.

Type locality. St. Augustine, Florida.

The Florida "salamander" ranges from the Florida side of the St. Mary's River south through all eastern Florida to Eau Gallie. In central Florida, at Orlando, Gainesville, etc., it begins to shade into the light colored form which occupies the western part of the peninsula. The large colony at Eau Gallie, that occupies the extensive white sand ridges about the town, is, I believe, the most southern colony of any size, although I have heard of its hills being seen even south of Micco.

Apparently *G. floridanus typicus* does not intergrade with *G. tuza typicus* anywhere, and I fancy the big Okefinokee Swamp, drained on the east by the St. Mary's River and on the west by the Suwannee River, makes of peninsular Florida an island so far as

Geomys is concerned. In Florida and Georgia one seldom finds Geomys hills anywhere but on the highest and dryest land, although once at Carterville, while walking along the edge of the marsh, I found three or four fresh salamander hills thrown up in the damp, black earth; on digging down through one, I came to the runway only a few inches below ground and half full of water. I placed a trap in the run and coming back in a short time had the salamander, a solitary old male living at least two miles from the nearest colony.

G. floridanus can be distinguished from *G. tuza* by its larger size, bigger hands and feet, duller coloring, and the presence of a white spot under the chin. While the cranial characters that separate the two species are well marked, *G. floridanus* having much larger audital bullae, wider ascending branches of maxilla, and narrower nasals, the old males of *G. floridanus* have a much greater tendency to develop a sagittal crest than have the old males of *G. tuza.*[1]

In February, 1897, I took thirty-one specimens of *G. floridanus* at Carterville, fourteen miles south of St. Augustine, and in March of the same year eleven at Eau Gallie. In April, 1896, I caught three at Rose Bluff on the Florida side of the St. Mary's River, and Mr. Brown took a series of 101 at New Berlin, Florida, on the St. John's River. Those from the last two places are a little brighter in color than the Carterville or Eau Gallie specimens, but in proportions and cranial characters show no approach to *G. tuza.*

Geomys floridanus austrinus subsp. nov.

Type from Belleair, Hillsboro County, Florida, ♂ adult, No. 6,983, collection of E. A. and O. Bangs. Collected, Aug. 3, 1897, by W. S. Dickinson.

General characters. Size and proportions of *G. floridanus typicus.* Color above much paler and more tawny; much more white on under parts. Skull slightly different.

Color. Upper parts: pale cinnamon and tawny shading on lower sides to ochraceous buff. In very fresh pelage sometimes slightly darker and somewhat shaded with drab. No darker dorsal stripe, though sometimes this is faintly indicated in the fresh pelage.

[1] Dr. Merriam probably did not have any very old male skulls of *G. floridanus* as he does not mention the sagittal crest of this form. In the large number of skulls of *G. tuza* that I have examined in a few of the oldest males the lateral crests have come entirely together so as to form a distinct sagittal crest. This condition is usual in the old males of *G. floridanus.*

Under parts: pale Isabella color to dull white; large irregular white markings under chin, on under side of legs and arms, on belly and along lower sides; hands, feet, and tail nearly naked, the scant hairs whitish.

Cranial characters. Skull similar to that of *G. floridanus typicus*, but slightly narrower with less spread to zygoma, and with rather shorter straighter rostrum.

Measurements. The type ♂ adult: total length, 303.5; tail vertebrae, 93; hind foot, 36.8. An adult ♀ from Tarpon Springs, No. 69,473, coll. U. S. dep. agric.: total length, 251.5; tail vertebrae, 78.8; hind foot, 31.8.

Remarks. *G. floridanus austrinus* is the form Dr. Merriam referred to when he said under *G. floridanus*, "specimens from further south on the peninsula are somewhat different." Dr. Merriam has told me that he came very near giving the form a name, which it certainly deserves. *G. austrinus* has an extensive range covering the western part of the Florida peninsula. All through central Florida, where salamanders are so very numerous, an intermediate form between *G. floridanus typicus* and *G. austrinus* occurs. Specimens from Orlando and Gainesville are very good intermediates. *G. floridanus typicus* occupies the eastern side of the peninsula and *G. floridanus austrinus* the Gulf side.

G. austrinus can always be distinguished from *G. floridanus typicus* by its different coloring, being paler and redder above and much more extensively marked with white below.

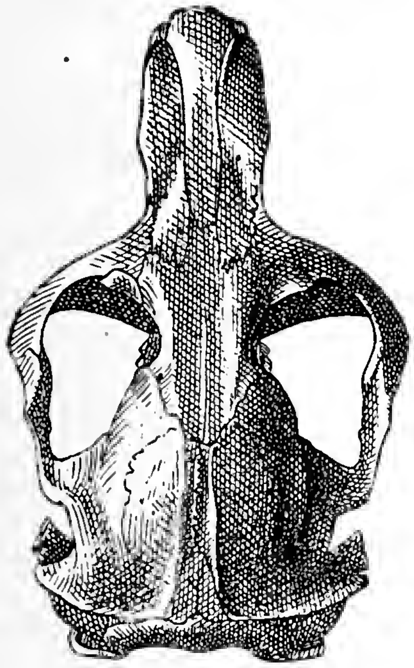
Geomys colonus sp. nov.

Type from St. Mary's, Georgia, ♂ old adult, No. 5,001, collection of E. A. and O. Bangs. Collected, March 21, 1896, by O. Bangs.

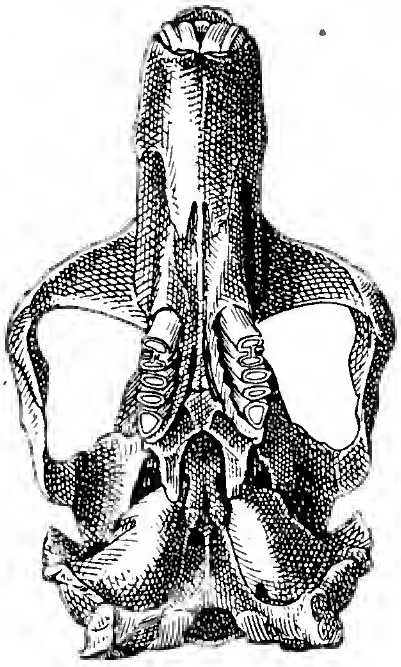
General characters. Size of *G. tuza;* color much darker (being darker than *G. floridanus* and even darker than *G. mobilensis*). Skull different.

Color. Upper parts between seal-brown and sepia, slightly washed along lower sides with russet and cinnamon; under parts: hairs plumbeous at base tipped with cinnamon, shading into fawn color about vent; no white marking under chin; hairs of feet, hands, and about wrists whitish.

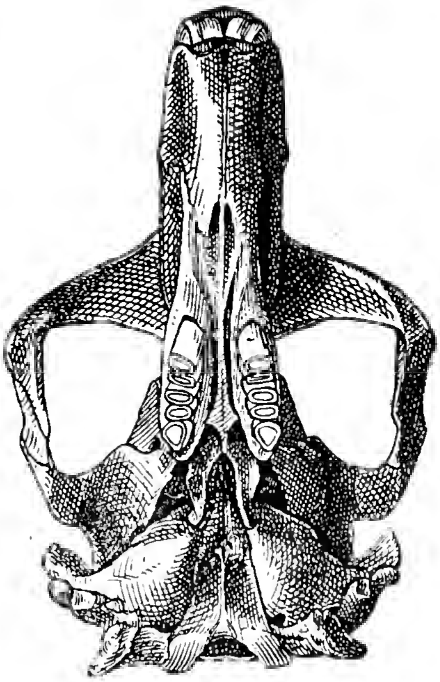
Cranial characters. The skull of *G. colonus* differs from that of either *tuza* or *floridanus* in having a very wide palate, between molar-form teeth and a wide round palatal notch. The nasals are short and strap shaped, not hour-glass shaped (as in *tuza*). The audital bullae are larger (nearly as large as in *floridanus*). The interparietal is notched, much as in *mobilensis*. Like *tuza* the old males usually do not develop a sagittal crest, and the ascending branches of premaxilla are narrow.



Geomys colonus.
Type, ♂ adult.



Geomys colonus.
Type, ♂ adult.



Geomys tuza.
♂ old adult.

Measurements. The type, ♂ old adult: total length, 280; tail vertebrae, 89; hind foot, 34. No. 5,002, ♂ old adult: total length, 288; tail vertebrae, 100; hind foot, 36. Average of six adult females: total length, 250.33; tail vertebrae, 77.83; hind foot, 31.75.

General remarks. When I was at St. Mary's, Georgia, in the spring of 1896, I trapped ten Geomys on the Arnot Plantation, about four miles west of the city. The colony from which I took these extends for many miles through the pine woods, probably reaching north to the Satilla River. This series shows a form very different from either *G. tuza* or *G. floridanus* and in no way intermediate between them, although, occupying the southeastern corner of Georgia, it lies geographically directly between the ranges of these two species. It is in all probability an isolated, colonial species with a very restricted range. At Rose Bluff, on the opposite side of the

St. Mary's River, I took *G. floridanus typicus*, while Sterling, Georgia, is the nearest point north of St. Mary's, Georgia, at which Mr. Brown got *G. tuza*. What happens to the westward I am unable to say.

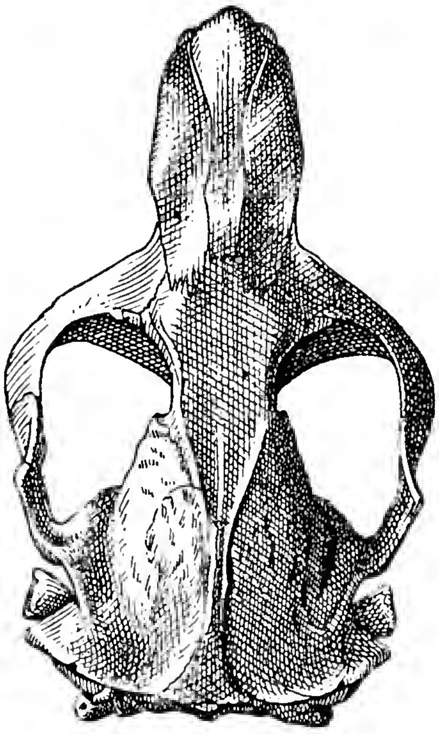
The very dark color of *G. colonus* will at once distinguish it from either *tuza* or *floridanus*, as do also its constant cranial characters.

Geomys cumberlandius sp. nov.

Type from the "Stafford Place," Cumberland Island, Georgia, ♂ old adult, No. 5,015, collection of E. A. and O. Bangs. Collected, April 17, 1896, by O. Bangs.

General characters. Size very large; tail long; color, russet, a darker dorsal stripe; skull large, the zygoma differently shaped from that of others of the *tuza* group.

Color. Upper parts: bright cinnamon — russet darkening along middle back into a well-defined darker dorsal stripe; under parts: hairs plumbeous at base and cinnamon at tips; irregular white markings under chin and about wrists; hairs of hands and feet grayish white.



Geomys cumberlandius.
Type, ♂ adult.

Cranial characters. Skull large, nasals long and slender; ascending arms of maxilla narrower than in *G. floridanus;* zygoma different from those of any of the *tuza* group, being extended farther backward and meeting the skull posteriorly without the decided angle seen in *tuza*, *floridanus*, etc.; the males develop a sagittal crest with age.

Measurements. The type, ♂ old adult: total length, 318; tail vertebrae, 107; hind foot, 36. Largest old male in series, No. 5,017: total length, 324; tail vertebrae, 114; hind foot, 35.5. Largest old female, No. 5,024: total length, 283; tail vertebrae, 96; hind foot, 34.

General remarks. Cumberland Island is the only one of the Sea Islands on which a Geomys occurs. In the spring of 1896 I heard that salamanders were found on Cumberland Island and, having secured permission to trap there, went over and caught thirteen salamanders, April 17–18. The colony was centered in some old fields on the Stafford Place, but the hills straggled off through the pine woods for miles. Mr. Brown, when he visited the island a year afterwards, did most of his trapping at the northern end and took there thirteen additional specimens of *G. cumberlandius*.

AVERAGE FLESH MEASUREMENTS OF FULLY ADULT SPECIMENS OF GEOMYS FROM GEORGIA AND FLORIDA.

NAME.	LOCALITY.	No. in aver.	Sex.	Total length.	Tail vert.	Hind foot.
G. tuza	Ga. Adam	18	♂	281.	92.	33.66
G. tuza	Ga. Adam	17	♀	245.76	80.82	30.
G. tuza	Ga. Hursman's Lake	7	♂	273.42	91 85	34.57
G. tuza	Ga. Hursman's Lake	7	♀	248.85	83.28	31.57
G. tuza	Ga. Sterling	5	♂	267.8	85.4	33.2
G. tuza	Ga. Sterling	3	♀	239.33	77.33	32.66
G. floridanus	Fla. Rose Bluff (St. Mary's R.)	1	♂	271.	88.	33.
G. floridanus	Fla. Rose Bluff (St. Mary's R.)	1	♀	268.	82.	33.
G. floridanus	Fla. Carterville	9	♂	280.88	88.55	34.72
G. floridanus	Fla. Carterville	7	♀	257.	78.14	33.35
G. floridanus	Fla. Eau Gallie	6	♂	290.	92.66	36 41
G. floridanus	Fla. Eau Gallie	4	♀	258.75	86.6	34.
G. floridanus	Fla. New Berlin	23	♂	279.	89.2	34.13
G. floridanus	Fla. New Berlin	20	♀	251.1	82.6	31.6
G. floridanus austrinus	Fla. Belleair, Hillsboro Co.	2	♂	297.81	94.61	34.92
G. floridanus austrinus	Fla. Tarpon Springs	2	♂	284.22	88.9	35.56
G. floridanus austrinus	Fla. Tarpon Springs	1	♀	251.46	78.74	31.75
G. colonus	Ga. St. Mary's	2	♂	284.	94.5	35.
G. colonus	Ga. St. Mary's	6	♀	250 33	77.83	31.75
G. cumberlandius	Ga. Cumberland I.	12	♂	305.92	102.83	35.3
G. cumberlandius	Ga. Cumberland I.	6	♀	263.66	90.5	32.5

G. cumberlandius is apparently nearer to *G. floridanus* than to *G. tuza*, with which latter it hardly needs comparison, its very much larger size and longer tail at once distinguishing it. From *G. floridanus* it can be separated by its brighter coloring, larger size, smaller audital bullae, narrower ascending arms of maxilla, and differently shaped zygoma.

Microtus (Pitymys) pinetorum (Leconte).

Psammomys pinetorum Leconte, Ann. N. Y. lyc. nat. hist., 1829, vol. 3, p. 132.

Microtus pinetorum Miller, N. Amer. fauna, 1896, no. 12, p. 60.

Type locality. "Pine forests of Georgia."

I have never taken the pine mouse in Florida or in Georgia, and Mr. Brown had but little better success, taking a single specimen, a fine adult female, at Montgomery, Georgia. Mr. Brown saw very little of the work of this subterranean species in Georgia. I never found a runway at St. Mary's that I felt sure belonged to this animal; it is, however, hard always to distinguish its work from that of the mole. The title of the pine mouse to a place in a list of Florida mammals still rests on Audubon and Bachman's record.

Microtus (Neofiber) alleni (True).

Neofiber alleni True, Science, 1884, vol. 4, no. 75, p. 34.

Microtus alleni Miller, N. Amer. fauna, 1896, no. 12, p. 69.

Type locality. Georgiana, Merrits Island, Brevard Co., Florida.

The singular water rat of Florida occurs in great numbers on the salt savannahs of the Indian River, living in underground runways, often full of water, and around the edges of the pools of salt water. It makes its breeding nest in an old stump, at the base of a black mango, or in a clump of bushes. At Oak Lodge I trapped seven. It was not common there at the time of my visit, owing to very heavy floods of about a year before, which according to Mr. Latham, who had studied the rats carefully for a long time, had almost exterminated it. The exact limits of the range of *M. alleni* I have never been able to determine. It apparently does not occur on the west coast of Florida, and I am certain it is not found so far north as Matanzas, probably not north of Indian River.

In the fresh-water ponds and marshes of interior Florida, in many places, *M. alleni* is common. Mr. Brownell took it as far south as Enterprise on the head of the St. John's River. At a large rather deep pond-like branch of the wet prairie near Gainesville, called Bidden's Arm, they were very abundant, and in early April, when I was there, were busily engaged in making large nests in the water bushes, Cephalanthus. The nests rested on the water, and had two entrances from below; they were built of water-lily stems, reeds, grass, and the green leaves of Sagittaria and Pontideria. The water below the nests was from a foot to two and a half feet deep. By carefully removing the tops of the nests, placing a steel trap on the little platform between the two entrances, and then replacing the roof, I caught fourteen rats in a few days; many others left a foot apiece behind them, but escaped. Several times when I had just taken the top off a nest, I saw the rat dart like a flash up one hole and down the other. At other times I saw them at work on their nests, generally pushing material up from inside, and once one came out and arranged some leaves on top of his house, working very fast with his fore feet; while I watched he suddenly vanished, and I could not tell whether he slipped off into the water or went down into his nest. I could not account for not seeing them swimming about or gathering material, as they evidently work in the day time, and were often engaged in house building while I was watching them.

Specimens from the fresh water of interior Florida are rather different from those from the salt savannahs of Indian River, but the differences are not enough to warrant dividing the species into two races. The interior form has blacker upper and whiter under parts, and a less hairy tail, than *M. alleni typicus*, which is colored more like a muskrat.

The discovery of Neofiber in Florida was one of the many surprises of modern mammalogy, but, to one familiar with it in life, aware of its great abundance, and the ease with which it can be trapped in the simple, old-fashioned steel trap, and looking at a pond studded with its conspicuous nests, it seems the strangest event in the history of American zoology, that no naturalist out of the multitude that have visited Florida since Bartram's time should have taken it, until, in 1884, it fell to the lot of my old friend Fritz Ulrich to get the type specimen which Dr. Wittfeld sent to Mr. True.

Neotoma floridana floridana (Ord).

Mus floridana Ord, Bull. Soc. philomath., Dec., 1818, p. 181–182.

Neotoma floridana Say and Ord, Jour. Acad. nat. sci. Phila., 1825, vol. 4, p. 352, plate.

Type locality. St. John's River, Florida. (Probably in the vicinity of Jacksonville.)

The Florida wood rat ranges over eastern Georgia and extends south well down the Florida peninsula. Florida specimens from north to a little south of the type locality are, however, not typical, being larger, redder, and not so dark in the dorsal region, and having tails not so hairy and less sharply bicolored than in true *N. floridana*. They appear to be perfect intermediates between true *N. floridana* and the large red form that occupies the lower Mississippi Valley, which I therefore describe here.

In Georgia and northeastern Florida the wood rat is common and is found in most hummocks and swamps, where it lives in hollow trees, holes in the ground, or in large nests that it makes in many different places, such as old buildings, along the banks of streams, at the foot of an old tree or stump, or under the roots of an upturned tree, and very rarely in the branches of a tree, like a squirrel's nest.

In peninsular Florida Neotoma becomes more local, but lives in large colonies in the places where it is found. Here its favorite haunt is the dense tangled growth along a stream in the heaviest cabbage palmetto hummock. In such a place it builds many nests, both on the ground and in the palmetto trees.

The wood rat can be trapped with ease, both in steel traps set in its path, or at the entrance to its home, and in the big Schuyler trap baited with meat or rolled oats.

The average measurements of nine fully adult males from New Berlin, Duval County, Florida, are: total length, 397.88; tail vertebrae, 185.13; hind foot, 37.44. Of six fully adult females, from the same locality: total length, 379.5; tail vertebrae, 173.66; hind foot, 36.83. Of three fully adult males from Micco, Florida: total length, 423.33; tail vertebrae, 191.33; hind foot, 39.66.

Mr. Brown collected a series of thirty-one fine specimens at New Berlin, Florida, on the St. John's River, about eight miles from Jacksonville, that can be considered topotypes. He also got specimens at Hursman's Lake, Barrington, and Montgomery, Georgia, and I took a large series at St. Mary's, Georgia. Of the form that occurs in peninsular Florida, that is intermediate between *N. floridana typica* and *N. floridana rubida*, I took eight at Micco, one at Oak Lodge, and fourteen at Gainesville, Florida, and have specimens from Citrus County, collected by F. L. Small.

Neotoma floridana rubida subsp. nov.

Type from Gibson, Louisiana, ♂ old adult No. 2,872, collection of E. A. and O. Bangs. Collected, April 4, 1895, by F. L. Small.

General characters. Larger than *N. floridana typica*; hind foot larger; color much redder (less grayish and yellowish) with fewer black hairs in back. Tail less hairy and not so distinctly bicolored. No cranial differences, though the skull of *N. floridana rubida* is rather larger than that of *N. floridana typica.*

Color. Adult, upper parts, dark cinnamon-russet, clearest on cheeks and sides, and somewhat intermixed with black hairs on top of head and along back. Under parts yellowish white, the hairs plumbeous at base only along lower sides; whiskers mostly black, a few colorless; feet and hands white; ears dusky; tail rather sparsely haired and indistinctly bicolored, reddish dusky above, slightly grayer below.

Measurements. The type ♂ old adult: total length, 403; tail vertebrae, 185; hind foot, 42. No. 2,871, old adult ♂ topotype: total length, 422; tail vertebrae, 200; hind foot, 44. No. 2,873, old adult ♀ topotype: total length, 425; tail vertebrae, 212; hind foot, 40.

General remarks. Neotoma floridana rubida replaces true *N. floridana* in the lower Mississippi Valley and probably the whole of western Florida. Specimens from all parts of the Florida peninsula are intermediate between the two forms, both in color and proportions, though they are usually rather nearer to *N. rubida* than to *N. floridana typica.*

In the spring of 1895 Mr. F. L. Small collected a large series of *N. rubida* from several localities in southern Louisiana, but, unfortunately, all but four of them were burned in a fire that destroyed the house in which he lived.

I have two specimens from Hancock County, Mississippi, which are exactly like the Louisiana ones. Through the kindness of Dr

Merriam I have examined the series of wood rats of this form, from many points in the lower Mississippi Valley, in the Department of agriculture collection; this series shows only a small range of color variation among the adults, which can be distinguished from the smaller, grayish, and yellowish true *N. floridana*.

Reithrodontomys lecontii lecontii (Aud. and Bach.).

Mus lecontii Aud. and Bach., Jour. Acad. nat. sci. Phila., 1842, vol. 8, p. 307.

Reithrodontomys lecontii Allen, Bull. Amer. mus. nat. hist., 1895, vol. 7, p. 116.

Type locality. Georgia (probably the Leconte plantation near Riceboro).

The little harvest mouse is found locally throughout eastern Georgia and northern Florida. Mr. Brown took only one example on his trip, an adult female that he caught at Pinetucky. I have taken it myself only at Gainesville, Florida. Here, in a large stretch of old fields partly grown up to hickory and deciduous oaks, and where the ground was covered in places by bunches of broom grass, I found it very common. I trapped a number, but hot weather and ants destroyed all but eight. These specimens are wholly referable to true *R. lecontii*, being neither darker in color nor smaller than examples of that form from Georgia or North Carolina. The four larger adults range in size between No. 7,055, total length, 127; tail vertebrae, 60; hind foot, 15; and No. 7,058, total length, 131; tail vertebrae, 58; hind foot, 15.

Reithrodontomys lecontii dickinsoni (Rhoads).

Reithrodontomys humilis dickinsoni Rhoads, Amer. nat., June, 1895, p. 589.

Type locality. Willow Oak, Pasco County, Florida.

It is with much hesitation that I include this doubtful Florida race of the little harvest mouse. It is still known only by the two specimens Mr. Rhoads had at the time he named the subspecies. Both these are now before me, having been kindly lent by Mr. Rhoads. The type is certainly of a very dark sooty color and can not be matched exactly in this respect by any I have seen from elsewhere, but the specimen from Tarpon Springs, can be easily matched in color by many skins from both Raleigh, N. C., and Gainesville, Fla.

The two specimens measure as follows: —

No. 2,240, the type, Rhoads Coll., ♀ adult: total length, 118; tail vertebrae, 56; hind foot, 15; No. 1,505, Rhoads Coll., from Tarpon Springs, Florida, ♀ young adult: total length, 116.84; tail vertebrae 49.53; hind foot, 13.97. These measurements are not particularly small, but are about the same as the average of young adults of true *R. lecontii* from Georgia, Florida, or North Carolina.[1] The ears of both the type and the Tarpon Springs specimen, while not measured in the flesh, seem smaller than those of more northern examples, but this may be due to drying in making the skin.

It is my opinion that Reithrodontomys only pushes its way into southwestern Florida in country not unlike that of the upper Austral zone; that is in places where hickory, deciduous oaks, and broom grass occur, imparting to the landscape a decidedly Carolinian aspect. Stretches of such ground are not uncommon in central and southwestern Florida. All the trapping I have done in eastern Florida has failed to secure Reithrodontomys there, and it must be remembered that Reithrodontomys is easily taken with the modern devices for trapping small mammals. It therefore seems to me very doubtful if the little harvest mouse living in south western Florida has become even subspecifically differentiated from true *R. lecontii.* More specimens are needed from the region around the type locality, however, before this can be proved, and for the present I include *R. lecontii dickinsoni* as a very doubtful subspecies.

Oryzomys palustris palustris (Harlan).

Mus palustris Harlan, Amer. jour. sci. and arts, 1837, ser. 1 vol. 31, p. 385.

Arvicola oryzivora Aud. and Bach., Quad. N. Amer., 1853, vol. 3, p. 214.

Hesperomys (*Oryzomys*) *palustris* Baird, Mam. N. Amer., 1857, p. 482.

[1] See Allen's list of measurements in "On the species of the genus Reithrodontomys" Bull. Amer. mus. nat. hist., 1895, p. 141.

Type locality. South Carolina (probably in the vicinity of Charleston).[1]

The rice-field mouse is common in all suitable places in eastern Georgia, shading southward gradually towards *Oryzomys palustris natator*. Thus, specimens from Ossabaw Island are slightly larger than those from North Carolina, but differ little otherwise; specimens from St. Mary's are of the size of those from Ossabaw, but begin to approach *O. natator* in color; while specimens from New Berlin and Burnside Beach, Florida, are perhaps nearer subspecies *natator* than true *palustris*, though good intermediates.

The rice-field mouse, while perhaps preferring fresh and salt-marshes as its abode, is by no means confined to such places. I have caught it in dry old fields, heavy swamps, and hummocks, and even on sand hills. It swims well and is common in the great salt-water marshes of the St. Mary's River, where it makes its nests in the grass as Bachman describes.

I have specimens from Hursman's Lake, Ossabaw Island, Cumberland Island, and St. Mary's, Georgia, and New Berlin and Burnside Beach, Florida. (Those from the last two places are not typical.)

ORYZOMYS PALUSTRIS NATATOR Chapman.

Oryzomys palustris natator Chapman, Bull. Amer. mus. nat. hist., 1893, vol. 4, p. 43–46.

Type locality. Gainesville, Florida.

Chapman's rice-field mouse ranges over northern, western, and middle Florida, south on the east side of the peninsula to about Oak Lodge and on the west certainly to Citrus County, the southern extremity of the peninsula being occupied by *O. palustris coloratus*, described below. *O. palustris natator* is easily distinguished from *O. palustris typicus*, being of larger size with longer tail, heavier pelage, and richer coloring. The skull of *O. palustris natator* besides its larger size shows strong characters when compared with that of *O. palustris typicus*. In *O. palustris natator* the upturned

[1] The specimen in the collection of the Academy of natural sciences, which Harlan used, was evidently without a skull, and was supposed to have come from Fastland, near Salem, New Jersey. If this locality was correct, the specimen in question was probably not an *Oryzomys* at all. Anyway Harlan used the skull of Dr. Bachman's South Carolina specimen (as positively stated by Bachman himself) in drawing up his description; and as the skull was of course the important factor in determining the new species, it seems that South Carolina must unquestionably be regarded as the type locality of *Oryzomys palustris*. Mr. Oldfield Thomas writes that the type of *Arvicola oryzivora* is extant in the British Museum.

bony ridge of outside frontals is much larger and more conspicuous, even in the young, than in *O. palustris typicus;* the nasals and rostrum are longer and the brain case proportionately narrower, giving the skull a long, narrow, and less rounded appearance; audital bullae are larger, deeper, and less flattened than in *O. palustris typicus.* These cranial characters, though marked in the extreme forms, intergrade, as do the external characters.

Chapman's rice-field mouse is a common animal, living for the most part in both fresh and salt marshes, and in swamps, though often found in drier situations.

I have specimens from Anastasia Island, Carterville, Gainesville, Enterprise, Oak Lodge, and Crystal River, Florida.

ORYZOMYS PALUSTRIS COLORATUS[1] subsp. nov.

Type from Cape Sable, Florida, ♂ adult, No. 4,470, collection of E. A. and O. Bangs. Collected, April 17, 1895, by C. L. Brownell.

General characters. Size larger than *O. palustris natator;* tail large and coarse; color about a lively reddish brown.

Color. Upper parts, rich reddish brown, about between hazel and ferruginous, most intense on rump and somewhat paler and yellower on sides and cheeks; a thick sprinkling of brownish black hairs along back and on head; under parts, white, often suffused with cinnamon, the hairs plumbeous at base; tail bicolored towards base, unicolor towards tip, dusky, dull whitish below towards base; feet and hands whitish; ears reddish brown inside, more dusky outside.

Cranial characters. Skull similar to that of *O. palustris natator*, but slightly larger.

Measurements. The type ♂ adult: total length, 301.6; tail vertebrae, 150; hind foot, 35. Average of three adult ♂'s from Cape Sable: total length, 301.06; tail vertebrae, 148.2; hind foot, 34.93. Average of six adults, males and females, from Flamingo, Florida: total length, 303.86; tail vertebrae, 152.5; hind foot, 34.7. The largest example in above averages is No. 4,460, ♂ old adult from Flamingo, Florida, total length, 309.8; tail vertebrae 160.4; hind foot, 33.4.

General remarks. In March and April, 1895, Mr. C. L. Brownell collected eleven specimens of this large, highly colored

[1] Coloratus = imbrowned.

form at Flamingo and twelve at Cape Sable. In this series there are many young of various ages, and these show the difference in color that separates *O. coloratus* from *O. natator* quite as strongly as do the adults.

Oryzomys palustris coloratus is the extreme form of the *palustris* series, both in color and size. It occupies only the southern, tropical part of the Florida peninsula. A series of Oryzomys from Oak Lodge, while referable to *natator*, shows an approach to the more southern form, both in size and color.

AVERAGE MEASUREMENTS OF OLD ADULT SPECIMENS OF ORYZOMYS.

NAME.	LOCALITY.	No. in aver.	Total length.	Tail vert.	Hind foot.
O. palustris	N. C., Raleigh.	3	235.	114.33	28.33
O. palustris	Ga., Ossabaw Isl.	7	255.58	116.14	30.14
O. palustris	Ga., St. Mary's	7	252.	117.	29.57
O. palustris	Fla., Burnside Beach.	4	266.25	122.75	29.5
O. palustris	La., Burbridge.	9	246.22	124.	29.72
O. texensis [1]	Tex., Rockport.	7	264.	132.	30.
O. natator	Fla., Gainesville.	4	287.75	149.25	34.12
O. natator	Fla., Oak Lodge.	6	293.66	144.66	33.66
O. coloratus	Fla., Cape Sable.	3	301.06	148.2	34.93
O. coloratus	Fla., Flamingo.	6	303.86	152.5	34.7

SIGMODON HISPIDUS HISPIDUS Say and Ord.

Sigmodon hispidus Say and Ord, Jour. acad. nat. sci. Phila., 1825, vol. 4, p. 354.

Type locality. St. John's River, Florida (probably in the vicinity of Jacksonville).[2]

The brown northern form of the cotton rat has a wide distribution extending in its extreme form from North Carolina south to eastern Georgia and west to Louisiana. Specimens from St. Mary's and Cumberland Island, Georgia, and the region about the type

[1] Measurements from Allen, Bull. Amer. mus. nat. hist., 1894, vol. 6, p. 177.

[2] The cotton rat was named from as unfortunate a region, from a systematic point of view, as it is possible to choose, as specimens from the St. John's River, Fla., are exactly intermediate between the brown northern form and the dark-colored form of eastern Florida. As Mr. Chapman has named the dark form from southeastern Florida (subspecies *littoralis*), I shall therefore be understood to mean the brown northern form when I speak of subspecies *hispidus*.

locality (New Berlin and Burnside Beach, Florida) agree very well among themselves, and are perfect intergrades between the brown form and *S. littoralis* of southeastern Florida. The fine series of thirty-five specimens collected by Mr. Brown at New Berlin and Burnside Beach, that may be considered topotypes, is of great interest. Skins can be picked out that will exactly match extremes of either race, but the general trend of the series is so perfectly intermediate between the two extreme races that it would be impossible to decide which form should best receive subspecific separation. Specimens from central Florida (Gainesville, etc.) are nearer the brown northern form, but begin to approach subspecies *S. spadicipygus*.

The cotton rat is the most abundant small mammal of the region it occupies, and lives everywhere except in the denser swamps and hummocks, though preferring open country. It often occurs in enormous numbers in the more favorable places. In the fields and patches of blackberry vines around the big wet prairie near Gainesville, Florida, cotton rats were as numerous as I ever saw any other small mammal.

The cotton rat is subject to a considerable range of color variation locally, the difference being much the same as seen in *Microtus pennsylvanicus* in the north. On Ossabaw Island there is a very pallid race, with a tendency to have pale buff or cinnamon under parts. On Cumberland Island the rats have a tendency to very dark-colored under parts, and so on. When I was trapping subspecies *S. littoralis* at the type locality, I could always distinguish examples taken along the upper beach from those I caught in the savannahs.[1] Mr. Brown and I found the cotton rat at all places we have, either of us, visited, except St. Catherine's Island and Skiddaway Island where the species is unknown.

I have specimens as follows: Georgia: Hursman's Lake, thirty-one; Pinetucky, twelve; Ossabaw Island, forty-eight; Montgomery, sixty; Barrington, eight; Sterling, one; Cumberland Island, eighteen; St. Mary's, six. Florida: New Berlin, thirty-two; Burnside Beach, three (those from the last four places are intermediate between *hispidus* and *littoralis*); Gainesville, fourteen; Crystal River, Citrus County, two (those from last two places approach subspecies *spadicipygus*, though much nearer *hispidus*).

[1] Mr. Chapman says he could separate the two series he caught on Corpus Christi Island, one on the marshes, the other in the chapparel.

SIGMODON HISPIDUS LITTORALIS Chapman.

Sigmodon hispidus littoralis Chapman, Bull. Amer. mus. nat. hist., June, 1889, vol. 2, p. 118.

Type locality. Oak Lodge, east peninsula, opposite Micco, Brevard County, Florida.

Chapman's cotton rat is a dark-colored form peculiar to the east coast of Florida, its range extending from about Miami north to northeastern Florida where it intergrades with *S. hispidus hispidus*. Its range coincides closely with that of *Geomys floridanus floridanus*, but extends farther to the south. All through central and western Florida it is replaced by *S. hispidus hispidus* and in extreme southern Florida by still another form, described below as subspecies *S. spadicipygus*.

It is extremely abundant and a great nuisance when one is trying to trap other animals, as it lives everywhere except in the denser hummocks. *S. hispidus littoralis* differs in color widely from *S. hispidus hispidus*, being nearly black above, very finely lined, gray or yellowish gray, in marked contrast to the brown upper parts of *S. hispidus hispidus* coarsely and irregularly varied with brownish black. The under parts of the two are quite as different, *S. littoralis* being dull whitish below rarely washed with dull buff; *S. hispidus* is much browner below, often strongly suffused with buff.

I have specimens as follows: Florida: Miami, two; Jupiter Inlet, two; Oak Lodge, one hundred and eight; Micco, six; Eau Gallie, one; Point Matanzas, three; Carterville, four; Anastasia Island, fourteen.

SIGMODON HISPIDUS SPADICIPYGUS subsp. nov.

Type from Cape Sable, Florida, ♀ old adult, No. 4,477, collection of E. A. and O. Bangs. Collected, April 18, 1895, by C. L. Brownell.

General characters. Size smaller than *S. hispidus hispidus* or *S. hispidus littoralis.* Color different from either, the rump much more rufous; skull smaller, molar teeth smaller.

Color. Upper parts finely mixed owing to the annulation of the hairs, brown (raw sienna to cinnamon), and black, the brown color predominating on face, cheeks, and sides; rump strong cinnamon-rufous, in marked contrast to rest of upper parts. Under parts dull brownish white, usually suffused with dull cinnamon; tail indistinctly bicolored, black above, dusky gray below; feet and hands dusky, sometimes slightly brownish; ears sparsely haired, dusky.

Cranial characters. Skull similar to that of *S. hispidus hispidus* or *S. hispidus littoralis* but decidedly smaller, molar teeth smaller.

Measurements. The type, ♀ old adult: total length, 263.5; tail vertebrae, 98.7; hind foot, 30.4; average of the six largest adults, males and females, from Flamingo, Florida: total length, 267.31; tail vertebrae, 100.4; hind foot, 31.33. Largest specimen, ♂ old adult, No. 4,486 from Flamingo: total length, 279.4; tail vertebrae, 108.1; hind foot, 31.9. (*S. hispidus hispidus* and *S. hispidus littoralis* are of about the same size, the latter perhaps averaging a trifle the larger, and old adults often exceed 300 m. in total length. The largest specimen measured is No. 3,351, ♀ old adult, topotype of *S. hispidus littoralis*, total length, 330; tail vertebrae, 113; hind foot, 34.)

General remarks. *S. hispidus spadicipygus* is the form Mr. Chapman mentioned in his list of the land mammals of Florida, where he pointed out some of its characters, but considered it not worthy of separation. His specimens were from Flamingo. It seems to me a too strongly marked race to remain without name.

Mr. C. L. Brownell collected for me, in the spring of 1895, seven specimens at Cape Sable and thirteen at Flamingo.

S. hispidus spadicipygus is confined to the extreme tropical point of south Florida, ranging on the east north nearly to Miami, where it passes rather abruptly into *S. hispidus littoralis*, and on the west probably to about Tampa Bay, where it shades more gradually into *S. hispidus hispidus*. It differs from *S. littoralis* in being much browner and less gray and in the cinnamon-rufous color of the rump, but agrees with that form in the fine markings of the upper parts. From *S. hispidus hispidus* it differs in much finer markings of upper parts with greater predominance of black, in the color of the rump, and in having a less distinctly bicolored tail and darker feet and hands. From both it differs in being much smaller.

Peromyscus floridanus (Chapman).

Hesperomys floridanus Chapman, Bull. Amer. mus. nat. hist., 1887, vol. 2, p. 117. (Young.)

Hesperomys macropus Merriam, N. Amer. fauna, 1890, no. 4, p. 53. (Adult from Lake Worth, Florida.)

Peromyscus floridanus Bangs, Proc. Biol. soc. Wash., 1896, vol. 10, p. 122.

Type locality. Gainesville, Florida.

The big-eared Florida deer-mouse is common in all suitable places throughout peninsular Florida, though its exact range is unknown. It lives only in the higher sandy ridges, where there is plenty of black-jack oak and turkey oak, and where the bare white sand is in places covered by scattered patches of scrub palmetto. It is the characteristic small mammal of such places, commonly known as "black-jack ridges," and I have never found it elsewhere. In the neighborhood of Gainesville, the type locality of the species, most of the country is under cultivation and spots suitable to its wants are not frequent. While there, I trapped with great persistence in the three or four most favorable black-jack ridges I could find, but took only one example of *P. floridanus* and this unfortunately not fully adult, being of about the age of the type. At Eau Gallie I caught a number of specimens, all but five of which were destroyed by ants. All the country in the immediate vicinity of the town of Eau Gallie is the kind *P. floridanus* particularly likes, and it is apparently common there.

In 1890 Dr. Merriam described as new under the name *Hesperomys macropus* the fully adult animal from Lake Worth, making his comparison with the type of *P. floridanus*, which is young. Mr. Chapman corrects this in his list of the land mammals of Florida, but in justice to Dr. Merriam it should be said that the young of *P. floridanus* has a disproportionately small hind foot, and much smaller ears than the adult.

P. floridanus is a very beautiful and distinct species and needs comparison with no other member of the genus. I have specimens from Gainesville, Citronelle, Eau Gallie, and Enterprise, Florida.

Peromyscus gossypinus gossypinus (Leconte).

Hesperomys gossypinus Leconte, Proc. Acad. nat. sci. Phila., 1853, p. 411.

Hesperomys cognatus Leconte, Proc. Acad. nat. sci. Phila., 1855, p. 442.

Sitomys megacephalus Rhoads, Proc. Acad. nat. sci. Phila., 1894, p. 254 (Woodville, Alabama).

Peromyscus gossypinus Rhoads, Proc. Acad. nat. sci. Phila., 1896, p. 189.

Type locality. The Leconte plantation near Riceboro, Liberty County, Georgia.

The cotton mouse inhabits the whole of eastern Georgia and northern Florida. It shades into the next form gradually. Specimens from New Berlin, Florida, are true *P. gossypinus*, while those from Carterville, Point Matanzas, etc., are but little different. Gainesville specimens, however, begin to approach *P. palmarius*.

P. gossypinus is to be found in many different situations, but the best places to trap it are in the heavier swamps and hummocks and around the edges of cleared fields in hummock land. It is very rare or altogether wanting in the "piny woods."

I have specimens from Hursman's Lake, Pinetucky, Montgomery, Sterling, Barrington, and St. Mary's, Georgia, and New Berlin, Burnside Beach, Carterville, Point Matanzas and Gainesville, Florida. (Those from the last point are not typical.)

Peromyscus gossypinus palmarius Bangs.

Peromyscus gossypinus palmarius Bangs, Proc. Biol. soc. Wash., 1896, p. 124.

Type locality. Oak Lodge, east peninsula, opposite Micco, Brevard County, Florida.

The Florida cotton mouse occupies the whole Florida peninsula, north on the west to Citrus County and on the east to a little south of St. Augustine. It is a common animal and lives pretty much everywhere except in the piny woods and black-jack ridges where I have never taken it.

P. gossypinus palmarius is distinguished from *P. gossypinus typicus* by being lighter in color, without so marked a dorsal stripe, and in having smaller hind feet.

I have specimens from Citrus County, Oak Lodge, Micco, Jupiter Inlet, Miami, and Flamingo, Florida.

Peromyscus anastasae sp. nov.

Type from Point Romo, Anastasia Island, Florida, ♀ adult No. 7,179, coll. of E. A. and O. Bangs. Collected, Feb. 15, 1897, by O. Bangs.

General characters. Size rather smaller than, but with the proportions of, *P. gossypinus typicus,* from which it differs in being much paler and more buffy in color.

Color. Adult, upper parts: buff clearest along lower sides, on cheeks, inside of flanks and base of tail, darkened along middle back into a dorsal stripe of about hair brown, with usually some buffy hairs intermixed; under parts grayish white, the hairs plumbeous basally; tail bicolored, dusky above, white below; feet and hands white; ears dusky.

Measurements. The type ♀ adult: total length, 165; tail vertebrae, 69.5; hind foot, 21; ear from notch, 16.5. Average of six adult topotypes: total length, 167.5; tail vertebrae, 69.5; hind foot, 21.4. Largest individual in above average, No. 7,180, ♀ adult: total length, 178; tail vertebrae, 75.5; hind foot, 20.5.

General remarks. I found this mouse living on the open sand hills of Anastasia Island, where it was not common, and was greatly outnumbered by *P. phasma* (described below). I caught only nine individuals; most of these were taken in thickets of bayberry bushes and Spanish bayonet that grow in the more sheltered places among the sand hills, but two were caught where there was no more cover for long distances than that afforded by the loose tufts of sea oats.

P. anastasae is an island form peculiar to Anastasia Island. I took *P. gossypinus typicus* on Matanzas Point only separated by a couple of hundred yards of turbulent water, where the tide runs like a mill-race, from Anastasia Island, and at Carterville on the main land opposite Anastasia Island. *P. anastasae* is easily distinguished from true *P. gossypinus* by its paler buffy coloring in beautiful harmony with its sandy environment.

Peromyscus insulanus sp. nov.

Type from north end of Cumberland Island, Georgia, ♂ adult No. 6,438, collection of E. A. and O. Bangs. Collected, April 10, 1897, by W. W. Brown, Jr.

General characters. Size rather small (for a member of the *gossypinus* series); tail short; hind foot proportionately large; color of upper parts drab or yellowish drab; no marked dorsal stripe; under parts purer white than in others of the *gossypinus* series; young, in second pelage, much lighter gray than the corresponding pelage of other forms.

Color. Adult, upper parts: usually dull yellowish drab (some specimens being nearly pale cinnamon, and others almost clear drab, with but few yellowish hairs intermixed), slightly darker along middle of back, but no marked dorsal stripe. Under parts, white, the hairs plumbeous at base (the under parts are whiter and less gray than the under parts of any other member of the *gossypinus* series); tail not so sharply bicolored as that of *P. gossypinus typicus*, being dull gray above and white below; feet and hands white; ears dusky.

Measurements. The type ♂ adult: total length, 168; tail vertebrae, 63; hind foot, 22; ear from notch, 17. Average of ten adult topotypes: total length, 168.7; tail vertebrae, 65.6; hind foot, 21.9. Largest individual in above average, No. 6,426, ♀ adult: total length, 178; tail vertebrae, 66; hind foot, 22.

General remarks. Mr. Brown took a series of twenty-eight specimens of this island form at the north end of Cumberland Island, where he found them in the scrub palmetto and along the upper beach. The mouse was not common, however, and he worked very hard for what specimens he got. Mr. Brown also took two Peromyscus on Ossabaw Island, and these, though not fully adult, appear much like the Cumberland Island form. Cumberland and Ossabaw were the only islands upon which Mr. Brown found white-footed mice. *P. insulanus* is very different in color from any other mouse of the *gossypinus* series, even the young being easily separated from the young of *P. gossypinus typicus*, by the more drabby coloring of their upper parts and the absence of darker dorsal stripe. Its very white under parts and short tail will usually serve to distinguish it from any of the other forms.

PEROMYSCUS NUTTALII (Harlan).[1]

Arvicola nuttalii Harlan, Monthly Amer. jour. geol. and nat. sci., Phila., April, 1832, p. 446. (Figured in Med. and phys. rec., 1835, p. 55.)

Mus (Calomys) aureolus Aud. and Bach., Jour. Acad. nat. sci., Phila., 1842, vol. 8, p. 302.

[1] Professor Baird was of opinion that Harlan's name *Arvicola nuttalii* must be used for the golden mouse, and after a careful study of the question it seems to me that he was right, and that Audubon and Bachman's appropriate name *aureolus* must lapse into synonomy. Harlan's figure and description are none of the best, but both are clearly meant for the golden mouse. It is now known that the range of this species includes the lower austral fauna of southern Virginia and therefore of Norfolk.

Type locality. Norfolk, Virginia.

The golden mouse is very rare or of local distribution in the parts of Georgia and Florida visited by Mr. Brown or myself. I have never taken a specimen. Mr. Brown took six at Pinetucky, Georgia, and one at New Berlin, Florida. It has been recorded from several places in both Georgia and Florida, and Mr. Brownell got it as far south as Enterprise, Florida, where judging by the two specimens I have seen, it is slightly smaller and of rather a paler yellow color than it is farther north, though this southern form seems hardly worthy of separation. Mr. J. Robertson took two examples of *P. nuttalii* at Gainesville, Florida (these were recorded by Mr. Chapman in his mammals of Florida), in a cane brake. He showed me the exact spot where he got these, and I trapped there for some days, but failed to take *P. nuttalii.*

P. nuttalii differs from all other North American deer mice in the young not having a plumbeous pelage, but being colored exactly like the adults.

Peromyscus niveiventris (Chapman).

Hesperomys niveiventris Chapman, Bull. Amer. mus. nat. hist., 1889, vol. 2, p. 117.

Peromyscus niveiventris Bangs, Proc. Biol. soc. Wash., 1896, vol. 10, p. 122.

Type locality. Oak Lodge, east peninsula, opposite Micco, Brevard County, Florida.

The beautiful little beach mouse is extremely abundant on all the beaches of the east peninsula from Palm Beach at least to Mosquito Inlet. Just how much farther north it extends, I am unable to say. At Point Matanzas I hunted for it in vain, but the beach, for walking distance south of the point, was not suited to it. The beach was steep and washed away to the dense overhanging growth of saw palmetto, leaving no upper beach with its invariable growth of sea oats (*Uniola paniculata*), which is the chosen home of *P. niveiventris.* On Anastasia Island there is a different beach mouse, while on the beaches north of St. Augustine apparently no beach mouse occurs. Mr. Brown spent a week at Burnside Beach and, though the beach there, with its fine growth of Uniola, was admirably suited to the wants of the little beach mouse, he found no trace of it whatsoever.

P. niveiventris is entirely confined to the sandy beaches and adjacent sand hills of the east coast of Florida, and never to my knowledge has been found inland. Its life depends on the sea oats, and it is never found where that plant does not grow. It is very abundant in favorable places, and its presence can always be detected by its little foot-prints which show distinctly in the white sand around the tufts of sea oats.

At the type locality I took, in January and February, 1896, over one hundred specimens, and have examined specimens from Jupiter Inlet and Palm Beach.

Peromyscus phasma sp. nov.

Type from Point Romo, Anastasia Island, Florida, ♀ adult No. 7,175, collection of E. A. and O. Bangs. Collected, Feb. 15, 1897, by O. Bangs.

General characters. Size and proportions of *P. niveiventris*; color different, being paler; the white of under parts extending farther up on the sides, on the cheeks to the eye, and covering the whole legs (in *P. niveiventris* the upper side of legs is colored like the back); nose and face white to the eyes; a white stripe over the eye; a white spot at base of ear.

Color. Adult, upper parts: varying from pale drab-gray to pinkish buff, the drab-gray predominating on middle of back and between ears, the pinkish buff on sides of back rump and between eye and ear; top of nose, a line or spot above eye, and a spot at base of ear white. Under parts, snowy white to base of hairs, the white extending high up on sides, leaving the colored portion of back scarcely wider than the dorsal stripe in many species; tail unicolor, white, sparsely haired; hands, feet, arms, and legs, both above and below, white; ears drab-gray with many silvery hairs on both inner and outer surfaces.

Measurements. The type ♀ adult: total length, 141; tail vertebrae, 54; hind foot, 19; ear from notch, 13.5. Average of ten adult topotypes, ♂'s and ♀'s: total length, 138.5; tail vertebrae, 53.5; hind foot, 18.7; ear from notch, 14.

General remarks. This lovely little mouse is apparently an island form confined to Anastasia. It fairly swarmed on the sand hills at the lower end of the island, where I took a series of twenty-nine specimens. I caught many more, but ants and hot, damp weather combined spoiled a great number. The abundance of Sigmodon on the island was also a hindrance to trapping Peromyscus, as night after night they filled up the greater part of my traps, and their numbers were inexhaustible. During my wanderings over the sand hills of Anastasia Island, I never saw a living mouse, though I tried hard to find out where *P. phasma* spends the day, and, judging by their foot-prints, there must often have been scores of them within a few rods of me. The loose sand in most places would hardly permit of their making burrows, and even in the firmer parts, I found few holes that seemed to be occupied by them. The protective coloration of this species is so wonderful, that I believe all it need do is to lie still on the sand near some object, as a half buried log or a tuft of sea oats, in order to escape even the closest scrutiny. I did not take a single young example of *P. phasma.* and therefore do not know what the young in nursing pelage is like.

P. phasma differs from its nearest ally, *P. niveiventris*, in its much paler coloring, in the greatly reduced width of the colored portion of the back, in the legs being white all around, and in having pure white markings on the upper part of the nose, over the eyes, and at the base of the ears. In nearly two hundred examples of *P. niveiventris* that I have examined, not one approaches *P. phasma*; while the series of *P. phasma* is wonderfully constant in all the characters pointed out above.

Peromyscus subgriseus subgriseus (Chapman).

Sitomys niveiventris subgriseus Chapman, Bull. Amer. mus. nat. hist., 1893, p. 340.

Type locality. Gainesville, Florida.

The diminutive old field mouse is found in suitable situations all through central and western Florida. It lives in fields and open places, and probably before so much of its range was under cultivation, was restricted to the sand hills and open drier prairies of interior Florida. I have never seen a specimen from eastern Florida and feel confident that, if it occurred there, I should have taken it. Neither do I know of any point where its range meets that of *P. niveiventris*, and even if some such place does exist, the two species are so different that intergradation is out of the question.

Mr. Chapman, when he described this pretty little mouse, said, "*Sitomys niveiventris* and its representative interior race *S. n. subgriseus* bear no closer relationship to any known member of the genus to which they belong." In making this statement Mr. Chapman must have overlooked the little mouse of the central prairies of the U. S., *P. michiganensis*, to which *P. niveiventris* and *P. subgriseus*, and their allies, bear the closest relationship, forming all together a compact group in the genus Peromyscus. Indeed the form *P. michiganensis pallescens* lately described by Dr. Allen (Bull. Amer. mus. nat. hist., 1896, p. 238) from San Antonio, Texas, is, judged by the description, very near *P. subgriseus*. This group is distinguished by small size, short tail, and particularly by the broad short skull, very different from the skull of the *leucopus* group. *P. niveiventris* and *P. phasma* are large for members of the group, and their skulls are rather narrower than and slightly different from those of the other species. All the species are inhabitants of comparatively open country.

Four adult topotypes of *P. subgriseus*, males and females, give the following average measurements: total length, 127.3; tail vertebrae, 46.6; hind foot, 16.3.

I took, last March and April, a series of 13 *P. subgriseus* at Gainesville, Florida, the type locality of the species, and have a series from Citronelle, Florida, collected by F. L. Small. The last mentioned specimens are of interest because intermediate between true *P. subgriseus* and the form described below as *P. subgriseus rhoadsi* from Tampa Bay.

Peromyscus subgriseus rhoadsi subsp. nov.

Type from the head of Anclote River, Hillsboro County, Florida, ♂ adult No. 6,980, collection of E. A. and O. Bangs. Collected, May 23, 1895, by W. S. Dickinson.

General characters. Size and proportions of *P. subgriseus typicus*, differing from that form in color, being much yellower above; having the hairs of under parts white to the base and tail unicolor, white, or grayish white.

Color. Adult: upper parts, fawn color shading on cheeks, rump, and along lower sides towards orange-buff; a slight admixture along middle of back (in fresh pelage) of blackish tipped hairs, but no decided darker dorsal stripe. In several skins of old adults a dull orange-buff is the predominating color of the upper parts. Under parts, pure white to base of hairs. Tail unicolor white, sparsely haired; feet and hands white; ears pale gray or yellowish (probably nearly flesh color in life).

Measurements. The type ♂ adult: total length, 124.46; tail vertebrae, 45.72; hind foot, 16.51. Average of ten adults, ♂'s and ♀'s, from region about Tarpon Springs, Florida: total length, 126; tail vertebrae, 47; hind foot, 17.

General remarks. I have named this form after Mr. Samuel N. Rhoads, its real discoverer, who, although seeing its distinctness, was obliged, in his "Contributions to the mammalogy of Florida" (Proc. Acad. nat. sci., Phila., 1894, p. 159), to refer it, on account of lack of material, to true *P. subgriseus.*

In color *P. subgriseus rhoadsi* in a general way somewhat resembles *P. niveiventris*, but the likeness stops there. Mr. Chapman supposed this form to represent an intergradation between *P. subgriseus* and *P. niveiventris.* This is of course not the case. *P. rhoadsi* is so widely separated geographically from *P. niveiventris* that intergradation is out of the question. Moreover, it is unreasonable to suppose that such very different species would intergrade even if they did come in contact. The skull is the broad short skull of true *P. subgriseus.*

P. subgriseus rhoadsi is of the size and proportions of *P. sub griseus typicus*, but differs from that form very much in color, being yellowish or fawn color above, having a unicolored tail, and the hairs of the under parts being white to the base. *P. subgriseus typicus* is brownish gray above, has a bicolored tail, and the hairs of the under parts are gray at the base.

P. subgriseus rhoadsi probably has an extensive range covering the southwestern part of the Florida peninsula, although I have seen specimens only from the neighborhood of Tampa Bay. It intergrades with *P. subgriseus typicus* in Citrus County, the specimens already referred to from Citronelle being perfect intergrades between the two forms.

Peromyscus subgriseus arenarius subsp. nov.

Type from Hursman's Lake (Savannah River), near Bascom, Scriven County, Georgia, ♂ adult No. 5,925, collection of E. A. and O. Bangs. Collected, December 15, 1896, by W. W. Brown, Jr.

General characters. Size and proportions of *P. subgriseus typicus*, much darker in color, with a decidedly darker dorsal stripe; ears and upper surface of tail black or nearly black; hairs of under parts strongly plumbeous at base.

Color. Adult, upper parts, varying from hair brown to Prout's brown with many blackish tipped hairs intermixed, thickening along middle of the back into an irregular darker dorsal stripe; sometimes a slight wash of fawn color along the lower sides; a conspicuous black orbital ring; under parts white, the hairs plumbeous at base; tail sharply bicolored, black above, white below; feet and hands white; ears dark, often nearly black.

Measurements. The type ♂ adult: total length, 125; tail vertebrae, 48; hind foot, 16; ear from notch, 13. Average of ten adult topotypes, ♂'s and ♀'s: total length, 126; tail vertebrae, 46.5; hind foot, 16.5.

General remarks. Mr. Brown collected a series of thirty-seven specimens of *P. subgriseus arenarius* on the open sand hills near Hursman's Lake, where it was very common and lived in burrows made in the sand. He did not find the species at any of the other points in Georgia at which he collected, but it is probably generally distributed throughout the sand-hill region of northern Georgia and southern South Carolina.

P. subgriseus arenarius is readily distinguished from *P. subgriseus typicus* by its much darker, browner coloring. In *P. arenarius* the upper half of the tail is black, while in *P. subgriseus typicus* the tail has a narrow line of dark gray along the upper surface. The ear also is nearly black, while in *P. subgriseus typicus* it is gray.

P. subgriseus arenarius has much the appearance of a small, short-haired *P. michiganensis* and very possibly meets the range of that species; it also without doubt passes into *P. subgriseus typicus*, and future careful collecting between the now known ranges of these species will probably show a complete gradation.

Mus musculus Linné.

Introduced. The house mouse is common in the neighborhood of settlements and dwellings all over Georgia and Florida, south to Key West.

Mus decumanus Pallas.

Introduced. The brown rat is now abundant throughout eastern Georgia, extending south certainly to Jacksonville, Florida. On Ossabaw and St. Catherine's Island it and the roof rat (*Mus rattus alexandrinus*) occurred in about equal numbers and apparently interbreed freely. The large series collected on these two islands by Mr. Brown contains many specimens that have every appearance of being hybrids between the two species.

Mus rattus rattus Linné.

Introduced. The black rat is the least common of the three large species of Mus occurring in Georgia and Florida. It apparently not infrequently breeds with the roof rat. At St. Mary's, Georgia, in a little abandoned hut in the woods, I caught a whole family of rats, the mother was a black rat, the father a roof rat, and of the six young three were black rats and three roof rats.

Mus rattus alexandrinus (Geoff.).

Mus tectorum Savi, "Nuovi giornale di lett." 1825.

Mus rattus alexandrinus Jerbury and Thomas, Proc. Zool. soc. Lond., 1895, p. 553.

Introduced. The roof rat is the common rat of Georgia and Florida and is found over the entire region south to Key West; it also occurs on all of the islands. It is most numerous in the settlements and about buildings, although I have trapped it in marshes and heavy hummocks, miles from the habitation of man. It apparently interbreeds with *M. rattus typicus* and *M. decumanus*, wherever it occurs with either of these animals. In places in New England where I have found *M. rattus typicus* and *M. decumanus* living together, they do not interbreed. It is therefore strange that in the south *M. rattus alexandrinus* should apparently cross with both.[1]

[1] A beaver, probably not *Castor canadensis* Kuhl., occurs in some parts of western Florida and southwestern Georgia. Mr. William Brewster has trustworthy information concerning its occurrence on Chipola Creek, Florida. A thoroughly reliable trapper, who formerly lived in southwestern Georgia, has told me that a beaver is still found there. I think from all I can learn that beaver do not occur in the region covered by the present paper.

Sciurus niger Linné.

Sciurus niger Linné., Syst. nat., ed. 10, 1758, vol. 1, p. 64.

Type locality. Southern South Carolina.

The southern fox squirrel is a common animal throughout the pine forests of Georgia and Florida, and from its retiring and wary nature is likely to hold its own for many years. Of course its numbers in the more thickly settled places are much reduced, though it still occurs in small numbers even in the vicinity of the larger cities.

I have specimens from the following localities: Georgia: Hursman's Lake, 4, Barrington, 10, and St. Mary's, 2. Florida: New Berlin, 1, and Citronelle, 37.

Sciurus carolinensis carolinensis Gmelin.

Sciurus carolinensis Gmelin, Syst. nat., 1788, vol. 1, p. 148.

Type locality. Carolina.

The southern gray squirrel is common in hummocks, swamps, and along the streams throughout Georgia and northern Florida, south to about the middle of the Florida peninsula, where it begins gradually to merge into the tropical form, *S. carolinensis extimus.* Thus specimens from Gainesville, Florida, are wholly *S. carolinensis typicus*, those from Citrus County begin somewhat to approach *S. extimus*, while those from Eau Gallie and Oak Lodge are referable rather to *S. extimus*, though not extreme.

The southern gray squirrel varies somewhat in color both individually and locally. In a heavy swamp near Barrington, Georgia, Mr. Brown took some grays that are very dark colored and have the under parts washed with buff; in color these skins suggest subspecies *fuliginosus*, but are of course smaller than is that form. At Gainesville, Florida, I took, March 30, 1897, in one swamp five grays; three of these are normal, while one, an old nursing female, is of a peculiar ferruginous color above, being about as red as summer specimens of the red squirrel (*Sciurus hudsonicus*), and another, a younger male, has a large admixture in the back and tail of the same red color. Melanistic individuals of this form are very rare. Mr. Chapman records a wholly black one from Tarpon Springs, and I have a skin from New Berlin, Florida, having an irregular black streak down the middle of the back.

On Cumberland Island Mr. Brown took eighteen gray squirrels. These specimens are peculiar, being different from those taken any where else along the Georgia coast. In many respects they appear more nearly like *S. extimus.* The tail is shorter than that of *S. carolinensis typicus*, the foot is smaller, and the hand is considerably smaller, the markings are very fine, and there is a pale, yellowish mealy cast to the whole upper parts. In all these characters they approach very nearly to *S. carolinensis extimus*, but differ from that form in being slightly larger, not so gray, and in having much less white in the tail. On the other hand, specimens from south of Cumberland Island on the Florida coast are true *S. carolinensis*, and the Cumberland Island form, though it appears to tend towards *S. extimus*, is completely cut off from contact with that form by true *S. carolinensis.* Perhaps there is something in the conditions of life on Cumberland Island, differing from that of the main land of Georgia and northern Florida, and approaching that of southern, tropical Florida. More probably, however, the Cumberland Island form is an incipient insular species, and its likeness to *S. extimus* purely fortuitous.

I have an enormous series, including specimens from Hursman's Lake, St. Catherine's Island, Harris Neck, Montgomery, Barrington, St. Mary's, and Cumberland Island, Georgia, and Rose Bluff (St. Mary's River), New Berlin, Gainesville, and Citrus County, Florida.

Sciurus carolinensis extimus Bangs.

Sciurus carolinensis extimus Bangs, Proc. Biol. soc. Wash., 1896, vol. 10, p. 158.

Type locality. Miami, Dade County, Florida.

The everglade gray squirrel occupies southern, tropical Florida and passes into true *S. carolinensis* about half way up the peninsula. It is a strongly marked form and very much smaller[1] and grayer, with much more white in the tail, than *S. carolinensis typicus.*

I have specimens from Miami, Oak Lodge, and Eau Gallie, Florida.

[1] A typographical error crept into my average measurements for this form in "A review of the squirrels of eastern North America," p. 158, where the measurement for hind foot should read 57 m. instead of "47."

Sciuropterus volans volans (Linné).

Mus volans Linné, Syst. nat., ed. 10, 1758, vol. 1, p. 63.

Sciuropterus volans Jordan, Man. vert., 1890, p. 324, foot note.

Type locality. North America.

The flying squirrel is common all through Georgia and northern Florida, and specimens from this region, though usually somewhat darker in color above, differ in no essential character from those from New England. Specimens from St. Mary's, Georgia, begin to show the first signs of an approach to the Florida form, *S. querceti*, which is carried a little farther still by some from New Berlin, Florida.

At St. Mary's I found the flying squirrel tolerably common and took ten examples, by driving them from hollow trees and shooting them. Mr. Brown took thirteen at Pinetucky and four at Montgomery, Georgia, and thirteen at New Berlin, Florida.

Sciuropterus volans querceti Bangs.

Sciuropterus volans querceti Bangs, Proc. Biol. soc. Wash., 1896, vol. 10, p. 166.

Type locality. Citronelle, Citrus County, Florida.

The Florida flying squirrel in its extreme form is probably confined to southern Florida. I have found it a rare animal and hard to get, and, though I have often heard of it in different places, have never taken it myself.

S. volans querceti is distinguished from *S. volans typicus* by more rusty coloration and much larger and more wheel-shaped audital bullae. I have only three specimens, all from the type locality.[1]

Blarina brevicauda carolinensis (Bach.).

Sorex carolinensis Bachman, Jour. Acad. nat. sci. Phila., 1837, vol. 8, p. 366.

Blarina brevicauda carolinensis Merriam, N. Amer. fauna, 1895, no. 10, p. 13.

[1] *Sorex longirostris* Bachman, type locality, swamps of the Santee River, S. C., may occur in eastern Georgia, although all efforts to get specimens of it there have failed. Mr. Brown had this shrew constantly in mind during his whole trip, and worked every kind of place with every bait he could think of, but never caught one.

Type locality. Eastern South Carolina.

The Carolina Blarina occurs over the whole of eastern Georgia and probably shades into the next subspecies somewhere in southeastern Georgia and northern Florida. The one example I took at St. Mary's was too badly decomposed to be skinned and is preserved in alcohol. It measures as follows: total length, 99; tail vertebrae, 15; hind foot, 12.5, and has every appearance of being about intermediate between *B. carolinensis* and *B. peninsulae.*

Mr. Brown took one on Ossabaw Island, one at Montgomery, and six at Pinetucky, Georgia.

Blarina brevicauda peninsulae (Merriam).

Blarina carolinensis peninsulae Merriam, N. Amer. fauna, 1895, no. 10, p. 14.

Type locality. Miami River, Dade County, Florida.

The everglade Blarina is of general distribution throughout the Florida peninsula. It is, in my experience, a rare animal. I have caught five individuals only, all at Oak Lodge, where I found them living under brush piles around the clearings, and at the edge of the savannah. Judging by Mr. Loring's experience at the type locality, it is more common in the everglades.

B. b. peninsulae differs from *B. b. carolinensis* in its blacker color, larger hind foot, and heavier molar teeth.

Blarina (Cryptotis) parva (Say).

Sorex parvus Say, Long's Exp. Rocky Mts., 1823, vol. 1, p. 164.

Blarina parva Merriam, N. Amer. fauna, 1895, no. 10, p. 17.

Type locality. West bank of Missouri, near Blair, Nebraska.

The small Blarina is common in eastern Georgia, its range extending south, though certainly not to the southeast corner of the state, for at St. Mary's I took *B. floridana.*

Some specimens from Montgomery, Georgia, seem to me to indicate that the two forms, *B. parva* and *B. floridana*, are only subspecifically distinct, although Dr. Merriam did not consider the Riceboro specimens he records intermediate.

The Montgomery specimens approach *B. floridana* more nearly both in size and color than they do North Carolina specimens of *B. parva*; in dental characters they are *B. parva*, although the skull is longer and more like that of *B. floridana.* I shall, of course, not change the standing of *B. floridana* as a distinct species, on this material, though I feel confident that some day intergradation will be found between *B. parva* and *B. floridana.*

Mr. Brown took a single specimen of Blarina on Skiddaway Island, Georgia, which, by the way, was the only mammal he found on that Island, that is peculiar. This specimen, No. 6,198, is very large, about equaling *B. carolinensis* in size, measuring as follows: total length, 92; tail vertebrae, 17; hind foot, 11; the skull was broken back of the palate, but the teeth are intact. The molar-form teeth are large and the palate consequently narrow. The coloring is very different from that usual in *B. parva*, being a uniform silvery gray, slightly paler beneath; the tail is short and hairy. This one example may be a "freak," but it certainly looks as if a very different species inhabits Skiddaway Island.

Mr. Brown took ten specimens of *B. parva* at Montgomery, Georgia, but did not find the species at any of the other places in Georgia he visited. Dr. Merriam records a series from Riceboro, Georgia.

Blarina (Cryptotis) floridana Merriam.

Blarina floridana Merriam, N. Amer. fauna, 1895, no. 10, p. 19.

Type locality. Chester Shoal, fourteen miles north of Cape Canaveral, Brevard County, Florida.

The small Florida Blarina is the common shrew of peninsular Florida, and extends its range northward certainly to southeast Georgia (St. Mary's).

It is not difficult to trap, and lives in every kind of situation, though preferring the moister places. I have taken it on barren sand hills, in dry old fields, in hummocks, swamps, piny woods, under brush piles, and at the edge of the salt marsh. Perhaps its favorite abode is among the rushes that fringe the borders of small fresh-water pools, especially near the edge of the salt marsh. At such a place near Carterville, with only a few traps set, I caught four during one night. It is difficult to save in good condition the specimens caught, because they spoil very quickly in the hot, damp climate of Florida, and like all shrews they have a great fondness for eating each other up in the trap; usually they begin with the head. I think I have never been able to save more than three out of every five caught.

B. floridana is larger than *B. parva*, with which I believe it intergrades, has a longer tail, and is grayer in color with a decided "pepper and salt" appearance, the molar teeth are different and the skull longer. The largest individual I ever caught is No. 3,444 from Oak Lodge. It measures, total length, 104; tail vertebrae, 26; hind foot, 12.

I have specimens from St. Mary's, Georgia, and Carterville, Point Matanzas, Gainesville, and Oak Lodge, Florida. At the latter place I collected a series of eighteen individuals.

Scalops aquaticus australis Chapman.

Scalops aquaticus australis Chapman, Bull. Amer. mus. nat. hist., 1893, vol. 5, p. 339.

Scalops parvus Rhoads, Proc. Acad. nat. sci. Phila., 1894, p. 157. (Tarpon Springs, Florida).

Type locality. Gainesville, Florida.

The Florida mole is distributed over the whole of eastern Georgia and Florida south to Lake Worth and Tampa Bay (except Anastasia Island, where a peculiar insular form occurs). Specimens from Gainesville, however, do not represent the extreme of the form, which the "*Scalops parvus*" Rhoads from Tarpon Springs does. The subspecies must, however, be known as *S. australis*, as the differences between *S. australis* and *S. aquaticus typicus* are much greater than those between *S. australis* and *S. parvus.*

Scalops australis does not vary to any considerable extent in the region between the Savannah River and Gainesville, in the characters that separate it from true *S. aquaticus*; namely, smaller size, short tail, relatively larger hind foot, smaller, lighter skull, smaller teeth, and lower and very much more slender coronoid process. On the peninsula farther south than Gainesville, the mole becomes still smaller with even a lighter skull.[1]

The Florida mole is very abundant and lives both in hummocks and piny woods, and the ridges — the roofs of its underground run-

[1] None of the peculiar characters claimed for "*S. parvus*" by its author, Mr. S. N. Rhoads, are more than individual variations, as is shown by a rather younger topotype and the type of *S. parvus*, now both before me. The type is a rather peculiar and apparently dwarfed individual, perhaps due to its having been kept alive in confinement. (See True's Monograph of the North American moles.)

FLESH MEASUREMENTS OF SCALOPS AQUATICUS AUSTRALIS.

No.	LOCALITY.	Sex.	Total length.	Tail vertebrae.	Hind foot.
5,972	Ga. Hursman's Lake	♀	153	24	19
5,967	Ga. Hursman's Lake	♂	148	23	18
5,975	Ga. Hursman's Lake	♂	148	23	18
5,969	Ga. Hursman's Lake	♀	145	23	18
5,976	Ga. Hursman's Lake	♀	144	22	17
5,971	Ga. Hursman's Lake	♀	142	21	18
5,973	Ga. Hursman's Lake	♂	142	22	18
5,968	Ga. Hursman's Lake	♀	137	23	16
5,974	Ga. Hursman's Lake	♂	137	22	17
5,970	Ga. Hursman's Lake	♂	135	21	17
6,169	Ga. Ossabaw Island	♂	157	23	19
6,168	Ga. Ossabaw Island	♂	155	25	19
6,170	Ga. Ossabaw Island	♂	148	23	19
6,171	Ga. Ossabaw Island	♂	140	20	18
7,091	Fla. Gainesville (Topotype) . .	♀	150	27	19
7,081	Fla. Gainesville (Topotype) . .	♂	147	28	18
7,087	Fla. Gainesville (Topotype) . .	♂	144	23	18
7,088	Fla. Gainesville (Topotype) . .	♂	143	24	18
7,083	Fla. Gainesville (Topotype) . .	♂	141	25.5	17
7,089	Fla. Gainesville (Topotype) . .	♀	137	25	18
7,085	Fla. Gainesville (Topotppe) . .	♀	137	21	18
7,086	Fla. Gainesville (Topotype) . .	♀	136	24	16.5
7,090	Fla. Gainesville (Topotype) . .	♀	136	22	16
7,084	Fla. Gainesville (Topotype) . .	♀	133	23.5	17.5
7,082	Fla. Gainesville (Topotype) . .	♀	131	23	17
3,465	Fla. Oak Lodge	♂	142	19	17.5
3,462	Fla. Oak Lodge	♂	140	22	18
3,464	Fla. Oak Lodge	♂	139	23	17
3,469	Fla. Oak Lodge	♂	139	23	17
3,471	Fla. Oak Lodge	♂	139	22	18
7,248	Fla. Oak Lodge	♂	138.5	19	17.5
7,246	Fla. Oak Lodge	♀	137	19.5	18
3,468	Fla. Oak Lodge	♀	137	24	18
7,243	Fla. Oak Lodge	♂	137	19	17.5
3,470	Fla. Oak Lodge	♂	136	20	16
7,247	Fla. Oak Lodge	♀	136	19.5	18
3,467	Fla. Oak Lodge	♀	134	16	16
3,463	Fla. Oak Lodge	♂	134	17	16
3,461	Fla. Oak Lodge	♂	133	24	17
3,466	Fla. Oak Lodge	♂	132	17	17
7,253	Fla. Oak Lodge	♂	132	18.5	17
7,244	Fla. Oak Lodge	♂	132	17.5	16.5
7,252	Fla. Oak Lodge	♀	131	19	17.5
7,251	Fla. Oak Lodge	♀	131	21	16.5
7,250	Fla. Oak Lodge	♀	129.5	17.5	17.5
7,245	Fla. Oak Lodge	♀	129	19.5	16.5
7,249	Fla. Oak Lodge	♀	129	18.5	16.5
1,469[1]	Fla. Tarpon Springs	♂	117	15	17
2,996[2]	Fla. Tarpon Springs	♀ ?	124	15.5	16

[1] Type of "*Scalops parvus*," probably a peculiarly small individual — perhaps dwarfed. Collection of S. N. Rhoads.

[2] Rather young, probably younger than any of the individuals given in above lists. Collection of S. N. Rhoads.

ways — can be found meandering about in all directions, almost anywhere in the drier soil. It is very easily trapped with the Wherry mole trap, or any of the devices that work on the same general principle.

Some moles taken by Mr. Brown on Ossabaw Island are a trifle larger than those from the main land opposite, and their skulls are rather longer and more slender. These differences, though now trifling, may perhaps in time, if exaggerated by the insulation of the animal, produce a race different from the main-land form. Those taken at St. Catherine's and Cumberland Islands apparently do not differ in any way from *S. a. australis.*

I have a large series of *S. a. australis* as follows: Georgia: Hursman's Lake, ten; Pinetucky, three; Montgomery, three; Sterling, one; Barrington, two; Cumberland Island, two; Ossabaw Island, four; St. Catherine's Island, four. Florida: New Berlin, three; Point Matanzas, three; Oak Lodge, twenty-two; and Gainesville, eleven.

Scalops anastasae sp. nov.

Type from Point Romo, Anastasia Island, Florida. ♂ adult, No. 7,192, collection of E. A. and O. Bangs. Collected, February 16, 1897, by O. Bangs.

General characters. Size of *S. a. australis*, color beautiful golden brown; skull short, massive; mandible heavy; dentition normal.

Color. In fresh pelage, deep, lustrous, golden ochraceous, with somewhat of an olivaceous or "old gold" cast, much marked with deep orange about wrists, on head, and on under parts. In worn pelage, golden buff. Feet, hands, and tail, flesh color; nails, white.

Cranial characters. The skull of *S. anastasae* as compared with that of *S. aquaticus australis* is shorter, more compact, and heavier, more solid. It is less constricted in the interorbital region, and the brain case is rather higher; mandible shorter, heavier throughout, and in old age becoming heavily ossified and filled in between the two halves. The dentition is like that of *S. australis.*

Skull, the type, ♂ adult: greatest length, 31; basal length, 26.6; zygomatic breadth, 14; mastoid breadth, 16.6; interorbital constriction, 7; greatest length of single half of mandible, 19.6.

General remarks. This beautifully colored island form, apparently confined to Anastasia Island, was abundant there; its runs extend in all directions over the barren sand hills and through the salt flats, that were formerly lagoons. I had three mole traps with me, with which I worked persistently for a week, but with rather poor success, taking only five moles. The very delicate nature of the runs formed in the light sand, and the ease with which new ones could be made, worked against successful trapping.

Among the five specimens I was fortunate enough to get three in fine fresh pelage, just completed or nearly complete, and two in worn pelage, with the new hairs appearing in spots. The two in worn pelage are females with nursing young.

S. anastasae is very differently colored from *S. aquaticus australis*, with which it agrees in size, but from which it differs in its heavy, short skull. The hands of *S anastasae* are large, and the nails long and strong, averaging considerably larger than those of *S. australis*.

At Matanzas Point, just across the Inlet from Anastasia Island, I took three examples of *Scalops aquaticus australis*.

Measurements of Scalops anastasae.

No.		Sex.	Total length.	Tail vertebrae.	Hind foot.
7,192	Type	♂	138	20	18
7,193	Topotype	♀	141	22.5	17.5
7,196	Topotype	♀	137	21	17
7,195	Topotype	♂	134	21	18
7,194	Topotype	♀	134	19.5	17

[At Mr. Bangs's request I have prepared the following notes on the Chiroptera of Florida and southern Georgia for insertion in his paper. As all but two of the twelve forms now known to occur in this region are members of the family Vespertilionidae, the matter here presented is essentially an extract from my recent revision of this group (N. Amer. fauna, no. 13). Most of the bats taken by Mr. Bangs's collectors, and a few sent me from Old Town, Florida, by Mr. Arthur T. Wayne, are now for the first time recorded. *Gerrit S. Miller, Jr.*]

ARTIBEUS PERSPICILLATUS (Linné).

Vespertilio perspicillatus Linné, Syst. nat., 10th ed., 1758, vol. 1, p. 31.

Artibeus perspicillatus Peters, Monatsber. K. preuss. Akad. wissensch., Berlin, 1865, p. 356.

Artibeus perspiccilalune (sic) Maynard, Bull. Essex inst., 1872, vol. 4, p. 10.

Type locality. Jamaica. (See J. A. Allen, Bull. Amer. mus. nat. hist., vol. 3, p. 170.)

Remarks. This bat, which should be carefully searched for by collectors in southern Florida, may be at once recognized by its large size (head and body about 70; forearm about 65), rudimentary tail, broad short muzzle terminated by a conspicuous "nose leaf," and absence of W-shaped molar cusps. Its single occurrence in Florida is thus recorded by Mr. C. J. Maynard: "While at Key West in the early winter of 1870, I observed several large bats flying about the city, which closely resembled in flight a species which I had seen in northern Florida two years before, but which flew so high that I was unable to shoot them. I was very anxious to obtain a specimen, but as shooting was prohibited in the streets of the city of Key West, and as I never saw the bats elsewhere on the island, I feared that I should be obliged to go away without one. I was, therefore, agreeably surprised one morning to see a boy enter my room with a bat in his hand which, from its large size, I knew could be no other than the species which I had so long desired to obtain. He said, that he had found it hanging upon the leaf of a tree, and had killed it with a piece of limestone." This specimen has been lost, but a drawing made by Mr. Maynard enabled the late Dr. Harrison Allen to identify the species.

While this is at present the only record of *Artibeus perspicillatus* in the United States, the bat may be looked for anywhere in or near the Tropical Zone.

CORYNORHINUS MACROTIS (Leconte).

Plecotus macrotis Leconte, McMurtrie's Cuvier, Animal kingdom, 1831, vol. 1, append., p. 431.

Corynorhinus macrotis H. Allen, Proc. Acad. nat. sci. Phila., 1865, p. 173.

Type locality. Georgia, probably near Riceboro.

Remarks. The big-eared bat probably occurs throughout the region included in the scope of the present paper. Hardeeville, South Carolina, and Greensboro, Alabama, are, however, the only localities near this region from which I have seen it. The late Dr. Harrison Allen records a specimen from Micanopy, Fla.

Myotis lucifugus lucifugus (Leconte).

Vespertilio lucifugus Leconte, McMurtrie's Cuvier, Animal kingdom, 1831, vol. 1, append., p. 431.

Vespertilio lucifugus austroriparius Rhoads, Proc. Acad. nat. sci. Phila., 1897, p. 227. (Tarpon Springs, Florida.)

Myotis lucifugus Miller, N. Amer. fauna, 1897, no. 13, p. 59.

Type locality. Georgia, probably near Riceboro.

Remarks. The little brown bat is without doubt a common species in southern Georgia and northern Florida, though the southern limit of its range is not known. The only specimens from the region under consideration that I have seen are the type and six topotypes of *Vespertilio lucifugus austroriparius* Rhoads from Tarpon Springs, Florida.

Lasionycteris noctivagans (Leconte).

Vespertilio noctivagans Leconte, McMurtrie's Cuvier, Animal kingdom, 1831, vol. 1, p. 31.

Lasionycteris noctivagans Peters, Monatsber. K. preuss. Akad. wissensch., Berlin, 1865, p. 648.

Type locality. Eastern United States, exact locality unknown.

Remarks. The silver-haired bat probably occurs as a migrant throughout Florida and southern Georgia. Mr. Brown took a specimen at Pinetucky, Ga.

Pipistrellus subflavus (F. Cuvier).

Vespertilio subflavus F. Cuvier, Nouv. ann. d'hist. nat., 1832, p. 17.

Pipistrellus subflavus Miller, N. Amer. fauna, 1897, no. 13, p. 90.

Type locality. Eastern United States, probably Georgia.

Remarks. While this species is without doubt abundant throughout Georgia and Florida, I have seen only four specimens from the region now under consideration. Two of these were taken at Old Town, Florida (Miller coll.), by Mr. A. T. Wayne, and two (Bangs coll.) at Blitches Ferry, Citrus Co., Florida, by F. L. Small.

Vespertilio fuscus Beauvois.

Vespertilio fuscus Beauvois, Catal. Peale's museum, 1796, p. 14.

Type locality. Philadelphia, Pa.

Remarks. The exact southern limit of the distribution of the brown bat in the southeastern United States is not known. I have seen four specimens from the region now under consideration, as follows an adult from Riceboro, Georgia (U. S. Nat. Mus.), and three from Blitches Ferry, Citrus Co., Fla. (Bangs coll.).

Lasiurus borealis borealis (Müller).

Vespertilio borealis Müller, Natursyst., Suppl., 1776, p. 21.

Lasiurus borealis Miller, N. Amer. fauna, 1897, no. 13, p. 105.

Type locality. New York.

Remarks. The red bat occurs in Florida and southern Georgia, though less commonly than the dark southern form.

Specimens examined. Total number ten, from the following localities: Florida: Old Town, one (Miller coll.); St. Mary's, one (U. S. Nat. Mus.); Georgia: Riceboro, eight (U. S. Nat. Mus.).

Lasiurus borealis seminolus (Rhoads).

Atalapha borealis seminola Rhoads, Proc. Acad. nat. sci. Phila., 1895, p. 32.

Lasiurus borealis seminolus Miller, N. Amer. fauna, 1897, no. 13, p. 109.

Type locality. Tarpon Springs, Florida.

Remarks. *Lasiurus borealis seminolus* is the common form of red bat throughout Florida and southern Georgia. It is readily distinguishable from the typical form by its dark mahogany-brown color.

Specimens examined. Total number twenty-two, from the following localities: Florida, Old Town, nine (Miller coll.); Lake Harney, two (U. S. Nat. Mus.); Citronelle, four (Bangs coll.); Deer Creek, Citrus County, one (Bangs coll.); Blitches Ferry, Citrus County, six (Bangs coll.).

Lasiurus cinereus (Beauvois).

Vespertilio linereus Beauvois, Catal. Peale's museum, 1796, p. 14 (obvious misprint for *cinereus*).

Lasiurus cinereus H. Allen, Monogr. N. Amer. bats, 1864, p. 21.

Type locality. Philadelphia, Pa.

Remarks. The hoary bat is another species which reaches the southeastern corner of the United States as a migrant only. Mr. Brown took one specimen at Montgomery, Georgia, and two at Sterling, Georgia. The species is recorded by Mr. Chapman from Gainesville, Fla.

Dasypterus intermedius H. Allen.

Lasiurus intermedius H. Allen, Proc. Acad. nat. sci. Phila., (1862), 1863, p. 146.

Dasypterus intermedius H. Allen, Monogr. N. Amer. bats, 1893, p. 137.

Type locality. Matamoras, Tamaulipas, Mexico.

Remarks. *Dasypterus intermedius* is probably a common bat throughout the Austroriparian fauna. In the region now under consideration it has, however, been taken at three localities only. The specimens from Florida are not typical, and more abundant material than that now at hand will probably show that they represent a well-marked geographic race.

Specimens examined. Five, from the following localities: Florida, Davenport, one (Miller coll.); Mullet Lake, one (U. S. Nat. Mus.); Old Town, three (Miller coll.).

Nycticeius humeralis Rafinesque.

Vespertilio humeralis Raf., Amer. mo. mag., 1818, vol. 3, p. 445.

Nycticeius humeralis Raf., Journ. physique, 1819, vol. 88, p. 417.

Type locality. Kentucky.

Remarks. This is one of the commonest bats of Florida and southern Georgia.

Specimens examined. Total number thirty-six, from the following localities: Florida, Chattahoochie, one (U. S. Nat. Mus.); Blitches Ferry, eighteen; Citronelle, thirteen (Bangs coll.); Old Town, three (Miller coll.); Titusville, one (U. S. Nat. Mus.).

NYCTINOMUS CYNOCEPHALUS (Leconte).

Nycticea cynocephala Leconte, McMurtrie's Cuvier, Animal kingdom, 1831, vol. 1, append., p. 432.

Type locality. Probably near Riceboro, Georgia.

Remarks. While I am not now prepared to discuss the relationship of the free-tailed bat of Florida and the Austroriparian fauna at large to the South American *Nyctinomus brasiliensis*, the chances that the former is the same as the latter are so remote, that I prefer to use for it the specific name *cynocephalus* Leconte, unquestionably based on the animal of the southeastern United States.

In September, 1894, one of Mr. Bangs's collectors secured twelve skins of this bat at Blitches Ferry, Citrus County, Florida, but unfortunately neglected to preserve the skulls. In color these specimens are remarkably uniform. The fur of the entire animal is dark, dull brown, wholly without trace of red. On the back the exact shade is intermediate between the "seal brown" and "mummy brown" of Ridgway, but nearer the former. In certain lights it shows a distinct grayish cast. Ventral surface paler than back, but without trace of gray. The hairs throughout the pelage, though not bicolor, are paler at extreme base.

Measurements. Nine females give the following averages and extremes:[1]

Total length: 99.7 (95–105); forearm, 39.5 (37–42); longest finger, 79.2 (75–83). Two males measure respectively: total length, 102; forearm, 38; longest finger, 80; and total length, 97; forearm, 41; longest finger, 84.

CARIACUS OSCEOLA Bangs.

Cariacus osceola Bangs, Proc. Biol. soc. Wash., February, 1896, vol. 10, p. 26.

[1]Total length from fresh specimens by collector, the other measurements from dry skins.

Cariacus (or *Damelaphus*) *fraterculus* Coues, The nation, May 21, 1896, vol. 62, p. 404.

Type locality. Citronelle, Citrus County, Florida.

The little Florida deer occurs all over peninsular Florida and probably the entire coastal strip of Georgia. At St. Mary's, Georgia, I saw several skulls and pairs of antlers of deer killed in the neighborhood; all were exactly like Florida specimens. I also examined on Cumberland Island, a tame *C. osceola*, caught there when a fawn. There is now a tremendous herd of deer on Cumberland Island, about all the island can support, and of course they are carefully protected.

Mr. Brown got none on his trip, owing principally to the fact that most of his collecting was done during the close season on deer. The same cause has prevented my getting specimens on all my trips in Florida and Georgia.

The remarkable rapidity with which Florida has been opened up, and the great number of railroads now running in all directions over the state, has played havoc with the deer, and in most places there is not one where a few years ago there were ten. In the more remote parts of the state, where they are less hunted, deer are said still to be very abundant.

I have only the original series from Citrus County, which I had when I described the species.

PROCYON LOTOR ELUCUS[1] subsp. nov.

Type from Oak Lodge, east peninsula, opposite Micco, Brevard County, Florida, ♂ old adult, No. 3,502, collection of E. A. and O. Bangs. Collected, Feb. 15, 1895, by O. Bangs.

General characters. Size of *P. lotor typicus* of the middle and northern states or rather larger; tail usually considerably longer; feet and hands larger; legs and arms longer, the animal standing, when on all fours, much higher; ear rounder, not so pointed; color of adult more yellowish above with much more distinct and brighter colored shoulder patch, in many specimens deep orange-rufous; pelage shorter and harsher; skull slightly different.

Color. Very variable; the type: under fur, mouse-gray to yellowish drab-gray; long hairs on upper parts, ringed with dull yellow

[1] E-lûcus = one who has been awake all night; hence a person drowsy or dreaming in the morning.

and black, giving a fine brindle effect, except above shoulders where there is a large, irregular shoulder patch of deep orange-rufous, some of the hairs black-tipped, narrowing and extending backward to middle of back; arms, hands, feet, legs, ears, and under parts dull yellow, becoming more strongly ochraceous about base of tail, on the vent, under side of throat and on cheeks; lips, and chin dull yellow; a broad black band running from each cheek through eye and meeting between eyes, above these black bands, a band of pale, dull yellow; tail ringed with dull ochraceous and blackish brown rings. Some adult specimens are grayer. The young are usually of a darker color than the adults, and more nearly agree with *P. lotor typicus* in color, except for the shoulder patch which is always more highly colored.

Cranial characters. Skull similar to that of *P. lotor typicus*, but usually somewhat larger and stronger, and never so abruptly constricted behind postorbital processes; frontal region higher and more arched.

Measurements. The type ♂ aged: total length, 892; tail vertebrae, 286; hind foot, 125. No. 2,495 from Citronelle, Florida, ♂ old adult: total length, 835; tail vertebrae, 285; hind foot, 125. A young adult ♂ topotype No. 2,501: total length, 800; tail vertebrae, 244; hind foot, 120.[1]

Skull, the type ♂ aged: basal length, 109.6; zygomatic breadth, 81.2; mastoid breadth, 64.6; interorbital width, 25; greatest constriction behind post orbital processes, 24.8; greatest length of single half of mandible, 88.4.

General remarks. I have a large series of raccoons from Florida and Georgia; those from the latter state begin to approach *P. lotor typicus*, especially the ones from the northeastern part (Hursman's Lake), but even these are perhaps referable to *P. lotor elucus.*

The Florida raccoon, like its northern relative, is subject to a considerable range of individual variation in color, size, and even proportions. The young as a rule vary more than do the adults, still there is a very prevalent belief among the trappers and hunters that there are two distinct species of "coons" in Florida, a short-tailed, compactly built one, and a long-tailed, "leggy" one. All of the former that have been shown me were, however, young indi-

[1] An old adult ♀ *Procyon lotor typicus* from Liberty Hill, Connecticut, No. 1,949, measures: total length, 832; tail vertebrae, 247; hind foot, 118. An old adult ♂ from Granville, Nova Scotia (the extreme northern limit of the species), No. 239: total length, 837; tail vertebrae, 240; hind foot, 116.

viduals. The Florida raccoon can be distinguished from the northern raccoon by its yellower color and much brighter shoulder patch, longer tail, larger hands and feet, more rounded ear, and shorter, harsher pelage; while the skulls of the two can usually, but not always, be separated. Seen in the flesh, the two forms have a very different appearance, the Florida raccoon being lighter built and much more "leggy."

P. lotor elucus is very common all over Florida and eastern Georgia, and is exceedingly abundant along the coast. In the salt marsh it wears, in many places, regular roads through the grass, where it can be trapped with ease. Often also one finds it curled up asleep in the fork of a tree. One day at St. Mary's, while crossing a small island surrounded by marsh and covered by a heavy growth of old pine, live oak, and water oak, a boy and I shot six raccoons that we discovered asleep in the trees.

The Florida raccoon swims well and does not hesitate to cross rivers and creeks, and thus finds its way to all the islands.

URSUS (EUARCTOS) FLORIDANUS Merriam.

Ursus floridanus Merriam, Proc. Biol. soc. Wash., 1896, vol. 10, p. 81.

Type locality. Key Biscayne, Florida.

The Florida bear is still comparatively common in Florida, especially on the east coast. It occasionally still occurs on Anastasia Island; a fine individual taken there, as a cub, about six years ago, is on exhibition in one of the small museums in St. Augustine. There are also bear, probably of this species, on Cumberland Island, where I am glad to say they are protected by the owners of the island.

It would be interesting to get specimens from the coast of Georgia still farther north, but all my efforts in this direction have been fruitless.

I have but one specimen, an old adult skull taken many years ago by Mr. C. J. Maynard on the Indian River.

A bear also occurs in the larger swamps of eastern Georgia, but as I have never been able to get a specimen I can not say whether it is the black bear (*Ursus americanus*) or the Louisiana bear (*Ursus luteolus*). Mr. Brown heard of them at several places, and they were reported to be common in the large swamps at Barrington, Georgia, but heavy freshets, that wholly submerged the swamps, prevented him from trying for one. The natives called them "Hog bear." Some years ago I spent a month on the Savannah River above Savannah, and bear were not uncommon then in the heavy swamps along the river. I saw two flat skins of bear killed in these swamps, but unfortunately did not buy them. They were black with whitish noses and rather small.

Dr. Merriam in his "Preliminary synopsis of the American bears" (Proc. Biol. soc. Wash., April 13, 1896, vol. 10, p. 79) gives the range of the black bear as "Forest — covered parts of North America north of the Lower Austral zone," and of the Louisiana bear as "Louisiana and Texas and probably other parts of Austro-riparian zone." From this one would expect this bear to be *Ursus luteolus*.

Mephitis elongata Bangs.

Mephitis mephitica elongata Bangs, Proc. Bost. soc. nat. hist., 1895, vol. 26, p. 3.

Mephitis elongata Bangs, Proc. Biol. soc. Wash., 1896, vol. 10, p. 142.

Type locality. Micco, Brevard County, Florida.

The long-tailed Florida skunk is found from the Savannah River well down into peninsular Florida. Mr. Cory says that "the Indians claim that it does not occur south of New River." The Indians being accurate observers, this is probably the case. Though somewhat local, it is a common species, both in the piny woods and hummocks, and at St. Mary's I caught one on the salt marsh. It is very apt to take up its abode in the towns, living about old buildings, sheds, wood piles, and the like. At St. Mary's I used to watch one that fearlessly came out every evening into the broad grassy main street of the city to feed.

I have specimens from Pinetucky and St. Mary's, Georgia, and New Berlin, Burnside Beach, Micco, Blitches Ferry, and Citronelle, Florida.

Spilogale ambarvalis sp. nov.

Mephitis bicolor Allen, Bull. Mus. comp. zool., 1871, vol. 6, p. 169. (Florida record of Spilogale; nec *Mephitis bicolor* Gray).

Spilogale putorius Merriam, N. Amer. fauna 1890, no. 4, p. 7 (not *Viverra putorius* Linné).

Type from Oak Lodge, east peninsula opposite Micco, Brevard Co., Florida, ♂ adult No. 3,481. Collection of E. A. and O. Bangs. Collected, Jan. 30, 1895, by O. Bangs.

General characters. Size small; hind foot small; tail very short; all the white markings extensive; pelage short and very soft, skull small, narrow, and high.

Color. As usual in the genus black striped and marked by white. All the white strips and marks large and conspicuous; in addition to usual markings there are white spots on outside of thigh, on upper surface of foot and at base of tail; a long white pencil at end of tail.

Cranial characters. Skull small, short, narrow, and high. Can be separated from the skull of *S. ringens* by its smaller size, larger mastoid capsules, rather narrower and deeper audital bullae, and by the difference in shape of upper molar tooth, the posterior-internal crescent of which is less broadly and evenly rounded.

Measurements. The type ♂ adult: total length, 381; tail vertebrae, 147; hind foot, 39.5. An adult ♀ topotype, No. 3,493: total length, 353; tail vertebrae, 119; hind foot, 39. Averages of five adult ♂ topotypes: total length, 383.8; tail vertebrae, 143.5; hind foot, 41.1. Averages of five adult ♀ topotypes: total length, 354.6; tail vertebrae, 121.2; hind foot, 38.8.

Skull, the type ♂ adult: basal length, 46; zygomatic breadth, 33; mastoid breadth, 27.8; breadth across postorbital processes, 16.8. An adult ♀ topotype, No. 3,483: basal length, 44; zygomatic breadth, 29.6; mastoid breadth, 26.6; breadth across postorbital processes, 16.

General remarks. Dr. Merriam in his revision of the little striped skunks of North America (N. American fauna, 1890, no. 4) used Linné's specific name *putorius* for the Florida Spilogale. This is a misidentification of the Linnaean name *Viverra putorius*, for in no way, either by reference or description, does it concern the Florida Spilogale. Linné based his name on Catesby and Kalm. Catesby's figure shows an animal mostly black with very narrow white stripes, and a long tail, *without* a white pencil. It appears to be a combination of *Mephitis mephitica* and *Spilogale ringens.* He does not mention it as occurring in Florida, only saying that it is found in most of the northern continent of America. Kalm's account is wholly of *Mephitis mephitica.* That Linné was not describing the Florida animal is patent as he says "cauda longitudine corporis," whereas the Florida species has a very short tail, less than half as long as the head and body.

Spilogale was not known to occur in Florida until Mr. C. J. Maynard found it in the winter of 1868–69 at Capt. Dummits on the east peninsula. Dr. J. A. Allen recorded Maynard's discovery in his mammals and winter birds of eastern Florida in 1871.

The Florida little striped skunk is one of the remarkable peninsulated Florida species, differing widely from its geographic nearest congener, *S. ringens.* It is very local in its distribution and is abundant only on the east peninsula of the Indian River.

I know of but one individual ever having been taken anywhere else — the one Dr. Merriam has from Kissimee Prairie. Perhaps it occurs also on some of the other interior prairies, but I have never been able to trap it anywhere except on the east peninsula.

At Oak Lodge I collected twenty-nine specimens, and found the animal very easy to trap in steel traps either baited or placed in paths leading through the saw palmetto near the beach, where the skunks were particularly abundant.

Spilogale ringens Merriam, type locality, Greensborough, Hale Co., Alabama, may occur in eastern Georgia or western Florida, though I know of no records for the region treated in the present paper. It is found in western Georgia and extends north to the western parts of Va. and to W. Va. (I have specimens from Lee Co., Va., and Mr. Thaddeus Surber has taken it at White Sulphur Springs, W. Va.) It is a large species with a longer tail and larger hind foot, and with all the white markings much reduced.

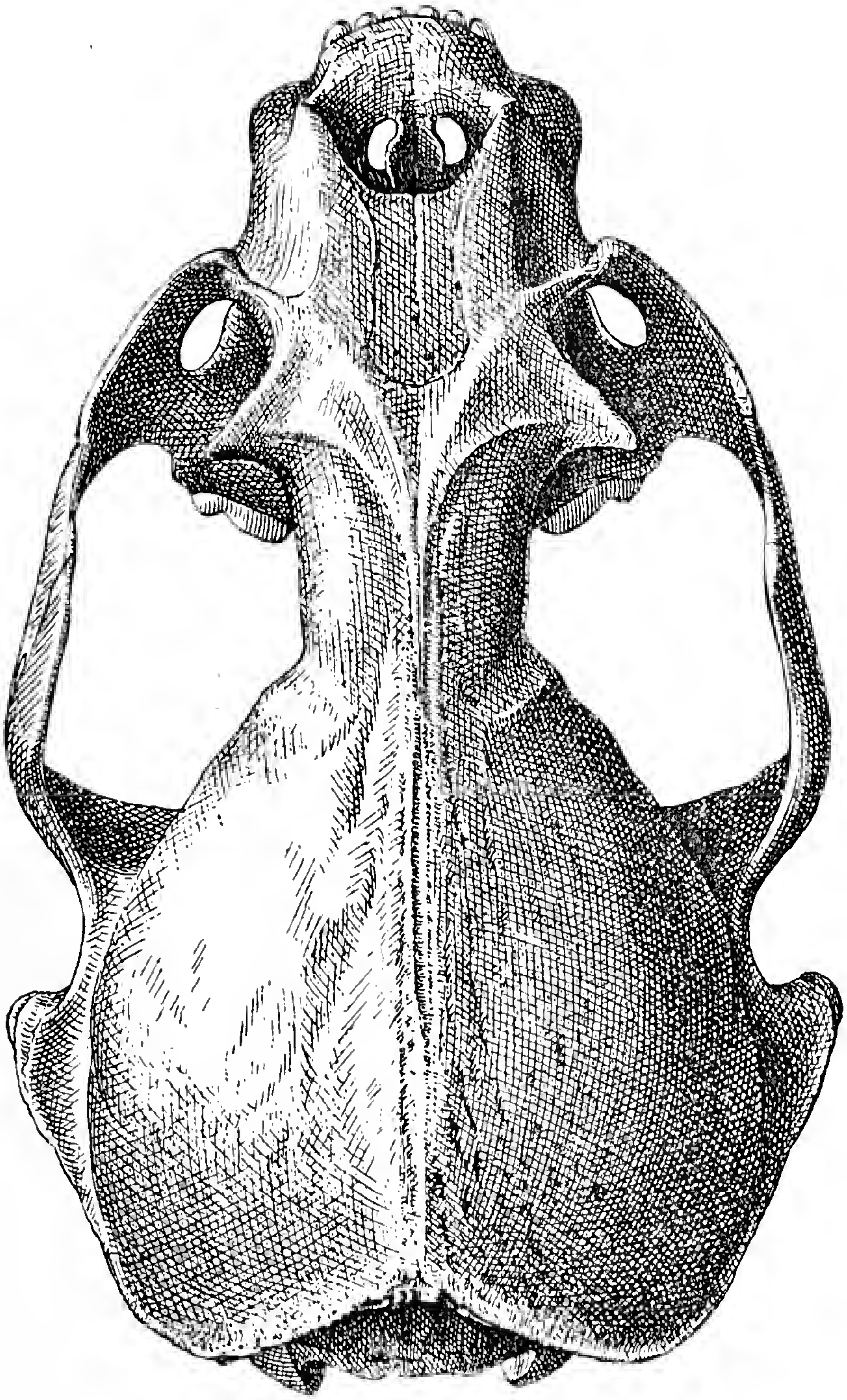
Lutra hudsonica vaga subsp. nov.

Type from Micco, Brevard County, Florida, ♂ young adult, No. 5,749, collection of E. A. and O. Bangs. Collected, March 17, 1897, by F. R. Hunter.

General character. Size slightly larger than *L. hudsonica typica;* tail longer; color much redder, less blackish; skull larger and broader across mastoids; much more constricted behind post-orbital processes.

Color. Lustrous chestnut brown, somewhat paler below; cheeks, lips, chin, throat, and sides of neck grizzled yellowish brown.

Cranial characters. Skull large, broad across mastoids, the mastoid processes large; slender and deeply constricted behind post-

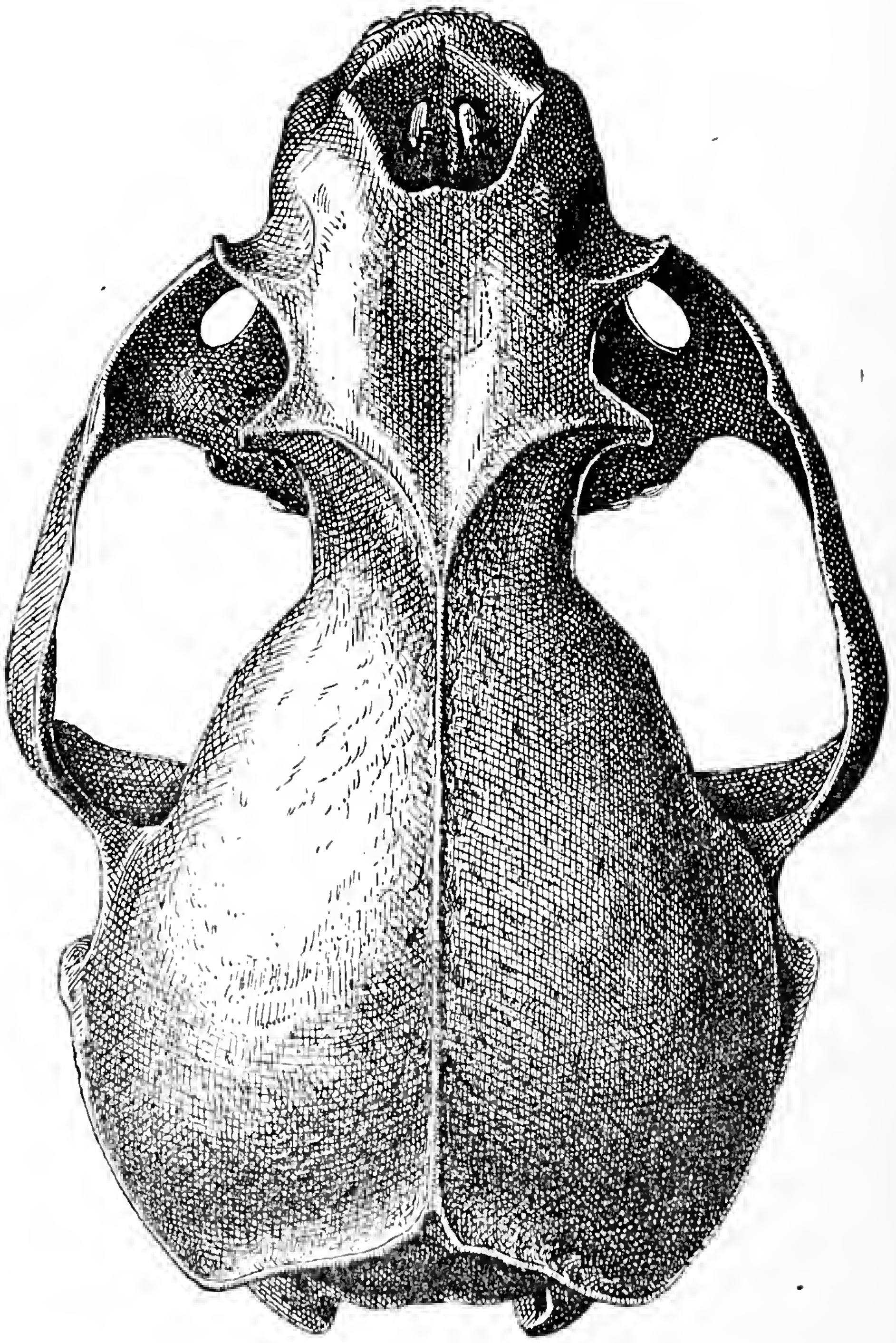


Lutra hudsonica vaga, young ♂.

orbital processes (this constriction being not only much deeper but much longer than in *L. hudsonica typica*). Dentition normal.

Measurements. The type was not measured in the flesh. A young adult ♂ from Citronelle, Florida, No. 4,998 (measured by F. L. Small): total length, 1,285; tail vertebrae, 487; hind foot, 130. An adult ♀ from Roseland, Brevard County, Florida, No. 4,995 (measured by W. L. Gibson): total length, 1,100; tail vertebrae, 400;[1] hind foot, 110.

Skull, the type ♂ young adult: basal length, 106.6; zygomatic breadth, 71; mastoid breadth, 71.2; interorbital constriction, 24; greatest constriction behind postorbital processes, 18.6; distance across postorbital processes, 35; last upper molar to end of pterygoid process, 29.8; foramen magnum to end of palate, 51.6; greatest length of single half of mandible, 74.4. An adult ♀ from Roseland, Florida, No. 4,995: basal length, 99; zygomatic breadth, 70.3;



Lutra hudsonica hudsonica, adult ♂.

[1] The collector's measurement for tail seems too short, judging by the skin.

mastoid breadth, 67; interorbital constriction, 21.8; greatest constriction behind postorbital processes, 17.8; distance across postorbital processes, 30; last upper molar to end of pterygoid process, 27; foramen magnum to end of palate, 49.2; greatest length of single half of mandible, 68.4.

General remarks. The Florida otter is generally distributed over Florida and eastern Georgia, being found in both fresh and salt water, though rather more common along the coast than in the interior. Formerly very abundant, it is steadily and, I am afraid, rapidly decreasing in numbers, being extensively trapped for its fur. It often breeds in the winter, at a time when it is trapped the most, and this may partly account for the rate at which it is decreasing.

Mr. Brown took one otter at Pinetucky, Georgia, and one at Hursman's Lake, Georgia; both are females. These two specimens are of interest as showing the first steps of an intergradation with *L. hudsonica typica.* They are in every way intergrades, but favor *vaga* rather more than *hudsonica typica.*

L. hudsonica vaga can always be separated from *L. hudsonica typica,* by the skull; the deep, long constriction behind postorbital processes, and large mastoid process with great width across that part of the skull, give it a very distinct appearance. The color of the two forms is also very different, *L. hudsonica vaga* being much the redder of the two, and never showing the dark seal brown sometimes almost black shades of *hudsonica typica.* *L. hudsonica vaga* is also rather the larger and has a longer tail.

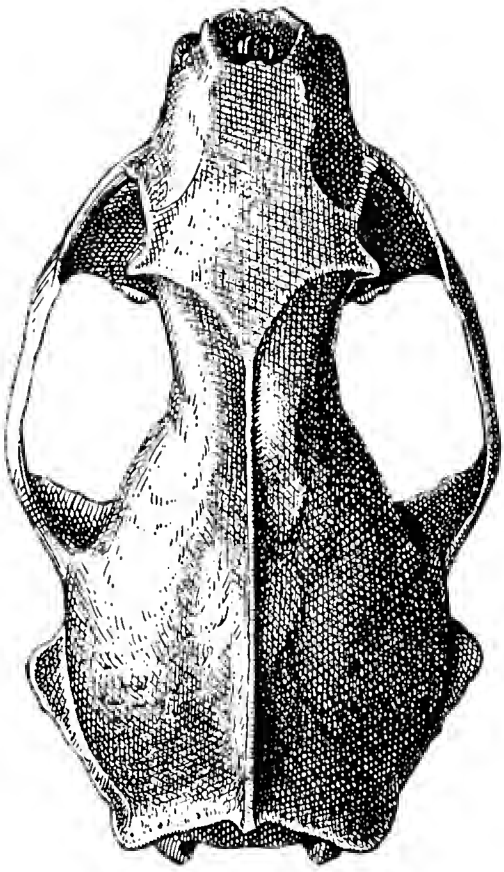
PUTORIUS (LUTREOLA) VISON LUTREOCEPHALUS (Harlan).

Mustela lutreocephala Harlan, Fauna Amer., 1825, p. 63.

Putorius vison lutreocephalus Bangs, Proc. Bost. soc. nat. hist., 1896, vol. 27, p. 4.

Type locality. Maryland.

The big brown or Carolinian mink occurs in interior Georgia, where it lives in swamps and along streams. It is replaced on the salt marsh of the coast by a very different form (described below as *P. lutensis*). Mr. Brown took the two forms within one hundred miles of each other; at Pinetucky, Georgia, taking two splendid old males of *P. lutreocephalus,* and at Montgomery on the salt marsh, eight examples of *P. lutensis.* In this short interval it does not seem probable that the two forms, living as they do under very different conditions, would be found to intergrade, but rather that *P. lutensis* has become a wholly segregated species, adapted to its peculiar habitat.



Putorius vison lutreocephalus, old adult ♂.

I do not know that *P. lutreocephalus* reaches Florida, though it may penetrate the extreme northwestern part of the state, the mammalian fauna of which is at present little known. Maynard reported mink as common at Cedar Keys, and also says he saw one at Blue Springs, but to just which form these belonged I can not say, having no specimens from either place.

The two specimens taken by Mr. Brown at Pinetucky, Georgia, measure as follows: —

No.	Sex.	Total length.	Tail vertebrae.	Hind foot.
5,983	♂ old adult	625	210	64
5,984	♂ adult	560	190	63

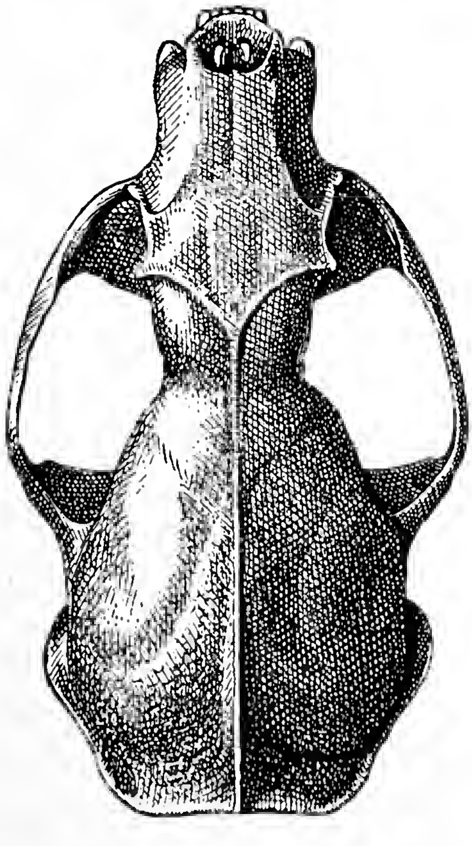
Putorius (Lutreola) lutensis[1] sp. nov.

Type from salt marsh opposite Matanzas Inlet, Florida, ♂ adult No. 7,225, collection of E. A. and O. Bangs. Collected, February 16, 1897, by O. Bangs.

General characters. Size rather smaller than *P. lutreocephalus*; tail shorter; hind foot larger; color paler, more yellow, less brown; skull long and slender with long narrow rostrum and frontals; zygomatic arch differently shaped; dentition very heavy and strong.

Color. Russet or yellowish clay color, usually some irregular white markings on chin and under parts; tail gradually darkening towards tip to dark reddish brown.

Apparently there are two seasonal pelages, a clay-colored spring and summer one, and a russet autumnal and winter one. Most specimens taken after the middle of February have wholly assumed the clay-colored dress. Specimens taken before that time are almost all in the russet pelage. Many specimens are "patched" with large irregular, distinct blotches of clay color and russet.



Putorius lutensis, old adult ♂.

[1] Lutensis = found or living in mud.

The change of color is not due to wearing of the hairs, but is apparently brought about by a moult.

Cranial characters. The skull of *P. lutensis* is very distinct; it is long and slender, deeply constricted interorbitally, with very long, narrow rostrum and frontals; the zygoma are slender, lie close to the skull, and slant backward from the rostrum, causing the forward part of the skull including the zygoma to have a wedge-like appearance (in other mink the zygoma stand out in a more abrupt curve). Postorbital processes short and weak; audital bullae larger and deeper than in *P. lutreocephalus*, though not so large nor so deep as in *P. vulgivagus.* The distance, measured from front of nasals or premaxilla to postorbital process, is much greater in *P. lutensis* than in the skull of any other mink, and will alone serve to distinguish the species. Dentition very heavy

FLESH MEASUREMENTS OF FULLY ADULT SPECIMENS OF PUTORIUS (LUTREOLA) LUTENSIS.

No.	Locality.	Sex.	Total length.	Tail vertebrae.	Hind foot.
7,225	Fla., salt marsh opposite Matanzas Inlet (Type)	♂	574	197	68
7,229	Fla., salt marsh opposite Matanzas Inlet	♂	550	182	68
7,228	Fla., salt marsh opposite Matanzas Inlet	♂	560	190	70
7,224	Fla., salt marsh opposite Matanzas Inlet	♂	553	203	69.5
7,226	Fla., salt marsh opposite Matanzas Inlet	♂	579	200	71
7,230	Fla., salt marsh opposite Matanzas Inlet	♀	477	161	57
5,032	Geo., St. Mary's	♂	583	188	72
5,030	Geo., St. Mary's	♂	539	180	70
5,031	Geo., St. Mary's	♂	564	192	66
5,034	Geo., St. Mary's	♂	526	180	61.5
5,033	Geo., St. Mary's	♂	536	179	61
5,035	Geo., St. Mary's	♀	501	162	61
6,309	Geo., Ossabaw Island	♂	615	185	72
6,303	Geo., Montgomery	♂	605	203	73
6,304	Geo., Montgomery	♂	605	185	76
6,302	Geo., Montgomery	♂	580	170	75
6,306	Geo., Montgomery	♀	550	175	64
6,308	Geo., Montgomery	♀	535	170	64
6,307	Geo., Montgomery	♀	501	160	60
6,305	Geo., Montgomery	♀	526	160	64

throughout, the upper molar teeth especially being very large. (The dentition is about equaled by that of the Louisiana mink, *P. vulgivagus.*)

Measurements. Skull, the type, ♂ old adult: basal length, 63.8; zygomatic breadth, 37; mastoid breadth, 31.2; interorbital width, 14.2; least width behind postorbital processes, 10.6; distance across postorbital processes, 16.2; distance from postorbital process to end of nasals, 19.2; greatest length of single half of mandible, 40.8.

An adult ♀ topotype, No. 7,230: basal length, 53.6; zygomatic breadth, 31.6; mastoid breadth, 27.2; interorbital width, 12.8; least width behind postorbital processes, 11; distance across postorbital processes, 14; distance from postorbital process to end of nasals, 18; greatest length of single half of mandible, 34.8.

General remarks. The home of *P. lutensis* is the illimitable salt marsh of the South Atlantic States. Its range extends from the marshes of the Matanzas River, Florida,[1] certainly to the coast of South Carolina. It is very abundant and in its favorite haunts about the muddy margins of the creeks, and in the wetter parts of the marsh, where the growth of marsh grass is the heaviest, it can be trapped in almost any numbers. At Matanzas I caught seven mink in two nights with only six sets. Both nights all the traps that did not catch, were tripped and the bait, mullet, stolen, and the first night a raccoon occupied one of the traps. On the marshes of the St. Mary's River, I found the salt-marsh mink nearly as common as at Matanzas. Mr. Brown took it on the marshes at Montgomery and Ossabaw Island, Geo.

Living under the peculiar conditions of the salt marsh a mink has developed, in *P. lutensis*, that is very different from its nearest geographical relative, *P. lutreocephalus*, with which it apparently no longer intergrades. The skulls of the two are very unlike. The long slender rostral and frontal region, and wedge-like form of the zygoma seem to adapt *P. lutensis* admirably for pushing its way through the dense growth of heavy marsh grass in which so much of its life is spent.

The dentition of *P. lutensis* is very heavy and strong, and in this respect, as also somewhat in color, it resembles the form of the

[1] The salt marsh proper ends about here, though occasional expanses may be found farther south, as at Merritt's Island, etc. It seems improbable that mink occur, however, in these small, isolated marshes. The salt savannahs of the Indian River are very different in character from the salt marsh of the coast farther north. I never have found any signs of mink on the Indian River.

coast of Louisiana, *P. vulgivagus.* The resemblance between these two forms is, however, not deep seated, as their skulls are wholly different, that of *P. vulgivagus* being heavy and short, with broad frontals and rostrum, heavy and broadly rounded zygoma standing well out from the skull at the forward end, and large, strong post-orbital processes. Moreover, I do not see how their geographical ranges can meet.

There is a confusion in regard to the name "mink" in Florida that must always be borne in mind in dealing with the hunters and the trappers there, many of whom call the Florida weasel (*Putorius peninsulae*) "mink." Wherever the salt-marsh mink (*P. lutensis*) occurs, it is, however, always called "mink."

PUTORIUS (ARCTOGALE) PENINSULAE Rhoads.

Putorius peninsulae Rhoads, Proc. Acad. nat. sci., Phila., 1894, p. 152.

Type locality. "Hudson's," Pasco County, Florida (fourteen miles north of Tarpon Springs).

The Florida weasel is by no means rare throughout peninsular Florida. It is one of the most difficult animals to trap; indeed no one has ever been able to trap it successfully, the few specimens that have found their way into collections having been either shot or taken, as it were, by accident.

About Gainesville it is fairly common, and several have been found on the railroad tracks there, killed by the train. Young Mr. Bell also shot a fine one at the edge of the great prairie about a year ago, but did not save it. I wasted more time in a vain endeavor to trap it there, than I ever did over any other animal. No bait lured it, and it always avoided any trap I set, though I several times saw fresh tracks, that I supposed were the footprints of this species.

It apparently lives on the cotton rat, Sigmodon, which it often kills in large numbers, just for sport, leaving the dead scattered over the ground in all directions. Probably the difficulty of trapping it is in part due to the great abundance of its natural food, so much so that it never is hungry.

P. peninsulae is a large, powerful weasel, belonging to the *longicauda* group, is wholly different from any other species, and needs comparison with none. Whether its range extends beyond Florida is uncertain; Mr. Brown did not get a weasel on his trip, nor could he hear of one anywhere in Georgia.

I believe no additional specimens have been taken since my record (Proc. Biol. soc. Wash., 1896, vol. 10, p. 10).

Urocyon cinereoargenteus floridanus Rhoads.

Urocyon cinereoargenteus floridanus Rhoads, Proc. Acad. nat. sci. Phila., 1895, p. 42.

Type locality. Tarpon Springs, Florida.

The Florida gray fox is a common animal in most parts of Florida and extends north over, probably, the whole of eastern Georgia, with the likelihood that it intergrades with true *U. cinereoargenteus* somewhere in northern Georgia. One that Mr. Brown took at Barrington, Georgia (No. 6, 421, ♂ adult), is scarcely different from Florida specimens.

The Florida form differs from true *U. cinereoargenteus* in being considerably smaller and much paler in color, the rusty markings are yellower, and the white markings on legs and under parts more yellowish and less purely white. The pelage is shorter and harsher.

Flesh measurements of U. cinereoargenteus floridanus.

No.	Locality.	Sex.	Total length.	Tail vertebrae.	Hind foot.
6,421	Ga., Barrington . . .	♂ old adult	975	355	142
2,490	Fla., Citronelle . . .	♂ adult	928	340	148
2,489	Fla., Citronelle . . .	♀ adult	909	309	132
2,491	Fla., Citronelle . . .	♂ yg. adult	900	335	135

I have specimens from Barrington, Georgia, and Citronelle and Micco, Florida.

Canis ater (Richardson).[1]

Canis lupus occidentalis var. *E. Lupus ater* Rich., Fauna Bor.-Amer., 1829, p. 70.

[1] It seems to me that Richardson's name *ater* must stand for the dark-colored wolf of Florida; for though Richardson mentioned specimens from Canada, the Mackenzie and Saskatchewan rivers, etc., which are of course black individuals of the northern wolf, at the end of his article he says, "It is reported to be plentiful in Florida where according to Bartram, the females are distinguished by a white spot on the breast." Moreover, Audubon and Bachman (Quad. North Amer., vol. 2, p. 126) limit the name to the southern animal.

Canis lupus var. *ater* Aud. and Bach., Quad. N. Amer., 1851, vol. 2, p. 126.

Type locality. North America.

The southern black wolf is now probably restricted to the everglades of Florida, where it still occurs in some places (see Cory, Hunting and Fishing in Florida, p. 345), unless the wolf of southern Louisiana be the same, where they are still comparatively common in some of the large tracts of swamp.

It is of the utmost importance that specimens of the Florida wolf should be procured before it becomes entirely extinct, and I believe Mr. Cory is now making every effort to obtain some.

Lynx (Cervaria) ruffus floridanus (Raf.).

Lynx floridanus Raf., Amer. mon. mag., 1817, vol. 2, p. 46 (based on the Lynx or wild cat of Bartram).

Lynx rufus var. *floridanus* Baird, Mam. N. Amer., 1857, p. 91, in text. Allen, Bull. Amer. mus. nat. hist., 1893, vol. 5, p. 32, in text.

Lynx ruffus floridanus Rhoads, Proc. Acad. nat. sci. Phila., 1897, p. 32, foot-note.

Type locality. Florida.

The Florida lynx is a common animal all over Florida and extends west to Louisiana and most probably north throughout eastern Georgia. It is a matter of great regret to me that Mr. Brown failed to secure specimens of lynx in Georgia, but undoubtedly *L. floridanus* is the form found there.

L. floridanus is very different, possibly specifically so, from *L. ruffus typicus*, and it would be of great interest to see a series from localities connecting the geographic ranges of the two.

I have specimens from New Berlin, Micco, Oak Lodge, and Citrus County, Florida, and from Burbridge, Louisiana.

Felis concolor floridana Cory.

Felis concolor floridana Cory, Hunting and fishing in Florida, Boston, 1896, p. 109.

Type locality. Region north of Lake Okeechobee and east of Kissimee River, Florida.[1]

[1] No type or type locality was assigned in the original description, but Mr. Cory has told me that he based the form on three specimens, all killed in this region by himself.

The very characteristic Florida "panther," puma, is still to be found in the more thinly settled parts of the state. The exact range of the form can not now be given, as the puma is extinct in all the region directly northeast of Florida, and I believe in northern Florida as well. None have been seen in eastern Georgia for many years. Pumas still occur in Louisiana, but I think these do not belong to the Florida form.

Probably *Felis floridana* is more than subspecifically different from *Felis concolor* Linné of Central America, but until the whole group is worked out, it is better to allow the name to stand as originally given. It seems a pity, though, that Cory should have given this fine cat the name "*floridana*," as many authorities, perhaps justly, consider the characters that separate Lynx from Felis of subgeneric weight; and if this course is followed, the name is preoccupied by the *Lynx floridanus* Raf.

I have six splendid skins and skulls, ♂'s, ♀'s, and young, of the Florida panther, all collected for me by F. R. Hunter, west of Sebastian, Florida, and therefore practically topotypes.

The largest of these, a ♂, stood three feet four inches high at the withers, and three feet six inches high at the rump.

I can say little of the characters of this form, not being familiar with true *Felis concolor*. But the Florida animal is small and has very small feet and hands and a long tail, and is of a bright yellowish bay color.

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THE GENUS ANTENNARIA IN NEW ENGLAND.

By Merritt L. Fernald.

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No. 8.— *The Genus Antennaria in New England.*

By Merritt L. Fernald.

The genus Antennaria has recently attracted a remarkable degree of attention from American systematists. As treated in the standard manuals of the country, the northeastern states are given only one very polymorphous species, the so-called *Antennaria plantaginifolia.* During the past year, however, no less than eight articles have appeared, each of them either describing or discussing different plants which have passed under that name. Many inquiries have been made about the recent treatment of these plants; and as the descriptions are either very scattered or else in journals hardly accessible to most New England botanists, the following synopsis of the New England species, as now understood, has been prepared. In determining these New England forms I have been greatly aided by Prof. E. L. Greene of the Catholic University at Washington, who has kindly compared specimens I have sent him with the types of some of his species, and who has furnished me specimens of other species about which there has been doubt.

In a recently published article [1] I have discussed the species which seems most probably to be the plant to which Linnaeus referred as *Gnaphalium plantaginifolium*, and to which the name *Antennaria plantaginea* was subsequently given by Robert Brown. In the same place I have stated the reasons why this name of Brown is taken up for the plant. That question need not now concern us; but as there has been great doubt in regard to the plant taken to represent *A. plantaginea*, it seems advisable to reiterate and if possible to make clearer the discussion of this point which was taken up in the article above referred to.

Of course the fundamental question to be settled, before describing new species in this group, is the identity of the Linnaean *Gnaphalium plantaginifolium.* Linnaeus described this plant in 1753 [2], but his description is so brief and with so little of a specific character that it is necessary to rely upon the earlier descriptions cited by him. There are two of these descriptions referred to, one by

[1] Asa Gray bulletin, vol. 5, p. 91.

[2] Sp., ed. 1, p. 805.

Gronovius, and the other, accompanied by a figure, by Plukenet. Gronovius, too, cites Plukenet's description and figure, so that it is upon these that the decision must largely depend. Accompanying my article in the Asa Gray bulletin, a plate was published giving a careful copy by Mr. Charles E. Faxon of Plukenet's figure. It represents a plant with a stem bearing a few scattered lanceolate leaves, and surmounted by a globular cluster of 8 or 9 heads, and at the very base are five small spatulate leaves. Two stolons are represented as coming from the base of the plant, one of them with a terminal cluster of very large ovate triple-nerved leaves; the other more elongated and bearing a few scattered small leaves similar to those of the flowering stem and a couple of ovate triple-nerved terminal ones. Plukenet's descriptive note,[1] "Gnaphalium Plantaginis, folio Virginianum, White Plantain (*i. e.*) Plantago candida Nostratibus, vulgo," was short; but, accompanied by the characteristic figure, it should be of service in settling what plant he had in mind. The small basal leaves, accompanied by such very large terminal ones as Plukenet represents, are not matched by any plant with which we are familiar; but considering the age and rather conventional character of the drawing it is most nearly approached by one of our common species.

In discussing, in the article already mentioned, the plant which I have taken to match Plukenet's figure and note I have said: "The plant which this figure represents, it will be remembered, came from Virginia, and, in looking through our American plants for the species which approaches nearest the original plate, we find a form coming not only from Virginia, but growing in some abundance from Maine and Wisconsin south to Louisiana. This plant has not only the large ovate basal leaves and the scattered lanceolate cauline ones of Plukenet's drawing, but the stems and leaves (at least when young) are covered with a conspicuous white pubescence, which might well have suggested the 'White Plantain (*i. e.*) Plantago candida' of Plukenet."

Continuing the discussion from which the foregoing extract is taken, I showed how different from this white-pubescent plant, which was taken for *A. plantaginea*, was the recently described *A. parlinii*. The drawing by Mr. Faxon of the latter plant brings out very clearly many of the striking differences, but the very important color characters could be brought out only by the descriptive

[1] Pluk. Alm., p. 171.

note: "The plant is conspicuous in the field on account of the smooth, bright-green upper surfaces of the basal leaves. The lower surfaces, however, are of a clear-white color, making with the bright-green a marked contrast. Another characteristic difference between the two plants, and one which is better brought out in the drawing, is in the cauline leaves. In *A. plantaginea*, as we have seen, the white-tomentose cauline leaves are lanceolate, acute and rather remote. In *A. parlinii*, on the other hand, the thicker oblong obtuse or acutish cauline leaves are more crowded below, and they are not white-tomentose, but green above and sordid-pubescent beneath, and covered on both faces with elongated [stipitate] glands. The stems, which in *A. plantaginea* are green, in *A. parlinii* are generally purple; and surely no one seeing the plant would think of Plukenet's 'White Plantain (*i. e.*) Plantago candida.'"

The striking white pubescence of the plant taken for *A. plantaginea*, and its strong habital resemblance to the Plukenet figure were considered nearly convincing evidence, and in discussing the plant at that time I had no thought but that Professor Greene had arrived at the same conclusion. Apparently he did lean then somewhat toward this decision, but, in a late number of his journal,[1] he described as a new species the white-pubescent plant, giving it the name *A. decipiens*, and leaving to represent *A. plantaginea* a stouter plant with more coriaceous basal leaves which are bright green and quite glabrous on the upper surfaces. In the same article where these plants are discussed by Professor Greene my *A. parlinii* was recognized as a distinct species. After corresponding with Professor Greene on the subject and receiving from him specimens of what he called *A. plantaginea* and also his *A. decipiens*, I found it impossible to reach his conclusions. The plant which he described as *A. decipiens* is exactly the form which I maintained was *A. plantaginea*. It is characterized, as Professor Greene emphasizes, by the white pubescence of the upper leaf-surfaces, and it also has small scattered cauline leaves, *i. e.*, it has the most striking characters of Plukenet's "*Plantago candida.*"

On the other hand, the glabrous-leaved plant, which Professor Greene referred to Plukenet's figure and description, is hardly distinguishable from what I have described and Mr. Faxon has figured as *A. parlinii*. The stems, though, are greener, and the broader involucral bracts white-tipped. The remarkable point is

[1] Pittonia, vol. 3, p. 278.

that in some of the specimens of this plant which Professor Greene has sent me not only are the habital and foliage characters as in that species, but the stolons are invested with many of the unique stipitate purple glands which are so characteristic of the young growths of *A. parlinii*. How so unusual a character in the genus as is this one could have so long escaped the attention of Professor Greene who made no mention of it in his descriptions and who kept separate from his plant *A. parlinii* is indeed hard to understand.

Leaving this question, though, we must return again for a moment to the fundamental one of the Linnaean *Gnaphalium plantaginifolium*. Professor Greene's argument for calling this smooth-leaved species the Plukenet plant was that it had firmer leaves than the other, and consequently the basal leaves were more like plantain. But in this connection it should be noted that in his description of *A. decipiens* (the pubescent-leaved species), aside from the thinner texture and the pubescence of the leaf, he gives us no leaf differences. In fact, from his description, "of the large dimensions, short stolons, broad petiolate triple-nerved leaves, and the general habit of *A. plantaginifolia*," one is led to infer that in size and outline the leaves are essentially the same. This is the case in specimens I have examined. A Louisiana specimen of his *A. decipiens* has the leaves practically as large as those he has sent me of what he called *A. plantaginifolia* which, in the accompanying letter, he says show "uncommonly well the fully developed leaves." The basal leaves of the two species are, then, alike in size and outline: their differences are alone those of color, pubescence, and texture. Professor Greene's *A. decipiens* has the old basal leaves generally glabrate dull and often rusted or blotched with purplish or brown. *A. parlinii* has the basal leaves bright clear green and glabrous from the first. Even admitting Professor Greene's statement that the leaves of the latter are more like plantain in texture, — a statement which, when one considers the variability of our commonest introduced plantain, is not entirely convincing, — one may perhaps be permitted to ask whether, if Plukenet had only one of these plants and did not know the other, he would make such a distinction; and whether, in view of the figure and note which he published, it is not better to consider as representing his plant the species which has the greatest habital resemblance to his figure and which best matches the impression given by his description "*Plantago candida*."

Later, however, Professor Greene has reversed[1] his view of the question — hardly seven weeks since he modified his first decision; and now he announces the same conclusion which was published by me in the Asa Gray bulletin. Though he agrees that the plant he described as *A. decipiens* is probably the plant figured by Plukenet, and, therefore, *Antennaria plantaginea* R. Br., he does not recognize the specific identity of the smooth-leaved species which he had formerly called *A. plantaginifolia* and the plant I have described as *A. parlinii.* At any rate, he describes this smooth-leaved plant as a new species, *A. arnoglossa*, though he cites no type specimen or specimens; and his description hardly differs from that of *A. parlinii* except in the addition of a characterization of the staminate plant and the description of the bracts of the pistillate heads where he says, "tips of their involucral bracts from obovate-oblong to oblong-linear, obtuse, seldom even the innermost acutish." Plants sent me by Professor Greene early this spring as typical of what he then called *A. plantaginifolia*, and which must now represent his *A. arnoglossa*, show the bracts of the pistillate heads to have white petaloid tips, the outer ones mostly obtuse. In *A. parlinii* the bracts have scarious acute tips. Beyond this difference I am unable to find any points by which to separate the plants, and I cannot think that the involucral characters are of sufficient constancy to justify our making specific distinctions upon them alone. It seems to me better in view of the variability of this involucral character to consider *A. arnoglossa* a southern variety of *A. parlinii* parallel with similarly distinguished forms of *A. neodioica* and *A. canadensis.*

Doubtless much yet remains to be made out before we shall have a satisfactory knowledge of these very common and long overlooked roadside plants, but, for the present, the following descriptions and notes will furnish a synopsis of all the species known to us in New England, and, so far as possible, it states the range of each species within our territory.

Synopsis of Species.

* Basal leaves and those at the tips of the assurgent stolons large, 5 to 12 cm. (in reduced specimens rarely 4 cm.) long.

+ Leaves dull, invested above with nearly persistent white pubescence, only the oldest basal ones sometimes glabrate: stems and stolons with no stipitate dark glands.

[1] Pittonia, vol. 3, p. 318.

A. plantaginea R. Br. Variable in size, from 1 to 4.5 dm. high, the stems, stolons, and younger leaves invested with whitish glandless pubescence: basal leaves distinctly 3-nerved, ovate or obovate, generally mucronate, the blades equaling or exceeding the petioles; cauline leaves rather scattered, lanceolate: heads densely or loosely corymbose: involucre in the pistillate plant 6.5 to 8.5 mm. high; the linear bracts with slightly lanate green or tawny herbaceous bases and more or less conspicuous white or purplish scarious or petaloid tips; the outer bracts generally blunt, the inner acute or bluntish: heads of the smaller staminate plants shorter, the less distinctly imbricated bracts with blunt oblong or linear-oblong, generally radiating, white petaloid tips.— Trans. Linn. soc., vol. 12, p. 123; Fernald, Asa Gray bull., vol. 5, p. 92, pl. 2, fig. 6, 7. *A. plantaginifolia* Hook., Fl. Bor.-Amer., vol. 1, p. 330; Greene, Pittonia, vol. 3, p. 173, as to staminate plant. *A. decipiens* Greene, Pittonia, vol. 3, p. 278. *Gnaphalium plantaginifolium* L. Sp., ed. 1, p. 850. *G. plantagineum* L., Syst. nat., ed. 12, p. 545. Common in southern New England where it flowers in late May and early June; extending northward to South Hero, Vt. (L. R. Jones), Jaffrey, N. H. (E. L. Rand and B. L. Robinson), Orono, Me. (George B. Fernald), and eastward to Mt. Desert Island, Me. (E. L. Rand). Professor Greene gives the southern limit of this species (his *A. decipiens*) as Maryland and Virginia. The following specimens in the Gray Herbarium from more southern stations are referred here: rich woods, Jackson, Tenn. (S. M. Bain, no. 69), Louisiana (Dr. Hale), the latter specimens pistillate plants.

var. **petiolata**. Plant lower and more slender than the species: basal leaves ovate-spatulate or obovate-spatulate, obtuse or acutish, on slender elongated petioles: pistillate heads more closely aggregated; involucre often more purple tinged, generally shorter and with narrower bracts.— North Berwick, Me., June, 1897 (J. C. Parlin, no. 1,016), Jaffrey, N. H., May 29 and 31, 1897 (E. L. Rand and B. L. Robinson, nos. 411, 412), Medford, Mass., May 11, 1854 (Wm. Boott), Waverly, Mass., May 26, 1895, and Lexington, Mass., June 6, 1897 (B. L. Robinson). A very common plant in eastern Massachusetts, forming extensive carpets on dry slopes and in open woods. At Providence, R. I., and particularly in the Elmwood district, Mr. J. F. Collins and I found many acres of plants presenting all imaginable gradations from this extreme variety to typical *A. plantaginea*.

++ Leaves of the stolons bright green, glabrous above, or in one form with arachnoid pubescence above, young stems and stolons bearing dark stipitate glands.

A parlinii Fernald. Plants generally tall, 1.5 to 5 dm. high, averaging stouter than the preceding species: stems purplish or sometimes green, with the stout stolons thinly white-silky or lanate above, and generally bearing, especially below, or near the inflorescence, stipitate purple glands: leaves thicker and greener than in the last; the basal ones distinctly 3-nerved, subcoriaceous, from broadly obovate to obovate-spatulate, rounded or obtuse and generally mucronate at the tips; lower cauline leaves more numerous and more crowded than in *A. plantaginea*, oblong or oblong-lanceolate, obtuse or acutish, mucronate, glandular on both faces, green above, sordid beneath: heads of the pistillate plant loosely or densely corymbose: involucre 8 to 10.5 mm. high, of about 3 rows of linear bracts with purple or greenish herbaceous bases and scarious tips; the outer bracts acute or obtuse, the inner long-attenuate: staminate plant unknown.— Garden and forest, vol. 10, p. 284, and Asa Gray bull., vol. 5, p. 92, pl. 2, fig. 1 to 5; Greene, Pittonia, vol. 3, p. 277. On woodland knolls and rich slopes or even in open rocky ground, flowering in late May and in June. Specimens have been examined from the following stations: Veazie, Me. (M. L. Fernald), Mt. Desert Island, Me. (E. L. Rand), North Berwick, Me. (J. C. Parlin and M. L. Fernald), Jaffrey and Dublin, N. H. (E. L. Rand and B. L. Robinson), Lexington, Mass. (B. L. Robinson and J. M. Greenman), Elizabeth, N. J. (Halsted's American weeds, no. 134, at least in part). The stipitate glands, which are abundant in early spring specimens, are either deciduous or very soon shrivelled—at any rate they are almost invariably absent in mid-summer specimens.

var. **arnoglossa**. Stems mostly greenish: involucral bracts of pistillate heads with broader white petaloid tips, the outer mostly obtuse, the inner hardly attenuate; "male heads," according to Professor Greene, "5 to 8, in a more dense cluster; milk-white tips of the involucral bracts very ample and showy, obovate or oblong-obovate, obtuse or nearly truncate, often marginate." *A. plantaginifolia* Greene, Pittonia, vol. 3, p. 173, as to pistillate plant, and l. c., 277, 278. *A. arnoglossa* Greene, l. c., 318.— Of more southern range than the type, occurring in both staminate and pistillate forms near Washington, but found only as a pistillate plant at New Haven, Conn., where it grows in great abundance with *A. plantaginea*, on the wooded slope of Mill Rock (A. W. Evans and M. L. Fernald).

var. **ambigens**. Generally shorter than the two preceding: stems, stolons, and leaves less glandular: cauline leaves larger; leaves of the stolons arachnoid above, and with early deciduous tomentum beneath: involucral bracts as in var. *arnoglossa*.—*A. arnoglossa* var. *ambigens* Greene, l. c., 320.—A puzzling form, in its pubescent leaves somewhat approaching *A. plantaginea*, but well distinguished by its brighter green color, larger, more crowded cauline leaves and the peculiar stipitate glands. Rather rare and only as a pistillate plant about Washington (E. L. Greene), but in both staminate and pistillate forms on river banks at Agricultural College, Mich. (C. F. Wheeler). In New England only pistillate plants are known, those from the following stations: Jaffrey, N. H. (E. L. Rand and B. L. Robinson), Wellesley, Mass. (J. M. Greenman, E. F. Williams and M. L. Fernald), Elmwood, Providence, R. I. (J. F. Collins and M. L. Fernald), New Haven, Conn. (D. C. Eaton).

* * Basal leaves and those at the tips of the stolon small, 2 to 4 cm. long (in very luxuriant plants rarely 5 cm. long).

+ Basal leaves, or at least those at the tips of the assurgent stolons, differentiated into petioles and obovate or spatulate blades: heads loosely corymbose or by elongation of the stem becoming subracemose, the lower ones often on elongated pedicels.

++ Leaves dull, invested above with nearly persistent white pubescence, only the oldest basal ones sometimes glabrate.

A. neodioica Greene. Stems slender, 1.5 to 4 dm. high, invested with very flocculent white pubescence; stolons numerous, rather short, and very leafy: basal leaves distinctly mucronate, the oldest ones sometimes glabrate; cauline leaves lance-attenuate, small, rather remote: involucre of the pistillate plant 6 to 9 mm. high, the bracts with green or tawny bases and scarious tips, the outer short and obtuse, the inner lanceolate, acutish or blunt; "bracts of the male involucre," according to Professor Greene, "all very broad and obtuse, or truncate, or even emarginate." — Pittonia, vol. 3, p. 184 and 280. — Apparently a common species on woodland knolls and banks or even in the crevices of dry ledges, flowering from late May to the middle of July. The following New England specimens, all pistillate, have been referred here: Orono, Me. (M. L. Fernald), Mt. Desert Island, Me. (E. L. Rand), Franconia, N. H. (Edwin Faxon), Jaffrey, N. H. (E. L.

Rand and B. L. Robinson), Lexington, Mass. (B. L. Robinson), Providence, R. I. (J. F. Collins and M. L. Fernald). Autumnal leaf-specimens from rocky shores and mountain summits in Aroostook and Penobscot Counties, Me., are to be referred here or to one of the following.

var. **attenuata.** Involucral bracts narrower, with scarious tips; the outer acute, the inner long-attenuate.— The common form in northern New England, habitually like *A. neodioica* but with its narrow attenuate bracts presenting a rather marked difference. Knolls in woods, base of Mt. Kineo, Me., July 9, 1897 (F. S. Collins and M. L. Fernald), also in woods and on rocky banks, Masardis, Island Falls, Sangerville and Orono, Me. (M. L. Fernald), abundant on Mt. Desert Island, Me. (E. L. Rand, Sara W. Boggs), Franconia, N. H. (Edwin Faxon), New Haven, Conn. (A. W. Evans and M. L. Fernald).

var. **petaloidea.** Heads large, the involucre 9 or 10 mm. high; the obtuse or acutish bracts with conspicuous white petaloid tips, equaling or exceeding the herbaceous bases.— Jaffrey, N. H., May 31, 1897 (E. L. Rand and B. L. Robinson), also Farmington, Me. (C. H. Knowlton), Franconia, N. H. (Edwin Faxon). Large leaved forms of this may usually be distinguished from reduced specimens of *A. plantaginea* by the numerous short stolons and the less distinctly triple-nerved leaves.

++ ++ Basal leaves clear green and glabrous above (the young leaves very rarely with a few early-deciduous hairs).

A. canadensis Greene. Stems slender, 1.5 to 5.5 dm. high, invested with flocculent white pubescence; stolons short and numerous, similar to those of *A. neodioica*: basal leaves spatulate or obovate-spatulate, acute or obtuse and mucronate; cauline leaves lance-attenuate, small and rather remote: involucre of the pistillate plant 7 to 10 mm. high, slightly lanate below; bracts linear or linear-lanceolate, chartaceous or herbaceous below, with whitish scarious or petaloid tips; the outer acute or obtusish, the inner attenuate ones often chartaceous or herbaceous nearly to the tips: staminate heads smaller, the bracts with broader obtuse white petaloid tips. —Pittonia, vol. 3, p. 275.— A common late flowering species in northern New England, specimens having been examined from the following stations: dry slopes and summits of Mt. Chase, Penobscot Co., Russell Mt., Blanchard, Peaked Mt., Clifton, and dry fields, Foxcroft and Milo, Me. (M. L. Fernald), dry gravelly soil, Orono, Me. (George B. Fernald), in dry open places or in woods, Mt. Desert Island, Me. (E. L. Rand, Sara W. Boggs), in almost pure sand, North Berwick, Me. (J. C. Parlin), hillsides and pastures, Franconia, N. H. (Edwin Faxon), open hillsides, Jaffrey, N. H. (E. L. Rand and B. L. Robinson), Charlotte, Vt. (C. G. Pringle). Specimens from Farmington, Me. (C. H. Knowlton), Lexington, Mass. (B. L. Robinson), Wellesley, Mass. (J. M. Greenman, E. F. Williams and M. L. Fernald), and some Mt. Desert plants are somewhat intermediate between this and the following.

var. **randii**. Stems mostly tall, 3 to 5.5 dm. high; stolons more slender and elongated: youngest leaves often sparingly pubescent, very soon glabrate: heads larger, involucre 8 to 11 mm. high; the broader more distinctly imbricated bracts with conspicuous long white petaloid tips, the outer blunt, the inner acute or bluntish.—A very attractive plant collected by Mr. Rand in 1897, at various stations on Mt. Desert Island, Me.: roadside near Ripples Pond, July 3; roadside, head of Northeast Arm, Great Pond, July 3; near Indian Point, July 1; High Head, July 1; shore, Somes Harbor, July 5; pasture, Somesville, July 2, and at many other stations.

++ Basal leaves cuneate or spatulate, without distinct petioles: stolons slender, hardly assurgent.

A. neglecta Greene. Stems slender, the pistillate plants 2 or 3 dm. high; stolons slender, prostrate, usually elongated, bracteate throughout, except at the leafy tip: basal leaves and those at the tips of the stolons at first often appressed silky above, soon glabrate; cauline leaves remote, small, linear, or linear-lanceolate: heads rather few, short-pedicelled, at first densely clustered, soon becoming distinctly racemose: involucre of pistillate plant 7.5 to 9 mm. high; bracts linear or linear-lanceolate, greenish, brown, or purplish below, with more or less scarious or petaloid white tips, the outer mostly obtuse, the inner obtuse or acute: heads of staminate plants smaller, the involucral bracts with broad white petaloid tips.— Pittonia, vol. 3, p. 173, 274.—The commonest species in southern New England, growing in almost every dry barren field and on sunny hillsides, and flowering in April or early May. The most northern specimens examined come from Charlotte, Vt. (C. G. Pringle), Franconia, N. H. (Edwin Faxon), Farmington, Me. (C. H. Knowlton).

var. **subcorymbosa**. Taller, 3 to 4.5 dm. high; heads loosely subcorymbose on elongated pedicels, the lowest sometimes 6 cm. long:

involucral bracts nearly all acute, the inner long attenuate. — Roadside, "Davis Farm," Seal Harbor, Mt. Desert Island, Me., July 9, 1897 (E. L. Rand).

A. campestris Rydberg. Plant forming dense closely appressed mats ; stems low, 1 dm. or less in height ; stolons shorter and rather thicker than in the former : basal leaves broader, obovate-cuneate, at first loosely pubescent above, the pubescence soon nearly all deciduous, often leaving a narrow white pubescent border to the leaf: heads densely clustered, perhaps not becoming racemose.— Bull. Torrey bot. club, vol. 24, p. 304.— This has been considered a species confined to the prairies west of the Mississippi, but it is apparently a frequent plant in rather rich dry fields or even upon ledgy shores in northern Maine. The following Maine specimens have been examined: ledgy river banks, Houlton and Island Falls, and dry fields, Milo (M. L. Fernald). Further study may show this plant to be rather an extreme form of the preceding species, but from our present knowledge, it seems wisest to keep them apart.

Aside from the surprising number of apparently distinct species which we have long overlooked—a case which, though an extreme, may be taken as a fair type of the questions which are frequently presenting themselves in American systematic botany — these Antennarias seem to present some further problems of a biological character. The plants are, so far as we know, dioecious ; *i. e.*, the individual plants bear only staminate or pistillate flowers. The staminate flowers, however, are not strictly without a trace of the pistil, for they have rudimentary thickened and undivided styles. The flowers having these undivided styles soon shrivel without producing akenes. In the other or pistillate flowers, no stamens seem to be present, the elongated generally purple style is deeply 2-cleft, and abundant akenes are produced. From the foregoing descriptions it will be seen that all the species produce stolons, often in great abundance ; and by means of these offsets the plants very soon cover large areas of ground. The earliest flowering species, *Antennaria neglecta*, is perhaps the most abundant. It grows in barren fields or on sunny hillsides almost everywhere and flowers in late April or early May. In this species both staminate and pistillate plants are very abundant. In the nearly related species, *A. campestris*, too, the staminate plants are apparently about as common as the pistillate. In one other species, *A. plantaginea*, a later plant than *A. neglecta*, staminate plants are sometimes found, though compared with the pistillate colonies they are often very scarce. In the other three species staminate plants are either quite unknown or else exceedingly rare. *A. neodioica*, which is abundant in New England, is known with us only as a pistillate plant. Further south, however, in Pennsylvania and Virginia, the staminate plants, according to Professor Greene, are frequent. Among thousands of specimens of *A. canadensis*, which have been examined from all over northern New England, only two stations of staminate plants have been detected; and in the case of the very characteristic *A. parlinii*, though many acute observers have watched in New England, only pistillate plants have thus far been found. Further south and west, however, staminate specimens of the two varieties have been collected. In these cases of *A. neodioica*, *A. parlinii*, if not likewise *A. canadensis*, though staminate plants may yet be detected, it must be apparent that they are very unusual. In the cases where staminate plants are known, it is noteworthy that the pollen is apparently very early discharged, at least the staminate inflorescence very quickly shrivels, though it remains entirely recognizable for a long time thereafter. In New England, then, so far as the evidence yet shows, of the six species only three have staminate plants in any abundance, though a fourth is known rarely to produce them.

The question must arise, how are these plants perpetuated, and do they all produce seed? From a superficial examination the akenes of all the species seem plump and as full of vitality as those of most Compositae. I am not aware, though, that any one has made tests of their fertility. Professor Greene asserts that the seeds of these plants are good,[1] though I cannot state to what extent he has experimented with them; and from this decision he draws the inference that we may here have a case of parthenogenesis.

Another possibility has presented itself, that the ovaries of these plants may be fertilized by pollen from what seem superficially to be quite different species. In southern New England, where the staminate plants of *A. plantaginea* are not rare, this might not be absolutely impossible; but in the Franconia region, where one of the keenest of our New England observers, Mr. Edwin Faxon, has found no trace of that species, and got staminate plants of only *A. neglecta*, — shrivelled long before the other species begin to bloom, — such an explanation seems very unsatisfactory. In northern Maine, too, where no *A. plantaginea* was found, I examined

[1] Plant world, vol 1, p. 102.

young pistillate flowers of *A. canadensis* and *A. neodioica* in July, when no staminate flowers could be discovered.

As already stated, propagation by stolons is highly developed in these Antennarias. This is so much the case that we find the plants growing in extensive colonies apparently all originating from one central plant. Or at other times colonies of different species originating near together soon produce an almost inseparable tangle of stolons and offsets. It has been suggested that as this vegetative method of propagation has become so highly developed, the necessity of reproduction by seed has been diminished; and that now, though the plants appear to produce good seed, and may sometimes do so, they are most often spread, as seems to be the case, by the numerous stolons. If these plants were often reproduced by the abundant akenes, we should expect to find scattered young plants in large numbers; but such scattered individuals, if they occur at all, are certainly very unusual. Instead we find colonies of plants near together, and in the case especially of the small-leaved species they form extensive mats.

The question is by no means solved: it is rather merely opened. It is such a problem as can be settled only by careful cultures; but for those who, during the spring and early summer, can give it critical attention, it offers a most attractive and productive field for investigation.

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NOTES ON A CARBONIFEROUS BOULDER TRAIN IN EASTERN MASSACHUSETTS.

By Myron L. Fuller.

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No. 9.— *Notes on a Carboniferous Boulder Train in Eastern Massachusetts.*

By Myron L. Fuller.

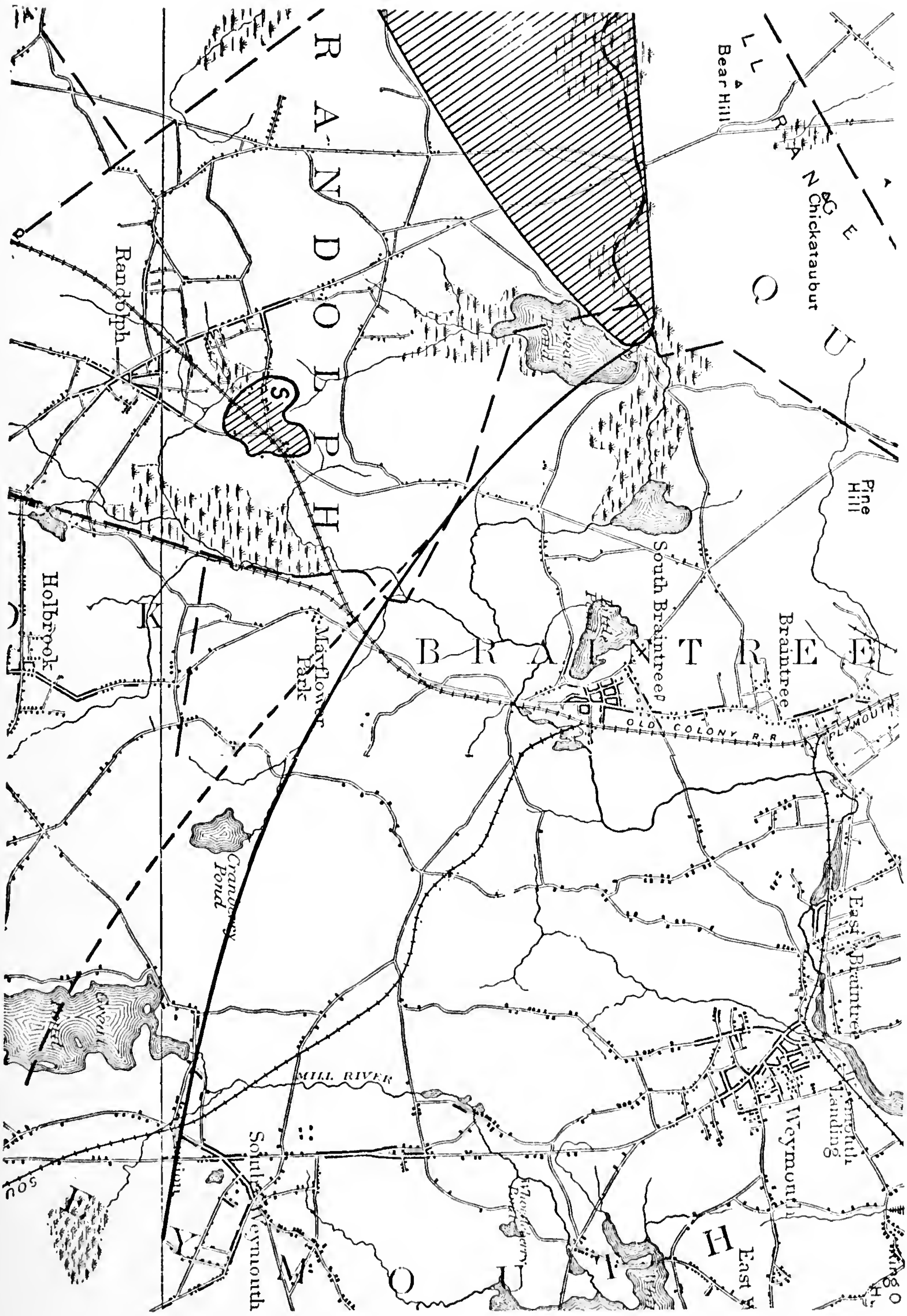
Introduction.

To obtain the best results from the study of a boulder train the source, as pointed out by Prof. N. S. Shaler ('93, p. 186), should be of limited area and of well-defined boundary; the rock should be of a character which renders it readily distinguishable from all others with which it might be associated in the boulder train; and it should be hard enough to resist speedy destruction. Such occurrences are difficult to find in eastern Massachusetts. There are, indeed, small outcrops of characteristic rock in several places, but they are not of a nature to furnish sufficient quantities of material to form an easily distinguishable train. I was obliged, therefore, to select for my investigations a rock which had by no means a limited area, and which presented only a single available boundary. This rock, which varies from a bright red shale to a dull red sandstone, is the upper member of the strongly folded series of Carboniferous strata occupying the basin between the granite of the Blue Hills of Quincy on the north, and the granite and diorite of South Braintree and Randolph on the south (shown approximately by the larger of the two shaded areas on the map). The underlying conglomerate, the base of the Carboniferous series, is a coarse gray rock which usually bears little or no resemblance to the sandstone. There are, however, especially in its upper portions, certain layers of purplish or even red material, which are sometimes difficult to distinguish from the sandstone. These layers, occurring, as they do, at some distance farther east than the normal sandstone, would tend, but for their relative scarcity which limited the number of boulders furnished, to have an appreciable effect upon the distribution of the boulders. The field observations showed, however, that, with the possible exception of the immediate vicinity of the ledges, the effect of these layers of reddish material in the conglomerate could be neglected. The somewhat prominent lamination shown by the sandstone in places, and the well-developed cleavage in the more shaly portions, both tended undoubtedly to furnish an unusually large number of boulders. The abrupt ending of the red series on the east made it possible to lay down with considerable exactness the eastern boundary of the train, but the extent of the series unfortunately prevented the making of similar observations on the western border.

Boundary of Train.

When the work of determining the boundary of the red Carboniferous boulder train was first undertaken, it was believed that a careful examination of the stone-walls for red boulders would give results sufficiently accurate for all practical purposes. A boundary based on such data was, in fact, worked out and is indicated by the dotted line on the map. It was found, however, on examination of exposures of till, that red pebbles, and even boulders, were to be found in places at a distance of a mile or more outside the boundary thus determined, and it became necessary, therefore, to redetermine the boundary, basing it upon a careful study of the till wherever exposed. This boundary (represented by the full line on the map) starts at the same point as the other, and for a mile and a half, or as far as North St., is coincident with it. From this point on, however, the easting of the latter is greater, increasing rapidly to about 55°, and passing just north of the railroad junction at Mayflower Park. Beyond the railroad the bearing of the boundary continues to change rapidly, increasing from S 55° E at the railroad to S 65° E just north of Cranberry Pond, and to nearly S 80° E at the South Weymouth station, beyond which it was not studied. A straight line drawn from the easternmost source of the red boulders to the South Weymouth station would bear approximately S 60° E and would, at its middle portion, lie about three quarters of a mile north of the boundary as determined by observation.

It will be noticed from a comparison of the two boundaries on the map that the difference between them increases rapidly as the distance from the source of supply of boulders becomes greater. This is evidently due to the rapid decrease both in the number and size of the boulders which renders them less likely to be represented in walls.



Map showing Boundary of Boulder Train. Scale: ¾ inch = 1 mile.

In working out the boundaries of the train, a distinction was made between boulders and pebbles found in the deposits of modified drift and those found in the till. The boundaries were based wholly on observations of the latter. An examination of the stratified deposits along the northward sloping valleys disclosed the fact that, contrary to what might be expected, red pebbles outside the boundary determined by observations on the till were exceptional, and only found after careful search, and even then only at slight distances beyond the normal boundary. The indications point strongly to a drainage reversed by the ice, the deposits being, in all probability, laid down during the higher stages of Glacial Lake Bouvé (Crosby and Grabau, '96, p. 128) when the confined waters still found outlet to the southward through the valley now occupied by Weymouth Great Pond, and also that lying between Holbrook and Randolph (Monatiquat Bay of Glacial Lake Bouvé). Red pebbles were also sparingly found in certain coarse and irregularly stratified deposits, probably of subglacial origin, lying in northward sloping valleys outside the normal boundary. Such occurrences are doubtless due largely to the tendency which subglacial streams must possess, especially after the movement of the ice has ceased, to follow the natural slope of the land even when it is directly opposed to the gradient of the ice when in motion.

The occurrence of pebbles or boulders of red sandstone outside the normal boundary in other than the modified drift just mentioned has been noticed at only one point, namely, in the till elevation near the northern end of Great Pond of Braintree. Here, quite a number of boulders with a more or less prominent tinge of red were noticed, but were clearly, in the majority of cases, simply arenaceous bands in the conglomerate. In other cases, the resemblance to the red outcrops was more perfect, leaving the origin in some doubt. If derived from the latter outcrops, they would indicate a movement considerably more easterly than the average. If such was the case, the movement was evidently spasmodic and of short duration, probably marking the last movement before the ice became stagnant. No traces of such boulders in the continuance of the line of motion indicated were observed.

Comparison with other trains of New England. — The average easting of the Carboniferous boulder train just described agrees closely with the train of red felsite observed by Prof. W. O. Crosby ('94, p. 272) in Hingham, the former having an easting of 60° and the latter of 67°. The outcrop selected by Professor Crosby, being of very limited area, allowed not only the determination of the eastern boundary, but that of the western boundary as well. The bearing of the latter is approximately S 23° E. Assuming a similar rate of fanning for both trains, this would indicate the most southerly movement of the ice passing over the ledges of red sandstone to be about S 16° E. In Hingham, as in Braintree and Weymouth, the boundary was found to be curved. The direction of the longer axes of the drumlins in the Hingham area corresponds roughly to the average direction of the ice movement; that is, about S 45° E.

In marked contrast with the rapid fanning observed in both of the above trains, is the slow fanning noticed by Professor Shaler ('93, map) in the study of the train leading from Iron Hill at Cumberland, R. I. In the Hingham train the width increases from a few hundred feet at the start to some 16,000 feet at a distance of four miles, while in the Iron Hill train nearly four times this distance is required to give a similar amount of fanning. The general direction of the Rhode Island train is about S 15° E near the point of origin, but becomes nearly due south on coming within the influence of the depression now occupied by Narragansett Bay.

In still more marked contrast with the Braintree and Hingham trains is the once famous Richmond train of western Massachusetts mentioned and discussed by Reid, E. Hitchcock, H. B. Rogers, W. B. Rogers, Lyell ('55), Perry, and Benton, which affords an example of a train that not only shows, at least in the limits studied, no fanning, but which shows an actual contraction in its width, decreasing from 430 feet at the start to 200 feet on Lenox Range (Benton, '78).

Cause of fanning. — Fanning, or the divergent distribution of material, may be brought about in a variety of ways. Of these, irregularities in the amount or in the distribution of the precipitation and the consequent irregularities in the velocities and directions of the ice movements are, perhaps, the most general. Following close upon these, in relative importance, are changes and irregularities in ablation both as the result of climatical changes and of the influence of debris in or upon the ice. Subglacial drainage may also, in cases, serve to carry material beyond the limits which the ice movements would have established for it. These causes, however, are all of a general nature, and, though indirectly of much importance, are not directly applicable to the fanning of the boulder trains of eastern Massachusetts. Topography, especially in the thinner stages of the ice sheet, may have had considerable influence on ice movement in this region. It is possible that the somewhat prominent elevation south of the railroad junction at Mayflower Park, though of little effect when the ice was at its maximum stage, was, during the opening and possibly the closing stages, an efficient aid in the deflection of the ice to the eastward.

The principle that the direction of movement in the continental ice sheet was in the direction of steepest gradient and normal to the ice margin is the foundation on which the more feasible explanations of fanning are based. This tendency, if exerted during the successive stages of a symmetrical retreat of an ice lobe, is, as pointed out by Chamberlain ('88, p. 201–202, fig. 25), an efficient cause for considerable variations in the directions of movement, and hence also for the distribution of the drift.

The assumption of successive stages is not, however, essential to an explanation of the occurrence of fanning in an ice lobe, for the thinning and *lateral expansion* of the ice consequent upon the *deployment at its margin* is amply sufficient to account for the moderate expansion of the fans of most boulder trains. The degree of fanning in the Braintree train, amounting to some 45°, is probably too great to be explained entirely in this way.

The line of morainic deposits extending from the junction of the Buzzards Bay and Cape Cod moraines northward to the vicinity of Massachusetts Bay, marks the line of junction of the main ice sheet covering Massachusetts with the lobe occupying the Gulf of Maine, Cape Cod Bay, etc. The ledges from which the Braintree train of boulders was derived are but a few miles from the north and south line of morainic material mentioned, and were, therefore, in a location most favorable to fanning by changes of movement during the symmetrical advance and retreat of the ice sheet, as postulated by Chamberlain. The more easterly movements would thus have occurred either in the opening or closing stages when the lobes were more or less distinctly separated from each other, while the southerly movement characterized the stages of maximum glaciation, when the lobes were confluent, or at least closely appressed. The curvature of the boundary is the direct result of the curvature of the lines of movement of the ice, which approximated more and more closely the normal to the margin as this margin was approached.

Character and Size of Fragments.

Not only do the size and angularity of the fragments decrease rapidly, in a general way, as the distance from the parent ledges becomes greater, but their character also simultaneously undergoes a considerable change. As previously indicated, the sandstone possesses, even in the more compact layers, a prominent lamination, while in the softer and more shaly portions a perfect cleavage exists. Naturally such portions would offer the least resistance to the moving ice and would, therefore, furnish a large percentage of the boulders. An examination of the till in the vicinity of the ledges shows clearly that this is the case; the thinness and angularity of many of the fragments, and the lamination and cleavage of others, all point to such an origin. A transportation of two or three miles is sufficient to destroy most of the boulders having a perceptible cleavage, while a transportation of twice this distance is usually sufficient to reduce to small fragments all boulders showing any considerable evidences of lamination. At a distance of ten miles, only those of a practically uniform texture are to be found.

Meanwhile the angularity is lost, the rounding becoming more and more marked as the distance from the source of the boulders increases, until finally, in some cases at least, all traces of the original angles are lost, the boulders being as truly *rounded* as those shaped by the action of water. It is possible that this rounding of the boulders of the till may not be due entirely to the action of ice, but in part also, as suggested by Professor Shaler ('93, p. 205), to that of water by which they may have been taken up and assorted again and again before finally being taken up by the ice for the last time. In general, of course, it was found that the pebbles and boulders of the modified drift were more perfectly rounded than those of the till. The slight rounding of many of the former was nevertheless quite noticeable, and probably indicates an englacial derivation, the shortness of the interval during which it was subjected to the action of water before its final deposition being the cause of the angularity.

In the study of the Iron Hill train a perfectly regular decrease in the size of the boulders was found to occur as the source became more distant. This of necessity is true in a general way for all trains, but there are sometimes, for short distances at least, marked deviations from the rule. Of this the Braintree train affords a good example. Considering only the fragments large enough to be represented in stone walls, I find it is possible to divide the portion of the train studied into four sections by lines normal to the axis of the train. In the first of these, which has, say, a width of two miles, an immense number of small boulders were found, with a few of large size, the average diameter being, perhaps, about ten inches. In the second section, the width of which I will assume to be about five miles, a great reduction in the number of boulders was noted, especially among those lying at the extremes of the range in size. The small fragments still predominate, however, bringing the average down to some six or eight inches. The third section with a width of some ten miles shows a still more marked diminution in the number of boulders, but the size, instead of decreasing as before, seems to have increased, the average length now being a foot or more. In the fourth section which comprises the remainder of the train the decrease in the number of boulders should be less rapid. The average size, which reached its maximum in the preceding section, should again begin to decrease and continue with considerable uniformity until the boulders finally disappear or reach the moraine.

For an explanation we must again refer to the nature of the ledges. From their possession of a marked cleavage it is evident that by far the larger number of fragments would be small in size; a considerable, but much smaller number, of medium size; while fragments of any considerable size would be rare. A ratio of 100 of the smaller fragments to 20 of the medium and 1 of the large is by no means improbable. According to this ratio there would be in every 1000 boulders torn from the ledges 827 of the smaller size represented by x, 165 of medium size represented by $2x$ and 8 of the larger size, varying perhaps from $3x$ to $5x$, but represented on an average by $4x$. The amount of loss by erosion will be assumed to be equal to the volume x for each *arbitrary* section passed over (not necessarily the sections referred to in the preceding paragraph). The effect will be as indicated below.

Boulders of Sec. 1:	$827\,(x) + 165\,(2x) + 8\,(4x)$	. . .	Av. 1.19
" " " 2:	$165\,(x) + 8\,(3x)$	. . .	Av. 1.09
" " " 3:	$8\,(2x)$	. . .	Av. 2.00
" " " 4:	$8\,(x)$	. . .	Av. 1.00

Of course the assumption that the erosion in traversing a given distance is the same in the case of the boulders of different sizes mentioned above, is not to be maintained. It is manifest, however, that the amount of surface exposed to erosion in proportion to bulk is less in large fragments than in small. This, in connection with the fact that erosion of fragments depends almost wholly on factors foreign to themselves and is therefore independent of size, indicates that the principle of decrease in size, as shown in the above table, holds good, though not to the full extent indicated by the figures.

That the same relation holds good in the deposits of modified drift was well brought out in an examination made by Professor Crosby and myself, with several others, of the composition of a prominent esker on the northeast shore of Weymouth. Quoting from Professor Crosby's description ('96, p. 142), we find that, "North of this point in the line of glacial movement are three broad belts of rocks: First, slates and conglomerates of the Boston Basin (Carboniferous) about thirteen miles; second, hornblendic granites, diorite, and felsite, with some Cambrian slate and quartzite, eight to ten miles; third, mica schists, muscovite granites and gneiss, pegmatite, etc., extending into New Hampshire. We found, on looking over some tons of material, that of all which was coarse enough for easy identification, about 50 per cent is from the first belt, 40 per cent from the second, and 10 per cent from the third." The average size of the pebbles and boulders, however, varied, as in the case previously described, *inversely* with the distance from which they were derived.

The greater regularity in the decrease of size in the case of the Rhode Island train is undoubtedly to be explained by the greater homogeneity of the iron ore, and the consequent slighter differences in the size of the fragments furnished. A regular jointing would also be favorable to a supply of fragments of similar size.

The results which I find to hold good as to the absolute size of the pebbles are also at considerable variance with the results obtained from the study of the Cumberland train, in which, according to Professor Shaler, no pebbles were found, in the till at least, having a diameter of less than an inch. This is certainly not the case in the train under discussion. In the many sections of till which I examined within the area of the sandstone train, I found not only an abundance of pebbles under an inch in diameter, but many that are less than half that size, while not infrequently they are found with diameters as small as a quarter or even an eighth of an inch. That they are not parts of larger pebbles which have been disintegrated by frost, or otherwise mechanically broken, is shown beyond all doubt by their well-rounded forms. In fact, a comparison between the pebbles of minimum size in the modified and unmodified drift shows no substantial difference, though from the nature of the deposit the minute grains were, of course, more common in the former.

Pertinent to the point in question are the observations made by Professor Crosby on the composition of the till in the region of Boston. Leaving out of account all pebbles over two inches in diameter he found that 10 per cent of the till, on the average, was composed of gravel between one quarter and one twelfth of an inch in diameter (Crosby, '91, p. 123).

Professor Shaler was inclined to regard the absence of small pebbles as due to the crushing force of the moving ice, which reduced to powder all fragments below a certain size. That this is not the true explanation seems to be indicated by the fact that in the Braintree train, although the ice was probably thicker than in Rhode Island, and although the red sandstone probably does not possess near the crushing strength of the iron ore, fragments of half an inch or less are common. Their absence in the Rhode Island train is probably to be accounted for in a large degree by the very limited area of the tract from which they were derived and the consequent rarity of fragments. When only a small fraction of one per cent of the till is made up of a given rock, it would certainly be very difficult, if not impossible, to find the smaller fragments.

Distribution of Boulders and Pebbles.

General distribution. — The distribution of the red boulders throughout the train shows in general a marked regularity, the amounts to be found in the till at a given distance from the source agreeing closely in the different parts of the train. It may be said that for a given distance from the source the number of red boulders varies directly with the amount of the till and will, therefore, as far as the absolute amount is concerned, show variations. Of course this relation of the number of boulders to the abundance of the till could not be expected to hold good up to the very boundaries of the train. The boundary, however, is much more sharply defined than one might expect, the lateral dying out of the boulders being far from gradual.

Influence of topography on distribution. — One of the earliest facts brought out by the study of the boulder train under discussion was that the distribution to a considerable extent has been affected by the topography. The difference between the number of boulders on the stoss and top slopes of the elevations and the number on the lee slopes was especially marked, the number in the former case far exceeding that in the latter. The best example of this was noted on a hill about a mile northeast of Stoughton Center, some five or six miles southwest of Great Pond of Braintree. Commencing at the bottom of the valley southeast of the hill in question, I examined the stone-walls along the road leading northwesterly to the top of the hill. Notwithstanding that the slope was very gradual, I succeeded in finding, in a distance of nearly a mile, less than 20 red boulders, while, when the top was reached, more than twice that number were observed in a distance of a few hundred feet. This points distinctly to the view so strongly maintained by Professor Crosby ('96, p. 128) that the material borne along in or under the basal portion of the ice sheet while ascending the stoss slope is not carried down in its entirety along the lee slope, but becomes, on the contrary, to a large extent englacial.

Another important feature in the distribution of drift, and consequently in that of the red boulders, which in all probability is to be referred, in part at least, to the influence of topography, is the occurrence of areas of scant drift. Closely adjoining areas often present the most marked differences in this respect. The distribution of the drift, however, differs in no way from the normal, the long level peneplain remnants being deeply and uniformly covered, while the rugged and highly irregular areas are almost bare.

Distribution in till. — In studying the occurrences of red boulders near the ledges from which they were derived, it became evident, that, while 75 per cent or more of the boulders represented in stone-walls were of this type, the amounts of fine material of this nature recognizable in the till were much less, being in some instances as low as 5 or 10 per cent. In this respect the Braintree train agrees closely with the Rhode Island train, the latter of which had at its outset not more than a tenth of its mass made up of fragments of the iron ore. In both cases the till shows a complete commingling of the local and foreign material even in the near vicinity of the ledges. The significance of this in relation to questions concerning the nature and origin of ground moraines is of no particular importance, for the resulting intermixture is readily obtained whether the ground moraine is composed of material torn from the ledges and dragged along beneath the ice, or whether it is composed of englacial material set free by basal melting.

Regarding the dying out with distance little more than that given on p. 257–258 need be said. As would be expected from the fragile nature of a large percentage of the fragments torn from the ledges, it would at first be extremely rapid, but would become less and less abrupt, as the distance increased, until it finally disappeared. If we should make a plot with the number of boulders as ordinates and the distances as abscissae, the resulting curve would have the form of a parabola.

The rapidity of the dying out varies considerably, according to the nature of the till. Dividing the till deposits into those once forming a part of the ground moraine and those derived from englacial material, we should, theoretically, find the decrease in the number of red fragments to be far more gradual in the latter deposits than in the former. Various deposits of till were studied with this view in mind, and the observations all point strongly to such a relation though the difficulty of readily distinguishing the two classes of till may, in a few cases, have led to erroneous conclusions.

Distribution in modified drift.— The differences in the rates of dying out of the boulders in the till and in the modified drift are still more marked than in the case of the two varieties of till, there being, apparently, several times as many pebbles in the deposits of modified drift as in the deposits of till at equal distances from the source. There seems to be no doubt that the sand plains which furnished most of the sections, from the study of which the above proportion was obtained, were formed by streams either of superglacial or englacial character. The material was, therefore, of englacial derivation which readily accounts for its preservation at greater distances than in the till.

An even more significant feature of the distribution of pebbles in the modified drift is found in the fact that in deposits of this nature near the ledges the pebbles are no more abundant, and in some cases apparently less abundant, than in the stratified deposits at a distance of five or ten miles. This is evidently due in part to the slowness with which the pebbles become englacial, the ice taking them up gradually, and also in part to the fact that considerable distances are necessary in order that the pebbles become by the internal movements of the ice sufficiently elevated above the base to come within the influence of the streams forming the sand plains.

Owing to the nature of the country few observations could be made as to the elevations attained by englacial drift within the ice. In the plains just north of the point where North St., Randolph, crosses the railroad (represented by shaded area marked S on the map) numerous pebbles were found at an elevation of 170 feet A T. The elevation of the top of this plain above the rock on which it rests is some 50 feet, and, as the plain was, with little doubt, derived from superglacial or englacial streams, it points to movements within the ice by which pebbles have, in a distance of about two miles, become elevated fifty feet or more from the base of the ice. The elevation of the ledges from which the pebbles were derived is somewhat doubtful, as they are found at all elevations from 100 to 200 or more feet A T; but whatever may have been the height at which the pebbles were taken, it is evident that they were truly englacial.

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ON THE VEINS OF THE WOLFFIAN BODIES IN THE PIG.

By Charles Sedgwick Minot.

With One Plate.

BOSTON:
PRINTED FOR THE SOCIETY.
July, 1898.

No. 10.— *On the Veins of the Wolffian Bodies in the Pig.*

By Charles Sedgwick Minot.

In transverse sections of pig embryos of 10 mm. and upwards in length, representing stages in which the Wolffian bodies (Mesonephroi) are well developed, no cardinal veins can be distinguished on the dorsal side of the Wolffian bodies. As we rely principally upon pig embryos for the class work in embryology at the Harvard Medical School, it was important to elucidate the history of the cardinal veins. During this undertaking I found certain relations of the veins, which seem to me worthy of description and illustration.

The material studied consists of twenty-five series of sections of pig embryos of from 6.0–24.0 mm. in length, corresponding in range approximately to Figs. 14–29 inclusive of Keibel's Normentafeln I. Embryos of 12.0 mm. were found to be especially instructive as regards the transformation of the cardinal veins, and accordingly the following descriptions are based chiefly on that stage. To render verification of the observations feasible, the sections are referred to by the number of the series, and the number of the section in the series. For example, Fig. 3 is taken from *Series* 6, *section* 423. The collection is the property of the Harvard Embryological Laboratory and is open to qualified investigators.

In pig embryos of 12.0 mm. the cardinal vein is a large stem, which may be said to end abruptly at the cephalic end of the Wolffian body, Fig. 1, although a prolongation of small caliber may sometimes be traced a short distance on the dorsal side of the body. The vena cava inferior is a large vessel a little to the right of the median line, Fig. 3, and receives its blood almost exclusively from the Wolffian bodies. The primitive kidneys have at this stage two large veins. The renal and iliac branches of the cava inferior commence their development in slightly older embryos. The left umbilical vein is a large blood channel, Fig. 5, which passes from the umbilicus, directly through the liver to the heart; it has numerous side branches in the liver. The right umbilical vein is markedly smaller than the left; in series 5 (transverse sections) it has a wide connection inside the liver with the portal vein; in series 6 (sagittal sections) the connection can be made out, but it is of small diameter; in series 7 (frontal sections) the connection is absent, and the right umbilical vein breaks up and is lost in the liver substance. From these observations we must conclude that it is at about this stage that the abortion of the right umbilical vein as a continuous blood channel through the liver is completed, but it varies in individual embryos. The portal vein is a well-developed vessel, which enters the right upper lobe of the liver, and there ramifies.

The relations of the cardinal veins are essentially alike upon the two sides. As shown in Fig. 1, the cardinal, *Card*, and jugular, *Jug*, veins unite and form the Ductus Cuvieri, *D. C.*, which descends obliquely towards the liver; on the right side, Fig. 1, the Ductus Cuvieri is joined also by the Vena Cava Inferior, *V. C. I.*, which ascends through the liver — compare also, Figs. 2 and 3 — to the heart. Between the liver and the heart the venous channel is homologous with the sinus venosus. A sagittal section, such as Fig. 1, shows the wide cardinal vein abruptly closed by the mass of tubules of the Wolffian body, *W. B.*, so that one receives the impression that the vein suddenly becomes a sinus in which the tubules are lodged. Closer examination with higher powers reveals that this conception is essentially correct.

Fig. 2 represents a sagittal section from the same series as Fig. 1, but is from the opposite side of the embryo, namely the left. It illustrates the connection of the vascular channels of the primitive kidney with the Vena Cava Inferior, *V. C. I.* This connection is established on the medial side of each mesonephros by a short wide channel, which shows well in transverse sections, Fig. 4, in frontal, Fig. 3, and also of course in reconstructions, Fig. 5. If we consider the Wolffian body as to its length the mesonephric branches of the cava inferior will be found near the middle so that they may be said to divide the cephalad from the caudad half of the organ. These venous stems being of enormous size, see Fig. 2, in comparison with the Wolffian body, renders this division a true anatomical division, and later when the true kidney grows headwards from its position at the caudal end of the Wolffian body, where it lies at this stage, it approaches the branches of the vena cava, and there results a complete interruption of the continuity of the Wolffian body, which thereafter is represented by a cephalic division and a caudal division. The former is presumably the anlage of the organ of Rosenmüller (Parovarium, Epididymis), and the latter is presumably the anlage of the organ of Giraldès (ParadidAfter Paradidymis, Paroöphoron). Unfortunately, I have not been able to follow the further history of these parts, so that the homologies indicated must be left for future investigations to verify or deny.

The mesonephric branches from the end of the cava inferior abut partly directly upon the Wolffian tubules, and partly indirectly, since they are each continued by a headward or upper and a tailward or lower branch, as illustrated in the reconstruction, Fig. 5. These branches lie upon the dorsal side of the organ and take an arching course. They were originally portions of the cardinal veins, and their connection with vena cava inferior is secondary. This change in the connections of the distal parts of the cardinal veins was described by Rathke long ago, **30.1, 38.3,** and has been studied more recently by Hochstetter, **87.2, 88.1, 88.3, 92.1, 92.3, 93.1, 94.3, 97.2,** and Zumstein, **96.1, 97.1.** I must point out that the diagram given by O. Hertwig in his Entwickelungsgeschichte, Fünfte Auflage, p. 537, and which I have reproduced in my Human Embryology, p. 543, represents the transformations of the veins incorrectly. It is incorrect especially in failing to show that each cardinal vein becomes discontinuous, and that the caudad segment of the cardinal vein becomes connected near its own middle with the end of the vena cava inferior, so that this segment is transformed into what appear as the two branches of the mesonephric vein. This change of connection is so important that the vessels of the new arrangement deserve a special name, and I propose therefor the term mesonephric vein (*vena mesonephrica*). The trunk of this vein is a new connecting stem established between the end of vena cava inferior and the cardinal vein; the two main branches of the vein are the remnants of the caudad division of the cardinal vein, and they may be conveniently styled the *superior* and *inferior* branches respectively, the superior being that lying nearest the head.

The Wolffian body of the pig is then remarkable for being furnished with two very large veins, both receiving their blood supply practically exclusively from the Wolffian body. It seems possible that this peculiar condition, which does not obtain in Guinea pigs or in man, is connected with the great functional activity of the mesonephros in the ungulates, which develop an enormous allantoic sack and fill the sack with a urinary excretion. Guinea pigs have a small, man a minimal allantois, and it must be assumed that the mesonephric functions are correspondingly reduced. As regards the veins in these two types Zumstein, **96.1**, **97.1**, has shown that the general course of the development is the same as in the pig, the mesonephric veins arising in the same way by the median fusion of the cardinals for a short distance. But as regards the size of the veins there is a marked difference from the pig. Thus in human embryos of 14 and 16 mm. the cardinal veins are not only smaller in width than the umbilical veins but smaller even than the dorsal aorta,— see Zumstein, **96.1**, p. 592–593. So also in the Guinea pig the relatively small size of the cardinal veins is recorded by Zumstein, **97.1**, in his figures 5–12, from embryos of 18–24 days. These observations justify the inference of a direct correlation between the functional activity of the mesonephroi on the one hand and the size of the two pairs of veins and of the allantois on the other.

The character of the circulation within the Wolffian bodies is not yet quite clear, for, although the connection of the blood channels between the tubules with veins is easily determined, the pathways of the arterial inflow are obscure. One sees readily the small arteries, which bring the blood from the aorta directly to the glomeruli. I have not studied the arterial supply carefully, and can therefore only state that the arteries running to the glomeruli are the only mesonephric arteries which I have noticed, without however being able to affirm that no others are present. If my supposition as to the vascular arrangements are correct, then the course of the circulation must be from the aorta through the numerous small glomerular arteries, into the glomeruli, from the glomeruli into the intertubular vessels of the mesonephros, and thence into either the mesonephric or the cardinal veins.

The intertubular vessels of the mesonephros of the pig are highly characteristic. They communicate freely with one another and with the veins, and they are in no sense capillaries. In Figures 1, 2, 3, and 4, the representation of the Wolffian body is in each case in so far diagrammatic that many details are omitted, including most of the blood spaces. Fig. 6 is from a drawing much magnified of a small part of the left Wolffian body (to the right in the figure) of Fig. 3. It illustrates the character of all the intertubular vessels. Their walls consist for the most part solely of a thin endothelium, so thin as to be merely a line except where the nuclei are lodged; the nuclei are large, granular, and protuberant, and are indeed similar to those of the adult vascular endothelium, although conspicuously less flattened. This endothelium, *endo*, lies for the most part immediately in contact with the epithelium, *Ep*, of the Wolffian tubules. Occasionally, as at *mnch* in the figure, a thin layer of mesenchyma intervenes between the vascular endothelium and the tubular epithelium, but the total amount of mesenchyma is insignificant. Almost everywhere the vascular endothelium is closely fitted against the tubules. It results that the mesonephros does not have a series of blood vessels in the ordinary sense, but is rather a single complex sinus, imperfectly subdivided by the Wolffian tubules. Hence every tubule is almost (or even for a certain part absolutely) completely bounded by a blood space, and accordingly bathed in blood from which it is parted only by the exceedingly thin endothelium. The circulation is therefore very unlike that through the capillary network of the pig's kidney, for in the true kidney the capillaries are much smaller in caliber than the renal tubules,[1] and consequently only a small proportion of the epithelial excretory cells are in *immediate* proximity to the circulating blood. In the mesonephros of the pig, on the contrary, the great majority of the excretory cells are in actual contact with the attenuated vascular endothelium.

In pig embryos, older than those of 12 mm., the Wolffian tubules are found increasing in length and (by budding) in number, but since the volume of the organ does not increase in the same measure, the tubules become more crowded, so that the intertubular sinus becomes more subdivided, and the vascular spaces of the sinus are reduced. Moreover the tubules occasionally become closely appressed, and then the blood space between them may be obliterated. The general result of these changes is to cause the blood spaces to appear in sections less like parts of a great sinus, and more like separated vessels. An attentive study, however, of pigs of 14, 17, and 20 mm. shows conclusively that the circulation is only modified, and preserves the essential characteristics which it presents in pigs of 12.0 mm.

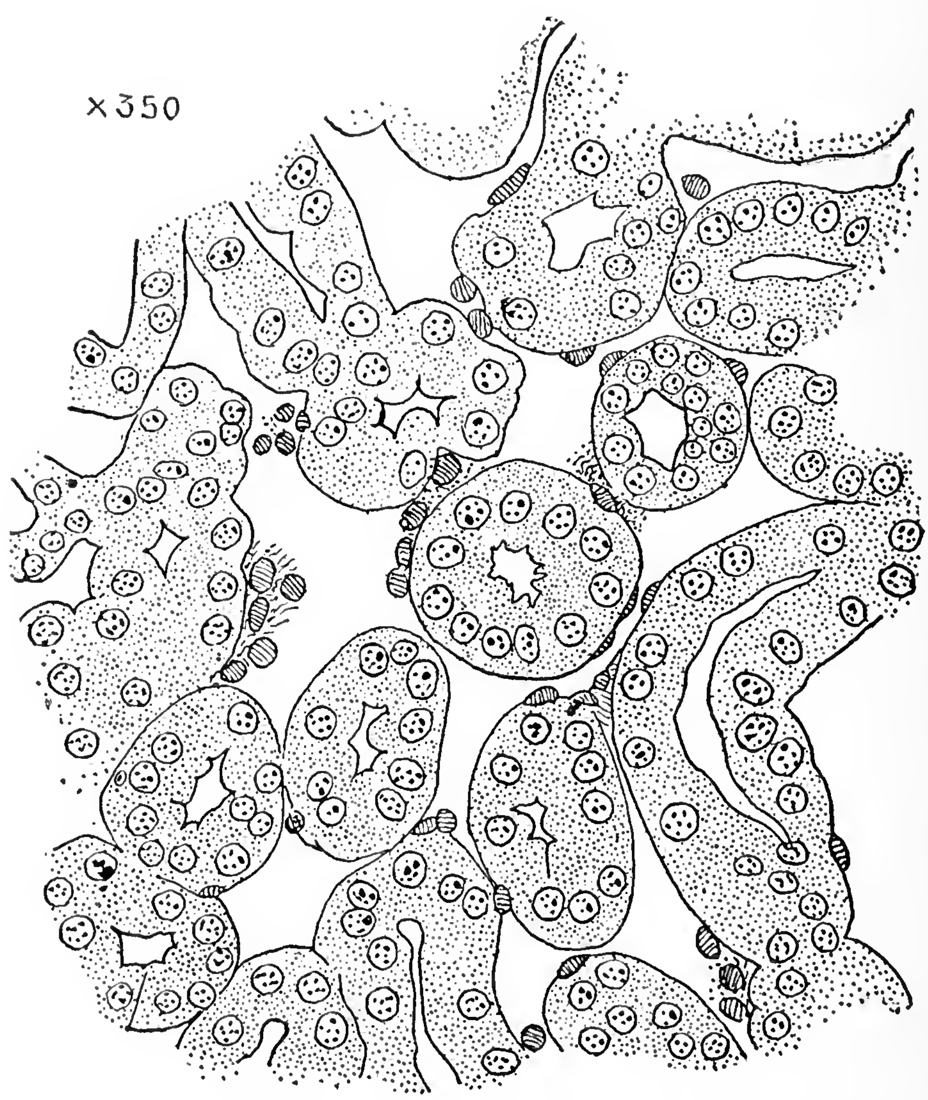
The entire absence of capillaries and the sinus-like disposition of the blood channels characterize the circulation of blood between the tubules of the Wolffian body of the pig. This fact has already been confirmed, since the preliminary announcement of my results (Science, N. S., vol. 7, p. 229), by Parker and Tozier, **98.1**. My observations show that both characteristics recur equally well

[1] Except of course the small portion of Henle's loop, which is almost as narrow as a capillary.

marked in the embryos of man, the cat, the rabbit, and the chick. Hence it seems to me fair to suppose that this feature is characteristic of the mesonephros of all amniote embryos, and marks a sharp distinction to be drawn between the mesonephros and the true kidney or metanephros.

It is inevitable to deduce the supposition that the mesonephros has no true intertubular capillaries in any species, not even in such types as preserve the mesonephros as the renal organ of adult life. Attractive as this supposition appears, it is evidently necessarily to be tested by more accurate and extended observations than are yet at our disposal.

Material already at my command enables me, however, to state positively even now that in the frog (Rana esculenta, R. halecina) the blood channels are not true capillaries but irregular spaces bounded by an endothelium, which is closely fitted against the



Part of a section of the mesonephros of Rana to illustrate the sinus-like arrangement of the blood vessels and the absence of true capillaries. For clearness the nuclei of the vascular endothelium are drawn dark. B.T.F.

epithelial surface of the renal tubules, the curves of which the endothelium follows closely. In a true capillary the endothelium on the contrary follows, so to speak, its own and independent curve. The figure in the text illustrates the facts recorded. [Since this article went to press, I have examined the kidney of *Necturus maculatus*, for which material I am indebted to the kindness of Dr. G. H. Parker. In this representative of the Urodela, I find the same circulatory conditions as in Rana, but with wider sinuses.]

The peculiar type of circulation to which I have called attention has, I believe, greater morphological (and physiological) importance than has been recognized. Comparison with the rete mirabili of various animals, for instance with the carotid gland of the frog, at once suggests itself. Even nearer lies the comparison with the form of circulation in two embryonic organs — the liver and the pronephros. As regards the liver, the comparison is especially facile in those lower types, in which the hepatic cylinders are tubular in form — compare the figure and brief description, which I have given in my "Human Embryology," p. 761, of the liver of an Acanthias embryo. As regards the pronephros, I will record that in tailed Amphibia, teleosts, and ganoids, I have observed the same circulatory conditions. As specific evidence on this point I will put down the references to certain sections in our collection.

These are: —

Necturus,	15.0	mm.	Transverse	Series	78,	Sections	300–330
"	"	"	Frontal	"	80,	"	95– 97
"	18.0	"	Transverse	"	16,	"	335–345
"	"	"	Frontal	"	84,	"	95–100
Ameiurus	9.0	"	Transverse	"	85,	"	55– 60
"	"	"	Frontal	"	87,	"	45– 50
Batrachus	9.5	"	Transverse	"	118,	"	218–236
"	"	"	Frontal	"	120,	"	100–104
Amia,	10.0	"	Transverse	"	19,	"	260–270
"	"	"	Frontal	"	20,	"	60– 67
"	13.0	"	Transverse	"	55,	"	231–240
"	"	"	Frontal	"	57,	"	74– 78

In the two teleostean forms, Ameiurus and Batrachus, and in the ganoid, Amia, the greater part of the space between the pronephric tubules is occupied by the blood channels, but there are also patches of tissue, the "*Pseudolymphoidgewebe*" of W. Felix, **97.1**, p. 443. In these patches the nuclei are crowded together, and they differ by their deep staining and in their minute structure very conspicuously from the nuclei of the pronephric tubules and of the vascular endothelium. In all three forms above mentioned, the pronephros is without capillaries, but has instead sinus-like vessels, the endothelium of which is in large part in close contact with the epithelium of the pronephric tubules.

The peculiarity of the pronephric circulation has been noted by previous writers. For example, the sinus-like character and the intimate relation to the veins were noted by Alexander Götte in 1875, see his *Entwickelungsgeschichte der unke*, p. 760, also by M. Fürbringer, **78.1**, Taf. I, fig. 4. In W. Felix's recent admirable monograph, **97.1**, the similar conditions in teleostean pronephros are referred to. The list of authorities upon this feature of the pronephros in Ichthyopsida might be considerably extended, in short its seems to me that one may safely regard the multifid intertubular venous sinus as an essential characteristic of the well-developed pronephros.

The facts presented bring us to question: Is there a constant and therefore typical difference between the pronephros and mesonephros on the one hand and the true kidney on the other as regards the form of circulation, a blood sinus developing about the tubules of the former, true capillaries about the tubules of the latter? The present possibilities indicate an affirmative answer, and such an answer would, in my opinion, go far towards establishing a morphological difference between the various renal organs and would tend to prove that the true kidney (metanephros) is not phylogenetically related to the mesonephros, but is a wholly new acquisition, not evolved from segmental organs (nephrotomes).

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EXPLANATION OF THE PLATE.

Abbreviations.

Ao.	Aorta.	*Mnph. i.*	Inferior mesonephric vein.
Au.	Auricle.	*Port. V.*	Portal vein.
Au. D.	Right Auricle.	*Si.*	Blood sinus.
Au. S.	Left Auricle.	*Sp. C.*	Spinal cord.
bl. c.	Blood corpuscles.	*St.*	Stomach.
Card.	Cardinal vein.	*Sup. mes.*	Superior mesenteric artery.
Con.	Connective tissue.	*S. V.*	Sinus venosus.
D. cho.	Ductus choledochus.	*Um. V.*	Umbilical vein.
Endo.	Endothelium.	*V. C. I.*	Vena cava inferior.
Ent.	Entoderm.	*V. C. I. D.*	Vena cava inferior dextra.
Ep.	Epithelium.	*V. E.*	Eustachian valve.
G. bl.	Gall bladder.	*V. S.*	Valvula sinistra.
Gln.	Ganglion.	*W. B.*	Wolffian body.
Jug.	Jugular vein.	*W. D.*	Wolffian duct.

PLATE 1.

Fig. 1. Pig, 12.0 mm. Sagittal series 7, section 39. (Compare also series 6, section 453.) Through the right Wolffian body. A short branch of the cardinal vein can be followed on the dorsal side of the Wolffian body in neighboring sections; see especially Section 24. × 28 diams.

Fig. 2. Same as above, but from section 51, to show the connection of the vena cava inferior with the right Wolffian body. The Wolffian tubules are not accurately drawn, and the small blood channels between them are omitted. The vena cava inferior shows no branches of any importance outside of the Wolffian body. In section 68, the vein comes very close to the dorsal aorta leaving only a very thin partition. × 28 diams.

Fig. 3. Pig, 12.0 mm. Frontal series 6, section 423, passing through the entire length of the *vena cava inferior.* The section also illustrates the influence of this vein, developed upon the right side, in forcing the stomach to the left. × 13 diams.

Fig. 4. Pig, 12.0 mm. Transverse series 5, section 705. Through the Wolffian bodies at the level of the connection with the vena cava inferior. × 17 diams.

Fig. 5. Pig, 12.0 mm. Frontal series 6. Abdominal veins in frontal view, reconstructed from drawings of every tenth section, but the branches of the umbilical vein in the ventral part of the liver are entirely omitted. × 13 diams.

Fig. 6. Pig, 12.0 mm. Frontal series 6, section 423. Part of the left Wolffian body to show the relation of the venous endothelium to the Wolffian tubules. × 267 diams.

Fig. 1.

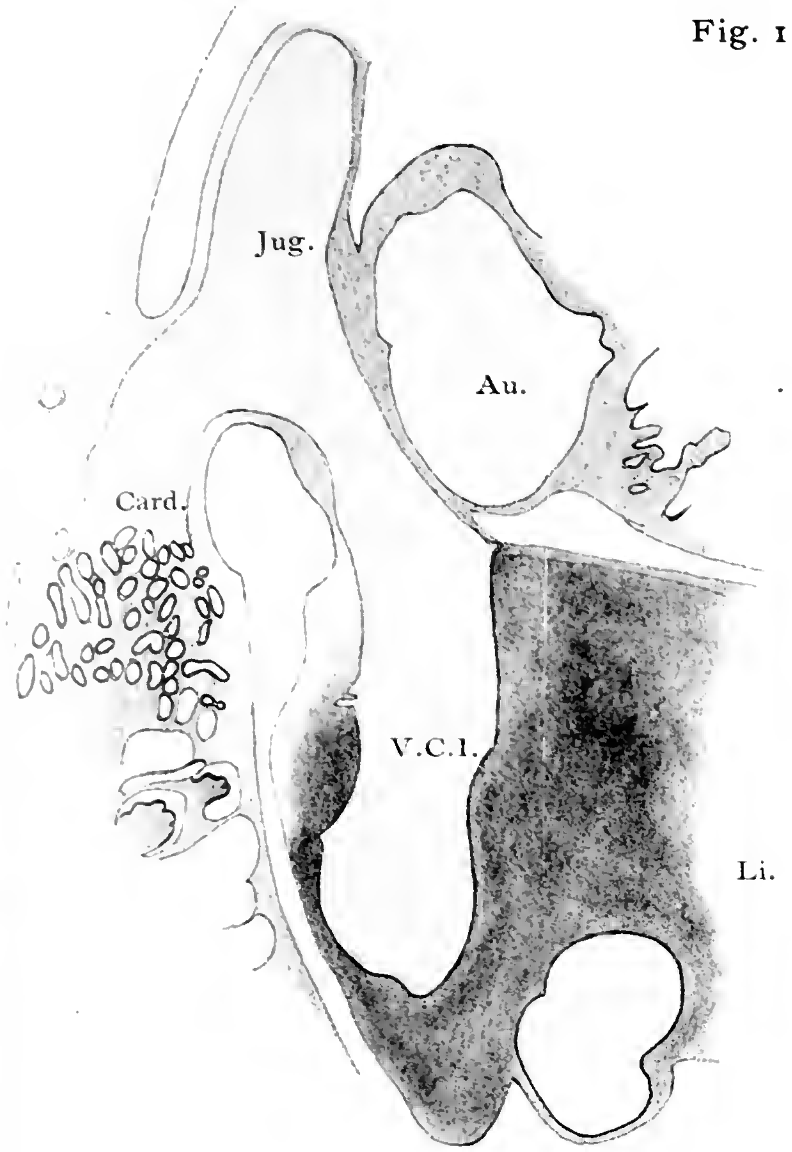


Fig. 2.

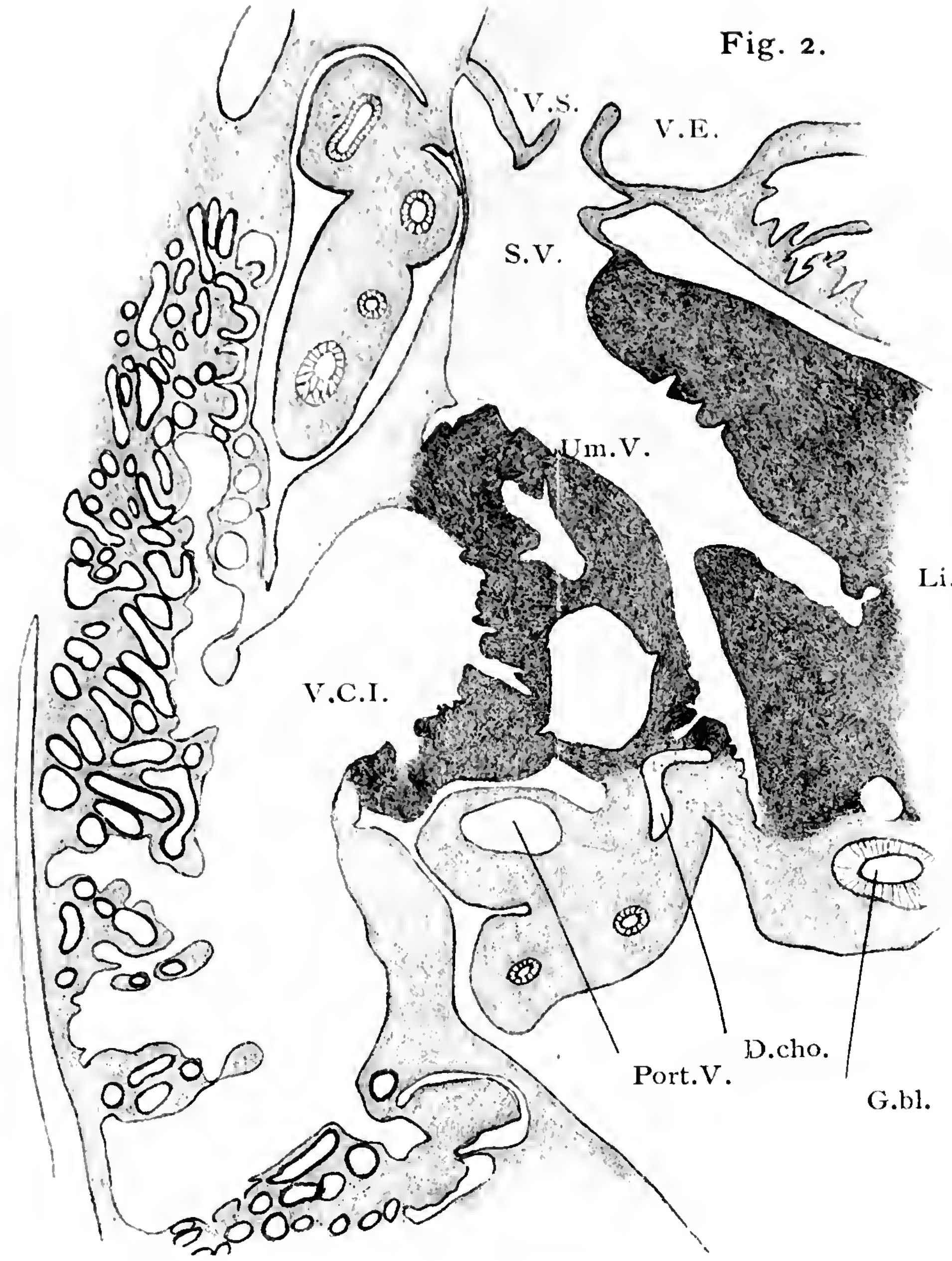


Fig. 3.

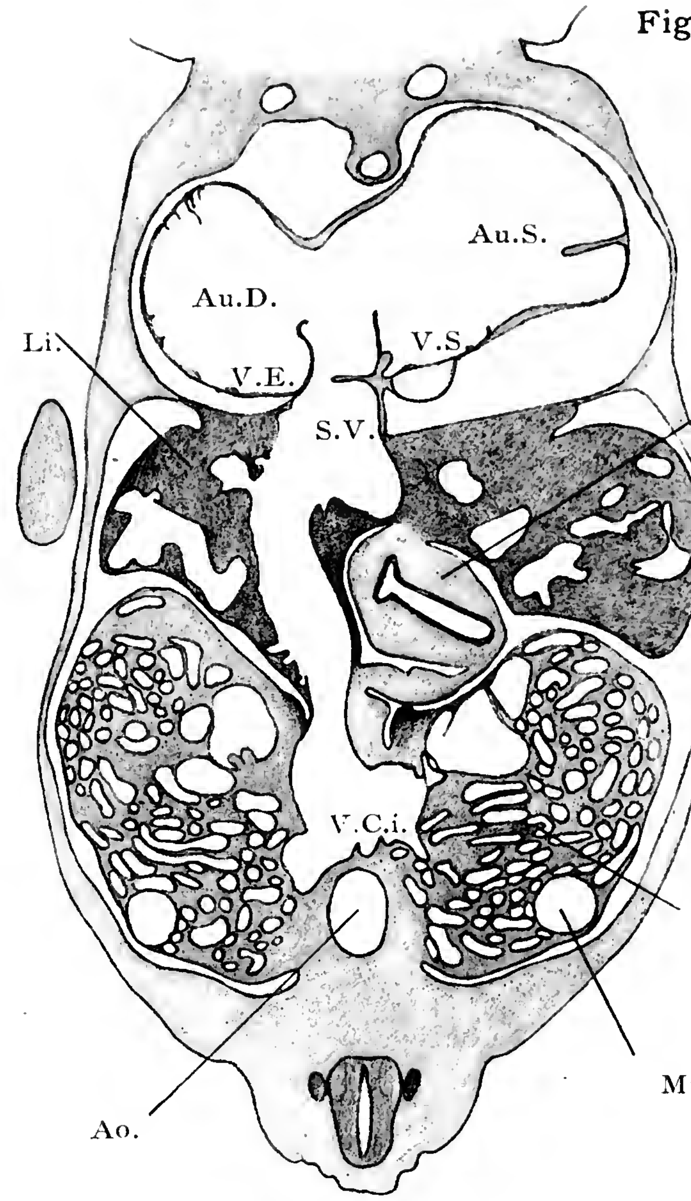


Fig. 4.

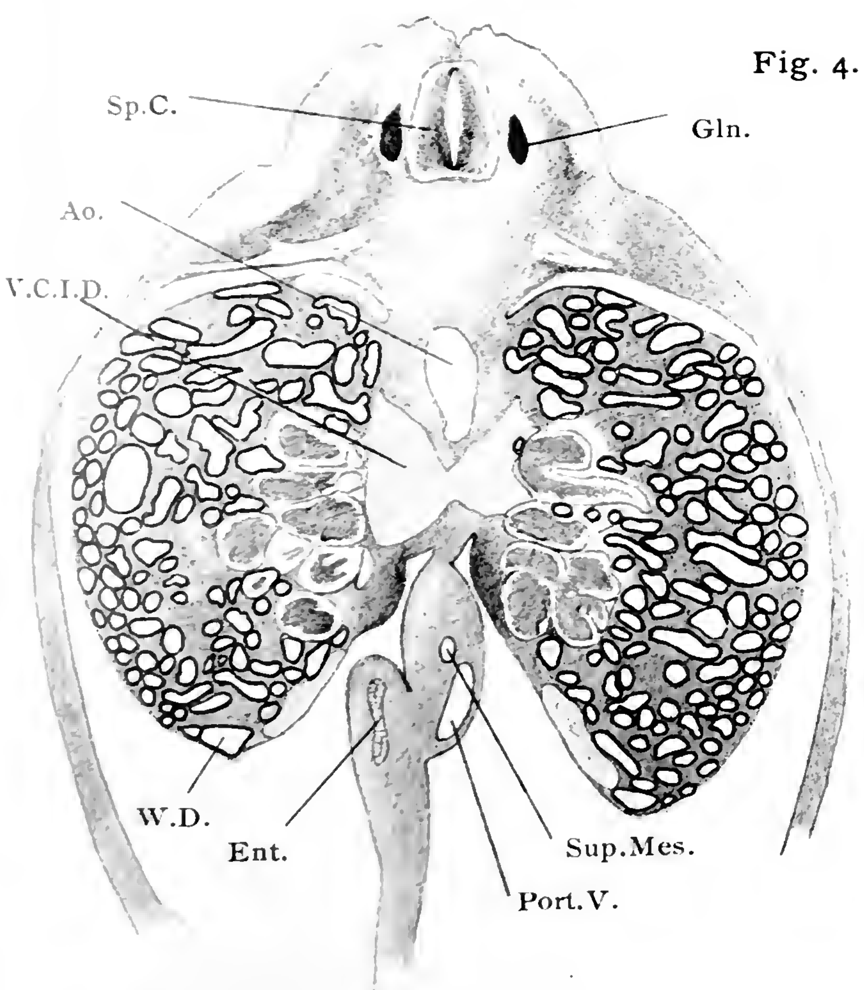


Fig. 5.

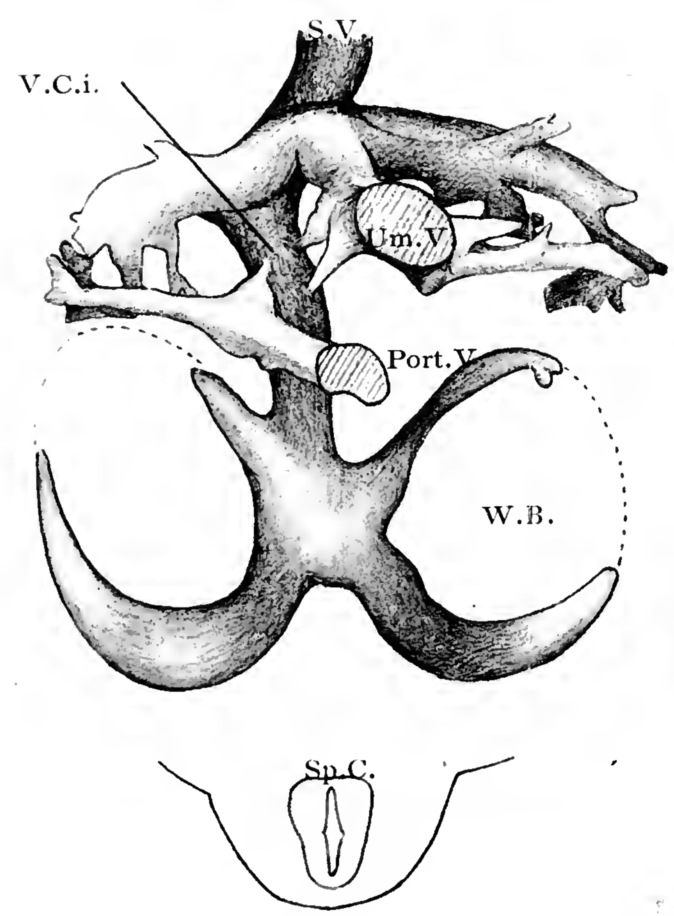
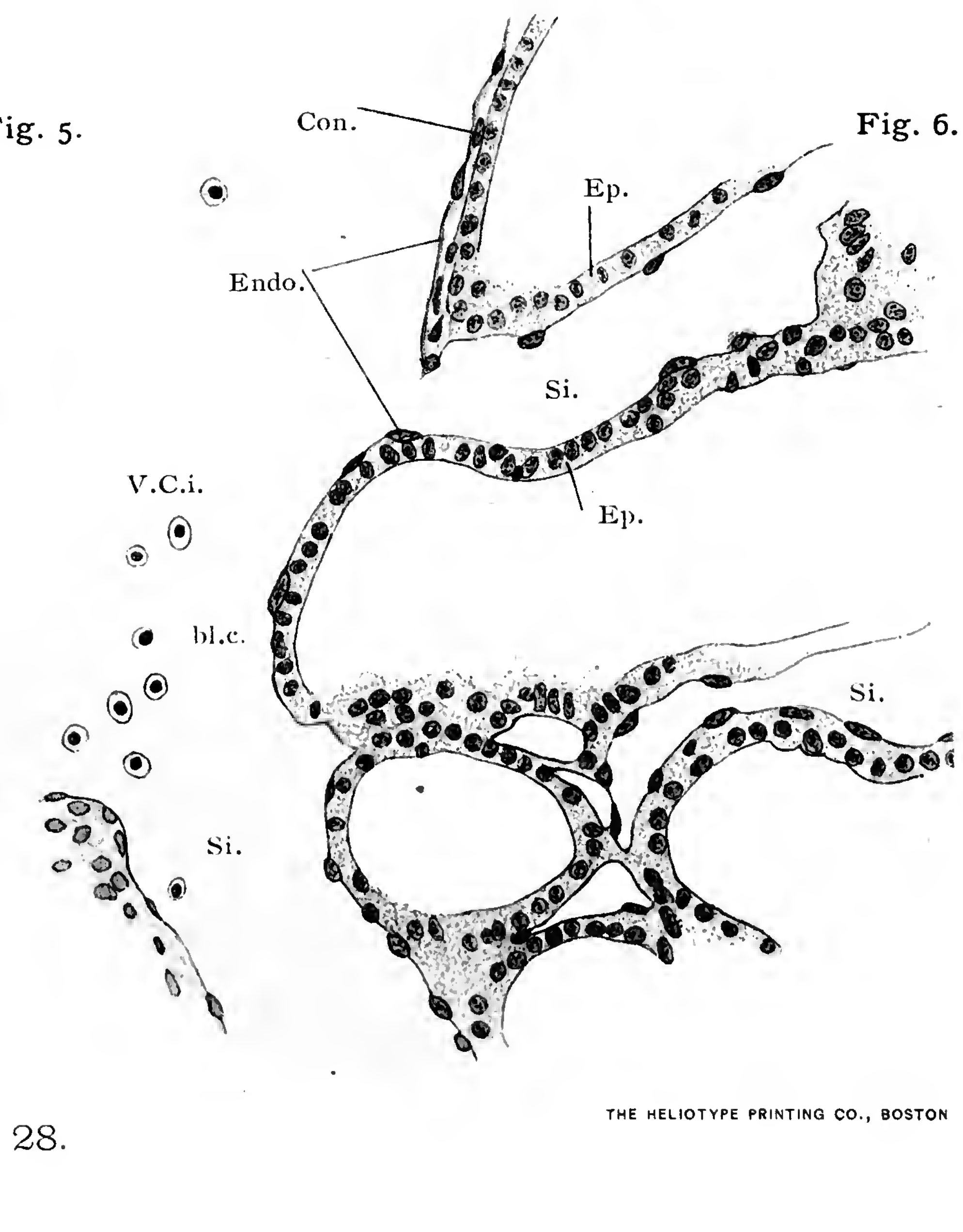


Fig. 6.



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No. 11.— *Proceedings of the Annual Meeting, May* 4, 1898.

Report of the Curator, Alpheus Hyatt.

For many years the Curator has been trying to arouse the Society to the need of making a united effort for a larger endowment to carry to fuller development what it has undertaken to do in the Museum. This year the needs are more pressing than ever, and it has finally come to a position where it must either increase or begin a process of retrogression.

In my Annual Report, May, 1889, it was announced with great satisfaction that a Boston lady had generously offered to maintain a guide in the Museum, to carry out the Curator's plan of employing an educated man and a capable teacher who would give lectures in the Museum and make it an effective instrument of public instruction. At that time this had not been attempted in any other museum, and it was an effort to place this Museum on a high plane so far as actual public usefulness was concerned. It was also an interesting attempt to raise the post of guide to the level of a professional occupation. This experiment succeeded under most trying circumstances, and finally, under Mr. Grabau, it has risen to a degree of usefulness that leaves no doubt of the future and opens new paths in the same direction. We can develop this indefinitely, and it will eventually make our Museum an instrument of instruction of the highest utility to the public, and materially help the Society in all its departments. Miss Harriet E. Freeman, the lady referred to, has conducted this department for nine years, and with admirable patience and at the expense of great personal inconvenience has enabled us to demonstrate what can be done. She has now announced with regret that circumstances will no longer permit her to continue the salary of the guide. If there is no one to take her place, and if there is not interest enough to raise the money to pay a moderate salary, the work of the last nine years and its results will be lost and the future prospects of the Museum materially diminished.

Another department of the Museum has been placed in a similar position by the retirement of Mr. John Cummings. The active connection of this gentleman with the botanical collections began in 1873–74. At that time the specimens were found to be in a precarious condition, and we should have lost a large part of them, if they had not received immediate attention. Mr. Cummings employed Miss Carter to assist him in 1874, and for many years also gave considerable of his own time to this work. During the last decade, however, he has been obliged to rely more and more upon the work of his assistant. The final results of more than twenty years of labor and generous giving to the cause of botanical science were given in the final report to the Society in May, 1895. In this the total of specimens and of genera and species was reported and the announcement made that the entire herbarium was accurately named. At that time the duplicates were not yet ready for a final report, the poisoning of all the preparations was not more than half done, and it still remained to complete the labeling of the Lowell herbarium with special labels. This result represents the expenditure of a large amount of time and money, and evinces on the part of Mr. Cummings and his assistant an interest in the subject itself that has laid all scientific men, and especially this Society, under obligations that cannot be justly disregarded. It has been ascertained also that the assistant in this department, in order to complete the work of poisoning and labeling, has been for an entire year previous to the last official year doing the work gratuitously. The utmost that the Society can do with its present income is hardly more than what is needed to reimburse her for traveling expenses. The value of the collection is well known, and independently of this, and the danger of leaving it without a proper person in charge, it is obvious that its usefulness in the future will be greatly restricted unless means can be found to pay the salary of an assistant. It has been consulted by scientific men to the number of over twenty persons annually. These have been allowed access to the plants and have spent all the way from an hour to a number of days in the work room under the superintendence of the assistant. Another consideration of great importance is that this department, after so many years of labor, has been brought to a point at which it can be most useful to science and has but just gained the stage of development at which investigations upon the flora of New England can be begun. That these, like those that have made the reputation of our geological department, will be valuable and permanent contributions to the progress of science there can be no reasonable doubt. The first duty of a museum is to secure the safety of its collections and put them in order, but this is only the first step, a beginning for further work, not an end in itself.

This department also has not an adequate exhibition of the morphology of the great organic subkingdom that it represents, and we ought to perfect this exhibition as well as conduct the department with due attention to the needs of science and the public.

One of the most important, if not the most important part of the Museum consists of a series of collections which have been systematically accumulated for the purpose of illustrating the natural history of New England. These are at present located in the respective departments in which they have been gathered, the New England minerals in the mineral room, the rocks in the geological room, and so on. As they are now, they interfere to a considerable extent with the arrangement and make it impracticable to write any general guide for the whole Museum that would be of use to visitors, or satisfactory to its author. If, on the contrary, they were assembled in a consecutive series, they would show the history of the natural features and natural products of New England and would afford a chance for exhibiting the results of investigations upon the geology, mineralogy, botany, and zoology of New England that would be practically unlimited and capable of any modification or expansion that the future might demand. In other words, it would be the beginning of a museum within our own, correlated in its arrangement but entirely independent and devoted to a purpose so distinct, that it might, if necessary, be taken out bodily in the future and put into a building of its own, and yet leave the rest of the museum entire as a consistent educational and general systematic exposition of the organic kingdom. If, during the coming visit of the American association for the advancement of science this summer, we could throw open such a series of collections that would enable them to pass in review the geology of the Boston Basin and of New England and the relations of the rocks to the configuration of the surface, and the minerals, the plants, and the animals of this same region, it would interest and instruct them more than any other exposition of natural objects possibly could.

This scheme of rearrangement in the Museum is entirely practicable, but like all other improvements demands corresponding expenditures, and the Society has not the means for such purposes.

The Museum has been used this year on other than public days by 298 pupils and teachers, representing 10 schools, and we have also as in the past allowed scientific men, artists, and teachers free admission and materially assisted them whenever they had any just claims to such aid.

Teaching in the Museum.

In addition to what has been written, it is essential to notice the work done in the past official year.

A course on the "Marine life of the New England coast" was begun by Mr. A. W. Grabau, April 17, 1897. This was subsequently transferred to the Teachers' School of Science and will be fully noticed under the proper heading.

The same gentleman, our official guide and lecturer, has also given a course of eight lectures on "The surface of the earth, its rocks, soil, and scenery." This course begun in April, 1897, continued through the month of May. The object of this series was to give the audience a comprehensive view of the action of cold and heat, of winds and waves, rains and rivers, and of the chemical effect of the atmosphere in the production of the natural features of the surface.

Special attention was given to the scenery of New England, and whenever practicable excursions were made to localities which could be used as illustrations.

One result of a similar course given in 1896, which has not been heretofore reported upon, was the formation during the summer of the same year of a class of thirty persons, summer residents of Kennebunkport, Maine; this class was under instruction by Mr. Grabau the greater part of each day for two weeks. The awakening of interest in local scenery has also led to his giving a lecture this past year in Belmont and two in Arlington, and he has thus been instrumental in a movement intended to preserve a valuable geologic monument, the local frontal boulder moraine on Arlington Heights. This is the only good and accessible example of such moraines near Boston, and its great importance to science need not be dwelt upon. In consequence of his work in this direction, Mr. Grabau was also invited to give a course of ten lectures on physical geography before the teachers of Medford, during the past winter.

The course, "Elementary principles of organic evolution," delivered in the autumn of 1896, by Mr. Grabau, was repeated by request during October and November, 1897, and consisted of eight lectures delivered in the Society's lecture room.

Mineralogy and Geology.

Additions to the general collections since my last report have not been numerous, but they consist almost wholly of specimens specially selected for their intrinsic interest or educational value or to fill gaps in the collections, and have consequently been of unusual value. As regards minerals, Professor Crosby has endeavored to build up and increase the New England collection, with a view to making it a more representative and creditable exhibit. Of the 130 new mineral specimens, 75 have been added to the New England collection and 55 to the general collection. The Society's aims and location require that the New England minerals should be the best in existence; and it is possible to make it so, if we were able to secure the specimens that are offered from time to time.

The new geological specimens, aside from the Boston Basin material, are few. They include several valuable illustrations presented by Mrs. J. M. Arms Sheldon, a series of specimens from the sandstone dikes of Ute Pass, Colorado, described by Professor Crosby in a recent paper in the Bulletin of the Essex institute; also three large and typical examples of the concretionary or "klot" granite from Smaland, Sweden, and a large group of basalt columns from Bennau in the volcanic district of the Rhine. The cost of the klot granite is $15, and of the basalt columns $185. Of this $200, Professor Crosby has already paid $50, which he has donated to the Society, and he is now endeavoring to provide for the remaining $150; any contributions for this purpose will be gladly received. The basalt columns are set up in our vestibule, and this is a unique and instructive illustration.

For pecuniary assistance in the purchase of minerals the thanks of the Society are due to Miss Marian Hovey and Mr. Thomas Gaffield.

Geology of the Boston Basin.

Professor Crosby's investigation of the Blue Hill's complex, — the third part of the geology of the Boston Basin, — is completed, and the results are worked up ready for publication with the exception of the Carboniferous strata, which are but a small part of the whole.

In explanation of the long time which this part has required, it may be stated that the area is nearly twice as great as that treated of in Parts 1 and 2 taken together. The geology is equally complex; and the topography, covering fully half the surface among the Blue Hills themselves, is far more difficult. It was absolutely necessary to walk over this part in a detailed and systematic manner, and to explore a large part of it repeatedly.

None of the rock formations of this vicinity are of greater areal or structural importance than the granitic series, including the diorite and the various types of granite and felsite. In the study of the Cohasset and Hingham areas (Parts 1 and 2) Professor Crosby was content with general descriptions of these rocks, realizing that the Blue Hills complex offered a far more favorable opportunity for investigating their origin and genetic and structural relations; and it is to these problems chiefly that he has addressed himself during the past year.

The amount of illustrative material in the way of specimens, maps, etc., collected in connection with these investigations is already so great as to make it desirable that a room be set apart for the permanent and complete exhibit of the local geology.

Professor Crosby, and in this the Society will most heartily join, desires to express his gratitude to Mr. Thomas A. Watson for his enthusiastic assistance and encouragement in the geological investigation of the Boston Basin. He has not only responded promptly and generously when money was needed, but has cooperated intellectually to the success of these investigations for a number of years. He has been urged to assume a share in the authorship, but having modestly declined, Professor Crosby wishes it to be clearly understood that he considers him to be justly entitled to a large part of the credit for whatever merit the work may possess.

Synoptic Collection.

This department has been making solid advances owing to the personal work and generosity of Mrs. J. M. Arms Sheldon. The worms have been worked over, fifty-three species have been carefully studied, and fifteen figures that show the development and evolution of the forms selected and described.

The Brachiopoda of the Cambrian and Ordovician were studied and specimens selected for exhibition. The brachial supports were also studied, seventy-one figures selected to show evolution of the cardinal area and twelve to show the general development.

The Echinodermata have been studied; about fifty figures have been examined and more or less prepared and thirty pages of the text revised.

A few other figures have been selected among mollusks and worms, and seventeen from among the insects.

Mrs. Sheldon has donated a number of species specially selected as the most suitable representatives of the different groups, and she has also prepared a considerable number of pages of manuscript not mentioned above.

Miss Martin was occupied during a large part of the summer in making colored drawings for this collection. These and the fine suites of specimens recently acquired will, it is hoped, soon be ready for exhibition, owing to the generosity of the assistant who is now having these mounted at her own expense.

Botany.

In addition to the facts stated above it is necessary to notice the work done during the year. Miss Carter has not, unfortunately, had sufficient remuneration and has not consequently been able to expend much time upon the collection. She, however, reports that the systematic arrangement of the duplicates is nearly completed and that progress has been made in poisoning the specimens of the general collection and the special labeling of the Lowell Collection.

A number of donations from Mr. Edward Roots, Miss Cora H. Clarke, and Mr. C. R. Jones have been received and are gratefully acknowledged.

Fascicle 15 of Seymour and Earle's Economic Fungi has been purchased.

Twenty-three persons have been permitted to consult the collections for special scientific purposes under the supervision of Miss Carter.

Paleontology.

Miss Elizabeth B. Bryant began work on this collection last June, immediately after her appointment as Assistant in the Museum, and has been occupied since almost exclusively in this department. The fossils of the American faunas on exhibition in Room G, except the New England collection contained in the central cases, and the Main Hall, and a large part of those of the European faunas of the Eser Collection have been removed, dusted, the shelving cleaned or repainted, and the specimens replaced. In order to carry on the work of revising the collection, it was necessary to get together all of the fossils that have accumulated in the past ten years. Part of this work had already been done, but Miss Bryant spent considerable time in going over and cataloguing the fossils stored in the trays under the exhibition cases of the Main Hall and the European room and those in the basement. The revision and renaming of the collections on exhibition had become necessary, and this has been carried out through the Devonian, Subcarboniferous, and a large part of the Carboniferous. This part of the work included the dismounting of the specimens upon each tablet and the repainting of the tablets in many cases as well as the writing of new labels. In making additions to the series of exhibited specimens from the new accessions, quite a large number of fossils had to be cleared of the rock in which they were more or less imbedded, especially among the Crinoidea, and this occupied considerable time.

The series of Palaeozoic corals received last year from Mr. G. K. Greene has been catalogued and selections made for exhibition.

We are indebted to Miss Isabel L. Johnson for the donation of a valuable series of sponges and other fossils from the Jura in the neighborhood of Oxford, England.

Mollusca.

The Curator has reported in preceding years upon the Society's collection of Achatinellae of the Hawaiian Islands, and his investigation of the laws that governed the evolution of this remarkable group. Although not consciously admitting the existence of the need of more materials in order to complete this work, he has really been gradually approaching a point beyond which progress could not be effectively made until more shells were obtained. This in brief has been effected after long negotiation by the purchase of the Rev. J. T. Gulick's personal collection. This accession makes the Society's collection the most complete in existence, if to the list of species and the number of shells we also add the facts that it is accurately labeled, contains seventy-two originals of the species already described, has a full representation of a number of now extinct varieties and species, and was collected so many years ago that it can be used in some localities to show that new species have arisen upon Oahu within the past ten or twenty years. There are at present under this roof about fourteen or fifteen thousand shells of this one group, which many naturalists consider to be but one genus. These practically all belong to the Society, and there are also about six thousand more, the property of Mr. Oleson, of Worcester, kindly loaned to the Curator for study; in all about twenty thousand shells.

The immediate and essential need of this investigation was the money necessary to get up a series of demonstrative illustrations. The march of the forms on Oahu and the evolution of the varieties and species as they migrated from valley to valley, could not be placed on record, or shown to any other investigator, or clearly described by the author himself, until the facts were recorded by photographic processes and in natural colors upon plates so closely set with figures that no gaps or omissions would be left to be bridged by the imagination. The Curator tried to impress the importance of this investigation and of such complete objective illustration upon the friends of research both scientific and unscientific, who controlled the means of successfully carrying out such an unusually expensive method of demonstration. Among the surprises of his life none have exceeded the unexpected results of this experience. It was found that it would be necessary to devote several years to what the missionaries would call conversion by education, before such gentlemen could be induced to consider matters from a favorable point of view. Just at this discouraging juncture, an inquiry came from a former pupil and present assistant in the Museum, whose aid had not been solicited, and the reply was followed by so liberal a donation that the publication of a series of complete illustrations embodying the results of these researches may be said to be secured. In consequence of this donation, amounting to two thousand dollars, the preliminary labeling and cataloguing of the large collections received this year from Mr. Gulick are already well advanced towards completion, having been carried on by a special assistant, and a complete report upon this accession will be made next year; the materials have been available for study for two months past, and good progress has also been made in setting up the illustrations, the first plate being nearly completed. The thanks of the Society are due to Mrs. J. M. Arms Sheldon for this opportune and generous assistance, and, personally, the Curator desires to express his deepest obligation for the saving of time, so precious to a man advanced in years, and for the equally important advantage that this donation has made it possible not only to have all the figures that are necessary but also to aim at the highest standard of excellence attainable by modern processes.

All of the duplicate shells and all of those without locality labels were brought together and roughly sorted in the early part of the official year by Mrs. Flint. These were placed in Miss Martin's room, who spent a large amount of time during the winter in comparing them with the named species of our collections in order to pick out specimens that were to be retained. When this part of the work is finished, it is proposed to make up the whole mass into sets that can be disposed of or conveniently stored. Miss Martin has also been occupied an unusual amount of time this year in looking up series of specimens in this and other departments that had to be prepared for loaning to investigators.

Crustacea.

Considerable work upon this collection has been done by Miss Martin, and in this process, it was ascertained that it would be necessary to look over the entire alcoholic collections of the Museum in order to find and renew faded labels. This work is now under way.

Birds and Mammals.

The New England collection of birds has been rearranged by Miss Martin, and an effort has been made to place them so that they may be more readily seen. It is now proposed to replace the old shelving with an improved style of shelving, which will bring the specimens nearer to the glass, so that they may be more readily seen, and the details of the coloration, etc., studied by visitors.

Mr. Batchelder has done considerable work throughout the year and reports as follows: — The mammals of the general collection have been labeled. Attention has been given to the bird collections, and they are in excellent condition. The Nuttall Club is continuing this season the work, which it began last year, of forming a New England collection of birds' nests and eggs for presentation to the Society. In anticipation of the probability that a portion of this collection will be received within a few months, preparations have been begun for new cases, which will give proper protection from insects, light, and dust, and at the same time afford the specimens suitable exhibition.

Laboratory.

The room of this department has been used, as in previous years, by the classes of the Boston University and the classes of the Teachers' School of Science. Miss Martin has done a larger amount of work than usual in this department, owing to an extra demand this year for diagrams.

Teachers' School of Science.

For some years past instruction has been given to a class from the Normal School of Boston by Prof. G. H. Barton. In some cases this instruction has been free, in others it has been paid for. This season thirty dollars was all the money available for this work, and as each lesson embraces at least a half day, it is considered that this was essentially a free course. The class of 1897 consisted of thirteen ladies who came unusually well prepared for the work, and seven very successful lessons were given to them in the field. The present season a similar class of twenty ladies has already taken two lessons of a proposed course of ten or twelve under the same lecturer.

A large amount of effective work in the direction of zoology has been done by Mr. A. W. Grabau with teachers of this city and suburban schools. A course of twelve lessons on "The animals of the shores of New England" was begun in April, 1897, and noticed briefly in my last report as having been successfully started with an attendance varying from forty to seventy-five persons. This was continued throughout the months of April, May, and June, by means of excursions to the seashore on Wednesday and Saturday afternoons in suitable weather. The beaches of Revere, Swampscott, Marblehead, the cliffs and tide pools of Nahant, Marblehead Neck, and Nantasket, and the mud flats and bridge piles of Beverly were visited and explored. One excursion was made to the outer shores of Cape Cod, taking in Buzzard's Bay on the return. A party of fourteen of the most enthusiastic of these pupils left Boston under Mr. Grabau's direction on Friday and did not return until the following Monday. Our thanks are due to the authorities of the Marine Biological Laboratory for courtesies shown this party and for the use of their steam launch.

This course originated at first in the work done by Mr. Grabau as lecturer and guide in the Museum, but was transferred to the Teachers' School of Science, because it was necessary to charge a small fee to cover the expenses.

Mr. Grabau also gave a course of ten lessons on Saturday mornings at nine o'clock in the laboratory of the Society. The class was as large as could be conveniently handled and accommodated. The members were instructed in the use of the microscope and in the technique of killing, staining, and mounting specimens of hydroids, and also in the structure of our common species.

After the regular course was finished, a ten days' excursion was made to Bayville on Limekilns Bay, coast of Maine. A laboratory was established, furnished with microscopes and accessories, and a small collection of text books and works on general natural history were placed in an adjoining room that served as a library. Four boats and collecting apparatus completed this equipment. Fourteen persons, mostly teachers of Boston schools, were members of this class. Collections were made and laboratory work done upon the animals gathered each day, special attention being given to hydroids in order to connect the work with that previously done in Boston. A little geology was mingled with this course in continuation of Mr. Grabau's previous lectures in this direction, and an island in the bay was mapped in detail. A small fee was charged each member of this class.

During July and August a course of twelve laboratory exercises of two hours each on invertebrate zoology was given by Mr. Grabau on Monday, Wednesday, and Friday afternoons. These were attended by six teachers and a small tuition fee paid.

During September, October, and November, a course of twelve field lessons on marine zoology was given by Mr. Grabau. The attendance averaged twenty persons. The same places were visited as those previously named in the account of the spring course, but the aim of the excursion was somewhat different. The main object was the study of animals in their various habitats.

During the winter Mr. Grabau gave a course of twelve lectures on zoology to a class of twenty teachers in the Society's lecture room on Saturday mornings. A small fee was charged for this course.

Mr. Grabau informs me that one of the results of this work was the formation of the Hale House Natural History Club, 6 Garland St. This is a club of teachers and others banded together for the purpose of promoting the study of natural history. Field meetings are to be held under the guidance of competent persons, classes in natural history for children are now being formed, and a large number of papers upon elementary subjects have been read and discussed at the winter meetings.

Lowell Free Courses.

Professor Barton's spring course of field lessons in geology began on April 24 and ended on June 26, 1897. The average attendance was 34. The regular number of lessons for this course is ten, but at the close by special request of members of the class three additional lessons were given free of charge, one at Nobscott Hill, a second at Clinton, and the third at Marblehead Neck.

The spring course for 1898 has been begun by Professor Barton and will be noticed in detail in my next annual report.

The autumn course of ten field lessons began on Sept. 11 and closed on Nov. 13, 1897. The average attendance was 29. The majority of the field lessons were given at points near Boston, occupying a half day's time, but a few excursions were made to more distant points, such as Clinton, Fitchburg, and Mt. Holyoke during the spring, and Newport, R. I., and the Hoosac Tunnel region during the autumn. The work at these more distant points had a direct bearing upon the lessons given in the vicinity of Boston and at the same time had a wider application to the general subjects of the course.

The winter course of fifteen lessons in historical geology was the fourth in a series on geology which had already occupied three years, the entire series being over 120 hours. The average attendance this winter was 83. The instruction in this course was given by means of lectures supplemented by numerous diagrams, charts, and maps, and also by specimens of rocks and fossils illustrating the various formations. Owing to the large size of the class and the great cost of many of the necessary specimens, the teaching collection of this course is not so well supplied as might be desired.

At each of the fifteen lessons, with the exception of the first and last, examinations were given covering all of the ground passed over previous to the time of the examination. A final examination was given two weeks after the last lesson. The aim of this was to present a résumé of the term's work.

Fifty-two persons took all the examinations; of these thirty-five passed with credit, four passed with honor, and the remainder passed with good standing.

Dr. R. W. Greenleaf gave a course of fifteen lessons of two hours each upon the elementary structure and function of the parts of flowering plants.

A syllabus of topics was distributed to the class, and abundant illustrative material was provided at each exercise. Each lesson consisted of a brief written examination on the work of the preceding exercise, and a lecture followed by laboratory work for another hour. The average attendance was thirty-nine.

At the close of the course a written examination, based on the work of the entire year, was held. This included the practical study and description of specimens. Twenty-seven persons presented themselves. Thirteen passed with honor, six with credit, five passed, and three failed. The progress of the class was satisfactory, considering the limited time given to the subject and more especially considering the extremely defective training of the pupils. This want of training was shown not merely by a lack of familiarity with the elementary facts of botany, but by their inaptitude in the objective study of facts.

The Curator gave the third in the series of courses on elementary zoology. It was found impracticable to do more in the thirty-four hours actually occupied than to study selected types of the Mollusca as regards their macroscopic characters. Seventeen lessons of two hours each were given, beginning Nov. 19, 1897, and ending March 26, 1898. The class was larger than in previous years, the average attendance being thirty. This was probably due to a revival of general interest occasioned by Professor Davis's lectures. An annual examination was held, at which eighteen candidates were present, and the results were entirely satisfactory. Teachers have learned that no amount of cramming will enable them to handle the test of specimens laid on the tables, and only those who have faithfully attended the lessons attempt the examination.

The Trustee of the Lowell Institute, in order to enable the School to issue certificates to those who passed the examinations in the different departments, very generously paid for the engraving of the necessary plate and for the printing of the first edition of the certificates. These will be issued only to those who have passed all of the examinations in each complete four years' course of from one hundred and twenty one hundred and forty hours of lectures accompanied by laboratory work.

The Trustee of the Lowell Institute, acting upon the suggestion of persons interested in the improvement of the teaching of geography in the public schools, requested the Curator to invite Prof. W. M. Davis to give a course of eight lectures on geography in the autumn and winter of 1897–98. The subjects treated were selected from among those presented in Professor Davis's course on geography in the Harvard Summer School, as affording material most directly applicable to the work of grammar school teachers.

These lectures were given in Huntington Hall, in the Rogers Building of the Massachusetts Institute of Technology, at 11 o'clock, on Saturdays, and at the end of each meeting opportunity was given for individual conference on questions suggested by the lectures. The first lecture was more largely attended than any single lesson given in our school since the opening one delivered by Professor Niles on the same subject in the year 1872. There were over seven hundred persons present, and the average attendance of the whole course was between four and five hundred. There has not been, since the beginning of the school, any course which has excited more interest among teachers, or one which has had more solid results. It is consequently a severe disappointment to hundreds of public school teachers of the very highest class, and a serious loss to the public interests of science, that the Trustee of the Lowell Institute does not feel able to continue this course.

REPORT OF THE SECRETARY AND LIBRARIAN, SAMUEL HENSHAW.

Membership.

During the past year one Honorary, ten Corresponding, and fifteen Corporate members have been elected by the Council. Two Honorary members, Rudolph Leuckart and J. J. Steenstrup, have died. From the list of Corresponding members we have lost eight names, Harrison Allen, E. Baldamus, Oscar Fraas, Frithiof Holmgren, G. H. Horn, Thure Kumlein, R. E. Rogers, and L. Rutimeyer. Nine Corporate members, C. Allen Browne, Isaac C. Cooper, Joseph S. Fay, Gardiner G. Hubbard, John Jeffries, John A. Loring, John Lowell, Theodore Lyman, and Jules Marcou, have died; four have resigned, and the names of two have been stricken from the list for non-payment of dues.

The membership of the Society corrected to May 4, 1898, consists of 11 Honorary, 141 Corresponding, and 363 Corporate members, a total of 515.

The number of Corporate members remains the same as reported last year and, though as high as at any time during the last seven years, falls short of what the city of Boston should furnish. A Committee on the increase of membership will endeavor during the coming year to enlist all interested in the objects and aims of the Society, and with the personal cooperation of the members it is expected that a material increase will be effected before May, 1899.

The names of the members elected and the dates of their election are as follows: —

Honorary. — Michael Foster. Feb. 16, 1898.

Corresponding.

Charles E. Beecher. Feb. 16, 1898.
Carl Claus. Feb. 16, 1898.
Sigmund Exner. Feb. 16, 1898.
James Geikie. Feb. 16, 1898.
David S. Jordan. Feb. 16, 1898.
Arnold Lang. Feb. 16, 1898.
Richard Lydekker. Feb. 16, 1898.
Felix Plateau. Feb. 16, 1898.
Hermann Snellen. Feb. 16, 1898.

Robert E. E. Wiedersheim. Feb. 16, 1898.

Corporate.

Henry B. Bigelow. Feb. 16, 1898.
Joseph W. Blankinship. Apr. 20, 1898.
Edwin T. Brewster. Feb. 16, 1898.
Miss Elizabeth B. Bryant. Feb. 16, 1898.
Charles Bullard. Oct. 20, 1897.
George L. Chandler. Oct. 20, 1897.
Miss Sara A. Downs. Feb. 16, 1898.
Thomas W. Galloway. Apr. 20, 1898.
Robert W. Hall. Dec. 15, 1897.
Miss Ellen Hayes. Dec. 15, 1897.
William R. Livermore. Oct. 20, 1897.
Mrs. Helen M. Tower. Dec. 15, 1897.
William L. Tower. Oct. 20, 1897.
Frederick C. Waite. Dec. 15, 1897.
Arthur W. Weysse. Dec. 15, 1897.

Meetings.

The interest in the meetings has been well sustained throughout the year. The total attendance, 1,191, at the fourteen regular meetings is larger than that reported a year ago and gives an average of 85 *plus* to a meeting; the total last year was 1,138, the average 81 *plus.*

The largest attendance at any one meeting was 352, the smallest 24; the largest last year was 280, the smallest 28.

Twenty-four communications have been made by twenty-four persons.

Nine papers have been presented by title.

The effective exhibition of microscopical preparations at the meetings is now possible through a simple addition to our equipment, and it is a great satisfaction to record that an electric lantern, the property of the Society, will be available for the meetings next season.

The meetings, attendance, and communications have been as follows: —

May 5, 1897. Annual meeting. Fifty-three persons present.

Reports of the Curator, Secretary, Librarian, Treasurer, and Trustees.

Dr. R. T. Jackson. Some principles of invertebrate palaeontology.

May 19, 1897. General meeting. Three hundred and fifty-two persons present.

Mr. J. E. Lough. The phenomena of telepathy.

Mr. W. E. Davis. Dodgerfield.

Miss Margaret Lewis. Description of Clymene producta sp. nov. (By title.)

Prof. W. O. Crosby. Pleistocene history of the Nashua valley. (By title.)

Dr. T. A. Jaggar, Jr. A microsclerometer for determining the hardness of mineral thin sections. (By title.)

November 3, 1897. General meeting. Seventy-five persons present.

Mr. J. B. Woodworth. Mr. Saville-Kent's illustrations of Australian coral reefs.

Dr. Hubert L. Clark. Synapta vivipara: a contribution to the morphology of echinoderms. (By title.)

November 17, 1897. General meeting. Seventy-one persons present.

Dr. B. L. Robinson. Notes on the flora of some of the islands of the Pacific.

Prof. A. E. Verrill. The causes that determine the flora and fauna of the smaller islands off our coast.

December 1, 1897. General meeting. Thirty-five persons present.

Prof. N. S. Shaler. Aeolian deposits in relation to river valleys.

Mr. A. W. Grabau. Some rare and interesting fossils from the upper Devonian of western New York, showing parallelism with European species.

Mr. Outram Bangs. The land mammals of peninsular Florida and the coast region of Georgia. (By title.)

December 15, 1897. General meeting. One hundred and five persons present.

Prof. W. M. Davis. A series of lantern slides showing physiographic features, taken during the summer of 1897 on excursions from the Atlantic to the Pacific.

January 5, 1898. General meeting. Forty-two persons present.

Mr. Frank Russell. Some notes upon the Indians of the Barren Ground of Canada.

January 19, 1898. General meeting. Thirty persons present.

Dr. G. H. Parker. A double-mouthed Metridium.

Mr. G. M. Winslow. An abnormal Amblystoma.

Prof. C. S. Minot. The morphology of the kidney.

February 2, 1898. General meeting. Sixty-five persons present.

Mr. William C. Bates. The scenery and folk lore of Jamaica.

Mr. J. W. Folsom. Collembola from Japan. (By title.)

February 16, 1898. General meeting. Twenty-four persons present.

Mr. John Murdoch. The animals known to the Eskimo of northwestern Alaska.

March 2, 1898. General meeting. Seventy-one persons present.

Mr. Hollis Webster. Some common mushrooms, edible and poisonous.

Mr. M. L. Fuller. Notes on a boulder train in eastern Massachusetts. (By title.)

March 16, 1898. General meeting. One hundred and fifty-two persons present.

Prof. William Libbey. Cuba.

Mr. J. Edmund Woodman. Geological history of the gold slates of Nova Scotia with the structure of three typical regions. (By title.)

April 6, 1898. General meeting. Fifty-seven persons present.

Report of the Nominating Committee.

Dr. C. B. Davenport. A precise criterion of species: its applicability to systematic zoology.

Mr. J. W. Blankinship. A precise criterion of species: its applicability to systematic botany.

Mr. A. W. Grabau. Moniloporidae: a new family of Palaeozoic corals, with descriptions of genera and species. (By title.)

April 20, 1898. General meeting. Sixty persons present.

Mr. Henry L. Clapp. Some native ferns of New England.

Publications.

There have been issued during the year the following publications: —

Synapta vivipara: a contribution to the morphology of echinoderms, by Hubert Lyman Clark. Memoirs, vol. 5, no. 3, 36 pp., 5 plates.

Proceedings of the annual meeting, May 5, 1897. Proceedings, vol. 28, no. 2, 28 pp.

The role of water in growth, by C. B. Davenport. Proceedings, vol. 28, no. 3, 12 pp., 8 cuts.

The Harvard geographical models, by W. M. Davis and G. C. Curtis. Proceedings, vol. 28, no. 4, 26 pp., 4 plates, 1 cut.

Clymene producta sp. nov., by Margaret Lewis. Proceedings, vol. 28, no. 5, 5 pp., 2 plates.

A contribution to the petrography of the Boston Basin, by Theodore G. White. Proceedings, vol. 28, no. 6, 40 pp., 5 plates, 1 cut.

The land mammals of peninsular Florida and the coast region of Georgia, by Outram Bangs. Proceedings, vol. 28, no. 7, 79 pp., 9 cuts.

Library.

The additions to the library exceed those reported in any previous year.

The total, 3,683, is made up as follows: —

	8vo.	4to.	Folio.	Total.
Volumes	328	65	1	394
Parts	2,192	534	1	2,727
Pamphlets	504	33		537
Maps				25
Total	3,024	632	2	3,683

The library contains 24,245 volumes, 1,339 incomplete (including current) volumes, and 12,110 pamphlets.

By exchange, gift, or purchase we have added twenty one serials: K. museum f. naturkunde, Zoologische sammlung, Berlin; Annotationes zoologicae Japonenses, Tokyo; British museum, Department of printed books, London; Zoological laboratory, University, Warsaw; Owen's college, Manchester; Balfour library, Cambridge; R. orto botanico, Palermo; Société Neuchâteloise de géographie, Neuchâtel; McGill university, Montreal; New York botanical club, New York; New York agricultural experiment station, Geneva; Asa Gray bulletin, Washington; Journal of applied microscopy, Rochester; Birds, Chicago; Zoological bulletin, Boston; Osprey, New York; Plant world, Binghamton; American journal of physiology, Boston; Journal of comparative neurology, Granville; Journal of school geography, New York; Psychological review, New York.

The society now exchanges its publications with 427 scientific institutions and periodicals.

Nine hundred and forty-seven books have been borrowed by 117 persons; 355 volumes have been borrowed for use in the building, and the library has been consulted 291 times.

Six hundred and twenty-one volumes have been bound in 329 covers; 50 pamphlets have been bound.

The following serials have been indexed: —

Danzig. Naturforschende gesellschaft. Neueste schriften.	4 vols.
Hamburg. Naturhistorisches museum. Bericht.	5 vols.
Mittheilungen.	9 vols.
Owens college. Studies from the biological laboratory.	3 vols.
University of Cambridge. Studies from the morphological laboratory.	3 vols.
Wien. Zoologisch-botanische gesellschaft. Verhandlungen.	15 vols.

The total indexed is 75 serials.

Another side of the basement room has been fitted with shelves and a very considerable rearrangement of the books effected. The method of self classification adopted in 1893–94 has been slightly modified, but still allows radical changes with a minimum of labor and expense.

Among the needs of the library the means to buy promptly standard works issued by publishers is the most pressing. The present income available for the library is wisely used for such serials as cannot be procured through exchange, and for binding; this leaves a very small amount for the purchase of books as such, while the number of desirable books is not only large but increasing.

The strong point of our library, the serial publications of societies, surveys, etc., is derived largely and directly from the publications of the Society and should be maintained at any sacrifice. The size and importance of this set of serials are not so well known as they should be. The list published by the Trustees of the Boston Public Library shows that 113 serials credited to our library are not currently received by any other library listed. The strength of our position in serials is emphasized when tested with that of the collections of other scientific institutions in this vicinity.

Walker Prizes.

The subjects selected by the Walker Prize Committee for the annual award were: —

(1). A cytological study of the sexual reproduction in Mucoraceae or Peronosporaceae.

(2). A contribution to our knowledge of color-vision, especially the evolution of color-vision.

(3). A contribution to our knowledge of cell-division.

(4). A study of the chemical and physical relations of any group of closely related mineral species.

(5). A geological study (including the mineralogy and economic geology) of any mineral deposit in the United States.

These subjects have proved unsuccessful in bringing forth an essay.

The Committee have not reported the subjects for the award in May, 1899.

The fifth award of the Grand Honorary Walker Prize was made by the Council, at their meeting, April 20, to Mr. Samuel H. Scudder of Cambridge for his contributions to entomology. According to the Walker foundation the Grand Honorary Prize "shall not be awarded oftener than once in five years;" it may be five hundred or one thousand dollars. In the award to Mr. Scudder, as in all previous awards, the Council voted the maximum sum, one thousand dollars. In acknowledging the award of the Council Mr. Scudder writes: —

(*Copy.*)

Cambridge, April 25, '98.

Mr. Samuel Henshaw,

Secretary, Boston Soc'y of Natural History,

My dear sir, —

I am in receipt of your esteemed favor of the 22d announcing that the Council of the Society has awarded me the Grand Honorary Walker Prize. I beg you will express to the Council my sincere thanks for this most unlooked for distinction. Having been Secretary of the Society at the foundation of the Prize Fund and the intermediary of its first announcement to the scientific public, I am well aware that this is the most signal honor which can await an American naturalist, and can only feel that I owe it as much to the generous partiality of my many friends in the Society with whom I have been so long associated as to the merit of the work which has engaged my life. But I accept the award with the deepest gratitude and pleasure, and freely promise that the sum which has been granted me shall be expended solely for the advancement of science.

Yours very sincerely,

(Signed) Sam. H. Scudder.

REPORT OF THE TREASURER, EDWARD T. BOUVÉ.

ANNUAL STATEMENT, APRIL 30, 1898. BOSTON SOCIETY OF NATURAL HISTORY.

To cash received from income General Fund	$5,017.88	By cash paid on account of Repairs	$31.75
“ “ “ “ “ Walker Fund	1,999.79	“ “ “ “ “ “ Fuel and Gas	287.99
“ “ “ “ “ J. W. Randall Fund	250.00	“ “ “ “ “ “ Insurance	1,292.50
“ “ “ “ “ H. F. Wolcott Fund	270.54	“ “ “ “ “ “ General Expense	914.04
“ “ “ “ “ Entomological Fund	27.28	“ “ “ “ “ “ Salaries	8,405.00
“ “ “ “ “ C. L. Flint Fund	236.09	“ “ “ “ “ “ Laboratory	59.99
“ “ “ “ “ Bulfinch St. Estate Fund	1,069.17	“ “ “ “ “ “ Museum	372.69
“ “ “ “ “ S. P. Pratt Fund	557.37	“ “ “ “ “ “ Library	943.76
“ “ “ “ Boston University	2,500.00	“ “ “ “ “ “ Publications	1,338 93
“ “ “ “ Massachusetts Inst. Technology	200.00	“ “ “ “ “ “ Walker Prizes	154.25
“ “ “ “ Admission Fees	85.00	By cash paid Trustees for Insurance Sinking Fund	500.00
“ “ “ “ Annual Assessments	1,058.00	“ “ “ “ “ Walker Fund	408.72
“ “ “ “ Museum Fees	125.53	“ “ “ “ “ Interest on deposits	17.21
“ “ “ “ Sale of Publications	389.66	“ “ “ “ Balance	483.04
“ “ “ “ J. Ritchie, Jr., donation library	15.30		
“ “ “ “ Library cards sold	.50		
“ “ “ “ General expense credits	98.05		
“ “ “ “ Insurance Sinking Fund	1,292.50		
“ “ “ “ Interest on deposits	17.21		
Total,	$15,209.87	Total,	$15,209.87

To cash received from Augustus Lowell, Trustee for the Teachers' School of Science	$2,862.75	By cash paid on account of Lectures and Supplies	$2,852.47
To cash received from Interest on deposit	8.23	Balance to new account	387.09
Balance from April 30, 1897	368.58		
Total,	$3,239.56	Total,	$3,239.56

To cash received from Miss Jenny Maria Arms,	$1,100.00	By cash paid for Services and Supplies	$250.00
“ “ “ “ Interest	.78	Balance to new account	850.78
Total,	$1,100.78	Total,	$1,100.78

The report of the Trustees was read; also the report of the Auditing Committee.

It was voted to proceed to the election of officers for 1898–99.

Messrs. R. T. Jackson and B. H. Van Vleck were appointed to collect and count the votes. They reported the election of

PRESIDENT,

CHARLES SEDGWICK MINOT.

VICE-PRESIDENTS,

CHARLES P. BOWDITCH.
EDWARD S. MORSE.
HENRY W. HAYNES.

CURATOR,

ALPHEUS HYATT.

SECRETARY,

SAMUEL HENSHAW.

TREASURER,

EDWARD T. BOUVÉ.

LIBRARIAN,

SAMUEL HENSHAW.

COUNCILLORS FOR THREE YEARS,

Charles B. Davenport.
James H. Emerton.
William A. Jeffries.
George G. Kennedy.
Augustus Lowell.
Miss Susannah Minns.
Thomas A. Watson.
Samuel Wells.

OFFICERS FOR 1898-99.

PRESIDENT,

CHARLES SEDGWICK MINOT.

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Thomas A. Watson.
Samuel Wells.

COUNCILLORS FOR TWO YEARS,

S. L. Abbot.
William S. Bryant.
William M. Davis.
Miss Catharine I. Ireland.
Benjamin Joy Jeffries.
N. T. Kidder.
William H. Niles.

COUNCILLORS FOR ONE YEAR,

Edward A. Bangs.
William Brewster.
Miss Cora H. Clarke.
William G. Farlow.
Robert T. Jackson.
George H. Parker.
A. Lawrence Rotch.
William T. Sedgwick.

COUNCILLORS *ex-officiis*,

John Cummings.
George L. Goodale.
F. W. Putnam.
Samuel H. Scudder.

Printed, July, 1898.

Proceedings of the Boston Society of Natural History.
VOL. 28, NO. 12,
p. 301–332.

THE ODONATE GENUS MACROTHEMIS AND ITS ALLIES.

BY PHILIP P. CALVERT.

WITH TWO PLATES.

BOSTON:
PRINTED FOR THE SOCIETY.
JULY, 1898.

No. 12.— *The Odonate genus Macrothemis and its Allies.*

By Philip P. Calvert.

With two plates.

In the summer of 1897, by the kindness of Mr. Samuel Henshaw, of the Museum of Comparative Zoology, Cambridge, Mass., the writer spent some weeks in studying the extensive collection of Odonata of that institution. Part of the time was devoted to a comparison of material collected in Mexico with that possessed by the Museum, particularly in the genera Macrothemis and Brechmorhoga. This necessitated a study of all the species referable to these two groups, preliminary to satisfactory identifications. It seems worth while publishing the results of this study, with some additions based on the collections in Philadelphia, although the present paper is not to be regarded as even an attempt to monograph the genera in question. On the contrary, the aim is merely to define more precisely some forms hitherto known from very brief descriptions, to indicate the differences between such forms, as well as some of the variations which they show. It is hoped that these data will aid in clearing the way towards acquiring a better understanding of the relationships of these insects when more extensive material is available.

The Common Characters of the Genera here treated. The genera Dythemis, Paltothemis, Brechmorhoga, Scapanea, and Macrothemis, of the subfamily Libellulinae, agree in the following characteristics : —

Eyes in contact for a distance less than the antero-posterior dimension of the occiput; hind lobe of the prothorax with its central portion produced backwards and narrower than the other lobes, its hind margin entire; no additional (or supplementary) transverse carina on the fourth abdominal segment; lower angle of the triangle of the front wings placed only slightly beyond (distad) the level of the outer angle of the triangle of the hind wings (*i. e.* not so far beyond as the length of the latter triangle); sectors of the arculus arising by a common stalk; no supratriangulars (hypertrigonals); last antenodal on the front wings not continued to the median vein; both sectors of the triangle, in the hind wings, arising from its hind (lower) angle; genital hamule of the males not bifid, more prominent than anterior lamina or genital lobe;

sides of the eighth abdominal segment not dilated (*i. e.* not "perfoliate," Kirby) in the females; vulvar lamina not prolonged, but with a median excision.

The chief peculiarity of these five genera, however, is *the modification of the armature of the second and third femora in the males, and of the tarsal nails in both sexes.* The details of the modifications are characteristic for each genus, Dythemis being the least, Macrothemis the most modified of the five (Pl. 1, figs. 1–12).

All these genera are confined in their distribution to the warm parts of America.

Variations from the above Common Generic Characters. 241 individuals, — 33 ♂ 29 ♀ Dythemis, 8 ♂ 2 ♀ Paltothemis, 17 ♂ 15 ♀ Brechmorhoga, 6 ♂ Scapanea, 76 ♂ 55 ♀ Macrothemis, — have been specially examined for the present paper. Special attention was paid to recording variations, in Baja Californian representatives of these genera, in Proceedings of the California academy of sciences, (2), vol. 4, p. 463, 467, *et seq.*, so that those data are also available. 241 individuals, however, is the basis on which all of the following percentages have been calculated, except where reference is expressly made to this last quoted paper. The variations noted from the preceding common characters have been: —

Supra-triangulars. One in the left front wing of one *Brechmorhoga mendax* female, .104 %.

Last antenodal on the front wings continued to the median vein in right front wing of one *B. nubecula* female, .207 %. Of 91 males, 62 females of *Dythemis sterilis*, two females had this last antenodal continued, in one wing only, in each case (Proc. Cal. acad. sci., (2), vol. 4, p. 524), .654 %. Total, .381 %.

Sectors of triangle in hind wings a little separated at origins, on one side only in one female *D. rufinervis*, one female *D. velox*, one female *Macrothemis vulgipes*, one female *M. tessellata*; on both sides in one female *M. vulgipes*, two males *M. inequiunguis*, one female *M. tessellata*, 2.49 %.

It is of interest here to note that, while the total numbers of males and females examined for *all* these characters are 140 and 101 respectively, the females offer a greater number of variations than the other sex, the percentages of variations in the variable characters being .357 (♂) and 1.238 (♀).

The Differences between the Five Genera are shown in the following table: —

Characters.	Dythemis.	Paltothemis.	Brechmorhoga.	Scapanea.	Macrothemis.
Antero-inferior row of teeth (males only) on 1. the second femora	mostly very short, like serrations, when inclined directed towards the knee.	short and nearly straight	directed towards the knee	directed towards the knee	directed towards the knee
2. the third femora	more numerous, like those on the second femora	like those on the second in size, shape, number, and direction	fewer, larger, directed towards the trochanter	fewer, larger, directed towards the trochanter	fewer, larger, directed towards the trochanter
3. Tooth of the tarsal nails (both sexes)	much shorter than the tip of the nail itself, acute.	shorter than the tip of the nail itself, sharper in the females than in the males	shorter than the tip of the nail itself, blunt	shorter than the tip of the nail itself, acute	as long as or longer than the tip of the nail itself, * (except in the first section of the genus)
4. Vertex at tip	concave	bifid	concave or bifid	concave	concave
5. Nodal sector in its middle	slightly but distinctly waved	waved	not waved	not waved	not, or but barely, waved

Characters.	Dythemis.	Paltothemis.	Brechmorhoga.	Scapanea.	Macrothemis.
6. Number of rows of cells in the middle of the field between the subnodal sector and the supplementary sector next below	two *	two	one *	two	one *
7. Arculus, position of	variable *	between first and second antenodals	variable *	variable *	variable *
8. Submedian cross-veins	one	one	one *	one	1–2 *
9. Discoidal triangle of front wings	crossed *	crossed	crossed *	crossed	free *
10. Discoidal triangle of hind wings	free *	free *	free *	free	free
11. Internal triangle of front wings	3–4 celled	3–4 celled	3-celled *	3-celled	1–3 celled
12. Posttriangular rows, front wings	3 *	3 *	2	3	2 *
13. Posttriangular rows, hind wings	2 *	2–3	2	2	1–2 *

The asterisk in the preceding table indicates characters in which variations have been noted, the statements given applying to the majority of individuals examined. These variations will now be recorded corresponding to the numbers in the first column of the table.

Variations in generic characters of Dythemis.

6. One female *tabida* has but one row in one front and both hind wings, 1.21%.
7. At the second antenodal or somewhat beyond in *rufinervis*, *velox*, and most *sterilis*; between the first and second antenodals *fugax*, *constricta*, some *sterilis*, one front wing of one male *rufinervis*, both front wings of one female *rufinervis*.
9. Free on both sides of one female *sterilis* from Tehuantepec, on one side of one male *tabida*, 2.419%. Among the 91 ♂ 62 ♀ of *D. sterilis* already quoted from Proc. Cal. acad. sci., (2), vol. 4, p. 524, no such variation was found, which would reduce the total variation in this one character to .465%.
10. Crossed on one side of two males and one female *fugax*, one female *sterilis* from Tehuantepec, one male *sterilis* from Guatemala; on both sides one male *fugax*, 5.645%.
12. In *sterilis* it is not uncommon to meet with two rows for 1–3 cells in the midst of the three rows.
13. Three in some *fugax*, but where this is the case there are two rows for one or more cells farther out in the field; considerable asymmetry prevails in the details.

 The variation in the variable characters 6, 9, and 10 is for the males 2.274%, for the females 3.017%, the number of individuals of these sexes being 33 and 29 respectively.

Variations in generic characters of Paltothemis.

10. Crossed on one side of one male *lineatipes*, on both sides of two males, 25%, all of which is furnished by males, viz. 31¼% ♂, 0 ♀.
12. Two or four rows may be inserted in the midst of the three rows for a distance of 1–3 cells in *lineatipes*, and there may be four cells immediately after the triangle.

Variations in generic characters of Brechmorhoga.

6. Two on both front wings and one hind wing of one female *mendax*, both front wings of one male *rapax*, one front wing of one male *mendax*, 4.68¾%.
7. On the front wings, nearer than the second antenodal in *mendax*, *praecox*, *postlobata*, one female *nubecula*, at or beyond the second antenodal in *rapax*, *pertinax*, one male and two females *nubecula*, *grenadensis*? (Chiriqui ♂). On the hind wings variable.
8. Two on one front wing of one female *nubecula*, .781¼%.
9. Free on one side of one male *mendax*, one female *nubecula*, on both sides of three males *postlobata*, one male *grenadensis*? (Chiriqui ♂), two females *nubecula*, one male *praecox*, 25%.
10. Crossed on one side of two females *mendax*, 3.¼ %.
11. Two-celled on one side of one male *mendax*, one male *postlobata*, and one male *praecox*, on both sides one male *grenadensis*? (Chiriqui ♂), 7.81¼ %.

The variation in the variable characters 6, 8, 9, 10, and 11 is for the males 7.983%, for the females 5.238%, character 9 offering an especially great amount. The number of individuals was 17 males, 15 females.

Variations in generic characters of Scapanea.

7. On the front wings between the first and second antenodals of four males and one side of one male; at the second on both sides of one male, one side of one male. On the hind wings at the second antenodal. The series of *Scapanea* at Cambridge was not studied, and the statements made in this paper are based on but six males.

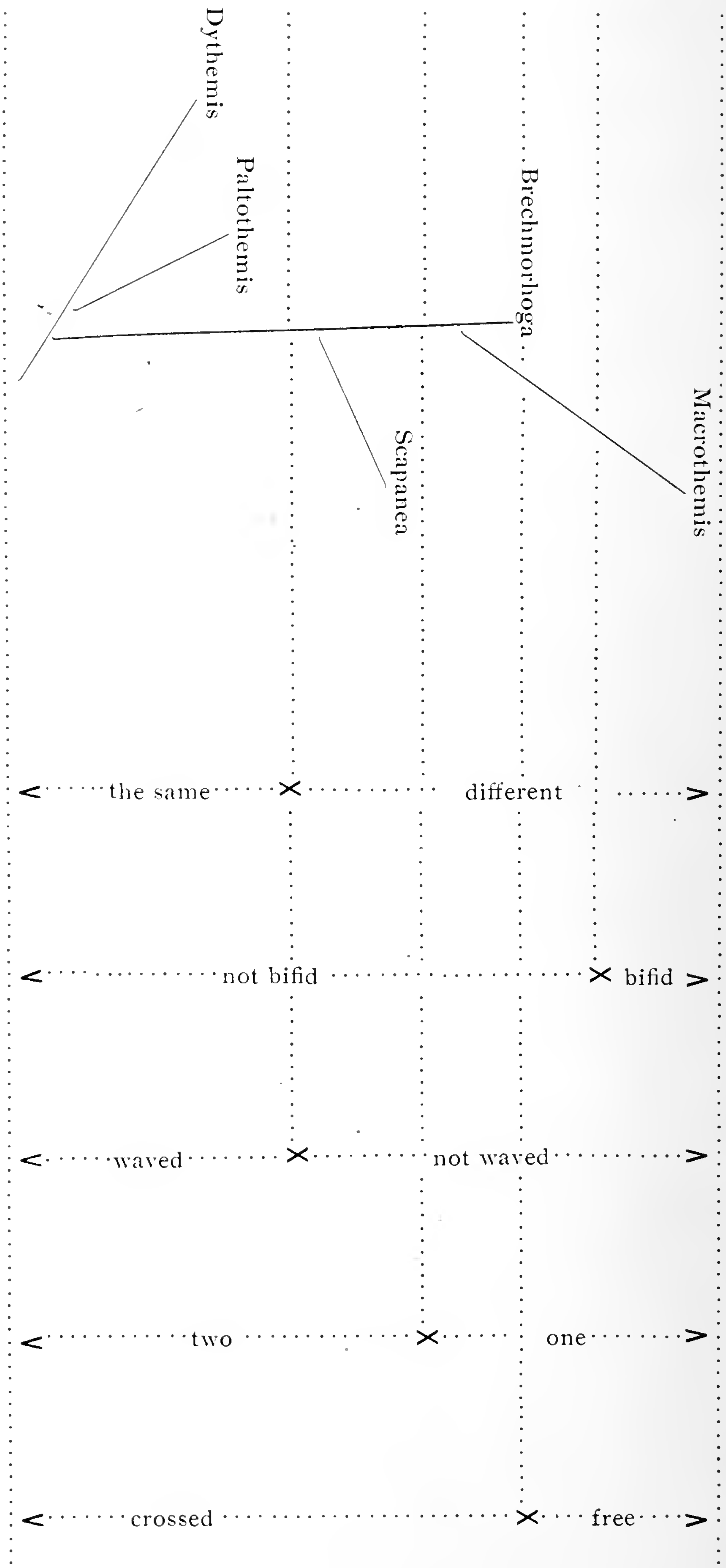
Variations in generic characters of Macrothemis.

3. In the first section of this genus the tarsal nails are distinctly shorter than the tip of the nail itself; in the second the nail is as long as or longer than the nail tip. *Celaeno* is of this second group, but some females have the nail as relatively short as it is in Dythemis.

6. Two rows for one or two cells in all wings of two females *celaeno*; in three wings only of one male and two females *celaeno*; in one front wing only of one female *inacuta*, three males and one female *celaeno*; in both hind wings only of one female *imitans*; in one hind wing only of one male *imitans*, one female *hemichlora*, three males and three females *celaeno*, 6.107 %.
7. On the front wings, slightly nearer than the second antenodal in the majority of *celaeno*, *hemichlora*, *marmorata* males, *pseudimitans* males, in some *inacuta*, *imitans*, *tenuis*, and *inequiunguis*; in others of the species implied by this statement, in *pleurosticta* and *tessellata*, at the second antenodal or slightly beyond. On the hind wings at or slightly beyond the second antenodal.
8. Normally *tenuis* and *marmorata* have two, the other species one; two exist on both hind wings of one male *inequiunguis*, one hind wing of one female *pseudimitans*, .57¼ %.
9. Crossed in one front wing of one female *pseudimitans*, .382 %.
12. Three cells then two rows, or three rows may be inserted in the midst of the two rows in *celaeno* as detailed *post* under that species. One row in the middle of the field in *marmorata* males.
13. One in *tenuis*, *marmorata*, *imitans*, *inequiunguis* males, *pleurosticta*, *hemichlora* males, *pumila* females, some males of *pseudimitans* and of *celaeno*; two in the others, as implied, or not mentioned.

The variation in the variable characters 6, 8, and 9 is for the males 1.579 %, for the females 5⅓ %, the numbers of individuals being respectively 76 and 55.

The accompanying diagram will perhaps indicate the relationship of these five genera in a more graphic manner than the table on pages 303–304. In its construction much weight has been laid upon the results furnished by the variations from the generic characters. For variations from generic characters may represent generic characters of ancestors. The beginning, Dythemis, and the end, Macrothemis, of this series of five genera seem to be indicated by the degree of modification of the legs. This much granted, the variations in gen-



(The numbers in parentheses are those of the characters in the table on pages 303–4).

(1 & 2) Direction of teeth on 2d and 3d femora.

(3) Tarsal nails.

(5) Nodal sector.

(6) Rows of cells between subnodal sector and next supplementary sector below.

(9) Triangle of front wings.

eric characters of the other three are to be compared with the corresponding characters of these two, and by such a method the diagram has been drawn up.

The preceding statistics of variation may also furnish some evidence — of rather negative kind it must be confessed — on the question of the relative stability or variability of the two sexes.

Specific Details.

1. Dythemis Hagen.

Hagen, Syn. Neur. N. Amer., p. 162, 1861. Calvert, Proc. Cal. acad. sci., (2), vol. 4, p. 522, 1895 (with synopsis of North American species).[1]

§ I. Wings colored at the base or apex or both. Anterior lamina of ♂ less prominent than genital lobe.

1. **D. fugax** Hagen. Pl. 1, figs. 6, 7. Hagen, Syn. Neur. N. Amer., p. 163, 1861.

This species, with *velox*, has undergone the least modifications in the femoral armature of the males. The antero-inferior row of teeth on the second femora consists of 10–15 teeth on the basal half, 7–8 spines on the apical half; on the third femora of 20–26 serrations, 6–10 spines; these are in all cases directed towards the knee. See plate 1, figs. 6 and 7.

Distribution. Texas: Pecos River, Waco, Carrizos Springs in Dimmit Co., Round Mountain in Blanco Co. (Schaupp). July, August. (Hagen, 1875, Coll. P. P. C.)

2. **D. velox** Hagen. Hagen, Syn. Neur. N. Amer., p. 163, 1861.

In the synopsis of species quoted above (Calvert, 1895) the frons and vertex of *velox* are stated to be "yellowish-green to brown." An examination of Hagen's types shows variation, possibly due to age-differences, from pale green and luteous through brown to metallic blue. This diminishes still more the differences supposed to separate *velox* from *sterilis*. I tabulated the various color peculiarities of individuals related to these two forms (there seem to be no structural differences), contained in the Museum at Cambridge and in my own collection, and have thus brought together a

[1] Full bibliographical references are not given in this paper when one of those quoted already contains a full list.

bewildering mass of details. So slight are the differences presented, so great the probability that they are due to age, that it does not seem worth while to reproduce the table here. Perhaps the most that can be said is that in typical *velox* the tips of the wings are brown for a distance varying from three cells to rather farther proximad than the outer end of the pterostigma (♂), or to the pterostigma (♀), while in typical *sterilis* the extent of the brown is less in both sexes. Neither this nor any other difference seems to be constant enough to be specific, so that I here place *sterilis*, and one or two others are mere varieties of *velox*.

Variety 1. *Sterilis*. Hagen, Syn. Neur. N. Amer., p. 317, 1861. Calvert, Proc. Cal. acad. sci., (2), vol. 4, p. 522, 1895. A synonym is *Dyth. broadwayi* Kirby, Ann. mag. nat. hist., (6), vol. 14, p. 227 (1894), of which I have seen the type in the British Museum.

Variety 2. *Tabida*. Hagen, Syn. Neur. N. Amer., p. 317, 1861 (no description). Of this I have seen the types at Cambridge — a male from Brazil, three females marked Bahia, Para, Brazil respectively. They have the vertex metallic blue, the frons luteous with a metallic blue point at the base of the superior groove, no black spot on the nasus, labrum green (♂) or yellow (♀), its free margin bordered with black, extreme base of front wings yellow, of hind wings yellow to the submedian cross-vein, apex of front wings hardly darker (♂), or brown of variable extent, reaching at most to the inner end of the pterostigma (♀). Abdominal segments 9 and 10 of the female are black, unspotted. Abdomen ♂ (broken), ♀ 25–26 mm. Hind wing ♂ 31, ♀ 28.5–30.

Distribution. "Typical" *velox* is from Texas: Pecos River, Round Mt. (Schaupp), July, August. *Sterilis* and the various intermediate forms are from Mexico: Tehuantepec, Tepic, Baja California in September and October; Guatemala; Colombia: St. Fea de Bogota; Venezuela: Porto Cabello; Guiana: Livingston in April; Brazil: Rio, Bahia, Para. Hagen in 1875 gave also Panama, Peru, Buenos Aires.

3. **Dythemis rufinervis** Burm. Pl. 1, fig. 4. Burmeister, Handb. ent., vol. 2, p. 850, 1839. Hagen, Proc. Bost. soc. nat. hist., vol. 18, p. 74, 1875.

Distribution: Cuba, Hayti in May; Jamaica: Kingston by E. M. Aaron.

§ II. Wings uncolored. Anterior lamina of male more prominent than genital lobe.

4. **Dythemis constricta** (Selys MS.) sp. nov. Pl. 1, fig. 16. Hagen, Proc. Bost. soc. nat. hist., vol. 18, p. 86, no. 2 (no description).

♂ Face greenish, frons above and vertex metallic blue, lips yellowish, median labial lobe black. Occiput and rear of eyes brown.

Thorax reddish brown, apparently much discolored, with a slight metallic blue reflection.

Legs black. The 3d tibiae with 14 spines on the anterior (outer) row, their lengths being equal to or less than the intervals separating them, and 35 shorter spines on the posterior (inner) row.

Abdomen widest at 2 and at 8 (3 mm.), narrowest at 5 (1.4 mm.) and at 10 (1.9 mm.), black, marked with reddish yellow as follows: greater part of the sides of 2 and 3 except the carinae and sutures; a spot on either side, at base, of 4–9, elongate and divided into two successive spots, the second larger, on 5 and 6.

Superior appendages as long as 9, blackish, curved downwards, slightly upcurved at apex, thickened before the apex, inferiorly with a row of eleven denticles for the greater part of the length of the appendage, following the last of which the appendage (viewed in profile) is truncated upward and backward to form the apex. Inferior appendage about one-sixth shorter, not reaching quite so far as the last denticle, its apex rather wide -- half as wide as at base.

Genitalia: anterior lamina and hamule very prominent, the latter more so, its profile resembling the prow of an ancient boat. Anterior lamina somewhat swollen in front, its apex rather narrow and rounded. Genital lobe small, slender, forming a finger-like process overlapping the vesicle of the penis. Pl. 1, fig. 16.

Wings somewhat smoky but uncolored. Pterostigma dark reddish brown. Reticulation and membranule blackish. Arculus between 1st and 2d antenodals.

Front wings: 11 (L) 12 (R) antenodals, 9 postnodals, the submedian cross-vein on a level with the first antenodal, triangle crossed, internal triangle of 3 cells, three posttriangular rows to beyond the nodus and 8 marginal cells.

Hind wings: 8 antenodals, 9–10 postnodals, submedian cross-vein nearer the base than is the 1st antenodal, two posttriangular rows (3 cells, then two rows on the right) to the level of the separation of the median sector.

Total length 45 mm., abdomen 32.5, front wing 38, hind wing 37, pterostigma 4, hind tibia 9.

Its robust form suggests *Paltothemis lineatipes* Karsch.

1 ♂ in Mus. Comp. Zool. labeled "P. Br." & "L. constricta" in Selys's handwriting. Hagen *l. c.* gives the locality as Brazil.

I do not know *Dythemis multipunctata* Kirby, Ann. mag. nat. hist., (6), vol. 14, p. 265, 1894, from the West Indies.

None of the undescribed species listed under *Dythemis* by Hagen in 1875, other than those mentioned above, belong to this genus as here defined.

2. Paltothemis Karsch.

Karsch, Berl. ent. zeit., vol. 33, p. 362, 1890.

Only one species is known:—

1. **P. lineatipes** Karsch. Pl. 1, figs. 1, 8, 9. Karsch, *l. c.*, p. 363, 1890.

Synonym: *Dythemis russata* (Hagen MS.). Calvert, Proc. Cal. acad. sci., (2), vol. 4, p. 526, pl. 16, figs. 46–49, 1895.

Distribution: Karsch's type, which I have studied, is from Brazil, those of *russata* from Baja California, in September and October, and Arizona. I saw this species in the K. k. naturhistorisches Hofmuseum at Vienna labeled "Merida," and a male at Cambridge from Texas.

3. Brechmorhoga Kirby.

Kirby, Ann. mag. nat. hist., (6), vol. 14, p. 264, 1894.

This genus was based on *B. grenadensis* Kirby, *l. c.*, p. 265, but includes a number of previously described forms, which resemble each other very closely. As a detailed description of one of them (*mendax*) exists, all that seems necessary here is to tabulate and describe their differences. I expect that additional specimens will prove many of these differences to be inconstant. It may be added that the "loop-nervure," upon which Mr. Kirby laid such stress, is by no means a constant character.

Analytical Table.

Sides of thorax predominantly pale (blue or green), lips mostly pale.

Genital lobe of ♂ with no posterior process.

Color at base of wings of ♀ reaching at most only to submedian cross-vein, of ♂ not so far. Hamule of ♂ sickle-shaped . . . . *mendax*

Color at base of wings of ♀ reaching half-way to the nodus (front) or to the origin of the subnodal sector (hind) for almost the entire width of wing, of ♂ to submedian cross-vein. Hamule of ♂ less strongly curved than sickle-shaped . . . . . . *nubecula*

Genital lobe of ♂ with a posterior process, hamule sickle-shaped . . . . *postlobata*

Sides of thorax predominantly dark (brown or black).

Labrum mostly yellow.

Size smaller, abdomen 30 mm., hind wing 26. *grenadensis*

Size larger, abdomen 36–38, hind wing 31–35. *praecox*

Labrum mostly black.

Lateral labial lobes mostly yellowish, inner posterior fourth black; pale spot on each side of dorsum of 7 nearly as wide as that side of the segment on which it lies, its length but little more than its own width, its anterior and posterior margins each bilobed . . *rapax*

Lateral labial lobes with at least the inner half black, elsewhere yellowish; pale spot on each side of dorsum of 7 one half as wide as that side of the segment on which it lies, its length four times as great as its own width, margins not lobed . . . . *pertinax*

In the above table *grenadensis* may perhaps be incorrectly located as I have seen no undoubted specimens.

1. **B. mendax** Hagen. Pl. 1, fig. 5, pl. 2, figs. 23, 30.

Dythemis m. Hagen, Syn. Neur. N. Amer. p. 164, 1861. Calvert, Proc. Cal. acad. sci., (2), vol. 4, p. 529, pl. 16, figs. 56, 57, 1895.

Hagen's types have little or no metallic blue on the vertex and upper surface of the frons, but a male from Round Mt., Texas, otherwise not distinguishable, has this color well marked. The large pale spot on either side of the dorsum of 7 distinguishes this species from *praecox*, *pertinax*, *postlobata*, and perhaps *grenadensis*.

Vulvar lamina excised, lobes rounded, diverging at a right angle (Pl. 2, f. 30); this aids in distinguishing from *praecox*.

Front wings with 11–14 antenodals, 6–9 postnodals, hind wings with 8–9 antenodals, 8–12 postnodals.

Abdomen ♂ 36–43, ♀ 37–45; hind wing ♂ 34.5–39.5, ♀ 36.5–43; pterostigma 2.25–3 mm.

Distribution. Texas: two males and three females, types of Hagen, Pecos River, July 2, August 5, 7, 24; one female San Antonio by A. Agassiz; five females no locality labels— these eleven in the Museum at Cambridge; one male Round Mt., Blanco Co., by F. G. Schaupp, in Coll. P. P. Calvert. Baja California, Mexico, Sept., Oct. (Calvert *l. c.* 1895).

2. **B. nubecula** Rambur. Pl. 1, fig. 18, pl. 2, f. 22.

Libellula n. Ramb., Névr., p 122, 1842.

The vertex and frons superiorly metallic blue (♂), yellowish or luteous with a trace of metallic blue (♀). Lips yellow.

Vulvar lamina excised, lobes extremely short.

Front wings with 13–14 antenodals, 8–12 postnodals, hind wings with 9–11 antenodals, 10–13 postnodals.

Abdomen ♂ 38, ♀ 35–36; hind wing ♂ 40, ♀ 37–39; pterostigma 2.5.

Distribution. One male, one female "Brasil Germ," two females "P. Br." in Selys's hand — all at Cambridge.

3. **B. postlobata** sp. nov. Pl. 1, fig. 13, pl. 2, fig. 26.

The character which has suggested the name of this species, — the presence of a posterior process on the genital lobe, — distinguishes it from all other species of Brechmorhoga. A detailed description has already been prepared for publication in the Proceedings of the California academy of sciences; here will be given only those details as for the other species. Frons superiorly and vertex with more or less metallic blue. Free margin of labrum partly or entirely edged with brown or black. Lateral labial lobes yellow, inner third or less brown or black. Wings faintly yellowish, darker yellow in the postcostal space for one cell at the extreme base.

Front wings with 9–11 antenodals, 6–7 postnodals, hind wings with 8 antenodals, 8 postnodals.

♂ Abdomen 36–37, hind wing 32, pterostigma 2–2.5.

Distribution. Mexico; Tepic, two males, November (Cal. Acad. Sci. Coll., Coll. P. P. C.); Mazatlan, October, 1873, by Crotch (Mus. Comp. Zool.).

4. **B. grenadensis** Kirby. Kirby, Ann. mag. nat. hist., (6), vol. 14, p. 265, 1894.

I have not seen this species, which was described from the Island of Grenada, West Indies, unless a male from Chiriqui, sent me once by Mr. C. C. Adams for identification, belongs here.

This Chiriqui male had the vertex and frons superiorly dark metallic blue, sides of the thorax dark brown with three uninterrupted green stripes, labrum lost, labium yellow unspotted, genitalia most like those of *nubecula*, wings hyaline very pale yellow in the basal half, triangles free. Front wings with 14 antenodals, 8 postnodals, two posttriangular rows almost to the level of the nodus. Hind wings with ten antenodals, 9–10 postnodals. Pale spots on 7 resembling those of *pertinax* and of *praecox*. Teeth on the third femora five in number, confined to the apical half. Abdomen about 30 (4th segment lost), hind wing 29, pterostigma 2 mm.

5. **B. praecox** Hagen. Pl. 2, figs. 25, 29.

Dythemis p. Hagen, Syn. Neur. N. Amer., p. 164, 1861.

The type, a female, has the frons above and vertex metallic blue, lips yellow; vulvar lamina bilobed, lobes rounded and approximated Pl. 2, fig. 29; wings smoky yellow throughout, the longitudinal veins and some of the cross-veins, from the base to the distal end of the triangle, bordered with brownish yellow.

The males which seem to be conspecific have, in some, the free margin of the labrum bordered with black, the inner third or less of the lateral labial lobes black, hamule sickle-shaped similar to that of *mendax*, wings very pale yellowish throughout, hardly darker than the extreme base of the hind wings. Here probably belongs *Dythemis columba* Hagen, Syn. Neur. N. Amer., p. 317, 1861 (no description), differing only in its smaller size, fewer cross-veins (the lower figures of those which follow are those of *columba*), and straighter hamule.

Front wings with 11–13 antenodals, 5–9 postnodals; in two males from Mexico and the type of *columba* the two posttriangular rows reach to the level of the nodus. Hind wings with 8–10 antenodals, 7–10 postnodals.

Abdomen ♂ 36.5–38, ♀ 37; hind wing ♂ 31–35; pterostigma 2–2.5.

Distribution. Mexico: one female by Thorey, Hagen's type (M. C. Z.); two males, one female Cuernavaca, October, 1897, by O. W. Barrett (collections P. P. Calvert and C. C. Adams).

Costa Rica: one male Bkistebu, Diquis Valley, 1000 metres, February, 1897 (coll. C. C. Adams). Columbia: one male (M. C. Z.). Venezuela: one male by Appun, type of *columba*; the sixth abdominal segment is lost, the abdomen has been mended, and I strongly suspect that the last four segments do not belong to this male.

6. **B. rapax** (Hagen MS.) sp. nov. Pl. 1, fig. 17, pl. 2, fig. 24. Hagen, Syn. Neur. N. Amer., p. 317, 1861 (no description).

In addition to the characters given in the preceding analytical table there is but to be added — frons above and vertex metallic blue; labrum black, a pale greenish spot each side at base, hamule like that of *nubecula* (Pl. 1, fig. 17), spot on 7 as shown in Pl. 2, fig. 24. Wings slightly smoky, hind wings yellowish along the membranule outwards for one cell only and for the same distance in the submedian space.

Front wings with 16–17 antenodals, 12–15 postnodals, hind wings with 12–13 antenodals, 13–14 postnodals.

♂ Abdomen 35–36, hind wing 42, pterostigma 3 mm.

Distribution. Venezuela: two males, types of Hagen (M. C. Z.).

7. **B. pertinax** Hagen. Pl. 1, fig. 20. pl. 2, fig. 21.

Dythemis p. Hagen, Syn. Neur. N. Amer., p. 166, 1861. Synonym? *Dyth. sallei* Selys, Ann. soc. ent. Belg., vol. 11, C. R. p. 67, 1868 (according to Hagen, Proc. Bost. soc. nat. hist., vol. 18, p. 75).

Vertex and frons above metallic blue; labrum black except for a yellow spot at the middle of base, hamule not so strongly curved as to be sickle-shaped, wings clear except for a very pale yellow tinge between the costa and the principal sector fading away between nodus and pterostigma.

Front wings with 15 antenodals, 9–10 postnodals, hind wings with 11 antenodals, 12–13 postnodals.

♂ Abdomen 39, hind wing 41, pterostigma $2\frac{1}{3}$ mm.

Distribution. Mexico, according to Hagen, 1861; one male with the label "Hell 6" at Cambridge.

4. Scapanea Kirby.

Kirby, Trans. zool. soc. Lond., vol. 12, p. 264, 298, 1889. Karsch, Berl. ent. zeit., vol. 33, p. 362, 1890.

The only species is

1. **S. frontalis** Burmeister.

Libellula f. Burm., Handb. ent., vol. 2, p. 857, 1839. *Dyth. f.* Hagen, Proc. Bost. soc. nat. hist., vol. 18, p. 75, 1875.

Distribution. Cuba: Cardenas in May and June; Isle of Pines; Hayti in May; Jamaica: Kingston in May, by E. M. Aaron, Portland by Johnson and Fox.

5. Macrothemis Hagen.

Hagen, Stett. ent. zeit., vol. 29, p. 281, 1868. Calvert, Proc. Cal. acad. sci., (2), vol. 4, p. 472, 531, 1895.

Analytical Table.

§ I. Tooth of the tarsal nails much shorter than the tip of the nail itself, as in most Libellulinae. One submedian cross-vein. Sides of thorax predominantly pale green or yellow with narrow brown stripes on the first and second lateral sutures.

Hind wings of females with two posttriangular rows.

Females with tips of all wings brown, yellow at base of wings to the outside of the triangle, frons not metallic above, abd. segments 1–7 with pale colors predominant. Males with superior appendages acute at tip and an inferior median tooth. . . . . . . 1. *inequiunguis*

Females with tips of all wings clear, yellow at base of wings to the second antenodal, frons mostly metallic blue; abd. segs. 1–7 with black predominant. Male unknown. 2. *vulgipes*

Hind wings of females with one posttriangular row (male unknown) . . . . 3. *tessellata*

§ II. Tooth of the tarsal nails as long as, or longer than the tip of the nail itself (or slightly shorter in some females).

Hind wings with two submedian cross-veins. Superior appendages of the males with the apical half curved upwards, an inferior tooth at two thirds their length.

Frons of ♂ pale green above, anteriorly with a transversely elongate black spot; green antehumeral stripe at its upper end just touching an oblong green spot in front of the antealar sinus; anterior lamina cleft to base; the two posttriangular rows on front wings not interrupted as below . . . . 4. *tenuis*

Frons of ♂ mostly metallic blue, no black spot; green antehumeral stripe not reaching an oblong green spot in front of the antealar sinus; anterior lamina bifid only at tip; the two posttriangular rows on front wings interrupted by one or more single cells in the middle of the field . . . . 5. *marmorata*

Hind wings with one submedian cross-vein.

Abdomen of ♂ not much widened on 7 and 8.

Size small, abdomen 15–17.5, hind wing 19–21.5; females with one posttriangular row on hind wings 6. *pumila*

Size larger, abdomen 27.5, hind wing 26 mm. at least; females with two posttriangular rows on hind wings.

Abdomen blackish brown with green or yellow stripes.

Sides of thorax blackish with three uninterrupted yellow stripes. Superior appendages of ♂ hardly longer than inferior appendage. 7. *catharina*

Sides of thorax dark brown, mesepimeron and metepimeron each with two pale spots placed obliquely one above the other. Superior appendages of ♂ longer than inferior, with a small inferior tooth at two thirds their length, their tips acute.

Labrum pale blue or yellow, no pale green spot behind the third coxa. 8. *pleurosticta*

Labrum entirely or partly black, a pale green spot on pectus behind the third coxa. . . . . . 9. *celaeno*

Sides of thorax predominantly pale green with black markings. Male unknown. 10. *musiva*

Abdomen luteous or pale brown, sutures and carinae black. Tips of superior appendages of ♂ not acute but rounded. . 11. *inacuta*

Abdomen of ♂ greatly widened on 7 and 8.

Sides of thorax dark brown with four pale spots: two on mesepimeron, two on metepimeron placed obliquely one above the other; antehumeral stripes cuneiform,

the lower end almost reaching the anterior mesothoracic border. Superior appendages of ♂ with an inferior row of denticles on the second fourth.
12. *pseudimitans*

Sides of thorax dark brown with three pale spots: two on mesepimeron placed obliquely one above the other, one on metepimeron; an antehumeral spot, not stripe, in front of the antealar sinus. Superior appendages of ♂ with a single, distinct, inferior tooth at a little more than half their length. . . 13. *imitans*

Sides of thorax pale green or yellow with a brown stripe on the first and on the second lateral suture, the latter sending a branch down on the metasternum; antehumeral stripes cuneiform, shorter in the ♂ than in the ♀. Superior appendages of ♂ with an inferior row of denticles in the second fourth.

Tip of inferior appendage of ♂ nearly as wide as the base, deeply bifid. . . 14. *hemichlora*

Tip of inferior appendage of ♂ one third as wide as the base, with a shallow excision. 15. *cydippe.*

Of the above species 6. *pumila* Karsch, Berl. ent. zeit., vol. 33, p. 368, 1890, from Bahia, and 7. *catharina* Karsch, *l. c.*, p. 366, from Theresopolis, S. Catharina, Brazil, have not been studied by me and are not further mentioned here.

1. **Macrothemis inequiunguis** Calvert. Pl. 1, fig. 2. Calvert, Proc. Cal. acad. sci., (2), vol. 4, p. 533, pl. 16, figs. 34, 40–45, 1895.

A male in the Mus. Comp. Zool. from Chili by Thorey standing after the label in Dr. Hagen's handwriting "D. typographa * Hag." (*Dythemis typographa* Hagen, Proc. Bost. soc. nat. hist., vol. 18, p. 86, 1875, no description) agrees with my description except in a few particulars which do not seem to be of specific value. These are: nasus with a small, brown, crescentic, central spot, labrum black with a small green spot at the middle of its base, the black on the lateral labial lobes leaves only their anterior margins yellowish, and the abdomen is more slender (width at 5 about .7 mm., at 7, 2 mm.), which may, however, be due to the manner in which the specimen dried. The size is that of the smaller measurements given for *inequiunguis.* It may provisionally be regarded as a variety.

Distribution. Mexico: Baja California in September and October; Tepic in November; Ecuador (Coll. C. C. Adams); Chili as above.

2. **Macrothemis vulgipes** sp. nov.

♀ Frons luteous below, above and the vertex metallic blue. Clypeus pale green, lips luteous, labrum narrowly edged with black at the middle only of its free edge, median labial lobe black. Occiput brown, a double green spot behind, with a slender forward prolongation between the eyes which are in contact for a distance a little longer than the length of the occiput. Rear of eyes brown and green.

Prothorax brown, anterior margin of front lobe, posterior margin of middle lobe greenish yellow.

Thoracic dorsum dark brown, a slender, pale green antehumeral stripe each side, whose width is about $\frac{1}{10}$ of the distance from the pale mid-dorsal carina to the humeral suture, confluent at its upper end with a transversely elongated green spot in front of the antealar sinus. Sides and pectus pale green, a narrow dark brown stripe on the second and on the first lateral sutures.

Feet black, trochanters and bases of femora paler, first femora pale green inferiorly. Spines of the posterior (inner) row of the third tibiae a little shorter and more numerous (17) than those of the anterior row (13). All tarsal nails with a short inferior tooth as in most Libellulinae, not bifid as in typical Macrothemis; this condition has suggested the specific name *vulgipes*.

Abdomen wider at 2 and at 8–9, black, 2–5 with a superior pale green stripe each side, interrupted by the black additional transverse carina on 2 and 3, and by a longer interval on 4 and 5 where it consists of a shorter basal and a longer posterior piece; a small pale spot each side at base of 6 in the Panama ♀; 7 with a green oval spot on the middle of the segment, slightly bilobed at either end by the mid-dorsal carina running through it, this spot is $\frac{1}{3}$ as long as the segment and on either side extends from the mid-dorsal carina a little more than half way to the lateral margin; 1 and 2 with an inferior green spot each side, 3–7 with an inferior luteous streak each side.

Appendages black, a little longer than 10.

Wings in great part or entirely faint yellowish, all the veins bordered with pale brown in the Panama female (a variation which occurs very frequently in various species of Libellulinae, *e. g. Pachydiplax longipennis*), subcostal, submedian, and postcostal spaces deeper yellow to the level of the second antenodal and back to the apex of the membranule on the hind wings. Pterostigma black. Membranule gray.

Front wings: 12–13 antenodals, 6–7 postnodals, internal triangle of one cell, two posttriangular cells to the level of the nodus increasing to 4 marginal cells.

Hind wings: 9 antenodals, 7–9 postnodals, two posttriangular rows (or first one cell due to the first cell of the lower row extending up to the outer angle of triangle) to the level of the origin of the subnodal sector, increasing to 9–10 marginal cells. The right hind wing of the Panama female has the posttriangular field thus 1 .1 .2 .1 .2 .2 .2 .3.+.

Total length 32 mm., abdomen 24, hind wing 27, its greatest width 8–9, pterostigma 2, appendages .6, hind tibia 4.

One female, Chiriqui, Staudinger, one female, Panama, both in Mus. Comp. Zool.

3. **Macrothemis tessellata** Burm.

Libellula t. Burmeister, Handb. ent., vol. 2, p. 849, 1839.

♀ Vertex truncated at tip, metallic blue; frons above metallic blue, below yellow, as are the clypeus and labium. Labrum, occiput, and rear of eyes metallic blue or black, or with a pale green spot at middle of base of labrum and on rear of eyes. Eyes in contact for 1.5 mm. or $1\frac{1}{2}$ times the length of the occiput. Prothorax dark brown, hind lobe narrower than the others, its shape that of a small segment of a circle, its hind margin entire. Thoracic dorsum dark brown with a pale green antehumeral stripe each side whose width is equal to $\frac{1}{4}$–$\frac{1}{6}$ the distance from mid-dorsal carina to humeral suture. Sides and pectus yellowish, a complete dark brown stripe on each of the 1st and 2d lateral sutures.

Feet blackish brown, first femora in great part, especially inferiorly, luteous. Hind tibiae with 11–12 spines on the anterior (outer) row, 14–15 on the posterior (inner), all long and slender. Tarsal nails toothed before the tip, tooth decidedly shorter than tip of nail itself.

Abdomen slightly wider at 2 and at 9, compressed at base and depressed at apex, black, each side of dorsum of 1–7 with a row of linear pale green spots, two to each segment as far as 6, one on 7; inferior tergal margins of 3–7 greenish.

Apps. black, straight, slender, as long as 10. Vulvar lamina with a very small median notch of more than 90°.

Wings clear, apex dark brown beginning half way between nodus and pterostigma for the entire width of the wing, many of the cells clearer in their centers. H. W. with a yellow tinge at extreme base to the level of the submedian cross-vein and backwards (caudad) to the apex of the membranule, a still smaller yellow tinge at base of front wings. Reticulation dark brown. Membranule grayish. Pterostigma dark brown, surmounting one or two cells and parts of two others. Arculus at or beyond the second antenodal, its sectors stalked, nodal sector not waved, supplementary sector next below the subnodal separated from it by one row of cells, no hypertrigonals, all triangles free; one submedian cross-vein, nearer the base than the first antenodal.

F. W. 11–13 antenodals, the last not continuous (continuous in both wings of one ♀), 6–8 postnodals, internal triangle of one cell, two posttriangular rows to beyond the level of the nodus, then three rows, with four marginal cells. First sector of the triangle correspondingly almost straight.

H. W. 8–9 antenodals, 7–8 postnodals, no internal triangle, one row of posttriangular cells (between short sector and first sector of the triangle) to the level of the origin of the subnodal sector, sectors of the triangle united at their origins in 1½, separated at their origins in 1½ individuals, inner side of triangle very slightly nearer base than the prolongation of the arculus would be.

Total length 35. Abd. 25. F. W. 32. H. W. 31. Pter. 2.5. Hind tibia 5.

Three females (Mus. Comp. Zool.)— (1) "————" "Heyer," (2) "Brasil Heyer," (3) "Brazil Mrs. Munroe," — so identified by Dr. Hagen, although not labeled by him.

4. **Macrothemis tenuis** Hagen. Pl. 1, fig. 14. Hagen, Stet. ent. zeit., vol. 29, p. 286, 1868. (nec Karsch.)

The Mus. Comp. Zool. contains four males by Beschke from New Freiburg near Rio, Brazil, types of Hagen. The color pattern of the sides of the thorax is rather diffuse and not easily described, but on the metepimeron inferiorly is a black spot extending from the lower end of the second lateral suture half way towards the thoraco-abdominal articulation. In *marmorata* males the same spot is represented by a stripe which reaches back to the hind margin of the metepimeron. The female type of *marmorata* has this color pattern of *tenuis*, hence I suspect it may be really the female of *tenuis*; Dr. Hagen probably considered it as *marmorata* on account of the "schwarzblaue metallische Färbung nur oben auf der Stirn" lacking in the males of *tenuis*, present in the males of *marmorata*.

These four *tenuis* males have on the front wings two posttriangular rows to the level of the nodus, increasing to 3–4 (5–6 in Michelis's ♂) marginal cells and the internal triangle of two cells (3 in left front wing of Michelis's ♂). Hind wings with 8 antenodals (7–8 Michelis's ♂), 6–8 postnodals, two posttriangular cells of which the upper reaches across the entire width of the field (three in one wing of one ♂), then one row for two to three cells, followed by two rows increasing to 8–10 marginal cells.

Total length 40, abdomen 29.5, hind wing 28.5, its greatest width 8, pterostigma 2, superior appendages 1.6, hind tibia 5.5.

In addition to the four types quoted above, I have studied a male from Brazil, by Michelis, given me at the Museum für Naturkunde, Berlin, in 1896.

5. **Macrothemis marmorata** Hagen. Pl. 2, fig. 33. Hagen, Stett. ent. zeit., vol. 29, p. 286, 1868. *M. tenuis* Karsch, Berl. ent. zeit., vol. 33, p. 364, 1890.

Karsch's detailed description of this as a new species was evidently (from his text) made in forgetfulness of Hagen's publication. Hagen's types of *marmorata* in the Museum of Comp. Zool., two males, one female, agree with Karsch's text except in a few, mostly unimportant particulars, as follows; ♂ a distinct tooth on the inferior surface of the superior appendages at little more than half their length from the base. ♂ and ♀ internal triangle (subtriangular space) of two cells, 6–7 postnodals on f. w.

Total length ♂ 39, ♀ 40. Abdomen ♂ 29, ♀ 29.5. Hind wing ♂ 28, ♀ 30. Width of hind wing ♂ 8, ♀ 9.5, pter. 2, sup. app. ♂ 1.6, hind tibia 5.5. App. ♀ 1.

In the two male types there are on the front wings two posttriangular rows for two to three cells, then one row for two to four cells followed by two rows which in one wing of one individual are again interrupted by a single cell; on the hind wings there are two posttriangular cells, the upper one reaching across the entire width of the field, then one row for three cells, followed by two rows increasing to 3 marginal cells.

In the female type, the front wings have two posttriangular rows to beyond the level of the nodus with 4 marginal cells, the hind wings two posttriangular cells, the upper reaching across the entire width of the field, followed immediately (left side), or after one cell (right side), by two rows increasing to 9 marginal cells.

Judging from the markings on the sides of the thorax, I am not certain that this type ♀ may not really be *tenuis* ♀, especially as

Karsch does not state that the females he studied differ from the males in the number of posttriangular rows.

8. **Macrothemis pleurosticta** Burmeister. Pl. 2, fig. 34.

Libellula p. Burm. Handb. ent., vol. 2, p. 849, 1839. *M. p.* Hagen, Stett. ent. zeit., vol. 29, p. 285, 1868.

♂ (Burmeister's type). Face pale green, frons superiorly and vertex metallic blue, labium yellow, its median lobe and the extreme bases of the lateral lobes blackish. Eyes in contact for a distance less than the length of the occiput which is brownish above, greenish behind. Rear of eyes varied with brown and green. Prothorax pale brown. Thorax dark brown, mid-dorsal carina yellowish, a complete pale green antehumeral stripe situated half way between mid-dorsal carina and humeral suture and whose width is little more than the thickness of the carina, but which is abruptly widened on its inner side at its upper end, in front of the antealar sinus, so as to almost reach the same carina. Sides with four green spots, one oblong on the lower part of the mesepimeron, a larger and more irregular below the base of the front wing, a triangular on the lower part of the metepimeron, and, smallest of the four, a double spot below the base of the hind wing.

Legs reddish brown, blackish inferiorly. Third tibiae with the spines of the posterior inner row slightly more numerous (14–15), a little shorter, but hardly stouter than those of the anterior (outer) row (11–12).

Abdomen slightly narrower at 3 (.8 mm.) than at 2 (1.7 mm.) thence gradually widening to apex of 9 (1.5 mm.), which is slightly wider than 10; black spotted with pale green as follows: a double spot on either side of the middle of the dorsum of 2, a longitudinal stripe on either side of dorsum of 3–8 at base, interrupted by the additional transverse carina on 3 or suture on 4–7, pointed posteriorly, not longer than half the segment, and an inferior basal spot on either side of 3 below the preceding. An indistinct pale streak just above the lateral carinae of 3–9.

Sup. apps. brown, almost as long as 9 + 10, curved somewhat downwards, thickened before the acute apex, the thickening being greatest at two thirds the length of the appendage where there is a small, but distinct, inferior tooth.

Inf. appendage one fifth shorter, about 1½ times as long as width at base, apex narrow, ending in the usual two upturned denticles.

Genitalia of 2: anterior lamina with somewhat conical profile and rounded apex which is not cleft, hamule nearly twice as prominent, slender, apex curved to form a hook, genital lobe the least prominent, hardly longer than wide, tip rounded.

Wings with a faint yellow tinge in their basal half near the anterior margin, with a deeper yellow cloud at the extreme base to about half way to the first antenodal. Pterostigma reddish brown, membranule whitish.

Fore wings: 15 antenodals, 8 R 7 L postnodals, internal triangle of two cells, two posttriangular rows to the level of the nodus, increasing to 4–5 marginal cells.

Hind wings: 10 antenodals, 9 postnodals, two posttriangular cells, the upper of which reaches across the entire width of the field, then one row for one (left) or two (right) cells, followed by two rows increasing to 12 marginal cells.

Total length 39.5, abdomen 28, hind wing 28.5, its greatest width 8, pterostigma 2, sup. app. 1.7, hind tibia 5.

The male type, Brazil (Mus. Comp. Zool.).

The differences between the markings on the sides of the thorax and on the abdominal segments given by Hagen as existing between this species and *celaeno* do not hold now that specimens of *celaeno* from Hayti agree with *pleurosticta* in these respects. The chief differences are those given in the analytical table.

9. **Macrothemis celaeno** Selys. Pl. 1, fig. 3.

Libellula c. Selys in Sagra's Ins. Cuba, p. 454, 1857. *M. c.* Hagen, Proc. Bost. soc. nat. hist., vol. 18, p. 76, 1875.

The two posttriangular rows on the front wings extend out to the level of the nodus, increasing to 4–6 (in 1 wing only of two ♂ 7) marginal cells, an additional cell is occasionally to be found inserted between those of the upper and lower rows before the level of the nodus, thus making three cells at the place of such insertion; in two Cuban individuals, one male, one female, and one Jamaican male, on the right wing only in each case, there are three posttriangular cells immediately next to the triangle, after which follow the two rows.

On the hind wings the two posttriangular rows extend usually to the level of the separation of the median sector; these two rows may be interrupted by a single cell reaching across the entire width of the field even in Cuban males, this cell being (as in other individuals of *celaeno* and in other species of Macrothemis) the upper of the two immediately after the triangle; two males from Cuba by

Gundlach and by Poey and four males from Jamaica have this cell succeeded by one or two single cells before the two rows begin, and this is a feature very commonly existing in the males from Hayti; on the other hand one female from Hayti shows three cells immediately after the triangle, then two rows. One Cuban male has two rows from the triangle out on the right side; two cells, one row for two cells, then two rows on the left.

The individuals of both sexes from Hayti in the M. C. Z. have the two pale green spots on the mesepimeron less separated from each other than in Cuban individuals in the same collection, and the same is true for the two spots on the metepimeron. Haytian and Cuban individuals in the collections at Philadelphia show no such difference, however.

The dark brown in the subcostal space usually reaches, in the males, half way or less to the first antenodal; in one male from Cuba it extends to this vein on the front wings and slightly beyond it on the hind wings; this extreme for the male is very common, but not universal, in the females. Hagen (Stett. ent. zeit., vol. 29, p. 285) has referred to the variations to be found in the yellow coloring of the wings.

The internal triangle (front wings) is mostly two-celled, but is one-celled on both sides of one Haytian male; is three-celled on both sides of three Cuban males, 3 Cuban ♀, 1 Jamaica ♀; is two-celled on one side, one-celled on the other in 1 Cuban ♂, 1 Haytian ♂, 1 Jamaican ♂; is two-celled on one side, three-celled on the other in 1 ♂, 2 ♀ Cuba, 2 ♂, 1 ♀ Hayti; three-celled on one side, one-celled on the other in 1 ♂ Cuba.

Distribution. Cuba (23 ♂, 17 ♀ by Poey, Gundlach, and Ch. Wright); Hayti (20 ♂, 6 ♀ by Uhler, Frazar from Samana, and W. L. Abbott); Jamaica: Kingston in May, Portland (4 ♂, 2 ♀ by C. W. Johnson, W. J. Fox, E. M. Aaron); St. Thomas (1 ♀). (M. C. Z. at Cambridge, Academy of Natural Sciences of Philadelphia, coll. P. P. Calvert.)

10. **Macrothemis musiva** (Hagen MS.) sp. nov. Pl. 2, fig. 31. Hagen, Syn. Neur. N. Amer., p. 317, 1861 (no description).

♀ Face and lips dark luteous, median labial lobe and inner (mesal) edges of lateral labial lobes blackish, frons above and vertex dark metallic violet. Eyes in contact for a distance about equal to the length of the occiput, which is brown. Rear of the eyes varied with brown and green.

Prothorax pale brown.

Thoracic dorsum dark brown, a pale green antehumeral stripe, $\frac{1}{4}$–$\frac{1}{6}$ as wide as the distance from the pale mid-dorsal carina to the humeral suture, reaching from the anterior mesothoracic margin more than half way up to the front wing base but not meeting a transversely elongated green spot just in front of those bases; a small green spot just in front of the lower end of the humeral suture; sides of thorax and pectus pale green, an irregularly-shaped blotch on the first lateral suture, a narrower stripe on the second lateral suture, a point on the metepimeron, and a short oblique pectoral stripe behind each third coxa — dark brown; the blotch on the first lateral suture is very much narrowed at its upper end and connected by a very slender prolongation with the brown below the base of the wings.

Legs brown, most of the first femora and the second femora inferiorly paler, perhaps green. Spines of the posterior (inner) row of the third tibiae a little shorter and more numerous (17) than those of the anterior (outer) row (12).

Abdomen wider at 2, perhaps a very little wider at 9 than in the segments immediately preceding; black, 2–6 with a superior, longitudinal yellow stripe each side which is interrupted in the middle only by the black additional transverse carinae on 2–3, but on 4–6 by a considerably greater interval ($\frac{1}{3}$ the length of the segment on 4, $\frac{1}{2}$ on 5) while on 6 there remains only a narrow line on the apical fourth and a point at base, 7 has a yellowish point each side before the apex; 1–9 with yellowish just above the lateral carinae, broadly so on 1–3, reduced to a streak on 4–9.

Apps. black, straight, a little longer than 10, apex acute.

Vulvar lamina with a rounded lobe on either side of the median excision.

Wings a little smoky in apical half and along hind margin (Teuscher's ♀), or clear yellowish from base to the triangle (front wings) or its apex (hind wings — Heyer's ♀); a brown streak in the subcostal space not reaching half way to the first antenodal on the front wings, but attaining that vein on the hind wings although clearer at the outer end, submedian space of the hind wings to the cross-vein and a few postcostal cells immediately beneath brownish (Teuscher's ♀), or the veins there bordered with brown (Heyer's ♀). Pterostigma reddish brown (Teuscher's ♀), ocher-brown and a little longer (Heyer's ♀). Membranule cinereous (Teuscher's ♀), whitish (Heyer's ♀).

Front wings: 10–11 antenodals, 5–6 postnodals, internal triangle of two cells, two posttriangular rows almost to the wing-margin, three marginal cells.

Hind wings: 7 antenodals, 6–9 postnodals, inner side of triangle a little, but distinctly, nearer the base than is the arculus, two posttriangular rows (in one hind wing of Teuscher's ♀ the upper posttriangular cell reaches across the entire width of the field, then follow the two rows) to the level of the origin of the subnodal sector, increasing to 7–8 marginal cells.

Total length 37 mm., abdomen 27.5. Hind wing 26–27, its greatest width 8. Pterostigma 1.7–2. Apps. .6 mm., hind tibia 4.5.

One female, Brazil, Heyer, the original type of Hagen, the last five segments of the abdomen lost. One female, Canta Gallo, Brazil, Dr. Teuscher, Thayer Expedition. Both in the M. C. Z.

Heyer's female is evidently a younger individual, as the colors throughout are pale. The only bases for doubting the specific identity of the two specimens are I believe the pterostigma and the membranule. On the other hand the thorax pattern, the markings of the abdomen, and the neuration agree, while the difference in the coloring of the wings is not greater than is to be found within such species as *celaeno* and *hemichlora*.

The head and the thorax pattern much resemble those of *marmorata* Hagen (*tenuis* Karsch), the chief difference in the latter being that the black point on the metepimeron of *musiva* is in *marmorata* connected with the stripe on the second lateral suture forming with that stripe a fork whose branches diverge dorsad. *Musiva* differs otherwise from *marmorata* in having on the hind wings only one submedian cross-vein, two posttriangular rows, and the inner side of the triangle not in the prolongation of the arculus, and longer pale stripes on the abdominal segments.

Miathyria flavescens Kirby, Ann. mag. nat. hist., (6), vol. 19, p. 600, pl. 13, fig. 2, June, 1897, seems from the description and figure to be a *Macrothemis*, and Mr. McLachlan writes me that he thinks it is undoubtedly so. In that case it seems close to *musiva*, differing chiefly by the "broad green band on each side, obsolete in front" on the thoracic dorsum. Further study will be necessary to determine the question of identity or distinctness.

11. **Macrothemis inacuta** sp. nov.

A detailed description and figure have long been in readiness for publication in the Proceedings of the California academy of science.

The chief characteristics are given in the preceding analytical table on page 318.

Distribution. Mexico: Acapulco by A. Agassiz, Tehuantepec by F. Sumichrast, Tepic in October by Eisen and Vaslit; Guatemala by Van Patten. (4 ♂, 2 ♀ M. C. Z., Coll. Cal. Acad. Sci.).

12. **Macrothemis pseudimitans** nom. nov. Pl. 2, fig. 35.

M. imitans Calvert (nec Karsch), Proc. Cal. acad. sci., (2), vol. 4, p. 531, pl. 16, figs. 33, 35–39 (fig. 34 is of *M. inequiunguis*).

Three males, with the abdomen pruinose, and a female from the Isthmus of Tehuantepec by F. Sumichrast, in the M. C. Z. The female differs somewhat from those described from Baja California in having the wings throughout faint yellowish instead of the apex only, and the streak in the submedian (median of previous nomenclature) space is deep yellow, not dark brown as are the subcostal streaks. As variations in neuration it may be noted that the postnodals on the front wings vary from 6 to 9, on the hind wings from 7 to 10, internal triangle of one cell on one front wing of one male, of three cells on one front wing only of one male and the female.

A female from Tepic, November, 1894, by Eisen and Vaslit (coll. Cal. Acad. Sci.), with many of the green spots changed to red in some way, belongs here and agrees with the female from Tehuantepec in the colors of its wings as above described.

Distribution. Mexico: Baja California in September and October, Tepic and Tehuantepec as above.

13. **Macrothemis imitans** Karsch. Pl. 1, figs. 10–12, 15, 19, pl. 2, fig. 36. Karsch, Berl. ent. zeit., vol. 33, p. 367, 1890 (nec Calvert).

The Museum of Comp. Zool. possesses a male from Canta Gallo, Brazil, by Dr. Teuscher, Thayer Expedition, of smaller size than the types: Total length 35 mm., abdomen 24, hind wing 28.5, its greatest width 9. Labrum black except its margins which are luteous. A ♂ and a ♀ from Brazil by Michelis from the Berlin Museum are in the writer's collection.

Distribution. Brazil: Theresopolis, S. Catharina (Karsch's types), Canta Gallo as above.

14. **Macrothemis hemichlora** Burmeister. Pl. 2, figs. 27, 32.

Libellula h. Burm., Handb. ent., vol. 2, p. 849, 1839. *M. h.* Kirby, Trans. zool. soc. Lond., vol. 12, pl. 54, fig. 3, pl. 57, fig. 11, 1889.

♀ (two types of Burmeister). Vertex and frons reddish yellow with metallic blue reflection, clypeus olive, labrum yellowish margin obscure, labium luteous, median lobe darker (labeled type); or face and lips greenish yellow, frons above and vertex metallic blue, inner edge of lateral labial lobes narrowly black (unlabeled type). Eyes in contact for a distance as long as the length of the occiput which is greenish, or black. Rear of eyes varied with brown and greenish, or black.

Prothorax pale brown. Thoracic dorsum dark brown, a complete pale green antehumeral stripe gradually widening upwards and hence wedge-shaped. Sides of thorax pale green or yellow, first and second lateral sutures each with a dark brown stripe, the latter wider, each stripe somewhat cleft at its lower end by green or yellow, the former less oblique in its upper half and uniting at its upper end with the brown of the dorsum; stripe of the second lateral suture giving off on its posterior margin, rather high up, at an acute angle, a straight branch which passes downwards, and on the metasternum, there uniting with its fellow of the opposite side to form a V, opening posteriorly.

Legs blackish, 1st femora greenish inferiorly. Spines of the posterior (inner) row of the third tibia shorter and more numerous (12) than those of the anterior (outer) row (8).

Abdomen a little wider at 2 and at 9, dark brown, 2–8 with a narrower, longitudinal, yellowish stripe each side from the base nearly to the apex of each segment, interrupted by the additional transverse carinae on 2 and 3 and sutures on 4–7. A yellow streak just above the lateral carinae of 2–9. Appendages black, nearly twice as long as 10, straight, tips acute. Median excision in the vulvar lamina semicircular.

Wings clear or pale yellowish throughout, front wings from nodus to apex, for entire width, slightly brownish yellow, a deeper yellow tinge at base of hind wings reaching half way to the first antenodal. Pterostigma dark ocher brown, membranule grayish.

F. W. 13–14 antenodals, 6–8 postnodals, internal triangle of (one, right side of labeled type) two cells, two posttriangular rows to the level of the origin of the subnodal sector or to that of the nodus, then three nearly to the wing-margin, with 5–6 marginal cells.

H. W. 9–10 antenodals, 8–10 postnodals, two posttriangular rows to the level of the origin of the subnodal sector, then increasing to 10–11 marginal cells.

Total length 33, abdomen 23–24, h. w. 27–29, its greatest width 8.5–9.5, pter. 2, apps. .6, hind tibia 4.

In the above description of the two types, where a difference exists between them as indicated by use of the word "or," the expression before the "or" refers to the type labeled "*hemichlora* Burm. Bahia" in what is believed to be Burmeister's handwriting, the words after the "or" to a female, also from Winthem's collection, labeled merely "Bahia," but possibly also seen by Burmeister. The head which this latter now possesses is probably of another species as no other female of *hemichlora* known to me has a head of the colors above indicated. The two types in M. C. Z.

Ten other females in the Mus. Comp. Zool., and one in my own collection, seem also to be of this species, taking the pattern of the thoracic markings as the chief criterion. They show considerable variations from the above described type.

These variations are face more or less luteous, labrum with a black band half as wide as the labrum itself along the greater part of its free margin; reduction of stripes on abdominal segments to as much as one fourth the length of the segment and lying upon its middle, and their entire absence on 8–10; the occurrence of clear areas on wings which are for the most part yellowish, such clear areas are between the median vein and principal sector (with upper sector of arculus) from the base to beyond the nodus and large part of the base of the hind wings near the anal angle; the absence of the deeper yellow at the apex of the front wings; the presence of yellow at base of all the wings out to just beyond the triangle but not reaching the hind margin on hind wings — on wings which are clear except for smoky yellow on f. w. from nodus to tip.

Front wings: antenodals 12–14, postnodals 7–9, internal triangle of 1–3 cells. All ten have the two posttriangular rows out to the level of the nodus, the marginal cells vary from 4–6.

♂. The Mus. Comp. Zool. contains two males which from their thoracic color pattern seem to belong to this species. They differ from the females as follows: Face and lips luteous (a spot on the nasus, labrum except at base, median labial lobe, bases and inner margins of lateral labial lobes dark brown in one of these two males, thus recalling the var? *typographa* of *inequiunguis*), greater part of the frons and vertex dark metallic blue, the wedge-shaped antehumeral stripes are somewhat shorter and reach but little more than half way down from the antealar sinus to the anterior mesothoracic margin. Abdomen narrower at 3 (.6 mm.), considerably widened in 7 (2 mm.) and 8, narrowed again to the tip, 8 and 9 with a small pale green spot at base; spot on 7 larger than in the ♀.

Sup. app. as long as 9 + 10, blackish, curved downwards in the basal half, nearly straight in the apical half where they are but little thicker, apex moderately acute, the second fourth with an inferior row of 4–5 denticles of which the last is largest. Infer. appendage $\frac{1}{3}$ shorter, nearly twice as long as width at base, apex almost as wide as the base, bifid for about $\frac{1}{5}$ the length of the appendage.

Genitalia of 2: anterior lamina with margin entire, hamule more prominent, apical half slender, hooked, genital lobe very small, barely as long as width at base.

Wings clear, faintly yellow to beyond the nodus, front wings with the internal triangle of one cell on both wings of one male, of three cells on one wing of the other, two posttriangular rows to the level of the nodus; hind wings with 7–8 postnodals, two posttriangular cells the upper of which reaches across the entire width of the field, then one row for two–three cells, followed by two increasing.

Total length ♂ 35–34. ♀ 33–27. Abdomen ♂ 24.5–23.5. ♀ 23–27. Hind wing ♂ 28. ♀ 27–31, its greatest width ♂ 9–8.5. ♀ 8.5–9.5. Pterostigma 2. Sup. app. ♂ 1.8. Apps. ♀ .7. Hind tibia 4.5.

Distribution. The two type females from Bahia from Winthem's collection; the other females from Colombia and Venezuela by Appun, Porto Cabello in the latter, Chiriqui (Staudinger); the two males from Porto Cabello. (M. C. Z.) A female from Rio Janeiro, George Peabody (Coll. P. P. C.).

15. **Macrothemis cydippe** (Hagen MS.) sp. nov.? Pl. 2, fig. 28.

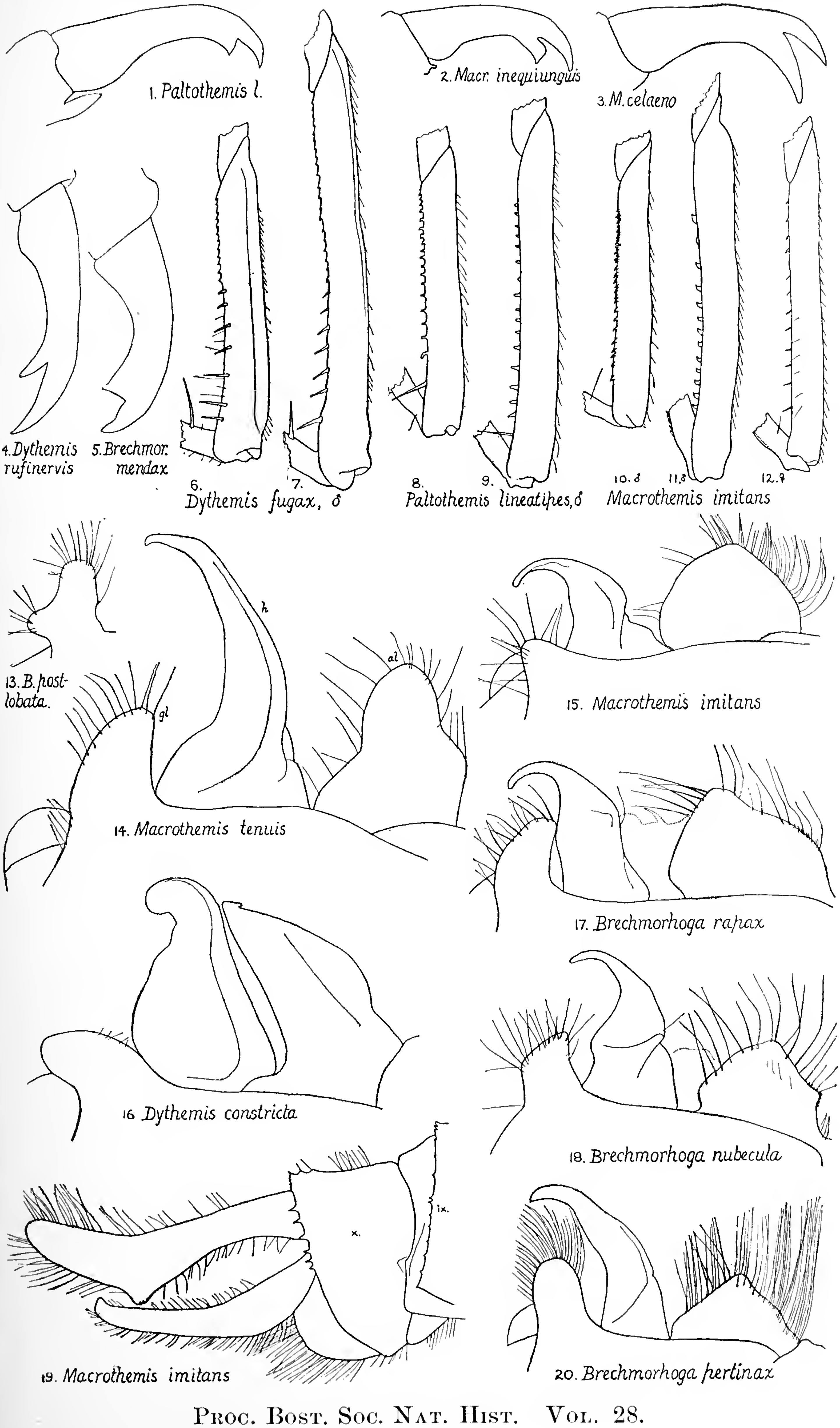
Dythemis c. Hagen, Syn. Neur. N. Amer., p. 317, 1861 (no description).

Very similar to the above-described males of *hemichlora* is one at Cambridge labeled "Rio, Olfers," placed after the label "D. *cydippe* Hag." It has the face and lips luteous, a pale spot on each side of 9 at base, and most of the dorsum of 10 greenish yellow. The only difference of any significance appears to be in the inferior appendage which is $\frac{1}{4}$ shorter than the superiors, apex about $\frac{1}{3}$ as wide as at base with a shallow median excision. The internal triangle on the right front wing is of a single cell. The dimensions are the same as those of *hemichlora* ♂. The constancy of the difference in the inferior appendage in other specimens will determine the distinctness of *cydippe*.

Printed, July, 1898.

PLATE 1.

Fig. 1. Tarsal nail from left third leg of *Paltothemis lineatipes* Karsch, male.
Fig. 2. The same of *Macrothemis inequiunguis* Calvert, male.
Fig. 3. " " " " *celaeno* Selys, male.
Fig. 4. " " " *Dythemis rufinervis* Burmeister, male.
Fig. 5. " " " *Brechmorhoga mendax* Hagen, male.
Figures 1–5 are all drawn to the same scale.
Fig. 6. Left second femur of *Dythemis fugax* Hagen, male.
Fig. 7. " third " " " " " "
Fig. 8. " second " " *Paltothemis lineatipes* Karsch, male.
Fig. 9. " third " " " " " "
Fig. 10. " second " " *Macrothemis imitans* Karsch, male.
Fig. 11. " third " " " " " "
Fig. 12. " " " " " " " female.
Figures 6–12 are all drawn to the same scale.
Fig. 13. Left genital lobe of *Brechmorhoga postlobata* sp. n., male.
Fig. 14. Left side, genitalia of second abdominal segment of *Macrothemis tenuis* Hagen, male. *al* anterior lamina, *h* hamule, *gl* genital lobe. The corresponding parts in figures 15–18, 20, which are drawn to the same scale, are plainly seen.
Fig. 15. The same of *Macrothemis imitans* Karsch, male.
Fig. 16. " " " *Dythemis constricta* Selys MS., male.
Fig. 17. " " " *Brechmorhoga rapax* Hag. MS., male from Venezuela.
Fig. 18. " " " " *nubecula* Rambur, male.
Fig. 19. Right side of apex of abdomen and appendages of *Macrothemis imitans* Karsch, male; ix ninth, x tenth abdominal segment.
Fig. 20. Left side, genitalia of second abdominal segment of *Brechmorhoga pertinax* Hagen, male.



1. Paltothemis l.
2. Macr. inequiunguis
3. M. celaeno
4. Dythemis rufinervis
5. Brechmor. mendax
6.
7.
Dythemis fugax, ♂
8.
9.
Paltothemis lineatipes, ♂
10. ♂
11. ♂
12. ♀
Macrothemis imitans
13. B. postlobata.
h
gl
al
14. Macrothemis tenuis
15. Macrothemis imitans
16 Dythemis constricta
17. Brechmorhoga rapax
18. Brechmorhoga nubecula
x.
ix.
19. Macrothemis imitans
20. Brechmorhoga pertinax

PLATE 2.

Figs. 21–26. One-half of the dorsum of the seventh abdominal segment of *Brechmorhoga pertinax* ♂ (type), *nubecula* ♂, *mendax* ♂ (type), *rapax* ♂ (type), *praecox* ♀ (type), *postlobata* ♂ (type), respectively, to show the extent of the pale coloring. All magnified five times. The spot on *praecox* ♂ is shaped as in *pertinax* but is proportionally a little longer.

Fig. 27. Inferior appendage of *Macrothemis hemichlora* Burm., male, viewed from below.

Fig. 28. The same of *M. cydippe* sp. n., male.

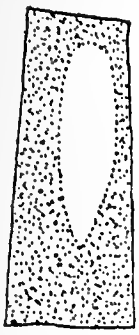
Figs. 29 and 30. Vulvar lamina of *Brechmorhoga praecox* ♀ (type) and *mendax* ♀ (type) respectively. viii, ix, eighth and ninth abdominal segments.

Figs. 31–36. Left side of thorax of *Macrothemis musiva* ♀ (type) *hemichlora* ♀, *marmorata* ♂ (type), *pleurosticta* ♂ (type), *pseudimitans* ♂ (type), *imitans* ♂ respectively, to show the color patterns. The lettering in fig. 35 indicates parts shown in all of the series, viz.: —

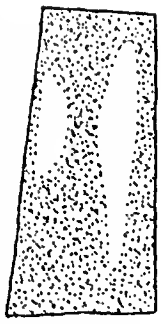
abi first abdominal segment
as antehumeral stripe
dc mid dorsal carina
fw base of front wing
hs humeral suture
hw base of hind wing
iep mesinfraepisternum
lvc latero-ventral carina
1 *ls* first lateral suture
2 *ls* second lateral suture
II base of second leg
III base of third leg.

Near the upper end of the first lateral suture is shown the metastigma.

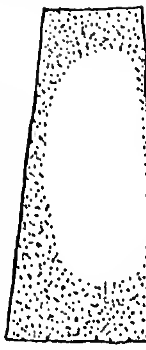
Figs. 20, 31, 33, and 34 have been drawn free hand, 21–26 by plotting measurements, the others by camera lucida and Leitz or Zeiss lenses.



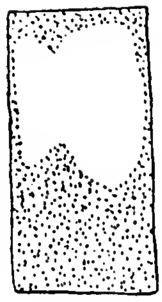
21. *pertinax*



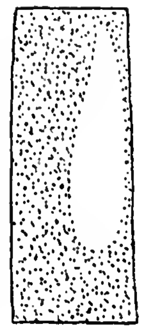
22. *nubecula*



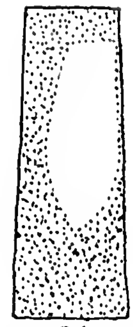
23. *mendax*



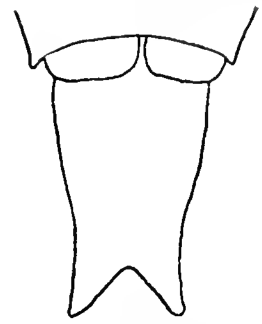
24. *rapax*



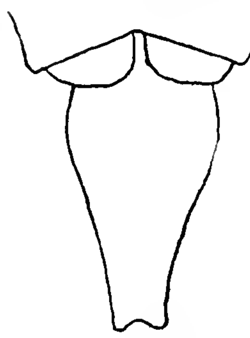
25. *praecox*



26. *postlobata*

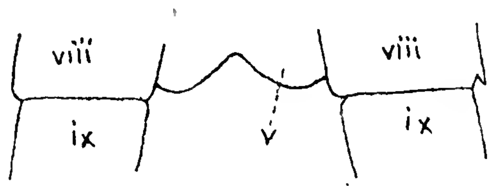


27. *hemichlora*

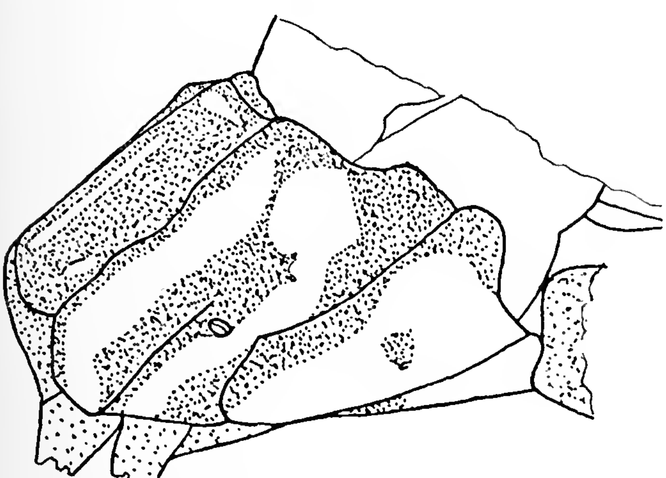


28. *cydippe*

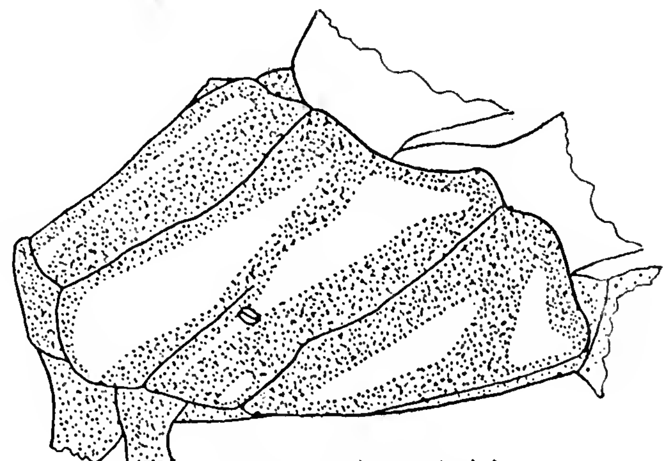
29. *B. praecox*



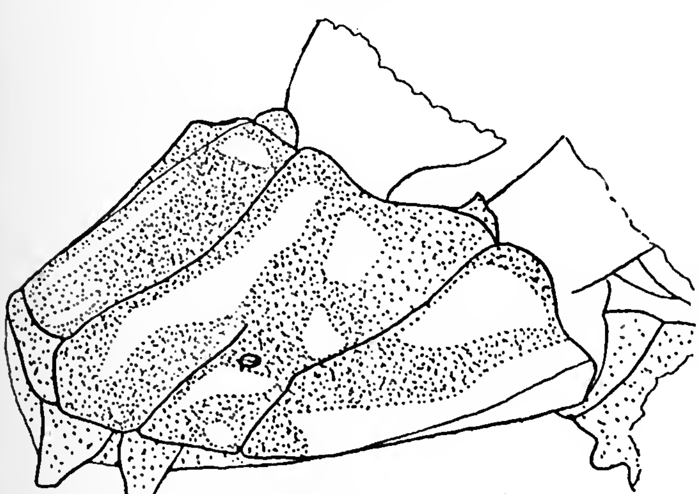
30. *B. mendax*.



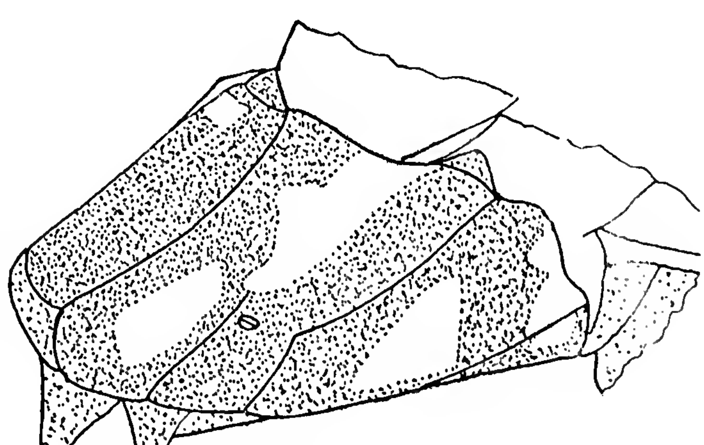
31. *M. musiva*



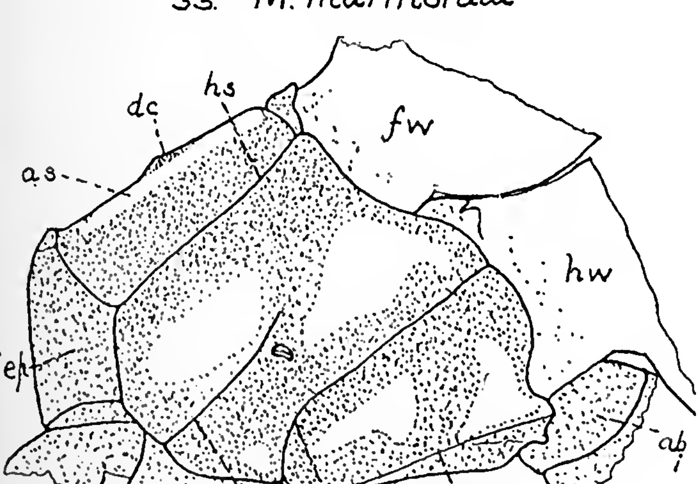
32. *M. hemichlora*



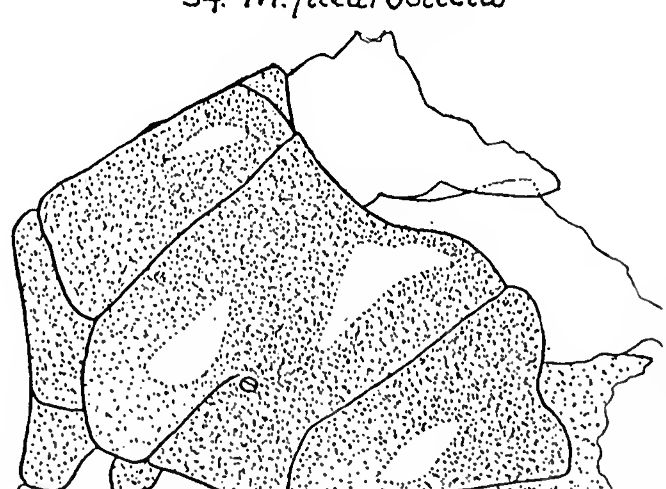
33. *M. marmorata*



34. *M. pleurosticta*



35. *M. pseudimitans*



36. *M. imitans*

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SOME HYDROIDS FROM PUGET SOUND.

By Gary N. Calkins.

With Six Plates.

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No. 13.— *Some Hydroids from Puget Sound.*

By Gary N. Calkins.

With six plates.

In 1876 Professor Clarke remarked on the scarcity of hydroids found on the west coast as compared with the east coast from Maine to New York, the ratio being nearly five to one in favor of the latter, although the eastern coast line from Maine to New York is but two thirds as long as the western. The twenty-four species which Clarke then described were collected along the coast from San Diego, California, to Vancouver Island, B. C., and did not include the forty Alaskan species which he described later in the same year. "It should be borne in mind however," says Clarke ('76a, p. 251), "that most of the collecting on the Pacific coast has been done along the shore, the dredge having been little used, and there is little doubt that when the fauna has been more thoroughly investigated the number of hydroids may be at least doubled. Such a variety as exists on the New England coast can hardly be expected from our Pacific shores south of Vancouver Island, for the waters there do not afford the same diversity in temperature." In addition to the difference in temperature must be noted the topographical differences in the two regions. The rocky, precipitous coast of the west shore with its great depths is very different from the long stretches of shallow water characteristic of the eastern coast. It will be observed, however, that the west coast hydroids have never been so extensively studied as those of the east coast, a few scattered localities only having been examined, and there is reason to believe that, when more points on the coast are searched, the number of hydroids will be found to be not only doubled but multiplied many times. When the Alaskan hydroids are more carefully investigated, the number of west coast species will be still more increased, for here the topographical conditions are less severe and, in the region about Sitka at least, the water is much more shallow and considerably warmer than farther south in the region of Vancouver, Washington, and Oregon. The collection of Sitka hydroids made during the summer of 1897 by the Columbia University zoological expedition was much more extensive than that made in Puget Sound, but the material, descriptions, and notes were lost in the wreck of the steamship "Mexico." The present paper, therefore, deals only with the hydroids collected in Puget Sound. Here the area examined was comparatively small, two points — Port Townsend and Bremerton — being the only localities represented in the collection. These two places, however, yielded no less than thirty species, a fact which promises well for the further investigation at different points on the Sound.

Puget Sound is a very deep arm of the sea lying mainly between 47° and 48° north latitude. It connects with the sea by the Straits of San Juan, a wide and deep body of water opening at Cape Flattery which, if we exclude Alaska, is the most northwestern point of the United States. Port Townsend is situated on a small bay about eighty miles from Cape Flattery. The water here is quite deep (nine to one hundred fathoms) and very cold (fifty-one degrees at all depths). Many of the hydroids were brought up by the dredge from the stony bottom across Townsend Bay between the mouth of Scow Bay and Marrowstone Point. Bremerton is almost opposite Seattle, about 38 miles from Port Townsend. Here a series of small bays connected by swiftly running channels offers a decidedly varied field for investigation. In some of the bays the water is rarely turned and becomes almost stagnant, so that all conditions of temperature are found, and here, as might be expected, the hydroids are quite abundant on stones, piles, and wharves.

Before describing the hydroids of this region, I desire to express my obligation to Mr. Agassiz and Dr. Woodworth for their kindness in placing the hydroids of the Museum of comparative zoology at my disposal for comparison; and to Mr. F. P. Keppel, to whom I am indebted for assistance in working over the material.

ATHECATA.

Pennariidae.

So far as I am aware, this family is represented on the Pacific coast by only a few species, three of which have been described by Clarke (*Tubularia elegans* Clarke, *T. indivisa* Linn., and *T. borealis* Clarke) and one by Agassiz ('65) (*Thamnocnidia tubularoides* A. Agas.).

Schneider ('97) calls attention to the fact that the main difference between Hincks's families, Tubulariidae and Pennariidae, lies in the point that the oral tentacles are capitate in the latter and filiform in the former. This difference seems hardly sufficient for a family distinction, and I follow Schneider in placing the present species of Tubularia in the family Pennariidae which he characterizes as follows: Hydrocaulus branched or unbranched. Hydranths much enlarged proximally with one ring of large filiform tentacles about the base and with another set of capitate or filiform tentacles distributed irregularly or regularly. Proboscis conical, short, and not distinctly limited but passing gradually into the hydranth. Gonophores in the form of medusae or of sporophores.

Tubularia Linn.

Hydrocaulus unbranched or slightly branched. Hydranths with the distal tentacles regularly or irregularly arranged. Gonophores medusae (Euphysidae) or sporophores springing from above the proximal tentacles (Schneider).

1. **Tubularia larynx** Ellis and Solander. Pl. 1, figs. 1, 1a.

Stems clustered, simple or slightly branched, slender, pellucid, pale horn-colored, ringed at pretty regular intervals; polypites small, light red, with white tentacles; gonophores clustered on short peduncles, oval, of a purplish red color. (Hincks.)

The Puget Sound form of this species is not constant in the above characters. The fourteen specimens are, with one or two exceptions, perfectly simple, and even the exceptions are not so fully branched as Hincks's. The adjective "small" conveys no meaning whatever. The hydranths in the western forms measure from 1 to 1.5 mm. in length and from 1.5 to 2.5 mm. in diameter at the basal region. Basal tentacles, in well-expanded individuals, measure about 2 mm. The stems are from 25 to 50 mm. in length and about 1 mm. in diameter, and taper slightly from the hydranth to the creeping stolon. In most cases the stems are irregularly annulated; when branched there is a set of three or four rings above the point of branching; in other cases the annulations extend from the stolon part way up the stem, a distance of 15 or 20 mm., but become indistinct as they reach the upper portion. In still other cases there are no annulations at all.

The gonophores "clustered on short peduncles" are from 6 to 8 in number on each, and in 8 or 9 clusters. The larger gonophores bear four tubercles, which in some cases are drawn out into tentacles 1 mm. long.

The aboral tentacles are several times longer than the oral and twice as numerous (18–19 aboral, 9–10 oral).

The hydranths in most cases are erect (fig. 1), but may occasionally droop as in fig. 1A. The color of the entire hydranth is pale red, or pink with darker red gonophores; the stems are light horn-colored.

Habitat. Dredged in 15 fathoms off Marrowstone in Port Townsend harbor. Mediterranean (Pallas); Mouth of the Elbe (Kirchenpauer); Grand Manan (Stimpson); Nova Scotia (Dawson).

Corynidae.

Hydrocaulus branched or unbranched. Hydranths spindle-formed or cylindrical, with simple or branched capitate tentacles distributed regularly or irregularly and occasionally with a lower whorl of filiform tentacles; proboscis conical and short, not distinctly marked from the rest of the body. Gonophores medusae or sporophores. (Schneider.)

2. Coryne mirabilis Agassiz. Pl. 1, figs. 2, 2A, 2B.

Sarsia mirabilis Agassiz. *Coryne mirabilis* Agassiz. *Syncoryne gravata* Hincks. *Tubularia stellifera* Couth.

Stem smooth, simple, or slightly branched; hydranths small, slender, with sixteen tentacles in the adult stage; gonophores globular, borne among the tentacles or immediately below them.

There is extreme difficulty in placing this species in accordance with the usual grouping. If the medusa-buds found among the tentacles are on the way towards a free adult life, the hydroid would be placed unquestionably in the Corynidae. But if they are fixed medusae expelling their generative cells while attached to the hydroid, they may be placed in the Syncorynidae of Ehrenberg. Based on the appearance of the medusa-buds the present species might be assigned to the Corynidae, but the number of tentacles and the general character of the hydroid indicate a connection with the other family. In view of these differences the question naturally arises as to the value of the mere attachment of the gonosome as a differential character. The name Coryne was originally given by Gärtner, but its limits seem to have been left quite unsettled, for many entirely dissimilar forms, such for example as *Hydra squamata*, were soon included with it. Sars ('28) attempted a revision by giving to *Hydra squamata* the name Coryne, while to Gärtner's original Coryne he gave the name Stipula. Ehrenberg later agreed to the revision of the old Corynes as expressed by Sars, but objected to Sars's name Stipula on the ground that it was already in use, and Ehrenberg substituted the name Syncoryne for Stipula, including Gärtner's original Coryne under it. Thus Coryne, Syncoryne, and Stipula became synonyms. Allman followed Ehrenberg in the use of the names Coryne and Syncoryne, but separated them into two families based upon the differences in the gonosome, and this causes the present difficulty: is the present species a Coryne or a Syncoryne? that is, is the medusa attached permanently or does it become free? and what, after all, is the real value of Allman's differential? From the observations of Agassiz and Clarke it appears that this differential has no value, for in this very species these observers noted that the gonosomes are of two kinds, free and fixed, the former produced during the earlier months of the year. Allman admitted that these observations, if verified, would be fatal to his proposed division, but he doubted the accuracy of the observations, and his two families have been widely accepted. Finally, Schneider ('97) regards the entire matter as leading to confusion through the multiplication of types, and returns to the earlier nomenclature, giving the original generic name Coryne to all of these questionable forms, a view which Levinsen ('93) substantially held. Schneider's remarks in connection with this change are so excellent and so pertinent to all matters of taxonomy, particularly in view of the past and present inclination to found new species and genera on the strength of slight structural differences, that I give briefly his main ideas.

The relationship of one form to another is so close and the connecting links so numerous that we must make the genera embrace many more species if we would have a consistent and natural group of the Corynidae. It is untenable to isolate the medusa-bearing forms, the trophosome of the two groups, as is well known, showing complete agreement. It can make very little difference to the colony whether the sexual individuals are movable or are attached to the colony, if the nutritive polyps are not affected by the difference. It cannot be said that the medusa-forming colonies are superior to the others, either in robustness or complexity. In the struggle for existence a Syncoryne appears to be no more hampered than Coryne, and the Syncoryne condition has been brought about only by degeneration from the more primitive medusa-bearing condition. The medusa-bud does not reach the condition of growth necessary for locomotion, and the sexual products are liberated in the immediate vicinity; — herein lies a point relating only to the reproduction of the genus, not of sufficient taxonomic value to separate otherwise closely allied forms. Whether medusa or sporophore, therefore, is a question of importance only for the species in question, but without importance in fixing relationship to any other forms. It is only changed conditions of existence that can affect changes in the trophosome, and these changes are of phylogenetic value. The sexual products do not arise in the medusa, but in the trophosome — the medusa is only an apparatus for distributing them over a wide area. Their form also is not the result of the completely different mode of life from that of the nutritive polyp but in all essentials depends upon the form of the latter. The medusae change step by step only as do the polyps, and no sufficient differences exist to distinguish Coryne and Syncoryne.

The principle by which Schneider divides his genera may be expressed as follows: —

A species must be considered as a sharply circumscribed group of individuals which can be safely distinguished from all others. All species form an unbroken chain with a great number of side branches; this chain often appears incomplete and with many gaps owing to our incomplete knowledge. The groups of species so distinguished from all other groups are the genera. The chief aim, therefore, of the systematist should be, not to create new genera, but to show the relationships of species to each other. Wherever we find transitional forms between groups of species, the artificial bounds of one should be stretched until, if necessary, 100 or 500 or more species are relegated to a single genus. The richer the genus is in species, — that is, the more forms we can place in close phylogenetic connection, — the nearer we come to the hypothetic ideal of the unity of animal forms. But the more we split up species into genera the more difficult does this become, although such splitting is of unquestionable value in the handling of a group; but it must always be borne in mind that a word like Syncoryne, for example, represents nothing but a certain number of closely allied species of one far-reaching genus.

The Puget Sound forms vary somewhat from *S. gravata* Hincks, but more especially in the size. The British form is very small, "only about a quarter of an inch in height," whereas the western forms are from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch (12 to 18 mm.).

When alive the trophosome is colored a delicate rose, due, according to Agassiz, to colored granules lining the digestive cavity and chymiferous tubes.

Habitat. Found growing on the edge of wharves and sunken logs, and floats, in great quantities at Bremerton in June, the mass having a delicate rose tinge. England (T. S. Wright; T. H.

Hincks); Greenland (Sabine); Grand Manan and Eastport, Me. (Stimpson); Massachusetts Bay (L. Agassiz).

Atractylidae.

Perigonimus Sars.

Coenosarc sheathed in a chitinous polypary, stem branching or simple, rooted by a thread-like stolon; polypites fusiform with a single verticil of filiform tentacles round the base of a conical proboscis; gonophores developed from the coenosarc. (Hincks.)

3. Perigonimus repens T. S. Wright. Pl. 1, figs. 3, 3A, 3B, 3C, 3D.

Atractylis repens (Wright). *Perigonimus pusillus* (Allman). *Perigonimus repens* (Allman).

Stems simple, erect, about 6 mm. high. Hydranth club-shaped, white, partly retractile into tube, tentacles 10 to 12. Gonophores pedicilate and borne on the stems.

In the Puget Sound form the stem of the gonophore is very long and the character is constant. The difference in length, however, does not seem sufficient to raise the form to an independent species.

Habitat. Found covering the back of the carapace and the appendages of a species of Pisa, dredged in Townsend Harbor. Wright describes it as growing on the Sertularians and upon the spider crab in the Firth of Forth, Alder on *Dentalium entalis* and other shells; and Allman on the operculum of *Turritella communis* in Shetland.

CALYPTOBLASTEA or THECATA.

The bulk of Pacific coast hydroids is made up of thecate forms. In the region of Puget Sound these do not impress one as being very abundant, due probably to the absence of many large branching forms like Obelia and Laomedia. Most of the thecates belong to Campanularia or allied genera which do not grow to large colonies. At Sitka, on the other hand, the piles and rocks are covered with great forests of Obelia and related forms, and one is impressed with their abundance. In regard to the smaller forms at Sitka I cannot speak. The Calyptoblastea have been a difficult group to deal with, and, as time goes on, the task becomes more difficult. This is largely because of the multiplication by various observers of species and genera and even families on small details of difference and often on insufficient ground. Of late there seems to be a reaction, however, and with it, it is to be hoped that the taxonomy of the hydroids will gradually be simplified. The trouble is probably due to the absence of an adequate differential.

Hincks ('68) divided the suborder Thecaphora into nine families, some of which have been retained, but many have been suppressed. These original families were, 1, Campanulariidae, 2, Campanulinidae, 3, Leptoscyphidae, 4, Lafoeidae, 5, Trichydridae, 6, Coppinidae, 7, Haleciidae, 8, Sertulariidae, and 9, Plumulariidae. From this collection of more or less artificial groups it was the work of succeeding observers to weed out what was unnecessary and to bring together those families which showed natural affinities. For example, the first four families were distinguished by very imperfect differentials or sets of characters which in the same family showed as many variations as in the different families. The dividing line was purely arbitrary, and in the critical examination which always follows such arbitrary divisions the weakness was pointed out. The first step in the reduction in number of families was taken by Levinsen ('93) who brought together in the family Campanulariidae all the forms possessing hydrothecae without opercula, with the form of a beaker, a bell, or a tube, and with a circular mouth opening. This family included most of Hincks's Campanulariidae, and the inoperculate forms of the Lafoeidae. All forms resembling the Campanularians in structure of the hydrotheca but provided with an operculum, and all the operculate Lafoeidae of Hincks were included by Levinsen in Hincks's second family — the Campanulinidae. The chief differential between the families, it will be noticed. lay in the presence or absence of an operculum. A further reduction in these families was made later by Schneider ('97) who showed that the opercular apparatus is only a modification of the toothed structure with which, in varying degree, nearly all Campanulariae are provided. In other respects the Campanulinidae as modified by Levinsen agree well with the first family, and Schneider accordingly reduces the two families to the one Campanulariidae. He distinguishes, however, between the Campanularian-type and the Lafoea-type, forming the subfamilies Campanulariinae and Lafoeinae.

Four of the nine families of Hincks have thus been reduced to one. Of the remainder, the Haleciidae is the most primitive of the thecate forms and with the closest athecate connections, as shown by the method of branching (see Driesch, '90) and the nature of the hydrotheca so-called. It was shown by Levinsen that the Coppinidae (with Hincks only a single species) are only gonothecae of species of the genera Lafoea, Filellum, and Grammaria (Marktanner-Turneretscher).

The Sertulariidae and Plumulariidae are retained as well-marked families, although Levinsen apparently takes a backward step in splitting the latter into two families, Plumulariidae and Aglaopheniidae.

These eight families including all of the true thecate hydroids are thus reduced to four and may be arranged in the following order: *Haleciidae*, *Campanulariidae*, *Sertulariidae*, and *Plumulariidae*.

HALECIIDAE.

The Haleciidae are usually regarded as one of the most highly differentiated forms of thecates because of the small cups, the incomplete retraction of the hydranth, and the peculiarity of the gonophores in that the blastostyle protrudes beyond the gonotheca and then gives rise to one or two hydranths. Levinsen ('93) showed the close connection between Haleciidae and Campanulariidae in the presence of stalked hydrothecae, lack of opercular apparatus, and circular mouth. He also found a ring of peculiar chitinous particles about the lower and wider part of the hydranth by means of which the hydranth is fastened to the cup, the same thing, he says, being characteristic of the Campanulariidae.

According to Levinsen a still closer connection is with the Plumulariidae, shown primarily by the shallow and wide beakers or cups, which have a well-developed diaphragm; the chief differential, he thinks, in distinguishing the Campanularians. In addition to this character the incomplete retraction of the hydranth and the occasional occurrence of nematophores on some Haleciidae are features common to the two families.

Schneider ('97) admits the close relationship of Campanulariidae, Haleciidae, and Plumulariidae, but points out that Levinsen gives no clue to the origin of the Haleciidae. He says these forms cannot be derived from the Campanulariidae, 1, because the branched Haleciidae never have a free stalk, the Campanulariidae invariably; 2, because the hydrothecae of the latter family are never so reduced as those of the former; 3, because the branching of Haleciidae is never regular like that of the Campanulariidae but more nearly resembles that of the Athecata, being midway between the racemose type of the Gymnoblastea and the cymose type of the Calyptoblastea. The smallness of the cup is better explained as a primitive than as a differentiated character, approaching closely to the type of cup formed by the enlargement of the chitinous periderm under the hydranth of many athecates, and into which some forms can partly retract. This is strikingly shown in *Halecium macrocephalum* Allman ('77), a form in which the theca is represented by only a sessile, narrow, membranous lip. Furthermore an additional point is seen in the peculiar character of the female gonophore and proliferating blastostyle mentioned above, which again shows athecate affinities.

The comparatively small family of Haleciidae is therefore of considerable phylogenetic importance and for the present at least may be regarded as the nearest approach to the gymnoblastic hydroids.

Comparatively few Haleciidae have been found in North American waters, while those which have been found on the Atlantic coast, according to Agassiz, appear to be confined mainly to the most northern waters. *H. halecinum* (Johnston) has been found in Greenland (Fabricius), on the northern coast of Maine (A. E. Verrill), and Massachusetts Bay (L. Agassiz). *H. muricatum* Ellis and Solander is reported from Nova Scotia (Anticosti expedition), from Eastport and Grand Manan (A. E. Verrill). On the Pacific coast, Clarke reports *H. tenellum* (Hincks) from San Diego, Cal., *H. halecinum* from Unalaska, Alaska, *H. plumularoides* from Nunivak Island, and *H. scutum* (Clarke) from Semidi Island to Unalaska.

Hydrocaulus unbranched, slightly, or much branched, hydranths without free stem, usually regularly and alternately arranged, hydrotheca flat, shell-like, never large enough to take in the hydranth, and without operculum. Sporophores. Female blastostyle a slightly reduced double hydranth, male blastostyle greatly reduced.

Halecium Oken.

The hydranths are very long, the lower part of the body being spindle-shaped, while the tentacle region of the body is strongly marked off, proboscis conical.

4. Halecium wilsoni sp. nov. Pl. 1, figs. 4, 4a, 4b.

Trophosome. Hydrocaulus erect, polysiphonic (stem and main branches), delicate, irregularly and slightly branched. Branches divided by more or less oblique joints into internodes 150 mm. long, each internode giving rise to one branch which is similarly divided into internodes, each one of which gives rise to one hydrotheca. In some cases there is an axillary branch which is always more or less annulated; each internode has a single annulation immediately above the joint. Hydrothecae more or less tubular with slightly everted margin.

Gonosome. Gonophore (male). Large circular discs with peculiar and decidedly characteristic blastostyle. Orifice at extremity directly in the center or very slightly to one side. Often placed on comparatively long stems having one, or occasionally two, distinct annulations. Irregularly placed on the colony stalk. Color of gonophores light red running into salmon. Color of trophosome very light horn. Similar in many respects to Alder's *H. labrosum* but smaller, more delicate, and quite different from the latter in shape and position of the gonosomes.

Dimensions. Height of colony, 50 mm.; diameter of main stem, .5 mm.; length of internodes, .15 mm.; length of male gonophore, 1.7 mm.; diameter of gonophore, 1.5 mm.

Habitat. Found at Bremerton in June on piles and floats.

5. Halecium densum sp. nov. Pl. 1, figs. 5, 5a, 5b, 5c.

Trophosome. Hydrocaulus erect, shrubby, 20–40 mm. in height, densely and irregularly branched, deep brown in color. Branches often, but not invariably, arising from shoulder-like processes, sometimes as many as three coming from a common point, and each with a single constriction or annulation just above the point of origin. Branches divided by constrictions into internodes of unequal length, usually one lateral branch to an internode, but sometimes with none at all. Hydrothecae tubular with much everted rims, placed irregularly, but with a tendency towards sub-alternate positions, and as a rule situated immediately below the joint. Gonosome not known.

The general appearance of this species recalls Clarke's description of *H. scutum*, but differs from this form in all of the details. All stems are divided into joints, which are of dissimilar size, many of them without branches or hydrothecae. Clarke notes, however, that his species is quite variable, and it is possible that the present form is one of these variations.

Dimensions. Height of trophosome, 35 mm.; length of hydranth, .3 mm.; width of hydranth, .1 mm.

Habitat. The under side of the wharf at Bremerton.

Campanulariidae.

It is to this family that the majority of the Puget Sound hydroids belong, a family which offers the greatest difficulty in classification. Hincks remarks in a footnote to his "key": "In this group the trophosome offers no generic characters. If the reproductive bodies are absent the student must treat it as a single genus and identify his zoophyte by reference to the specific description." Generic differences based on the absence of reproductive bodies have led to the multiplication of species and synonyms, until the family has become badly confused. The structure of the hydrotheca, as Hincks intimates, has played little part in classification. The method of reproduction, however, is an unsuitable differential. Campanularia and Gonothyraea, for example, form reproductive bodies either as sporophores or as undeveloped medusae which never become free. Clytea and Obelia, on the other hand, produce free-swimming medusae, those of the latter belonging to the genus Eucope. The trophosomes of Gonothyraea and Obelia agree in having a free branching stem, but they do not agree in the gonosome. Campanularia, on the other hand, includes both branched and simple species. To the branched forms Lamouroux gave the name Laomedia and to the simple forms the name Clytea. The classification based on the trophosome was given up by Hincks as not representing the natural affinities, and he, with Agassiz and others, made the gonosome the chief differential.

Allman ('88) limits the genera very strictly to the characters of the gonosome, regarding the presence or absence of a free-swimming medusa of sufficient generic value. He distinguishes Campanularia and Obelia in the following manner:—

Campanularia: "Trophosome. Hydrotheca pedunculate, campanuliform, with serrate or entire margin, destitute of operculum and with the cavity distinctly differentiated by a perforated diaphragm from that of the peduncle; peduncle springing from the sides of a simple or a ramified, free or adherent hydrocaulus. Hydranths with a trumpet-shaped hypostome. Gonosome. Gonophores adelocodonic, *i. e.* never issuing from beneath the cover of the gonangium."

Obelia. "Trophosome. Hydrocaulus simple or branched, fascicled or monosiphonic. Hydrotheca campanuliform, destitute of operculum, pedunculate, with the cavity distinctly differentiated from that of the peduncle. Gonosome. Gonophores medusiform, vesciculate planoblasts with shallow umbrella, four radial canals on which the gonads are developed, short manubrium with four-lobed mouth, numerous rather rigid marginal tentacles whose roots are plunged into the substance of the umbrella, otocysts carried each close to the base of a tentacle, velum rudimental."

He makes a similar difference between the genera Laomedia and Gonothyraea. The trophosome is similar in both, the gonosome with free-swimming medusa in one (Laomedia), with reduced medusae in the other. This division of the genera is as satisfactory as any can be when based solely on the presence of gonosomes, but when these are absent the problem is as complicated as ever. To offset this difficulty, Levinsen has proposed the adoption of a new differential in the "diaphragm," which had been earlier recognized by Allman as a family characteristic. Levinsen claims that the diaphragm has a certain definite structure in the various species of Campanulariidae and that, according to the similarity of structure in various cases, the species can be grouped into genera. The differences in diaphragms he finds correlate fairly well with the mode of growth of the trophosome, and with this differential he could retain the older division of the family as made by Lamouroux.

In the simplest form the hydrotheca encloses a simple space which connects directly with the hollow in the peduncle, but in Campanulariidae the connection is not direct, the cavity of the hydrotheca opening into a second space,— the "basal chamber" of Levinsen, — which connects with the cavity of the peduncle. The basal chamber is separated from the hollow of the hydrotheca by a chitinous partition — the diaphragm — Levinsen's chief differential. It is of variable thickness and is perforated by a more or less wide aperture for the coenenchyme. According to this observer, all forms of Campanulariidae having a free, branched, primary stem are classed under the genus Laomedia *s. ext.* with three subgenera, Obelia, Gonothyraea, and Laomedia *s. str.*, including in the latter all of those branching forms which have hitherto been placed in the genus Campanularia. Finally, the latter genus is characterized by a simple, unbranched primary stem and by a thick diaphragm which consists of two parts, one "thick and rather high, a ring-formed process from the beaker; the other a thin chitinous membrane which is secreted from the basal part of the hydranth." In genera, on the other hand, which are characterized by a free, branched, primary stem "the diaphragm shows no such distinction in outer and inner parts" (Marktanner-Turneretscher, '95, p. 400).

The application of this latter differential in placing species leads only to "confusion worse confounded." Levinsen and Marktanner-Turneretscher use *Campanularia integra* as a type showing the double diaphragm in which the lower layer is extremely thick. This is undoubtedly true here, and a thin "membranous" layer is found above it, as shown in fig. 12 F, Pl. 6, but in the closely allied *C. caliculata* we find the extremely thick portion, with no trace whatsoever of the thin membranous partition (Pl. 6, fig. 11D). Again in the free branching forms, according to these observers, the diaphragm "shows no distinction between inner and outer parts." *Campanularia gracilis* is a branching form with free and erect stem (Pl. 3, fig. 13), but the diaphragm has two distinct layers, an upper and a lower (Pl. 6, fig. 13D); and *Obelia dichotoma*, another branching and erect form has a distinctly double diaphragm. What now becomes of the differential?

Schneider has severely criticised the use of the diaphragm as a differential character and comes to the unequivocal conclusion that "die Diaphragmabeschaffenheit hat für die Systematik der Genera gar keine Bedeutung" ('97, p. 512).

Thus the question stands, and we are no nearer well-defined diagnostic characters than heretofore. The diaphragm, however, may be more important than Schneider is inclined to believe, for in the Puget Sound species there are well-defined differences and all gradations in the different genera and species. In *C. caliculata* the thickened portion at the base of the polyp is not a part of the stalk but an inner thickening of the hydrotheca, and to all intents and purposes is a diaphragm (Pl. 6, fig. 11D). In no case is the diaphragm anything but an ingrowth of the chitinous periderm, but in *C. caliculata*, *C. integra*, etc., it is much thicker than in others (cf. 17, 9, 27, 21, etc.). Sometimes the diaphragm bears a circular ridge upon which the polyp rests (Pl. 6, fig. 8, 9D). Again, there may be a thin lamella extending inward from the thickened part, as Levinsen maintained (*C. integra*), in which case the diaphragm might be called double, and finally in still other forms the diaphragm is exceedingly delicate and finely drawn out (Pl. 6, fig. 20D). What real value the diaphragm has in classification remains to be proved. The differences presented by the Puget Sound forms certainly indicate a well-defined differential, although perhaps not of such importance as Levinsen and Marktanner-Turneretscher assume.

In connection with the diaphragm we must take into consideration the configuration of the coenosarc immediately below the hydranth. In nearly every case the living substance owes its shape to the structure of the diaphragm and basal chamber. When there is a space it tends to spread out, where there is a chitinous partition or wall it is confined. *C. integra* (Pl. 6, fig. 12F) is a good illustration to the point. Here there is a well-defined basal chamber, also a thin partition upon which the polyp rests, and a thickened lower part of the diaphragm. The coenosarc spreads out in the free space of the basal chamber but contracts to pass through the smaller aperture of the projecting diaphragm. In the various forms of bases the characteristic shape of the coenosarc can be readily seen. It is of course not infallible; in many cases there may be a space without a corresponding swelling of the coenosarc, while in other cases a distinct tube is secreted by the coenenchyme in the basal chamber (Pl. 6, fig. 5E).

Schneider characterizes the family Campanulariidae as follows: — Trophosome unbranched or branched. Hydranths (at least the branched forms) invariably with free stalks; regularly alternate. Hydrotheca large, with the upper part of the stalk swollen out into a single cup; usually conical or tubular, with or without operculum, and capable of taking in the entire polyp. Schneider's genus Campanularia is included in the subfamily Campanuliinae which he characterizes as follows: — Trophosome unbranched or branched. Hydrotheca conical or slightly cup-formed, with distinct base invariably on a free stalk. Gonophores in the form of medusae or sporophores. Gonothecae separated.

Campanularia.

Hydrotheca with smooth or toothed margin without operculum. Blastostyle producing medusae or sporophores — a number always developing at the same time.

6. **Campanularia johnstoni** Alder. Pl. 1, figs. 6, 6A, 6B, 6C. Pl. 6, fig. 6D.

Sertularia volubilis Ellis and Solander. *Campanularia volubilis* Johnston. *Eucope campanulata* Gegenbaur. *Clytea bicophora* Agassiz.

Stems long, transparent, simple or slightly branched, ringed at base and at top with the intermediate portion smooth. Hydrotheca deep and sharply toothed (10–15 teeth). Stem ringed at base and below cup. Gonotheca with short, ringed stalk coming from rhizome and with only one deep constriction in place of the usual large number of annulations. Producing medusae (5 at one time), all from one side of the blastostyle. Diaphragm a single piece which turns downward at the aperture to form a short tube through the basal chamber (Pl. 6, fig. 6D).

Dimensions. Length of stem, 1½–2 mm.; length of cup, .65 mm.; length of gonotheca, 1 mm.; width at apex, .35 mm.; number of teeth on theca, 13–15; number of tentacles on hydranth, 21–22; number of tentacles on medusae, 4; number of annulations at base, 8–10; number of annulations below cup, 2–5.

I refer this species to *C. johnstoni* provisionally. There seem to be some differences from the form described by Hincks, Schneider, and others, especially in regard to the gonotheca, which in the European species is strongly ringed with 7 or 8 annulations, whereas in the present species, there are at most only two formed by a single constriction in the center. I hesitate to make it a new species on this difference and regard it as only one of the many variations for which the species is noted. It may be identical with Clarke's *Campanularia denticulata* from Alaska.

Habitat. Found on algae at Port Townsend. Quite common and generally distributed. Previously reported from England (Hincks and others), Norway (Van Beneden), France (Lacaze-Duthiers), New England coast (Agassiz), Alaska (?) (Clarke), Rovigno (Schneider).

7. Campanularia johnstoni var. Pl. 1, fig. 7.

A minute form growing on *Halecium wilsoni*. Bell very deep, tapering gracefully from margin to base, proboscis trumpet-shaped, stem unbranched, annulated throughout the entire length or only in part, and shorter than the bell. Tentacles 10–14. Gonotheca not present.

Dimensions. Length of stem, 1 mm.; length of hydrotheca, .6 mm.; width at top, 3 mm.; number of teeth on hydrotheca, 9.

I find only four specimens of this delicate form and no gonophores. It is very small for *C. johnstoni*, but comes nearest this species and may be classed with it provisionally.

8. Campanularia inconspicua (Forbes). Pl. 2, figs. 8, 8A, 8B, 8C. Pl. 6, fig. 8D.

Trophosome. Stems short and simple or branched once, arising at irregular intervals from a creeping stolon. Much ringed, 12–13 at base and 4–5 or more below theca. Hydrotheca deep with slight taper towards the base. Margin of bell ornamented with seven large, rounded teeth.

Gonosome. Gonophores borne on short ringed stem which gradually enlarges from stolon to base of gonotheca. Gonotheca large, borne on stolon, widening gradually from base to apex, and with large irregular aperture situated at the wide extremity. Bears four medusae-buds on the blastostyle. The older medusae with tentacles. Diaphragm a simple partition with down-turned edge at the aperture. The hydranth rests upon an elevated annular ridge near the outer edge of the diaphragm, and the basal chamber is a part of the stem cavity (Pl. 6, fig. 8D).

Dimensions. Height of hydrocaulus, 6–8 mm.; length of hydrotheca, .6–.65 mm.; length of gonotheca, 1.3 mm.; width of gonotheca at apex, .35 mm.

I place this species with Forbes's *Thaumantias inconspicua* because of the small number of large teeth. It differs from *C. raridentata*, which I take to be a synonym, in some respects, notably in its smaller size, in the absence of "bulbous swelling" at the base of the stem, and in the large number of annulations. A very noticeable character is the annular ridge on the diaphragm which, with the exception of the closely allied form described below, was not observed in any other hydroid.

Habitat. Found on red algae near Port Townsend, also found in England (Alder and Hincks).

9. Campanularia attenuata sp. nov. Pl. 2, figs. 9, 9A, 9B, 9C. Pl. 6, fig. 9D.

Trophosome. Stems flexuous, very long, branched, given off at short intervals from a creeping stolon, 10–16 rings at base and above point of branching. The parent stem is not ringed above the branches. With from 2–7 or 8 well-marked rings below hydrotheca, but often reduced in diameter as it approaches the base of the hydrotheca. The branches are given off at long intervals and are bent directly upwards, parallel with the parent stem. The hydrothecae are large with 9 or 10 rounded teeth on the margin and have a slight taper from margin to base.

Gonosome. Gonotheca large, borne on short, ringed stalk on the parent stem just above the axils of the branches; smooth, oval, and with a terminal aperture. The blastostyle as a rule bears three medusae, the oldest of which are provided with a well-marked manubrium and four tentacles. The diaphragm is a simple partition with down-turned edge at the aperture. The hydranth is limited by an annular ridge which, however, is not so pronounced as in the preceding species, being more of a swelling. Coenosarc very much attenuated in basal chamber, becoming gradually thicker as it approaches the stem. The basal chamber is a part of the stem.

Dimensions. Height of trophosome, 4–9 mm.; length of stem to primary branches (variable) from 3.5–7 mm.; length of hydrotheca, .5 mm.; width of hydrotheca margin, .25 mm.; length of gonotheca, 1.3 mm.; width of gonotheca at apex, .45 mm.; width of gonotheca at base, .15 mm.; number of tentacles on hydranth, 16.

In some respects this species is similar to *C. inconspicua*, possessing more teeth, however, and having a different mode of growth. The parallel course of the branches and stem and their great length give the species a characteristic appearance, although it agrees with *C. inconspicua* in the size and shape of the gonosomes and in the structure of the diaphragm.

Habitat. On red algae at Port Townsend, Scow Bay. Like the preceding species, the stems, branches, gonothecae, and hydrothecae are covered with a small diatom belonging to the genus Cocconeis.

10. Campanularia (Gonothyraea) gracilis Sars. Pl. 2, figs. 10 A, 10 B, 10 C. Pl. 6, fig. 10 D.

Laomedia gracilis Sars. *Gonothyraea gracilis* Allman.

Trophosome. Stems flexuous, rather long, much and irregularly branched, given off at intervals from a creeping stolon, 8–10 rings at the base and 3–8 rings above origin of branches. As in *C. attenuata* the branches run almost parallel with the main stem but not so noticeably as in that species. The hydrothecae are long, large, and deeply campanulate. The margin has from 10–11 large teeth. The walls of the cup are so delicate that perfect specimens are rare.

Gonosome. Gonothecae arise on short, ringed stems immediately above or in the axils. They are slightly longer and more slender than the hydrothecae and are deeply wrinkled. Medusae-buds 2–5, and 3–4 are usually enough developed to show the manubrium and tentacles.

Diaphragm slender and delicate, forming an indefinite tube around the coenosarc. The basal chamber forms a part of the stem cavity.

Dimensions. Height of colony, 4–12 mm.; length of hydrotheca, .75 mm.–1 mm.; width of hydrotheca at top, .5 mm.; width of hydrotheca at bottom, .1 mm.; length of gonotheca, 1.3 mm.; width at top, .25 mm.; width at bottom, .15 mm.; number of tentacles on hydranth, 18.

Habitat. On red algae at Port Townsend; tests of ascidians, sponges, etc. (Brady); Bergen, on Laminaria (Sars).

11. Campanularia caliculata Hincks. Pl. 2, figs. 11, 11A, 11B, 11C. Pl. 6, fig. 11D.

Trophosome. Stem simple, of variable length, with one well-marked ring immediately behind the hydrotheca; occasionally one or more irregular segments below the ring,— while from here down the stem is perfectly smooth. The base is much branched, forming a complicated meshwork of stems on the red algae to which it is attached. Walls of calycles greatly thickened, the thickening projecting inwards at base to form the diaphragm on which the hydranth rests; with clean even ring. Tentacles very numerous (22–28) and small.

Gonosome. Gonotheca with a short stalk, truncate at the end, and with a decidedly flattened form, wide aperture, and perfectly smooth walls. The capsule contains two sporosacs, a large one above and a smaller (very much smaller) one below. Four branched gastro-vascular canals arise from the base.

The *diaphragm* is formed solely by the ingrowth of the thick walls of the calycle. The coenosarc is not constricted by the diaphragm, and the basal chamber is a mere tube formed by the thickened chitin and is distinctly a part of the calycle.

Dimensions. Height of hydrocaulus, 6–10 mm.; length of stems, 6–10 mm.; length of hydrotheca, .45 mm.; width at top of hydrotheca, .30 mm.; width of bottom of hydrotheca, .25 mm.; length of gonotheca, 2 mm.; greatest width, 1 mm.; thickness of gonotheca, .5 mm.; number of tentacles, about 26.

This is one of the most characteristic hydroids of the entire collection; the hydranth, with its thickened, drooping bell, cannot be mistaken. There is considerable variation in the thickness of the chitin at the base, in some cases the bell being short and almost cubical with an immensely thickened diaphragm, while in others it is more drawn out and the diaphragm less thick; in short, I have found the same variations noted by Hincks, Levinsen, and others. I do not agree with Levinsen and Marktanner-Turneretscher in regarding *C. caliculata*, *C. integra*, and *C. gracilis* as merely modifications of one species. In addition to the difference in the form of the bell and in annulations below the hydranth, there is a very characteristic difference in the gonophores and in the diaphragm. The latter in *C. caliculata* has no shelf of chitin projecting inwards from the thickened hydrotheca, whereas *C. integra* (?) has such a shelf well developed. The gonophores are much more reduced in *C. integra* than in *C. caliculata* and the gonothecae are of very different size and shape. *Campanularia compressa* Clarke is very closely allied to the present species, if not the same, the difference in hydrothecae being no greater than the variations on the same specimens; while in *C. caliculata* I note the same compression of the gonotheca and the same form.

Habitat. On red algae off Pt. Wilson, Port Townsend, and at Bremerton. Common. Previously noted from England (Hincks, Allman, etc.); Bergen (Sars); Labrador (Hincks); Messina (Sars); Massachusetts (Agassiz); Rovigno (Schneider); Alaska (?) (Clarke).

12. Campanularia integra MacGillivray. Pl. 2, figs. 12, 12A, 12B, 12C, 12D. Pl. 6, fig. 12F.

Trophosome. Stems longer than in *C. caliculata*, simple, unbranched, with at least one, sometimes two or three, deeply cut rings below the hydrotheca. In some cases the stem is waved throughout the entire length, and at times, but not always, it is slightly twisted at the base. The hydrothecae are slightly thickened at the base and on the walls. The thickening at the base forms only a part of the diaphragm (Pl. 6, fig. 12 F). The margin is perfectly smooth. The hydranth has many tentacles (28–30). The hydrorhiza is much branched.

Gonosome. Gonothecae borne on hydrorhiza, elongate, slightly oval with truncate end. The blastostyle produces eggs directly (Pl. 2, fig. 12). The wall of the gonotheca is heavily ribbed.

Diaphragm. The thickening at the base forms a part of the diaphragm, but the hydranth rests mainly upon a thin ledge or shelf of chitin which extends inward from the upper part of the thickened portion. This shelf gives a characteristic appearance to the coenosarc which, in order to pass through the narrow aperture, is considerably constricted at this point, swelling out below to partly fill the basal chamber (Pl. 6, fig. 12 F).

Dimensions. Length of stem, 6–8 mm.; length of hydrotheca, .6 mm.; width of margin, .3 mm.; number of tentacles, 28–30; length of gonotheca, 1.5–1.8 mm.; greatest width, .65 mm.

Habitat. On red algae off Point Wilson, Port Townsend, and Bremerton. Common. Previously reported from England (various authors); Labrador (Hincks); Spitzbergen (Marktanner-Turneretscher); Alaska (Clarke); Greenland (Levinsen).

13. Campanularia exigua Sars. Pl. 4, figs. 19, 19 A, 19 B.

Laomedia exigua Sars.

Stems very delicate, slightly flexuous, giving off simple pedicels at each bend, ringed at base and above each branch. Hydrotheca small, regularly funnel-shaped, with smooth and even rim. Gonothecae (Hincks) axillary, elongate, smooth, somewhat fusiform.

The *diaphragm* is simple, extremely fine and difficult to see. The basal chamber is contained in the hydrotheca.

Without the gonophore I cannot place this species more definitely. It is a ragged looking form, the rough and irregular coenosarc filling the stem. The margin of the bell is often sinuous and wavy.

Dimensions. Height of colony, 6–7 mm.; length of hydrotheca, .4 mm.; width at margin, .3 mm.

Habitat. Port Townsend, on stones, etc.

14. Obelia gracilis sp. nov. Pl. 3, figs. 13, 13A, 13B, 13C. Pl. 6, fig. 13D.

Trophosome. Hydrocaulus erect, simple, or slightly branched, growing on a creeping and slightly branched hydrorhiza. Primary stem with from four to six annulations at the base and with from one to three above each branch or hydrotheca stem. The branches as well as the primary stem have four or more annulations at the base and are occasionally provided with tendril-like processes. Hydrothecae placed regularly and alternately at the angles formed by the very slight zigzag of the main axis. Usually there are two hydrothecae at each angle, but in the older angles one of these is borne on a comparatively long stalk having four annulations at the base and three below the hydrotheca. The other hydrotheca is on a stalk borne in the axil of the former. While the stalk in the latter case is much shorter than that of the former, the cup on the other hand, and with it the hydranth, is perceptibly larger. The difference is so constant and so noticeable that it can be measured. The smaller hydrothecae, *i.e.*, those on the longer stalks, are on the average .32 mm. long and .19 mm. wide, while the larger or axillary hydrothecae are .36 mm. long and .32 mm. wide. Not only is there a difference in size, but the shape, as shown by the dimensions, differs as well. All hydrothecae have plain margins. Hydranths with about 28 tentacles.

Diaphragm. The diaphragm is distinctly double, consisting of a lower portion with a tendency to follow the coenosarc down into the stem, and an upper shelf-like part which supports the hydranth. The basal chamber forms part of the stalk cavity. (Pl. 6, fig. 13D.)

Gonosome. The gonothecae are borne in the axils of the lower hydranth and correspond in position to the long-stalked hydranth higher up. They are distinctly club shaped, enlarging gradually from the base to the extremity, which is surmounted by a well-defined collar, and they are slightly wrinkled. Medusae-buds spring from all sides of the blastostyle. The older ones are flat with about 28 closely pressed tentacles, and with a four-cornered mouth.

Dimensions. Height of hydrocaulus, 6–20 mm.; length of larger hydrotheca, .36 mm.; length of smaller hydrotheca, .325 mm.; width at margin of larger hydrotheca, .34 mm.; width at margin of smaller hydrotheca, .19 mm.; length of gonotheca, .750 mm.; diameter at extremity, .26 mm.

Habitat. On grasses at Scow Bay, Port Townsend Harbor.

The present species agrees with *Campanularia coruscans* Schneider in dimensions but differs in other respects. The trophosome resembles that of Agassiz's *Eucope diaphana* except that the hydrotheca-stalk is ringed throughout in the latter; the gonosome on the other hand differs completely.

15. Obelia surcularis sp. nov. Pl. 3, figs. 14, 14A, 14B. Pl. 6, fig. 14c.

Trophosome. The hydrocaulus is erect, and borne on a creeping and branched hydrorhiza. There is never more than one branching primary stem. The branches are regularly alternate, turned upwards, and generally end in long filiform tendrils slightly expanded at the extremity and bearing, in some cases, one or two hydrothecae. Six to eight annulations are found at the base of the main stem, three or four above each branch. The stem of the hydrotheca is often ringed throughout, tapering from the point of origin to the calycle. The hydrotheca is a little swollen at center and has a slightly everted and smooth margin.

Diaphragm. A simple shelf projecting inwards from the cup. The basal chamber is not separated from the cavity of the stalk.

Gonosome. Gonothecae are borne in axils and on the branches, on short ringed stalks; it is questionable whether they are ever borne on the hydrorhiza. They expand rapidly from base to extremity, where they end in a flattened top with a very shallow and flat projection containing the aperture. Medusae develop on all sides of the blastostyle, in most cases as many as 28 developing at once. The older ones are flat with a four-cornered mouth and about 24 tentacles.

Dimensions. Height of colony up to 25 mm.; length of hydrotheca, .3 mm.; diameter of hydrotheca at margin, .25 mm.; length of tendril-like processes, 1.2–5 mm.; length of gonotheca, .75–.90 mm.; greatest diameter of gonotheca, .15 mm.; number of tentacles on hydranth about 24.

The tendril-like processes which form such a striking feature of this species are decidedly characteristic and cannot be mistaken. Other characteristic features are the long regular branches, each of which bears two or three gonothecae always in axils of branches or hydrothecae-stems.

Habitat. On water grasses. Abundant in Scow Bay, Port Townsend Harbor.

16. Obelia fragilis sp. nov. Pl. 3, figs. 15, 15A, 15B. Pl. 6, fig. 15c.

Trophosome. Hydrocaulus clinging and never erect. Stems polysiphonic, long, flexuous, branched at regular intervals, branches also comparatively long and flexuous, slightly ringed at the base and with four rings above each branch. Hydrotheca deep bell-shaped; the chitinous periderm is exceedingly delicate and easily wrinkled or folded. Hydrothecae placed alternately and at some distance apart. Margin sinuous; stems short and annulated throughout. A single hydrotheca in the axil of each branch.

Gonophores unknown.

Diaphragm a simple well-defined shelf below the hydranth. Basal chamber a part of the stem (Pl. 6, fig. 15c).

Dimensions. Length of colony, 30 mm.; length of branches, 9 mm.; distance between branches, 1.5 mm.; length of hydrotheca, .5 mm.; width of margin, .4 mm.; number of tentacles, 22–24.

This exceedingly graceful hydroid recalls Marktanner-Turneretscher's *O. chinensis*, which according to this author resembles Hincks's *Gonothyraea hyalina*. I cannot carry the resemblance so far, and it differs also from *O. chinensis* in its much smaller dimensions (*O. chinensis* — internodes .2 mm. thick and often 4.5 mm. long) and in the length of the stem bearing the hydrothecae.

Habitat. Dredged in Port Townsend Harbor on *Aglaophenia struthionides.*

17. Obelia dichotoma Linn. Pl. 3, figs. 16, 16 A, 16 B, 16 C, 16 D. Pl. 6, fig. 16 E.

A few good specimens of this species were found at Bremerton. Hincks's description is as follows: "Stem filiform, slender, nearly straight, irregularly branched, ringed above the origin of the branches, of a deep horn color; branches suberect; often very long and more or less ramified; ringed at intervals and with a single calycle in the axils. Hydrothecae alternate, broadly campanulate and deep; polyhedral above, each side corresponding with a very slight sinuation of the margin borne on ringed pedicels. Gonothecae axillary, slender, smooth, widening from base upwards and terminating above in a raised somewhat conical aperture."

Diaphragm. A shelf consisting of two portions, the upper forming the main part of the diaphragm and extending inwards to confine the coenosarc; the other or lower portion bends downwards to form a tube confining the coenosarc, and connects with a second diaphragm at the first annulation. The coenosarc at this portion is smooth and even, but below the first annulation it becomes ragged and irregular.

Dimensions. Length of hydrotheca, .35 mm.; diameter at margin of hydrotheca, .2 mm.; number of tentacles on hydranth, 22–24; length of gonotheca, .8 mm.; diameter at extremity, .3 mm.

Habitat. On piles and stones at Bremerton. Common.

18. Obelia plicata Hincks.

This species with its exceedingly delicate calycles was not very abundant or in good condition. The polysiphonic stems and the method of branching together with the short-ringed pedicels place it in this species.

19. Obelia gelatinosa Pallas.

A fine specimen of this widely distributed species was dredged at Discovery Bay, but it was not in fruit.

Diaphragm a simple partition below the hydranth turning down to form a tube about the coenosarc. The basal chamber is a part of the stem.

20. Obelia griffini sp. nov. Pl. 4, figs. 18, 18A, 18B, 18C. Pl. 6, fig. 18D.

Trophosome. The stems are much branched growing on creeping stolons. Branches are regularly alternate and about .5 mm. apart, giving a much-branched appearance to the colony. The primary stems are ringed at the base (6 rings) and above the joints up to middle of the internode. The hydrothecae are borne on stems .1 mm. long, ringed, as a rule, throughout the entire length (about 9 rings). The hydrothecae are alternately arranged, with plain rim, deep and gracefully curved. Tentacles on hydranth about 24.

Diaphragm a simple partition with down-turned edges. The coenosarc broadens out below to fill partly the basal chamber which is a part of the stalk.

Gonosome. The gonothecae are elongate, borne on short ringed stalks, rather attenuate and nearly uniform in diameter. From six to eight medusae develop on the blastostyle at one time. The older medusae are discoid, with about 24 tentacles.

Dimensions. Height of colony, 25–50 mm.; distance between hydrothecae, .08 mm.; length of hydrotheca, .25–.35 mm.; length of gonotheca, .8–1. mm.; diameter at widest part, .25–.3 mm.

CALICELLA Hincks (in part).

Schneider does not consider the operculum of sufficient importance to distinguish genera and unites with his family Campanulariidae the four families of Hincks as follows: (1) Campanulariidae, (2) Campanulinidae, (3) Leptoscyphidae, (4) Lafoeidae. He regards the operculum as little more than a toothed margin, the teeth coming together to form a covering. The form of the polyp, which according to Levinsen is of little moment, is quite similar in all four families, and the constancy of type should be recognized. The operculum on the other hand is an adaptive structure.

21. Calicella syringa Linn. Pl. 4, figs. 20, 20A, 20B, 20C. Pl. 6, fig. 20D.

This form agrees perfectly with Hincks's description.

Diaphragm a simple shelf of dissimilar thickness, thickest at the outer extremity and running out to a very fine ledge under the hydranth. The basal chamber is part of the stem.

Habitat. On stems of *Tubularia larynx*, *Hydrallmania falcata*, etc., at Port Townsend Bay. Also reported from Iceland (Hincks); Alaska (Clarke); East Spitzbergen (Marktanner-Turneretscher).

SERTULARIIDAE.

It has been difficult to characterize this family, and to find a chief differential of value. Hincks's early description is insufficient. It is: — "Hydrothecae perfectly sessile, more or less inserted in the stem and branches; polypites wholly retractile with a single wreath of filiform tentacles round a conical proboscis; gonozooids always fixed." Levinsen endeavored to improve upon this by finding a chief differential in the structure of the operculum. He says: — "Forms with a well-developed segmented stem, whose bilaterally placed operculated hydrothecae are usually stemless, and frequently sunk into the stem or branches." His diagnosis is based upon comparatively few genera and species, and the nature of the operculum, its insertion, and the opposite-placed "collar" are points which necessitate a complete rearrangement of the old family Sertulariidae. Until these characters have been approved by further investigation and upon living material, and until the natural affinities are better understood than they are at present, it seems a better plan, in a work of the present kind, to adhere to the older system notwithstanding Allman's objection to Gray's division of the family. Schneider's division of the family into a number of types is very convenient and probably represents as nearly as possible, considering our present knowledge, the natural affinities of the groups.

1. *Sertularella group.* The hydrothecae distinctly alternating,

with a more or less distinct joint between each two. Mouth of the hydrotheca toothed, operculum of many parts (all of Hincks's Sertularellas; also those of Allman and Bale).

2. *Dynamena group.* The hydrothecae opposite, a joint between each pair; side branches, when present, arising from one or from both components of the pair of hydranths; mouth of hydrotheca generally with two teeth; operculum simple. To this group belong Hincks's *Diphasia rosacea* and *D. attenuata; D. fallax* Johnston; *D. pinaster* Ellis & Sol.; Pallas's *D. tamarisca* and *D. pinnata;* Hassall's *Sertularia pumila* and *S. gracilis; S. operculata* Hincks; *S. bispinosa* Gray; *S. minima* Thompson; *S. macrocarpa* Bale.

3. *Thujaria group.* Hydrotheca more or less alternating, often almost opposite, closely placed and many to an internode. Side branches invariably arising from a singly-placed hydranth. Mouth of the theca generally smooth, operculum simple. Here belong Hincks's *Diphasia alata;* Ellis and Solander's *Sertularia filicula, S. abietina, S. argentea; Sertularia cupressina* Hincks; *Thujaria thuja* Hincks; *T. lonchitis* Hincks; *Sertularia diffusa* Allman; *S. elongata, S. tenera* Sars; *S. maplestonei* Bale; *S. huttoni, Diphasia mutulata* Busk; and *Dynamena tubuliformis* Marktanner-Turneretscher.

4. *Pasythea group.* Hydrothecae opposite; a variable number of pairs closely packed upon the middle portion of an internode. Here belong a few easily recognized forms, e. g., *P. denticulata* Ellis and Solander.

5. *Selaginopsis group.* Hydrothecae arranged in more than two rows, closely packed together in great numbers on an internode. *Selaginopsis cylindrica* Clarke and *S. fusca* Johnston.

6. *Hydrallmania group.* Hydrothecae on side branches distinctly in one row, many packed together upon an internode. *H. falcata* Linn.

1. *Sertularella group.*

22. Sertularella conica Allman. Pl. 4, figs. 22, 22A, 22B.

Hydrocaulus attaining a height of about an inch and a half, simple or with an occasional branch. Hydrothecae springing from points close to the distal ends of the internodes; they are tumid towards the base and narrowed towards the orifice and slightly marked with corrugations on the upper side.

Dimensions. Height of colony, 10 mm.; length of hydrotheca, .7 mm.; length of internodes, .65 mm.

The specimen which I place here was of very small size and without gonosomes. The only character, and this a small one, by which to distinguish it from the very wide-spread *S. polyzonias*, is the well-marked wrinkling on the adcauline side of the hydrotheca.

Habitat. Attached to stone dredged in Townsend Harbor.

23. Sertularella tricuspidata Alder. Pl. 4, figs. 21, 21A, 21B, 21C.

Trophosome. Stems slender, alternately branched or divided dichotomously, often bipinnate at the top, jointed above each calycle and twisted at intervals. The hydrothecae are distant, cylindrical, smooth, slightly expanded and everted above, and have a 3-toothed aperture.

Gonosome. The gonotheca is large, and strongly cross-ribbed, with a plain funnel-shaped aperture which arises from a bowl-like expansion.

Dimensions. Height of colony, 35–40 mm.; length of hydrotheca, .4 mm; diameter at top of hydrotheca, .15 mm.; broadest diameter, .2 mm.; length of gonotheca, 1.6 mm.; greatest diameter of gonotheca, .6 mm.; length of internodes, .5 mm.

Except for the expanded and slightly everted margin the Puget Sound form agrees perfectly with Hincks's description of this species. The joints are very slightly marked and often difficult to see.

Habitat. Port Townsend Bay, dredged in 15 fathoms of water, off Marrowstone. Previously reported from Iceland (Hincks); Greenland (Buck); Strait of Belle Isle (A. S. Packard, Jr.); Alaska (Clarke).

24. Sertularella nodulosa sp. nov. Pl. 5, figs. 29, 29A, 29B.

Trophosome. Stems simple or slightly and irregularly branched, branches also irregularly subbranched, the latter arising immediately below the hydrothecae. Hydrothecae large, smooth or slightly waved, with a slight bulge below and a taper at the extremity. The margin bears three teeth and a three-parted operculum. The joints are slightly oblique and hydrothecae are deeply inserted midway between them. The hydranth contracts with a peculiar fold which is highly characteristic.

Gonosome. Gonotheca large, conical, given off midway between two adjacent hydrothecae. Characterized chiefly by the presence of nodules on the distal half. These are arranged in three circles. The first circle is made by four nodules at the extremity. The second circle is about one quarter of the length of the gonotheca from the extremity, and consists of 6 nodules; the third row is about midway between the apex and the base and consists of eight nodules. The aperture is small.

Dimensions. Height of colony, 25–50 mm.; distance between joints (length of internodes), .5 mm.; length of gonotheca, .58 mm.; greatest diameter, .35 mm.; length of gonotheca, 1.1 mm.; greatest diameter of gonotheca, .8 mm.

Habitat. Dredged in 15–20 fathoms off Marrowstone, Townsend Harbor. Not common. It bears a slight resemblance to Heller's *S. crassicaulus.*

3. *Thujaria group.*

25. Thujaria thuiaroides.

A small specimen of this hydroid was found among algae and not in very good condition. Gonothecae absent.

Described also by Clarke from Alaska.

26. Sertularia fabricii Levinsen. Pl. 5, figs. 24, 24A, 24B.

The shoots are bushy with a spiral arrangement of the branches. The latter turn upwards and give a characteristic spiral appearance. The branches are given off alternately about 1½ mm. apart, and they are branched and subbranched in turn to form fan-shaped offshoots. The hydrothecae are subalternate, narrowed towards the upper part which is free and divergent; from 5–7 to an internode; the latter are of different lengths. The aperture is small and oblique. Gonothecae (Hincks) broad at the top, attenuated downwards, with two spines above (or sometimes only one) and a slightly raised circular aperture.

Dimensions. Height of colony, 35 mm.

Habitat. Dredged off Marrowstone, Townsend Bay, 15–18 fathoms. Previously reported from England (Hincks and others); mouth of Elbe (Kirchenpauer); Greenland (Fabricius); North Cape (Sars); Southern Labrador (A. S. Packard, Jr.); Nova Scotia (Dawson); Grand Manan (Stimpson); Massachusetts (Agassiz); South Africa (Busk).

5. *Selaginopsis group.*

27. Selaginopsis cylindrica Clarke. Pl. 3, figs. 17, 17A.

Thujaria cylindrica Clarke.

The hydrocaulus is erect, simple, stout, gradually tapering from the distal end to the base, and divided by oblique joints into internodes of variable length; 3–4 annulations at the base, regularly branched; branches alternately arranged, cylindrical or polygonal in section. The hydrothecae are tubular, almost entirely imbedded, tapering at extremity and curved slightly outwards. Aperture oval. Hydrothecae on stem arranged in six longitudinal rows in such a manner that the appearance of oblique transverse rows is given. Gonophores not known.

Dimensions. Length of main stem, about 45 mm.; length of branches, 18 mm.; length of hydrotheca, .45 mm.; greatest diameter of hydrotheca, 2 mm.

Habitat. Dredged with Aglaophenia in Townsend Bay. Reported from Alaska (Clarke).

6. *Hydrallmania group.*

28. Hydrallmania falcata Linn. Pl. 5, figs. 25, 25A, 25B.

The stems are fairly stout, not flexuous; destitute of calycles, with 3–4 plain rings about the base. The branches are alternate, distant, regularly pinnate, and given off above each joint. The hydrothecae, 3–4 to each internode, are tubular, closely appressed, slightly tapering towards the margin, and are turned alternately towards the right and left. Joints oblique. Aperture plain. Gonothecae (Hincks) ovate, tapering below with a slightly tubular neck.

Dimensions. Height of stem, 25–30 mm.; length of hydrotheca, .45 mm.; greatest diameter, .2 mm.; length of internodes on stem, 1.5–2 mm.

Habitat. Port Townsend Bay. Not common.

PLUMULARIIDAE.

29. Plumularia setacea. Pl. 5, figs. 27, 27A, 27B, 27C.

Trophosome. The shoots are delicate, and the stem is slightly waved and regularly jointed. Pinnae alternate, one to each internode, originating immediately below the joint, composed of longer and shorter internodes placed alternately, the former bearing the calycles; hydrothecae small with an even rim, very distant, separated by two joints; the nematophores are elongate, two abreast behind and above the calycle, two in a line below it, one at the origin of the pinnae, and one on each segment of the stem. Gonothecae borne on the axils of the pinnae (Hincks).

Dimensions. Length of stem, 40–50 mm.; length of pinnae, 2–3 mm.; distance between hydrothecae, .55 mm.; length of hydrothecae, .12 mm.; length of nematophores, .05 mm.

Habitat. Point Wilson on stones, etc. Common.

30. Plumularia echinulata (variety). Pl. 5, figs. 28, 28A, 28B, 28C.

The shoots are very delicate, the stem curved or straight; jointed, the internodes short and bulging in the center, bearing each a single branch. The branches are alternate, arching gracefully upwards, with two joints immediately above the axil. Hydrothecae small, basin-shaped, separated by a single joint. Nematophores very minute, simple, adnate to the side of the stem, one behind and above the calycle, one below it, and one or sometimes two (Hincks) in the axils of the branches. Gonothecae not present.

Dimensions. Length of stem, 13 mm.; length of branches, 2 mm.

I make this species a variety of *P. echinulata* because of the greater thickness of the branches and also because of the occasional presence of two joints between the hydrothecae. On no less than 7 of the 28 branches of one specimen I find one interthecal space with two joints, although the usual number is one. In *P. setacea* two joints between cups is the rule, here it is the exception.

Habitat. On algae and stones at Port Townsend. Uncommon.

31. Aglaophenia struthionides (Murray) Clarke. Variety B. Pl. 5, figs. 26, 26A, 26B.

Trophosome. The stems are clustered, simple, erect, divided by the oblique joints into short internodes of equal length, each bearing a single pinna; varying from light to dark horn color; the shoots tall, plumose. The pinnae are slightly curved towards each other, divided into internodes slightly larger than those of the stem, each internode bearing one hydrotheca. The hydrotheca is large and cup-shaped, expanding towards the distal end; the aperture is also large, with rim of 9 teeth more or less sharp.

Nematophores tubular, the lateral ones of medium size projecting ear-like from the sides of the cups, the anterior one long, adnate except at the extremity which is free, and extending beyond the toothed rim. Aperture small, terminal. The nematophores on the corbulae are a trifle larger, and arranged in rows which pass upwards to the dorsal side, make a short turn there, and come down again parallel. The corbulae are large and cylindrical, with numerous ridges (10–16) composed of oblique rows of nematophores, and with 4 hydrothecae at the base.

Clarke figures this corbula with rings of nematophores around the ventral ridge; but in the present specimens there are no such rings and no nematophores on the ridge except at the extreme tip where there is one.

Habitat. On rocks dredged from 15 fathoms at Marrowstone, Townsend Bay. Common.

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PLATE 1.

Fig. 1. Tubularia larynx. Nat. size. *a.* Hydranth with gonophores. × 18.

Fig. 2. Coryne mirabilis. Nat. size. *a.* Hydrocaulus. × 18. *b.* Medusa-bud. × 80.

Fig. 3. Perigonimus repens on leg of Pisa. Nat. size. *a.* Hydrocaulus. × 18. *b.* Hydranth. × 80. *c.* Medusae-buds. × 80. *d.* Hydranth. × 80.

Fig. 4. Halecium wilsoni. Nat. size. *a.* Male gonophores. × 18. *b.* Hydrotheca. × 80.

Fig. 5. Halecium densum. Nat. size. *a.* Portion of hydrocaulus. × 18. *b.* Hydranth. × 80. *c.* Hydrotheca. × 80.

Fig. 6. Campanularia johnstoni. Nat. size. *a.* Portion of hydrocaulus. × 18 *b.* Hydrotheca and hydranth. × 80. *c.* Gonosome. × 80.

Fig. 7. Campanularia johnstoni var. × 80.

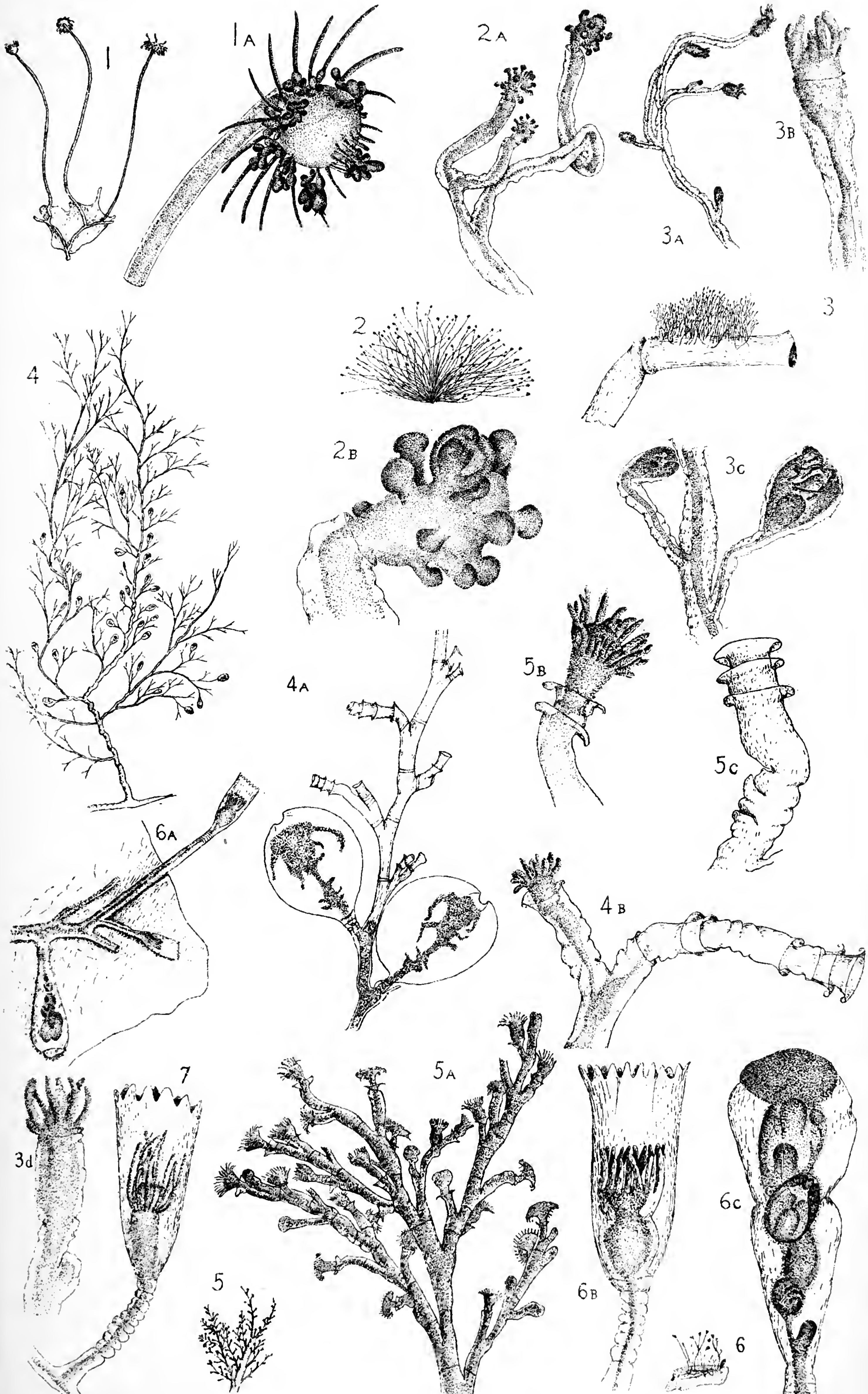

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PLATE 2.

Fig. 8. Campanularia inconspicua. Nat. size. *a.* Hydrocaulus. × 18. *b.* Hydrotheca, hydranth, and stalk. × 80. *c.* Gonosome. × 80.

Fig. 9. Campanularia attenuata. Nat. size. *a.* Hydrocaulus. × 18. *b.* Hydrotheca and hydranth. × 80. *c.* Gonosome. × 80.

Fig. 10. Campanularia gracilis. *a.* Hydrocaulus. × 18. *b.* Hydrotheca and hydranth. × 80. *c.* Gonosome. × 80.

Fig. 11. Campanularia caliculata. Nat. size. *a.* Hydrocaulus. × 18. *b.* Hydrotheca and hydranth. × 80. *c.* Gonosomes. × 80.

Fig. 12. Campanularia integra. Nat. size. *a.* Hydrocaulus. × 18. *b.* Hydrotheca and hydranth. × 80. *c.* Gonosome. × 80. *d.* C. integra var. Nat. size. *e.* Hydrotheca and hydranth. × 80.

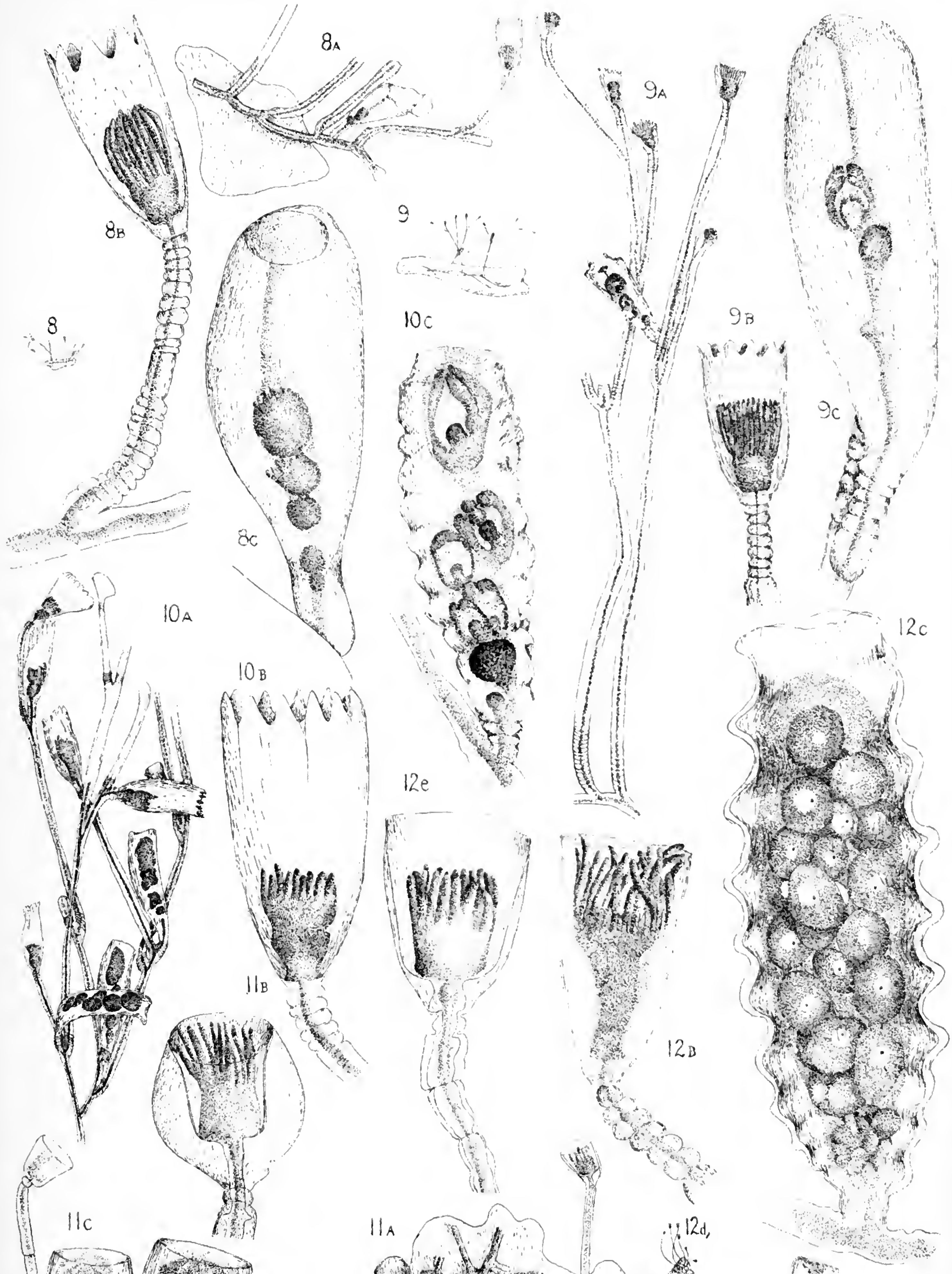

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PLATE 3.

Fig. 13. Obelia gracilis. Nat. size. *a*. Hydrocaulus. × 18. *b*. Hydrotheca and hydranth. × 80. *c*. Gonosome. × 80.

Fig. 14. Obelia surcularis. Nat. size. *a*. Hydrocaulus. × 18. *b*. Hydrotheca, hydranth, and gonosome. × 80.

Fig. 15. Obelia fragilis. Nat. size. *a*. Portion of hydrocaulus. × 18. *b*. Hydrotheca and hydranth. × 80.

Fig. 16. Obelia dichotoma. Nat. size. *a*. Hydrocaulus. × 18. *b*. Hydrotheca and hydranth. × 80. *c*. Gonosome. × 80. *d*. Distal end of gonosome. × 80.

Fig. 17. Selaginopsis cylindrica. Nat. size. *a*. Portion of pinna. × 80.

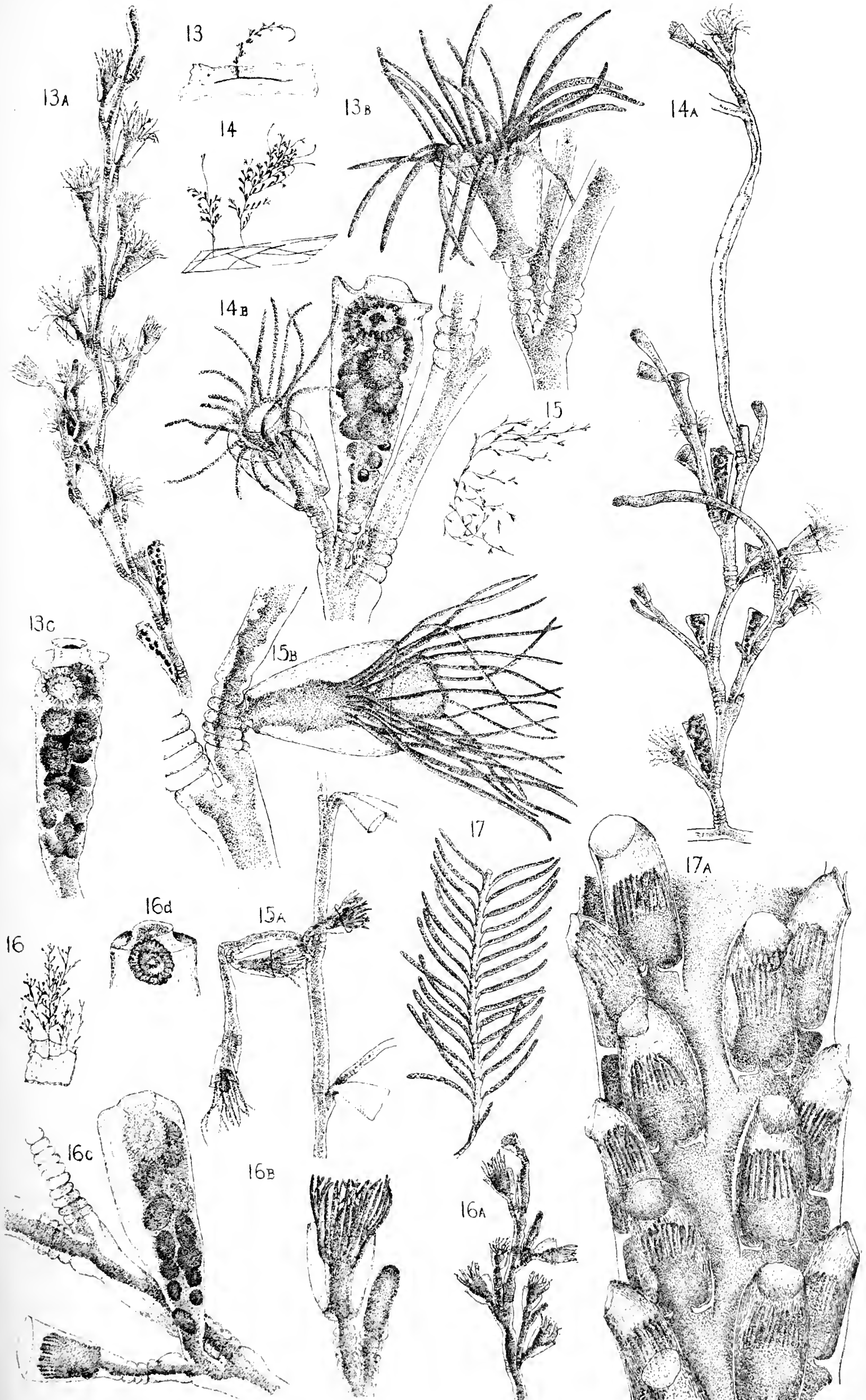

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PLATE 4.

Fig. 18. Obelia griffini. *a.* Hydrocaulus. Nat. size. *b.* Hydrotheca and hydranth. × 80. *c.* Gonosome. × 80.

Fig. 19. Campanularia exigua. Nat. size. *a.* Hydrocaulus. × 18. *b.* Hydrotheca and hydranth. × 80.

Fig. 20. Calicella syringa. Nat. size. *a.* Hydrocaulus. × 18. *b.* Hydrotheca and hydranth; operculum thrown out. × 80. *c.* Hydrotheca and hydranth; operculum drawn in. × 80.

Fig. 21. Sertularella tricuspidata. Nat. size. *a.* Hydrocaulus. × 18. *b.* Gonosome. × 80. *c.* Hydrotheca. × 80.

Fig. 22. Sertularella conica. Nat. size. *a.* Hydrocaulus. ×18. *b.* Hydrotheca. × 80.

Fig. 23. Obelia plicata. Nat. size. *a.* Hydrotheca and hydranth. × 80.

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PLATE 5.

Fig. 24. Sertularella fabricii. Nat. size. *a*. Hydrotheca. × 80. *b*. Hydrocaulus. × 18.

Fig. 25. Hydrallmania falcata. Nat. size. *a*, *b*. Front and side views of hydrotheca. × 80.

Fig. 26. Aglaophenia struthionides. Nat. size. *a*. Hydrotheca. × 80. *b*. Gonosome (corbula). × 18.

Fig. 27. Plumularia setacea. Nat. size. *a*. Hydrocaulus. × 18. *b*. Hydrothecae and nematophores. × 80. *c*. Nematophore, much enlarged.

Fig. 28. Plumularia echinulata. Nat. size. *a*. Hydrocaulus. × 18. *b*. Hydrotheca and nematophores. × 80. *c*. Nematophore, much enlarged.

Fig. 29. Sertularella nodulosa. Hydrocaulus. *a*. Hydrotheca and hydranth, the latter contracted in a characteristic manner. *b*. Gonosome.

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PLATE 6.

Variations in the diaphragm.

Fig. 6d. Campanularia johnstoni. Diaphragm prolonged to form a tube around the coenosarc.
Fig. 8d. Campanularia inconspicua. An elevated ridge on the diaphragm.
Fig. 9d. Campanularia attenuata. Diaphragm with small wing-like elevations.
Fig. 10d. Campanularia gracilis.
Fig. 11d. Campanularia caliculata.
Fig. 12f. Campanularia integra.
Fig. 13d. Obelia gracilis.
Fig. 14c. Obelia surcularis.
Fig. 15c. Obelia fragilis.
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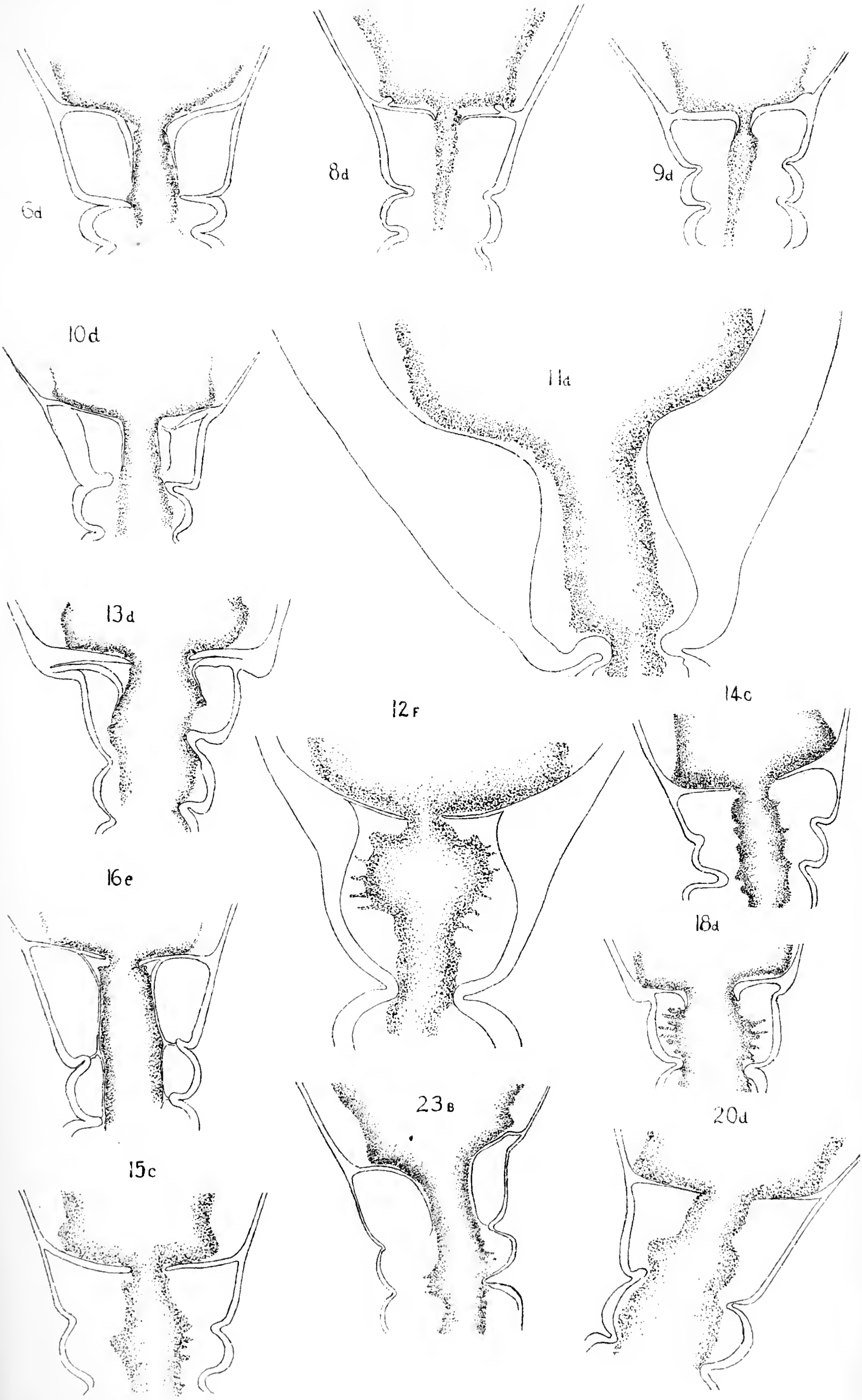
Fig. 18d. Obelia griffini.
Fig. 20d. Calicella syringa.
Fig. 23b. Obelia plicata.

All figures magnified 375 diams.

All figures drawn with camera lucida from permanent preparations.



G.N.C. & A.M.C. del.

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NORTH AMERICAN WOOD FROGS.

By Reginald Heber Howe, Jr.

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No. 14.—*North American Wood Frogs.*

By Reginald Heber Howe, Jr.

Prof. Spencer F. Baird described (Proc. acad. nat. sci. Phil., April, 1854, vol. 7, p. 62), a wood frog, *Rana cantabrigensis*, "*Hab.* Cambridge, Mass. (Collection of Prof. Agassiz.)" The type has been lost to all intents and purposes, although it may be an old, shrunken, and unlabeled specimen found with a lot from the Saskatchewan, Can., in the collection of the Museum of comparative zoology.

Baird's diagnosis answers to this specimen very well and is as follows:—

"15. *Rana cantabrigensis*, Baird.—Above yellowish brown. A dark vitta through the eye, margined below by whitish. Lateral fold of skin light colored, as is also a median dorsal line extending from the snout to the anus. A narrow light line along the posterior faces of the thigh and leg. Tibia half the length of body. General appearance and size of *R. sylvatica.*

Hab. Cambridge, Mass. (Collection of Prof. Agassiz.)"

The examination of a large series of *Rana silvatica* from New England does not show a single specimen approaching the supposed type in characteristic measurements or color or corresponding with the diagnosis of it, and the conclusion is reached that Baird's *R. cantabrigensis* never came from Cambridge, but probably from the west or northwest of North America, and Cambridge, Mass., the habitat given, probably arose from the specimen being in the collection of Professor Agassiz. Having a large series of *Rana silvatica* I give for comparative purposes a detailed description of this closely allied form.

Rana silvatica Leconte, Ann. lyc. nat. hist., N. Y., 1825, vol. 1, p. 282.

Measurements, average:—

Body, snout to anus	4.2 cm.
Femur	2.3 cm.
Tibia	2.5 cm.
Leg and foot	7.8 cm.

Form.—*Head.* Width equal to the distance from the snout to the axilla. Eyes invisible from ventral view. Nares half way between anterior corner of the eye and the end of snout. Distance between the nares equal to the interorbital distance. Tongue ovate, notched at the posterior end, and attached anteriorly for about two thirds its length. Groups of vomerine teeth round, close together, and directly between the internal nares. Nares opening internally immediately forward of the eye. Tympanum smaller than eye. A distinct notch on each side of symphysis of the lower jaw.

Body. Slender. Dorso-lateral folds from the posterior corners of the eyes nearly to the cloacal opening. Back, flanks, and lower belly slightly granulate.

Fore legs. Two tubercles on the palm, three on the first, second, and fourth digits and four on the third digit. First toe slightly longer than second and fourth which are equal. Third toe one third longer than second.

Hind legs. Dorsal sides of the femur and dorsal sides of the tarsus and often posterior ventral sides of the femur granulate. Web, including second joint of the fourth digit, deeply incurved on the margins. A large tubercle on the inner side of the foot and another on the under side of the digital joints. *Legs long and slender. Tibia almost one and one half times the length of the body. Distal end of the tibia reaching to the snout.* Length of first toe equal to that of second joint of second toe. Second toe reaching one half way up second joint of third toe. Third toe reaching nearly to third joint of the fourth toe. Fourth toe longest. Fifth toe equal to third.

COLOR. — *Dorsal surfaces.* Very dark brown to pale grayish. Often the color of the dried leaves, among which this frog is found, except during the short breeding period. Head with a dark vitta on each side, behind the eye, including the tympanum and extending foward as a line from the corner of the eye, through the nares to the end of the snout. A light line extends from the end of the snout to a point above the axilla. Other parts of the head obscurely marked with darker. Body between lateral folds indistinctly marked with darker. Lateral folds lighter and more brilliant in color.

Fore legs. A dark mark along anterior edge of humerus. Two indistinct dark transverse bars on the ulna.

Hind legs. From two to four more or less distinct dark transverse bars on each joint.

Ventral surfaces. Pale, light grayish white sometimes tinged with yellow or greenish. Throat mottled with dusky.

Hind legs. Faint yellowish.

The distribution of this species does not, as far as known, extend north of Quebec, Can., south of South Carolina, or west of the Great Plains. Prof. E. D. Cope, Bull. 34, U. S. nat. mus., in his table of localities, includes one specimen each from the Selkirk Settlements, Can. (5381), Athabasca River, Can. (9384), Moose River, British Amer. (5922). Although I have not seen these specimens, I doubt very much their being *Rana silvatica*; they are more probably *Rana cantabrigensis* Baird.

Rana cantabrigensis cantabrigensis Cope, Bull. 34, U. S. nat. mus., 1889, p. 436.

Rana cantabrigensis Baird, Proc. acad. nat. sci. Phil., 1854, vol. 7, p. 62. Boulenger, Bull. soc. zool. France, 1880, vol. 5, p. 209. Boulenger, Cat. Batr. Sal. Brit. mus., 1882, p. 45.

Rana sylvatica DeKay, Nat. hist. N. Y., 1842, vol. 3, p. 64, pl. 20, f. 50, pl. 21, f. 54. Boulenger, Bull. soc. zool. France, 1879, vol. 4, p. 174.

Rana temporaria var. *silvatica* Günther, Cat. Brit. mus., 1868, p. 7 (part).

Rana temporaria subsp. *cantabrigensis* Cope, Bull. 1, U. S. nat. mus., 1875, p. 32.

MEASUREMENTS, averages: —

Body, snout to anus	3.6 cm.
Femur	1.8+cm.
Tibia	1.8 cm.
Leg and foot	5.6 cm.

FORM. — *Head.* Width equal to the distance from the snout to the axilla. Eyes invisible from ventral view. Nares half way between the anterior corner of the eye and the end of snout. *Distance between the nares greater than interorbital distances. Tongue shorter and more ovate than in R. silvatica.* Notched at posterior end and attached anteriorly for about two thirds its length. *Groups of vomerine teeth oblong and farther apart than in R. silvatica,* and directly between internal nares. Nares open internally immediately forward of the eye. Tympanum smaller than the eye and a distinct notch on each side of the symphysis of the lower jaw.

Body. Stout. Dorso-lateral folds *indistinct. Back, flanks, and lower belly smooth.*

Fore legs. Two tubercles on the palm. *One prominent tubercle on the first and second digits. Two tubercles on the third and fourth digits.* First finger slightly longer than second and fourth, which are equal. Third finger one third longer than the second.

Hind legs. Posterior ventral sides of femur only granulated. Web, including nearly the whole of the second digit, deeply incurved. A large tubercle on the inner side of the foot and on the under sides of the digital joints. *Legs not so long or so slender as in R. silvatica. Tibia one half the length of the body. Distal joint of the tibia reaching not quite to the snout.* First toe equal the first joint of the second. Second toe reaching half way up to the second joint of the third toe. Third reaching nearly to the third joint of the fourth toe. Fourth longest. Fifth reaching to third joint of the third toe.

COLOR. — *Dorsal surfaces.* Dark brown to pale yellowish gray. Head with a dark vitta through the eye, on each side behind the eye including the tympanum and extending forward as a line from the corner of the eye through the nares to the end of the snout. A light line extends from the end of the snout to a point above the axilla. Other parts of the head more or less marked, with darker. *A light median dorsal line from near snout to anus sometimes present.* Body between lateral folds, varying from almost unicolor to distinctly marked with darker. *Lateral folds somewhat lighter and bordered by a dark streak.* Sides in many cases heavily spotted.

Fore legs. A dark mark on anterior edge of humerus. *Spotted more or less with irregular markings.*

Hind legs. Barred, *but sometimes irregularly spotted* with darker.

Ventral surfaces. Pale grayish yellow, faintly mottled, except on hind legs.

Hind legs. Yellowish.

The distribution of this species, so far as known, extends from Illinois and Minnesota northward probably to the region of Great Slave Lake, Can., and eastward to St. James Bay, Can. Professor Cope included four specimens from western Missouri in his locality list of *Rana cantabrigensis* in Bull. 34, U. S. nat. mus. He made an error in his identification, however, for the specimens (3457) are without doubt the western form of *Rana pipiens*.

Rana cantabrigensis latiremis Cope. Proc. Amer. philos. soc., 1886, vol. 23, p. 520.

MEASUREMENTS, averages: —

Body, snout to anus	4.4 cm.
Femur	2.1 cm.
Tibia	2.0 cm.
Leg and foot	6.7 cm.

FORM.— *Head.* Width greater than the distance from snout to axilla. Eyes invisible from ventral view. Nares half way between anterior corner of eye and end of snout. Distance between nares much greater than interorbital width. *Tongue as in R. cantabrigensis.* Group of vomerine teeth small and oblong. Tympanum smaller than eye. A distinct notch on each side of symphysis of the lower jaw.

Body. Stout; dorso-lateral fold-lines *very distinct.* Back, flanks, and lower belly smooth.

Fore legs. One tubercle on the palm. One tubercle each on the first, second, and fourth digits. Two tubercles on the third digit. First, second, and fourth fingers equal. Hind finger about half as long again as others.

Hind legs. Posterior ventral sides of femora only granulated. Web much broader than in *R. cantabrigensis*, in the majority of specimens examined, not curved.

The broader web, perhaps in part a secondary sexual character, is more prominent during the breeding season. A large tubercle on the inner side of the foot, and a small one on the outer side and on the under side of digital joints. *Legs thick and short, much more so than in R. cantabrigensis cantabrigensis. Tibia slightly over one third the length of the body. Distal joint of tibia reaching orbit.* First toe equal to first joint of the second toe. Second toe reaching one half the way up the second joint of the third toe. *Third toe reaching to the third joint of the fourth toe.* Fourth longest. Fifth nearly equal to the third toe.

COLOR. — *Dorsal surfaces.* Dark brown to pale yellowish gray. Head with a vitta through the eye and on each side behind the eye, including the tympanum and extending forward as a broad line from the corner of the eye through the nares to the snout. A light line extends from the end of the snout to a point above the axilla; other parts of the head faintly marked with darker. A light median dorsal line from snout to anus present in many specimens.

Body between lateral folds varying from almost unicolor to definitely marked with darker. Lateral folds, if present, light and bordered by a line of dark spots, the spots sometimes forming a streak. Sides generally heavily marked.

Fore legs. A dark mark on anterior edge of humerus, and otherwise spotted lightly and irregularly.

Hind legs. Faintly barred, but generally spotted with darker.

Ventral surfaces. Pale white. Faint and almost no dusky markings. The distribution of this species covers the greater part of Alaska, and extends southward to the region of Great Slave Lake, Can.

Cope, Bull. 34, U. S. nat. mus., 1889, recognized a color variety, *Rana cantabrigensis evittata*, but this owing to the great instability of coloration common to wood frogs cannot stand. The diagnostic character he mentions in addition to coloration, viz: "three phalanges free," I find on looking over a series of specimens does not hold; and Cope could not have had a very clear idea of the form himself when he identified with it a specimen from Moose River, Can. (5366), whereas this specimen is without doubt *Rana septentrionalis* Baird.

In examining a large series of wood frogs it becomes at once evident that the only stable character that can be followed for identification is the comparison of measurements; the most important being the comparison of the length of the tibia to the body. The following table shows how distinctly these measurements separate the two species and subspecies.

Rana silvatica. Tibia *more* than half the length of the body.

Rana cantabrigensis. Tibia *one half* the length of the body.

Rana cantabrigensis latiremis. Tibia *less than one half* the length of the body.

The distribution also, to a great extent, separates the three.

In preparing these descriptions alcoholic specimens in the case of *R. cantabrigensis* and its subspecies have been used and an allowance for faded coloration should be made, although some consideration was taken of this fact when writing the descriptions.

I take this opportunity to thank Mr. S. Garman and Mr. G. M. Allen for their great kindness in helping me in many ways in the preparation of this paper, and also Mr. F. W. True for his kindness in forwarding me specimens from the United States national museum.

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STUDIES IN THE GOLD-BEARING SLATES OF NOVA SCOTIA.

By J. Edmund Woodman.

WITH THREE PLATES.

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March, 1899.

No. 15. — *Studies in the Gold-bearing Slates of Nova Scotia.*

By J. Edmund Woodman.

With three plates.

CONTENTS.

General Statement.

Along the Atlantic side of Nova Scotia a series of gold-bearing rocks extends from Cape Canso irregularly westward to Yarmouth, in a belt which averages from ten to forty miles in width. It covers an area estimated at somewhat over 6,000 square miles; but fully half must be deducted for the many intrusions of granitic rocks. The sediments consist of slate, sandstone, quartzite, chloritic slate, and schist, always pyritiferous, and here and there a conglomerate. They have been profoundly metamorphosed, both by dynamic and igneous agencies. No fossils are known from them, and their exact age is in doubt. From the best fragments of evidence, however, they may be regarded as probably Algonkian. Between and occasionally cutting the strata are veins of quartz and calcite containing gold, both free and in the various sulphides, which are abundant. The sediments themselves are impregnated with sulphides, gold being found at considerable distances from veins. The whole mass, sediments and veins alike, has been thrown into east-west folds, and cross-folded and faulted north and south; and the crests of these folds have been denuded, fixing the location of the roughly elliptical mining areas.

During the season of 1897 I visited a number of the most promising portions of the series, with the intention of deciphering its history, as far as opportunity allowed. A review of certain points was possible during the following season. Much work has been done by local geologists in exploiting single areas; but, as far as the literature shows, no attempt has been made before to connect the bits of evidence which go to make up the story of the rocks. The region studied includes many of the exposures over an area roughly estimated at thirty miles square in the counties of Halifax and Colchester, and stratigraphically near the center of the series, where the auriferous slates and veins are most prominent. Special attention was paid to Moose River Mines, Gay's River Mines, Waverly, and Cow Bay.

I am greatly indebted in the prosecution of the research to Prof. N. S. Shaler, and to the officers of the several mining companies in whose shafts and tunnels I worked.

Structure and Characteristics of Portions of Halifax and Colchester Counties.

Sediments. — Two main divisions of the series were early recognized by Campbell ('63). Of these only the lower, called by him the quartzite group, contains workable bedded veins. The latter are exposed intermittently in belts, especially east of Mount Uniake.

The slates vary in texture, but their chief differences are due to secondary causes. The color is usually bluish; frequently, however, altered to green by chlorite, to brown by the oxidation of pyrite, or to a gray by the loss of iron upon highly weathered surfaces. Alternations of color in some places are frequent, while in others considerable masses may be uniform. This depends upon how thinly the rocks are bedded. Often, in the coarser sediments, leaves of schistose slate, only a fraction of an inch thick, will be found persistent for many feet. Again, it is a common condition for isolated sheets and lenses of slate to occur in the midst of a massive bed of sandstone.

The arenaceous sediments include what the miners call "whin." This term, originally used by Hutton in the sense of trap, and still employed in Cornwall with the same meaning, has been applied here to any kind of rock, other than slate, which cannot be mined.

Thus, one hears of the three-fold division of the series into ore, slate, and whin — the erroneous idea prevailing that neither slate nor whin is available as ore. As a whole, these coarser sediments are thickly bedded, and comparatively uniform in color and texture through a considerable thickness. They vary, however, in degree of consolidation from quite friable sandstone to dense quartzite; and, although prevailingly fine-grained, they grade into pelites on the one side and, through grits, into conglomerates on the other. Their color is generally dark green in unaltered specimens; upon weathering first becoming brown through oxidation of sulphides, then bleaching to a yellowish white.

At Moose River Mines and at Waverly the sediments can be studied readily. In the former settlement artificial outcrops are few, but a number of vertical faces in quarries can be used. At Waverly there are few pits, and the shafts follow veins; but natural exposures can be found, including a total of several hundred feet of strata.

Regional metamorphism affects the whole series. Both coarse and fine rocks have been hardened, although subsequently rendered fissile by cleavage. Muscovite, chlorite, and calcite have been developed, in some cases along bedding-planes, in others along cleavage planes. A large proportion of the sandstone has been altered to a rock which always has been called quartzite by students of the series. It breaks with the lustrous fracture noticeable in that species; but microscopic examination shows that much of it is in a state which will not permit the use of the term. In these cases secondary deposition of silica is slight, while chlorite and muscovite are developed somewhat; calcite is abundant, giving free effervescence with acid. This is noteworthy, in view of the statement of several observers (Gilpin, '88, and others) that little lime is to be found in the series. In some cases it is not possible to tell whether the muscovite is fragmental or secondary, because of the small size of the particles. Occasionally the sediments become chloritic schists or mica-schists, and in many more instances the microscope reveals distinct schistosity in a minute way.

The presence and position of sulphides and sulph-arsenides in both classes of fragmental rocks and in veins deserve separate treatment. Gilpin ('82) mentions, as accessory to the gold, "sulphides and arsenides of iron, galena, blende, copper pyrites, oxide of iron, copper glance, molybdenite, native copper," etc. The principal sulphides are pyrite, arsenopyrite, chalcopyrite, and galena. The galena occurs only in veins, so far as my observations go. The others are present in both veins and sediments, and much of the gold is locked up in them. Pyrite occurs in small cubes and minute granules, rarely in masses of several crystals; arsenopyrite is found in typical striated prisms, often half an inch long, and in massive form; chalcopyrite exists chiefly in irregular masses.

Pyrite is the most abundant sulphide, and in the sediments its attitude is characteristic. The strata have planes of division, unevenly distributed, which mark the more abrupt changes in texture and color, and along which the fissility is more marked. These may be called major planes of division. Between them are other minor planes at which the cohesion is greater, and which represent smaller changes in the conditions of sedimentation. In the slates the pyrite lies along major planes of division, and in some cases along minor ones, and is scattered sparingly through the mass of the stratum. Rarely it is irregularly distributed in large quantities within the bed. This position is so constant that, where stratification in the slate cannot be deciphered by color-bands and is obscured by cleavage, layers of pyrite, if present, serve to give strike and dip. Usually the mineral is abundant along the base of a layer and decreases upward. In other instances it is plentiful in the center of a bed and concentrated again at the division-plane. In the coarser strata it is less regular in distribution, but in general follows the same rules as in the slates. In veins a considerable amount is to be found, but it has no regularity of position. Frequently it protrudes from the sediments into the quartz. On the borders pyrite is often collected in sheets, chiefly on the hanging-wall. It is less abundant or absent on the foot-wall. In the oxidized zone near the surface, all this is brought out clearly; below that it is not so easy to find.

Arsenopyrite occurs most abundantly in the whin, distributed irregularly, often with its crystals lying at an angle to the bedding-planes. It is also situated sparingly along these planes, and in a few cases has been seen to lie directly across them, part being in one stratum, and part in the other. In veins it is common in massive form, but crystals are comparatively rare.

The whole metamorphic series is cleaved strongly. The strike of the laminae averages not far from that of the rocks in many localities, and is persistent throughout the series, showing unity in the force which produced it. Slates show this cleavage to a high degree. In many places the rock is given the sheen peculiar to those stages of metamorphism of slates on the way to becoming mica-schists and chloritic schists. The presence of the oxidized zone has not affected the degree of fissility to any marked extent in the region as a whole. Cleavage has more varied effects upon whin, which is quite brittle. Deep below the surface of the earth, the rock to the eye presents little fissility; but in the oxidized zone it is cleaved strongly in most instances, falling to pieces with ease under the pick. No doubt this result is aided by the stretching of pyrite, the crystals of which lie at the major planes of division; and the rusting of the sulphides and separation of the strata give a serrated appearance to the cross-section of the beds thus affected. Upon close examination, this serration is seen to be due, in some places at least, to strain-slip cleavage. Two places show this well. The first is at Moose River Mines, on the eastern face of a large quarry. The second is at West Waverly, about three hundred feet south of the old crusher west of the railroad track. Here a number of parallel thin lenses of slate, none of them more than a few inches in length, have been so sheared by the cleavage as to present the appearance of a series of ragged fringes overlapping one another, and giving the impression of involved igneous contacts.

The fissility is not all vertical; nor are its planes parallel over considerable areas, but dip now to the north, now to the south, always at a high angle. The axial planes between the two sets of dips, while in the main parallel to those of the folds first formed in the sediments, are not coincident with the latter, but may lie anywhere between the axes of the anticlines. The series is traversed by many joints. For the most part the systems formed by them are only local, and often several systems are to be found in the same territory.

Veins. — The chief interest in this series attaches to the gold-bearing stratified veins, often called "leads." These are from a fraction of an inch to six feet in thickness and in most cases of unknown length and depth. Many have been traced for a large fraction of a mile by intermittent outcrops, and this is probably only a small portion of their total length. Apparently they are not of unlimited extent, but die out and are replaced by others on adjacent planes. This has been reported from many mines, but has not been observed by me. They lie strictly in the bedding of the sediments as a rule, leaving it only to cut across abruptly from one stratum-plane to another. This irregularity is never so extensive as in the case of many veins filling ordinary fissures; and often the structure of a region can be deciphered by the inclination of the shaft-heads. In position, they sometimes lie between strata of slate, still more often on the contact between slate and sandstone or quartzite, and very seldom between beds of sandy material. It is common for a number of veins to lie parallel, separated by a few inches of country-rock; and these can generally be proved to have connection with each other. Both Moose River and Waverly show this. In the latter village the "barrel lead" east of the lakes is composed in places of parallel sheets of quartz, separated intermittently by thin laminae of slate, the whole forming one large vein. In very many places stringers, locally called "angulars," run out from the main veins into the country-rock above and below; and it is claimed by miners that they are most abundant in the hanging-wall of a "roll," and indicate the proximity of a pocket of gold.

The composition of the vein filling is uniform. By far the larger part of the gangue is quartz, which in many places is the only mineral; but often calcite is plentiful, erratically distributed. There is no definite order of growth, and frequently the quartz and calcite are indiscriminately mingled; yet in some cases quartz lines the walls, and calcite fills the interior. The former is usually compact, but seldom of the density and whiteness seen in many of the north-south barren fissure-veins. In places it has a cellular structure, showing successions of growth in the crystals; rarely drusy cavities are seen in the center of the veins, with free crystal terminations projecting into them. Frequently the quartz has been given a somewhat mealy appearance by the crushing which it has endured. Indeed, in its generally shattered and fragmentary state, most noticeable in thin veins, but observable often in thick ones, it bears witness to the action of powerful orogenic forces. The most complete shattering of the rocks, accompanied by small dislocations, usually is found where the folds plunge east and west; and for the most part the bedded veins have not taken advantage of the conditions. Much secondary growth has taken place, later additions of quartz, in some instances, increasing the thickness of the veins several fold. This is especially true in "rolls," to be described later, where the largest amount of accretion is to be observed. In places the successive layers or generations of growth can be seen distinctly, separated from one another by films of impurities or by differences in the alignment of the layers of quartz.

In regard to the origin of the bedded veins, two views have been held, as noted in the historical portion of this paper. The possibility that all the gangue was deposited as a mechanical or chemical precipitate in open water was early denied, and since 1870 has not been defended. Fissures which extend above and below the main veins, crossings from one stratum to another, and horses of country-rock enclosed in the quartz are irréfutable arguments against this view.

There is another hypothesis, however, which it would be well to consider, although it has not appeared in print before. The suggestion has been made that the veins began as films of sedimentary silica, and that they have grown by secondary deposition of material which has entered in solution, in the usual manner. There certainly has been growth, amounting in some instances to much more than the original thickness of the vein, and subsequent to its first formation. But where are we to look for films of silica deposited in the sea, and where not? Is such a primary layer present throughout the length of a single vein? If so, especially in the case of the longest ones, there must have been a remarkable uniformity of conditions on the sea-bottom; if not, considerable portions were formed by ordinary methods. Moreover, where the growth of the veins can be studied in the field, the evidence is of continual accretion inward, on both sides, as in other fissure-veins, and not from a central primary layer outward. In addition to this, the field conditions do not point to a sedimentary origin of *any* of the quartz. We know that silica can be dissolved, to an appreciable extent, in water of ordinary temperatures; but deposition of the substance in continuous sheets of some size would require a previous concentration of material from a larger region than it is easy to credit. Again, such a substance of necessity could be deposited in a pure state only in places where no mud and other coarser foreign particles were being dropped. Yet we find abrupt transitions from silica to slate, and from silica to coarse sand, the particles of which must have been deposited in water having a very appreciable motion.

It seems as though no more proof than has been given by previous writers is necessary to show that these are fissure-veins, and that the difference between them and others is merely in their attitude and the character and origin of the fissures.

If the quartz and calcite are not directly sedimentary in their nature, they must have one or more of three origins. They came from below, or from the surrounding rocks of about the same horizon, or from above. If they descended, the solutions must have been cold, and the same probably may be said if lateral secretion accounts for their presence. There were no cross-fissures, else the water would have deposited its burden in them. If any gold existed in the sediments, its collection might have been effected; but the concentration of gold appears to have taken place for the most part at a later date than that of the formation of the first crevices. Solutions would penetrate more readily the coarser and looser textured sandstones, and the finer grain of the pelites below would cause deposition of minerals along the contact. But we find veins at the under as well as the upper contacts of slate strata. If the clay intercepted descending solutions, the veins ought to be most frequent in the upper portion of the series, where there is abundant opportunity for such interruption. But they are by far the most common near the middle, where the proportion of slate to sandstone is greatest.

Against lateral secretion the same arguments hold, in part. The coarser beds do not look as though much silica had been carried through them in solution, for they have comparatively little secondary growth on the quartz grains. The silica necessary for the formation of the veins would have necessitated an extensive leaching of the surrounding rocks, and would have left its mark in the condition of those rocks; and the arenaceous sediments, which were formed principally from sand, would probably have received most of the veins.

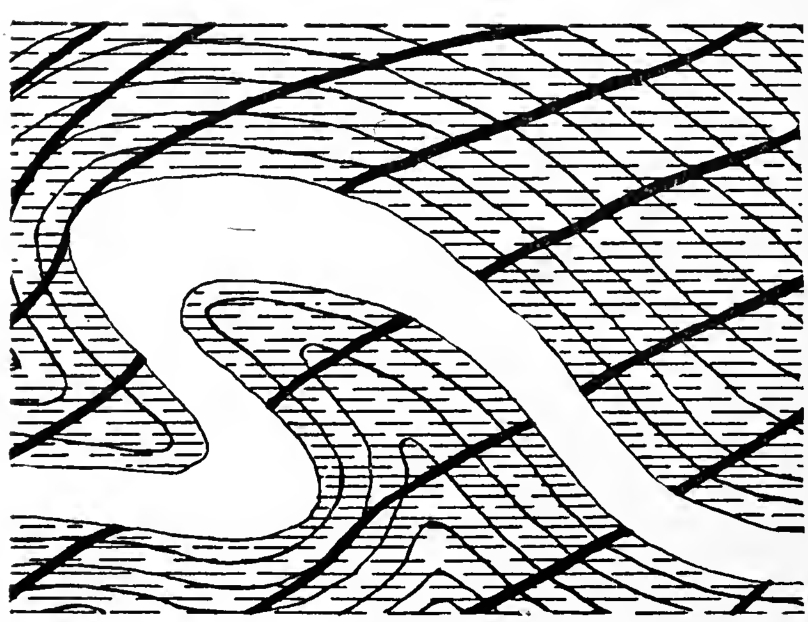
It is more natural, and in better accord with the facts, to suppose that, although the veins lie parallel to stratification planes, they came from below in the same way that many others have done, and were formed from hot waters which bore various substances in solution. Their distribution appears to have no reference to a possible local supply, but does agree with planes of weakness along which they could force their way under pressure. There is much calcite in the cement of the arenaceous sediments; and it might be supposed that at least this portion of the gangue came from them. But usually it is either closely mixed with the quartz or fills the interior of the vein, and thus appears to have a common origin with the silica, and to have entered the fissures at the same period.

There are very many veins filling crevices not coincident with stratification. These include, as one class, stringers connecting various bedded veins, and the "angulars" running off from them; but they belong to the age of the main leads, and need not be considered here. In addition there are "cross-leads," as they are called locally, younger than the others and independent of them, and filling irregular crevices or regular joints or fault-planes. In Nova Scotia they belong, in part, to a series running in planes of dislocation formed at the second period of folding and faulting, but erratically distributed, and not occupying all the faulted area. For the others it is impossible to find any system. Most of these and a large number of the former are barren; but at Cow Bay a definite series occurs, carrying a fair amount of ore.

The veins at that locality lie in nearly vertical fissures striking in general N. 25° W., and intersecting rocks which have the usual strike and an average dip of 40° S. The gangue is chiefly quartz, with some calcite. Pyrite and arsenopyrite are abundant, the latter massive. Galena and sphalerite are more common than in the bedded veins, and often are associated closely with gold, which is found free as well as in sulphides. The structure of the gangue is on the whole much more open and cellular than in stratified leads, and drusy cavities in the center of the mass are frequent, sometimes filled with galena and sphalerite. The quartz lies in part in distinct crystals perpendicular to the walls, in layers separated by films of impurities. However, in the larger veins the gangue is quite dense. The sulphides occur chiefly in the middle, and evidently were among the last minerals to form; but their order and position are not constant. In a few cases, chalcopyrite was the last mineral to enter, and includes other sulphides. Arsenopyrite is scattered through the gangue, and occasionally projects from the whin contact into the quartz. It is abundant also in the whin. Pyrite is perhaps the commonest sulphide, and often is found as a coating on horses. The galena is stated to carry silver.

The veins are very persistent in strike and dip; but they send out innumerable small branches into the country-rock, and often two master-veins are connected through irregular cross-fissures which do not correspond to any definite structural feature of the sediments. The walls are far less definite than in the bedded veins. Horses are abundant, and in some cases the wall-rocks are brecciated for several inches and impregnated with minerals. The series lies, as far as my observation shows, within what may be regarded as essentially a single bed of whin. The latter is composed in reality of many heavily bedded strata interspersed with a few thin layers of slate carrying some veins of the bedded kind; but the proportion of slate to whin is exceedingly small. On the south of this belt, which is one or two miles broad, 2,000 feet of slate overlie the gold-bearing rocks. On the north those who live in the district report another broad band of slate, with a small amount of whin. The cross-leads die out on the margin of the slate on the south, and have been looked for in vain on the north. If the fissures extended beyond the belt of whin, veins would be found in them. It seems, then, that here may be a case on a large scale of what the studies of Mr. J. B. Woodworth have shown to be common in a small way — a system of joints, confined to a series which is essentially homogeneous, and disappearing when rocks of different texture are reached.

Cleavage has had no effect upon either the bedded or fissure-veins of the series. The quartz has been more or less crushed, but it is impossible to say that this was accomplished by the force which produced the parallel fissility. As a rule, cleavage has ignored the veins, stopping on one side and beginning again on the other; but occasionally it has swerved a little from a true plane. This happens where the side of a roll presents surfaces nearly parallel to the



Diagrammatic section of quartz vein in slate, Moose River Mines. Vein, white; stratification, light full lines; cleavage, light dashed lines; joints, heavy full lines.

cleavage, but departing from that relation gradually towards the top and bottom. The metals within the vein, and even on contacts between gangue and country-rock, have not shared in the general distortion, and thus appear to have been protected by their relations to the resistant quartz. The cleavage planes of the calcite in the veins are often curved; but it is not possible at present to designate which of the various orogenic forces concerned in the history of the series produced the result.

Structure. — The whole series of rocks is folded in a direction averaging N. 65° E. in Halifax county, becoming more northerly in the western part of the Province. It is noticeable that the general trend of the peninsula also changes correspondingly. The force producing these plications probably came from the south, although the evidence on this point is not clear. A second folding took place subsequently in a direction nearly at right angles to the former, culminating in an extensive series of faults, which strike roughly north-south. These newer flexures are said to be less frequent in the eastern portion of the field, and to become gradually more abundant westward. They have been equally instrumental with the earlier ones in locating the present mining settlements, by doming veins up so that denudation has given intermittent exposures.

The faults are both normal and reverse. As they were formed in the main by pressure, the latter are most abundant, and tension or gravity faults afforded local relief. In places their magnitude is considerable, the throw being several hundred feet. Most of them belong to the end of the second period of folding, and those formed as a result of the first plications are small.

The structures produced by these orogenic processes can be seen in most of the mining districts. Oldham, Renfrew, and Moose River Mines are cases in point. The first two have been mapped in a general way (Hind, '72). Of the last, a detailed map on a scale of 1: 3,000 has been published by Mr. Faribault of the Geological survey of Canada.

In many places the bedding is smooth but in many others it is disturbed by corrugations, which vary from minute crenulations up to "rolls" several feet from crest to crest and two or more in depth. The large cases are known locally as "barrel quartz," and from smallest to largest are all the same in character and in origin. They start in veins, and are participated in by them and the adjacent slates, very rarely and only to a slight extent by other members of the series. They are found sparingly on the sides of the east-west anticlines, but are common where the axes of these are made to plunge downward by the doming effect of the north-south folding. In a few instances they may be horizontal; but usually they have a distinct pitch dependent upon the degree of inclination of the axes of the folds, the thickness of the leads, and the character of the country-rock. In this they are not exactly coincident with the bedding, for on a plunging axis they converge at smaller angles than those of the strike lines.

A noticeable feature is the local nature of the distortions. Near the vein the stratification of the slate follows closely the twisting of the quartz. As one recedes from it, however, the bedding-planes become less strongly crenulated, until from an inch to several feet away the waves die out. The coarser the sediment, the less it has yielded visibly to the forces; and in contact veins the quartzite wall is even, and the slate wall rolled more than is usual in veins which lie wholly within the slate, at some distance from any whin. The appearance suggests that there may be a compensation, the rigidity of the whin forcing greater buckling in the more plastic slates. In still other cases, where the vein is in slate, but within a few inches of a quartzite bed, the slate on the side toward the whin is crenulated and crushed till the particles have little power of coherence; and on the other side the rolling is regular and the slate bent without fracture. In general, however, the corrugation has weakened the sediments near it.

A structure similar to rolling is observable in sections of the Cretaceous clays and sands of the Atlantic coastal plain. In these water, often bearing iron, has buckled up the clay laminae in a manner precisely similar, leaving adjacent sands untouched. The phenomenon has no necessary relation to the concentration of gold, although barrel quartz is considered by many Nova Scotian miners as sure to be rich; but in some veins it appears that gold was either brought up by the new solutions, or concentrated from the sediments at about the time of corrugation, and now lies on the borders of these rolls in pockets.

In Moose River rolling can be studied in detail, although the lack of coincidence between the attitude of the rolls and that of the axes of the main folds is not very marked. The best places for observation are quarries near the road, and winding tunnels following the Great North or "Serpent" lead, which bears quartz over a foot thick flexed in large waves. The parallelism of quartz layers also is marked here. In the quarries much smaller examples show many points not brought out so clearly in the large cases.

At East Waverly occurs what must remain as the type case of rolled or barrel quartz. It has been described by some of the earlier writers, and in one or two cases figured in a diagrammatic way. The resemblance noted by Silliman and others to a corduroy road or a succession of barrels ceases when both sides of the vein are seen. Instead of a series of cylinders laid side by side, the rolls are merely what would be made by corrugating any flexible sheet, and their two walls are parallel for the most part. The lead lies almost on the contact between slate and whin, and the tunnels show both walls in many places. The adjacent slate is plicated as closely as the vein, while the hanging-wall of whin is perfectly even. The rolls are regular, and show a divergence with the bedding which increases as one goes towards the axis of the older fold at the end of the main tunnel. At West Waverly none of the leads have distinct rolls so far as observed.

In this district of Waverly, which embraces an area roughly two miles east and west, by one north and south, all the complications attendant upon the two series of orogenic movements are highly developed, and well revealed by erosion. For this reason I have chosen it for description as a type of the kind of structures originating in the Province under such circumstances. So far as I am aware, the form which it presents has been seldom noted in text-books, when treating of dynamical geology. It is thoroughly characteristic of the series, although presenting some individual peculiarities; and its main features are more accentuated than in most of the other cases which the series exhibits. On the eastern border, as at Isaac's Harbor, the main anticlines are so long that their plunging ends may not be met within the range of a single settlement.

The structure of East Waverly is that of an east-west anticline, which begins to plunge eastward at a very low angle beyond Willis Lake. Near lakes William and Thomas, at a point about 750 feet east of the shore road, it commences a steep plunge to the west, the vein dropping 185 feet in 425, and continuing downward at an angle of at least 50° when last seen, at lake-level. This vein, famous as the type of rolled or "barrel" quartz, has been well opened for several years. On the summit of the hill 1,200 feet of the crest of the fold have been exposed by open quarries, but nearly half of this distance is now obscured. In addition, a tunnel runs 670 feet east along the axis from the lake-front, intersecting all the rock overlying the vein. From its end an up-raise is excavated along the vein, till the axis reaches nearly a normal horizontal position; and from the same point branch tunnels run north and south, following the strike of the vein in its change eastward, giving completely the structure of the pitching fold.

One of the points most noticeable in the openings, particularly in the quarries, is the flatness of the crown. This crown was the only portion exposed when the region was visited by Silliman and later studied by Hind, and gives a belt fifty feet wide in places, with almost no dip. This can be explained, however, by the fact — which a study of the whole field reveals — that it lies at the top of a folded series, and that it is immediately under a massive cap of whin. In contrast to this is the evenness of dip of the sides of the anticline. The vein in its descent soon reaches an angle which is almost constant throughout the vertical range observed, a total of 230 feet directly and of nearly 1,200 by means of the fault-blocks and shafts to the west. This must mean either that some of the folds to which we give full swelling sides in section should be drawn with straighter shanks and narrow but flat crests, or that the fold in question is larger and deeper than anyone has hitherto thought. If it be true that the deformation is more extensive than has been thought, it has a direct bearing upon the possibility of deep mining in the district — a plan which has been urged often by Canadian geologists, and as often rejected by conservative investors.

The tunnel shows that a thick cap of whin overlies the vein, with but few thin bands of slate and one or two small veins. The surface outcrops on the hills, north and south of the axis, show nothing but whin for at least 500 yards.

West of Fishing Lake is another area of whin, which, as far as my present study can determine, is a continuation of the cap overlying the barrel quartz lead of East Waverly. It runs for an unknown distance westward, at least to the line of the Intercolonial railroad. Its attitude can be discovered only by occasional thin bands of slate; and by these it appears to form the end of a fold pitching west, like the other portions of the field. As it lacks economic importance, detailed study of it has not been made. No bedded veins have been observed in it, but it contains several barren cross-leads striking roughly north-south and dipping east. The location of the fault on its eastern border is marked by an escarpment seventy-five feet high, which serves to bring out forcibly the difference in resistance of the whin and slate.

East of the whin cap are the fault-blocks that contain most of the profitable veins. The first of these has an up-throw of 967 feet, the flat portion of the barrel quartz lead at East Waverly being taken as a datum-plane. At the center of the anticline, immediately west of the railroad, appears a mass of whin of greater visible thickness than any other except the cap; and it seems to mark the base of this local gold series. The ledge presents a great contrast to that which exposes the summit of the series. Instead of lying in a broad flat crown, the beds dip steeply from the very axis, showing a greatly pinched condition of this portion of the fold. Outwardly north and south from this axial outcrop are many veins, some worked, others idle, and all running with the bedding. They must be far more numerous than the outcrops show; but here, as in Moose River and most other mining settlements in Nova Scotia, little or no attempt has been made to uncover the bed-rock in a trench across the strike and bring to light all the leads that come to the surface. Only three veins are shown upon the map, because of the small scale employed; but enough are set down to give the structure of the area. The edge of the slate series on the north has been determined in several places; but its extension westward in the curve shown on the map is partly inferred from the plunge of the fold and the relations of various beds. Drift hinders detailed work in most places where artificial exposures do not aid the observer. This is especially true on the south side of the fold, where few veins are mined; and as a result, the southern limit as given on the map is conjectural, and liable to a possible error of 400 feet. Indeed, it is probable that on account of greater denudation the margin is slightly farther to the south than is shown.

The pitch of the axis is not uniform, but is steeper at first, more gentle in the center of the block, and continues at a very gentle grade towards the western margin. This is shown by the convergence and dip of the leads where observable. The south dips are less steep than the north ones; hence the axial plane of the fold does not lie vertical, but dips somewhat southward. The denudation of a plunging anticline of this character would cause a slight northward migration of the surface outcrop of the axis where the plunge occurs. This is hardly appreciable, however, in a fold so little unsymmetrical. The same may be said of the axis at East Waverly.

The next fault-block presents some structural problems that cannot be solved with the present data. No veins are now worked south of the axis; and the position of those mapped in Hind's report ('69) is, in view of the errors of location of other structural features, problematical. On the north of the axis the veins have been thrown north 190 feet. This leaves two possibilities. The motion may have been a vertical one, the axis upon denudation remaining in the same position, and the veins on the south being thrown as far southward as the others migrated northward; or the whole block in its movement may have been wedged northward 190 feet. At Moose River the horizontal component is marked, and very probably conditions are the same here. This conclusion is provisional, but is based upon what appears to be a common method of faulting in the series. If it be correct, then there has been horizontal motion along an almost vertical plane, due to pressure from the south; and in a section along the axis it would appear as though no additional dislocation had taken place.

The admission of the two small fault-blocks west of the lakes rests upon two pieces of evidence. One of these is the map accompanying Hind's report mentioned above, which gives two faults. The other is the statement of the owner of the land on which the full-line portion of the fault lies, and who has uncovered the land in years past for certain leads. At present there are no outcrops, hence the direction of the veins in these two blocks cannot be determined directly. I have copied Hind's map in this respect, because there is no other authority. The offset of the easternmost block is based upon the same data as the existence of the third fault.

Ores. — In the sediments gold is largely in sulphides, even near the surface. Slate holds it in paying quantities often at considerable distances from veins, but some localities appear to have little. This may be due in part, however, to the lack of accurate tests in those places. At Moose River pure slate yields in crushing over $2.00 of free-milling gold per ton, and is as rich away from veins as near them. Whin is popularly supposed to be barren, but recent assays have shown gold up to one or two dollars per ton. Sufficient tests have not been made to show relations between the presence of gold in the whin and the proximity of veins. In the latter gold is more erratic than in the country-rock, and often a whole region is characterized by the presence of "pockets" with lean places between. Below the drainage level of the region most of the metal is in sulphides; and this proportion increases downward for some distance, as less and less water penetrates the rock. The free gold here, in the veins, occurs in the same forms and positions as in those nearer the surface. Within the oxidized zone above, some gold is free in the country-rock, and a large proportion in the veins. In the latter it occurs along the walls, tonguing into the gangue, or disseminated in fine particles through the latter. Where the metal lines the sides of rolls, it is usually bounded toward the country-rock by a rusted zone. From here it runs inward in stringers, often along distinct fractures. So far as I am aware, no analyses or assays have been made systematically, to discover how much is still imprisoned within the influence of water action. As a rule the free gold appears without distinct crystallization; but one crystal, having a dodecahedral form, has come to my notice, and a few others have been reported in years past. The one noted above came from Cow Bay, where it probably has a deep-seated origin.

The method of occurrence of gold in the veins of this series, its distribution in the country-rock, and its relations to sulphides point strongly to the conclusion that at least a large part was deposited in the sediments and has been long in process of concentration in the veins by water which comes downward from the surface. It is possible that not all the gold in a region of so complicated a history has the same source; but while some may have been brought up with the quartz, the facts so far observed do not show that more than a small share of it had that origin.

An exception to the sedimentary origin of the gold must be made in the productive fissure-veins observed thus far. Of these Cow Bay affords the best example. Here the metal occurs chiefly near the walls, but is not confined to that position. There is a local belief, well founded for certain veins, that values are higher in "rough" or cellular quartz. Examination of many specimens shows that the most frequent attitude is in planes parallel to the vein-walls, in quartz the crystals of which are not visible, or between layers of crystals. Where the veins cut across intercalated slate bands there is no corresponding change in the "carry" of the ore. This is against lateral secretion as a method of concentration. So far as seen, no gold occurs in whin, and the superjacent slate is reported to be barren by those who have tested it. Experience elsewhere shows that, when gold has come from the country-rock, its source has been chiefly slate. In this region the latter occupies scarcely one per cent of the section traversed by the veins; hence to have been leached of sufficient gold to give over an ounce per ton of quartz, as is yielded in some shafts, the rock must have been extraordinarily rich. There is no evidence whatever that this has been the case. On the other hand, the structure of the veins and the character and positions of the accompanying minerals point strongly to a deep-seated origin for the metal.

Eruptives. — The only eruptives that have come under my notice belong to the granitic series. Their general distribution can be seen on any of the later geological maps of the Province. The edge of one boss lies a short distance east of Waverly, but it has not been possible to give it a careful examination. What has been seen confirms the general conclusions of the later writers. The rock alters already metamorphosed strata; yet Gilpin in '82, and again in '85, agreed with Dawson in claiming the rough contemporaneity of the intrusion of the granites and the formation of the veins. In '88, however, Gilpin implied the greater age of the latter, in stating that by the intrusions they are not "changed from their normal character beyond any slight variation due to metamorphism of the small percentages of lime, etc., commonly occurring in them."

In Halifax another large mass of granite has its eastern boundary. The rock is a coarse hornblendic granitite, whose contact has not yet been studied closely. Near it the slate loses its fissile character and largely its jointing, and becomes harder and more compact. Between the granite and this portion of the slate, where I have seen it, is a rock which in the field appears to be a rather coarse trap. Microscopical study of the problem has not been possible. The granite near this trap is fine-grained, and becomes steadily coarser for half a mile away from the contact. As it grows coarser a porphyritic structure appears, the orthoclase crystals attaining a length of from one to one and a half inches. The rock as a whole is very feldspathic and weathers rapidly. This field west of Halifax is one which could be employed to great advantage in a study of the relations between the granites and the clastics.

Denudation. — The structure of the series as a whole is not well enough known to determine how much of the sediments originally deposited have been lost by erosion. Lower Carboniferous conglomerate near Gay's River contains metamorphosed slate and whin with fragments of the attendant quartz veins; and undoubtedly its gold is also derived from them. The older rocks at the contact with the conglomerate show a much denuded surface, with rounded projections, in appearance like small roches moutonnées, and about four feet long. From the structure of the neighboring slates it seems probable that a great amount of the erosion had taken place before the lower Carboniferous was deposited, and that the proportion lost since that time is relatively small.

It cannot be determined yet whether the older rocks were above water during most of the time between their first folding and the era of the conglomerates, but this seems probable. Debris from the gold series has not been recognized in younger sediments, except in boulders of the age just mentioned. But if the auriferous rocks were submerged during the intervening period, or even during any considerable portion of it, we find it necessary to account for the disappearance of all the sediments that were laid down, not only over the area of gold rocks as now seen, but also over the territory occupied by such Carboniferous strata as lie directly upon the gold formation.

In a large measure the present topography was produced by pre-Pleistocene denudation. Drift has determined details in the course of many of the streams, but the main features were there before ice over-rode the land. In many places, as at Moose River and Cow Bay, the peneplain level is preserved. For miles the rock is within a foot or two of the surface, covered with a loamy soil or a growth of Sphagnum and other moisture-loving plants, whose presence is due to the sluggishness of the drainage. In others, as the region about Waverly, an uplift, which appears to have occurred since the peneplain was formed but before the Pleistocene epoch, has allowed the etching of broad waterways. The place just mentioned lies in a north-south valley which is the highway for a chain of lakes and connecting streams flowing northward across the peninsula to the Bay of Fundy. East of the junction between lakes William and Thomas, steep hills rise from the water's edge to a total height of 240 feet, the average being 190 feet. West of the lakes the faulted areas are low, scarcely more than fifty feet above the water at any point. Still farther west beyond Fishing Lake, the overlying whin, stratigraphically the highest area in the region, stands up as a hill sloping west, and presents an abrupt fault-scarp to the east. The surface of the higher hills may be taken as approximately the level of the peneplain. The etching has been due to the uplifting of blocks into heights of more rapid denudation, in consequence of which the durable whin overlying the auriferous slates has been removed and the softer rock below eroded to a lower level than the whin of the unfaulted areas to the east and west. Both fault-blocks in which the beds plunge westward have their steepness of surface in accordance with the dip of the beds, although not so high. At East Waverly the whin cap is eroded over the axis of the fold to within a few feet of the slate, and a view from the west shows a depression of the crest-line at that point, indicating a near approach to the unroofing of the anticline.

The distribution of mining regions and the shapes of the outcropping areas are due to the intersection of domes of various shapes by the peneplain surface.

History of the Series.

The question of the age of the series is as yet a matter of doubt, and it is probable that this uncertainty will continue until fossil evidence has been found. I can add nothing to what is already known, for all the "fossils" I have found turn out to be concretions which so far have not shown even an organic nucleus. The most rational view appears to me to be that of Becker ('95), who, after summing up the evidence given by various writers, concludes that the sediments are more probably Algonkian than Cambrian.

The following is an attempt to reconstruct the apparent history of the series from the data which are available at the present time.

Deposition, on a sea-floor somewhat irregularly rising and sinking. The lower division of the series is said to become coarser toward the top, indicating shoaling. Above this comes the finer grained upper member, which apparently shows a return to deeper water with more uniform conditions.

Consolidation, gradually, by weight of added sediments. Despite this tendency the pressure from above was sufficient to keep that part now forming the series in a plastic state. The original thickness, even after consolidation, must have been several times that of the beds which are exposed to-day. This is shown, not only by the amount which can be demonstrated to have been eroded even before lower Carboniferous times, but also by the almost entire absence of faults at the first period of folding.

Formation of bedded veins, by solfataric action from below. The main portion of the process took place rapidly, but some veining lingered until after part of the later jointing, or else at intervals new activities arose, in no case with the same power as the first. A small amount of gold may have been brought up in the solutions. The presence of the veins prevailingly in stratification planes is another point concerning the great pressure under which the series lay, and the cross-stringers show that the rocks had already begun to suffer differential stresses sufficient to cause irregular fractures. Of the primary planes of weakness, those were most pronounced which lay at the contact of two beds of diverse physical characteristics, and the solutions chose these in many cases.

Metamorphism and concentration of much of the ore. The possibilities in regard to the origin of the pyrite and arsenopyrite may be grouped as follows. (1) The sulphides in both country-rock and veins may have a common or separate origin. (2) Those in the sediments may be the product of metamorphism of original ingredients, or may be due to solfataric action; and those in the veins may be concentrations from the sediments, or have resulted from the same process which filled the veins. Neither can be proved with the knowledge we possess at present. Both slate and whin are thickly impregnated with the sulphides, and as much away from the veins as near them; and often in positions where solfataric solutions must have penetrated very thoroughly and have gone far from their place of entrance. Besides, they are ordinary products of metamorphism, where the proper ingredients are present in the rocks. If their source were deep-seated, however, their relation to the veins remains to be determined. At present it is not possible to decide this with accuracy. It appears that much of the sulphides in the veins has been concentrated from the country-rock, like the gold.

Whatever the facts concerning the origin of the ingredients of the sulphides, their concentration is easier to follow. It occurred mainly before the first period of folding and, of course, after the entrance of the veins. The presence of the ores along bedding-planes, and their folding with the sediments, indicate this. This is true uniformly of the pyrite, and to a great extent of the arsenopyrite. In some places chalcopyrite appears in cleavage planes, in thin sheets with bright surfaces. In such cases it is still a question whether it was deposited there, or whether it has been drawn out by subsequent displacement. The gold was concentrated at the same time with the sulphides. The gathering took place under the influence of solutions percolating laterally and still more downward, as shown by the attitude of much of the ore. This movement has continued in a very small way ever since its beginning. The faults of the two periods of disturbance are rarely filled with ore, and where they are its origin is not clear. Regional metamorphism of the series, manifesting itself in yet other ways, belongs to the same period. The chlorite is chiefly in bedding-planes, as far as studied; but much remains to be learned. The same may be said of the secondary muscovite and calcite.

Granites may have come in between this and the next event, but probably not until after both periods of orogenic disturbance and before the cleavage. They are said to intrude between bedding planes in some places, and to have no perceptible influence upon the distribution of the veins, or of the gold in them or in the sediments; but few data are available. The granite at Halifax appears not to run into bedding-planes, nor do these planes seem to buckle up over the intrusive mass. One thing must be remembered, however, in any attempt to classify the intrusives of granite in a time-scale of the history of the series. We have no proof whatever that the areas of granite are all of the same age, and for the present the evidence presented by each batholitic mass must be examined separately.

First period of folding, giving east and west folds, with few faults, flexing veins and bedding-planes alike. The coarser grits were corrugated with as much ease as the finest pelites, as though the mass were quite plastic. This condition obtained from the lowest to the highest member of the series as we have it now, showing that vastly more of it existed then.

Second period of folding, extending forward for a considerable time and forming waves whose axes run roughly north and south. The action loosened the strata somewhat, giving opportunity for the following consequences.

Rolling of portions of the veins and adjacent beds, at points on the sides of the second series of folds where the axes of the first folds plunge. They were made by a revival of vein activity. Either some concentration of gold took place at the same time, as shown by certain pockets on the sides of rolls, or else all or part of this gold was brought up by the new solutions.

As regards origin, field evidence leads directly to the theory that rolling was caused in part by the north-south folding, in part by the slow entrance, subsequent to the formation of the veins, of more silica than could be accommodated readily in the space. The orogenic forces had created weakness. The new silica made its way along these planes, where pressure was relieved by parting of the strata. Not being satisfied with the space already provided, it buckled up the strata nearest it, whenever the surrounding sediments were not too unyielding, until the pressures were equalized and no more material could enter. Faulting, closing the second epoch of orogenic action. These dislocations ran in the direction of the newer folds, and cut off the rolls. In some instances simple joints were formed, without lateral movement. Where the second period of disturbance has not faulted the rocks, it appears in some regions to have jointed them north and south, and a few of the fissures are filled with veins. Other systems appeared probably at various times, and the history of each district must be studied separately. Very little mineralization took place after these last planes of separation were formed. In some places joints have curved in passing rolls, as cleavage has done.

Local revival of vein action, marked in such places as Cow Bay. The gold in the veins there probably entered from below with the gangue.

Cleavage, striking about N. 60° E., and cutting all the veins. The effect was produced by pressure apparently nearly parallel to that which gave the first folding. The conditions of the sediments were different, however, at this later epoch. Instead of the plasticity due to youth, lack of complete consolidation, and a considerable load of superincumbent rock, the force had to deal with rigidity, rendered greater by the quartz veins scattered through the mass, and probably with a much reduced load, which would of itself decrease plasticity.

After these occurred certain other details of the history, to which no definite order is assignable. An irregular local faulting is one of the latest in many places, and may be due to comparatively recent warping from some of the last oscillations of the peninsula.

This or some other orogenic movement of wide extent and slight effect has inclined the cleavage at most points. As it has not altered the strike of the planes of fissility, it acted parallel to the force which produced these planes. A small concentration of sulphides may have taken place also since the cleavage (Hamilton, '66); but the presence of sulphides in the planes may be due, on the other hand, to the stretching and shearing of crystals which lay in the bedding. These occurrences often accompany bright slickensides. Veins of various ages fill irregular fissures, and are generally barren. I have not found any penetrating into the lower Carboniferous rocks, and believe that they are all older than this period but younger than the cleavage and most of the jointing.

How many cycles of erosion the series has suffered cannot be determined. At Gay's River Mines all the features noted elsewhere can be seen in the rocks underlying the lower Carboniferous conglomerate, but stop at its base. The latter has suffered no disturbance sufficient to fold or fault it, although slickensides on the pebbles and cement tell of internal movement. It is highly probable, therefore, that all of the effects outlined above had been completed long before that time, for the boulders in the conglomerate, largely from the slate and whin and veins, exhibit the same phenomena as the underlying rocks. The structure of the older sediments, and the character of their contact with the conglomerate above, show that the former series was denuded before Carboniferous times, probably the larger part of the original mass having been lost. The history since the Carboniferous is in great measure problematical, but what we know of the structure indicates that the topographic changes have been far less than those which took place before.

Summary of Early Studies.

The metamorphic series early attracted the attention of observers, but the main activity shown in its study was manifested immediately after the discovery of gold about 1860. On the whole, the work done upon the rocks has been unsystematic, with the exception of that carried on by the Geological survey of Canada. The following notes are arranged chronologically, to give the advance in knowledge of the whole series rather than of particular problems connected with it.

Jackson and Alger ('32) noted the slates, finding granite protruding through them. The latter are the older, and the sediments were laid horizontally upon them.

Gesner ('36) first mapped the series definitely, giving also a brief description. In '43 he made another map and description, publishing the former in '45. The lowest of the metamorphic sediments he called Cambrian, and described as graywacke, clay slate, becoming micaceous and chloritic in places, and quartz rock. General relations with the granites on the north and south were shown.

Dawson ('50) called the rocks "compact and flaggy quartzite (often weathering white), mica slate, and clay slate." He recognized the granites as intrusive, and considered the sediments lower Silurian or older. In 1855 he referred to them as lower than the Devonian, and perhaps equivalent to the Potsdam, Utica, and Hudson River beds elsewhere. A general map shows the distribution of the formation, and calls it "perhaps altered lower Silurian." In '60 he suggested that it may correspond to the Paradoxides zone in Newfoundland, a position approved by Billings ('60).

The date of the original discovery of gold is unknown. The sands of the Avon were panned many years ago as a pastime. It is more than a century since Waverly was said to contain gold, but no active work was done until '58 (Gilpin, '86). A somewhat later date has been given by Marsh for the discovery, who stated in '61 that it was first seen in March of that year, in the bed of a small tributary of the Tangier River, and soon after in quartz veins. In the same paper he noted the irregularity of strike of the veins at Tangier, and the probable obliteration of all fossils in the sediments by regional metamorphism. Where the slate carries gold, the value of the veins is not diminished, and on the whole the quartz is less pockety. The metal probably comes from the slate.

Dawson ('61) considered the veins "strictly a continuation of those which run along the eastern Appalachian slope as far as Alabama."

Campbell ('62) thought the leads true veins, lying mainly in the bedding-planes, but occasionally crossing them. Marcou, in the same year, referred the rocks to the Taconic system. Honeyman ('62) described Allen's and Laidlaw's property at Waverly. In the former mine the veins are nearly vertical, and stratigraphically lower than at Laidlaw's, where they lie flat, "somewhat like a stratum."

Campbell ('63) gave a generalized section across the series, and divided the rocks into a lower or quartzite group and an upper or slate group. He regarded the cross-leads as younger than the bedded veins.

Hartt ('64) proved the pre-Carboniferous age of the concentration of gold, by its presence in lower Carboniferous conglomerate, in boulders of the metamorphic series. The leads in the lower rocks end abruptly upward against the conglomerate.

Dawson ('68) mapped the outlines of the series in a general way, and called attention to the clay slates near the Atlantic coast. Hunt ('68) called the bedded veins contemporary sedimentary deposits, as did also Hind a year later ('69). In the latter paper the first announcement of fossils was made, the forms given being *Palaeotrochus major* and *P. minor* (Emmons), with accompanying concretions. Many similar reports have been made since, but in no case is the status of the form well established. As yet, nothing has been found so clearly organic that it is of the least value for evidence. By means of these fossils Hind sought to establish the series as upper Potsdam and lower Calciferous, and equivalent to the gold-bearing rocks of North Carolina described by Dr. Emmons. He also mentioned eruptive bedded rocks at Waverly, calling them "diorites, diabase, dolerite, etc." In the next year ('70, '70[b], '70[d]) he gave the thickness of the whole series as 12,000 feet, with Huronian strata below. The granite which protrudes through it was stated to be sedimentary and older than the auriferous rocks; its apparent intrusion having been caused by up-faulting while in a plastic condition.

Selwyn ('72) considered that the opening and filling of the stratification planes, the slaty cleavage, and the rolling of the quartz were all produced by the same force. The veins are thus true veins, and younger than the country-rock. He mentioned the discovery by himself of Eophyton at the Oven's Bluff; and from this and other evidence concluded that the series "resembles the Cambrian and the Lingula-flag series of north Wales."

Dawson ('78) called the rocks Cambrian, but admitted the imperfection of the evidence.

Poole ('80) found horses of slate in veins at Tangier, and stringers running into the country-rock; thus proving beyond doubt that the deposits are true veins. At the same place a bedded lead is capped and penetrated by granite, showing the greater age of the former.

Mica and feldspar occur with the quartz as gangue minerals. How ('68) had already reported albite from Waverly.

Murray ('81) compared the series with the gold-bearing strata of Newfoundland underlying the Aspidilla or St. Johns slates, deposited, apparently, at the close of Algonkian times.

Gilpin ('82) distinguished only one period of folding. The strata were opened and the rolls formed at the same time and by the same force, the veins entering subsequently at an unknown date. The bedded veins were filled to a great extent before lower Carboniferous times, the cross-leads perhaps after that period. Later ('86) he assigned the series to the lower Cambrian, and called the veins and granite intrusions roughly contemporaneous.

Faribault ('87) regarded the Eophyton of Selwyn as inorganic. He divided the rocks of the series into an upper graphitic and a subjacent lower Cambrian division. The latter contains 15,000 feet of strata, 11,000 of which are in Campbell's lower group and 4,000 in his upper division.

Gilpin ('88) placed the summit of the auriferous beds 2,800 feet below the base of the upper slate group, and gave them a thickness of 5,000 feet. They contain little carbonate of lime, while the veins contain much. The latter are associated with predominant slates and fine-grained whin, and their filling appears to have come from the country-rock, especially the slate. The granite intrusions are probably later than the folding, although in places they tongue into the sediments along the bedding-planes.

Walcott ('91) thought that the Cambrian may be represented in the gold series, but much of it is older.

Van Hise ('92) regarded Eophyton as organic, but considered the series as probably Algonkian.

Becker ('95), after compiling the written evidence on the subject, considered the veins to have been formed by the same force that produced the cleavage.

Problems for Solution.

Perhaps of chief importance in the study of the rocks is to ascertain their age with some degree of certainty. This can be done only by discovering fossils more unequivocally organic and of more stratigraphic value than any now known along the borders of the series.

For these, it would seem that some of the least metamorphosed sandstones present the best opportunities.

The petrographic character of the sediments, the contact metamorphism near granite bosses, the character of these intrusions, all must receive careful treatment before the history of the series can be well understood. An examination of the metamorphism of the sediments will throw some light upon the origin of both veins and gold, and upon the history of the latter. The so-called pre-Cambrian volcanics in the eastern part of the Province also may have some connection with the auriferous series, and deserves the attention which is being paid to the old extrusions of the Atlantic coast farther south.

In connection with the occurrence of the gold, the reason for its prevalence in the argillaceous members of the formation, which is not so simple as that of the frequency of veins in the same rocks, may receive at the hands of another an answer different from the one given here. The age, progress, and extent of the denudation of the series has yet to be studied, and may throw light upon the distribution or concentration of the gold which has been removed during the process. Finally, the nature, origin, and direction of the two great orogenic forces which have influenced the series have not been studied with the care they deserve.

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PLATE 1.

Map of Waverly, scale 1: 14,400. A, upper whin; B, auriferous slate with leads; C, lower whin. Contacts are lines of dash and two dots; faults, dash and dot; veins, dash; axis of anticline, full heavy line.

Section of same, along axis of fold. Horizontal scale, 1: 14,400; vertical scale, 1: 24,000. Symbols and lines same as in map. Where the axis is offset by faulting, the section, for convenience, still follows it, except in the case of the two narrow blocks on the east, where it keeps its previous trend.

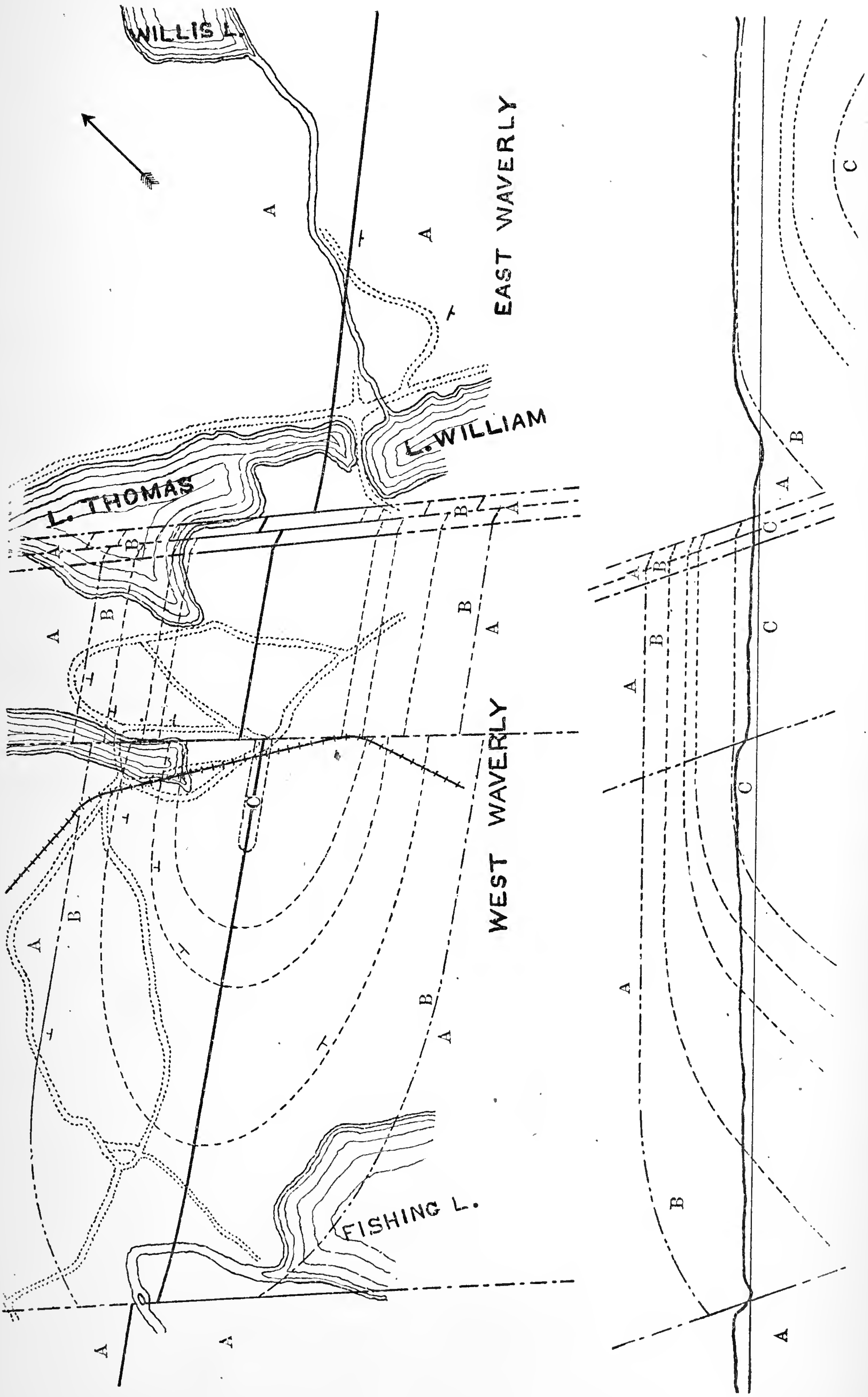
WILLIS L.
EAST WAVERLY
L. WILLIAM
L. THOMAS
WEST WAVERLY
FISHING L.

PLATE 2.

Section of the barrel quartz lead at East Waverly, showing true dip. Taken on northwest side of plunge.

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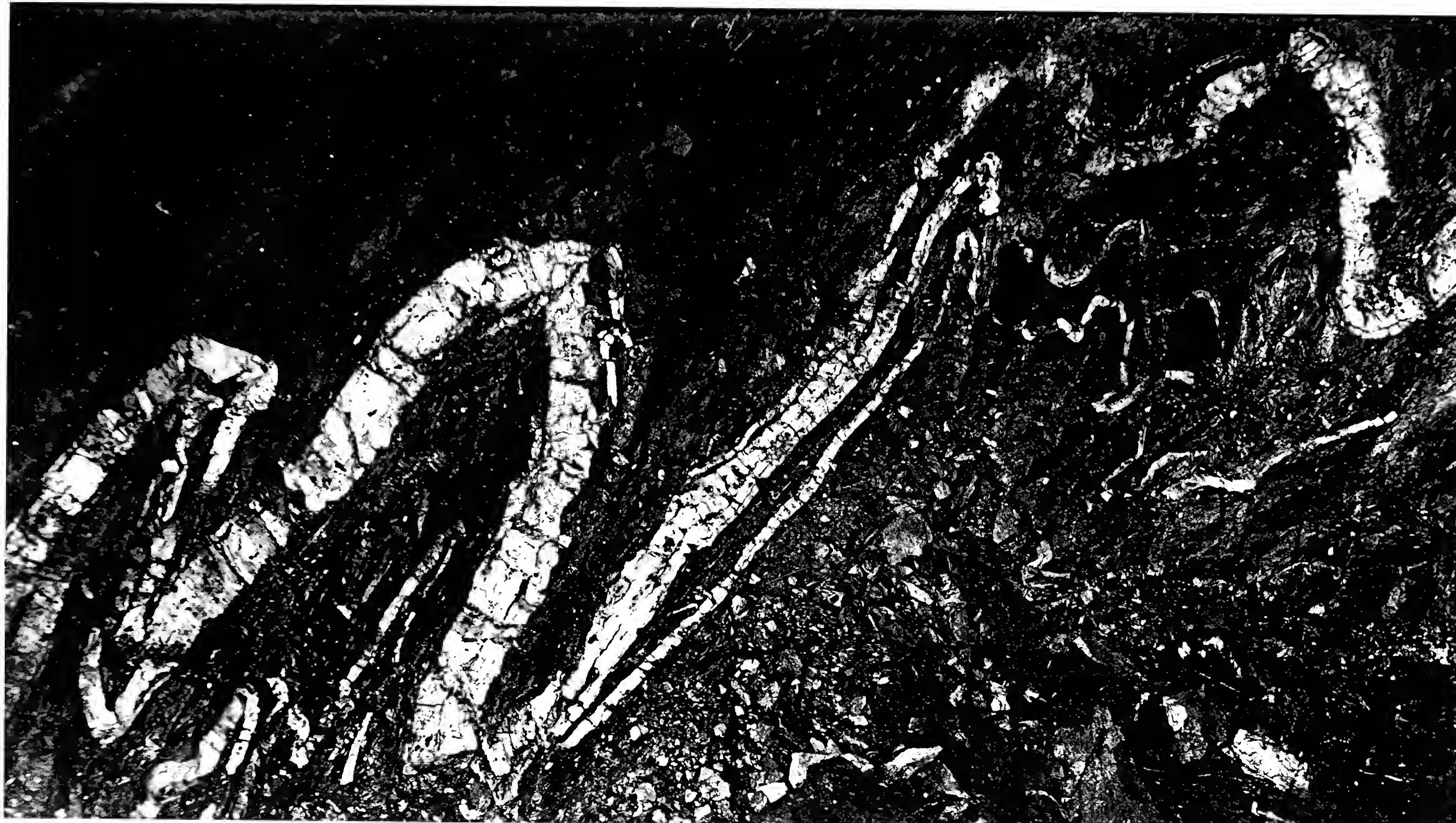
PLATE 3.

Section of Great North or "Serpent" lead, Moose River Mines, near the crest of the anticline.



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MONILOPORIDAE, A NEW FAMILY OF PALAEOZOIC CORALS.

By Amadeus W. Grabau.

WITH FOUR PLATES.

BOSTON:

PRINTED FOR THE SOCIETY.

April, 1899.

No. 16. — *Moniloporidae, a new family of Palaeozoic Corals.*

By Amadeus W. Grabau.

The genus Monilopora was erected by Nicholson and Etheridge in 1879 for *Cladochonus crassus* M'Coy. This species differs from the typical species of Cladochonus in the open character of the visceral chambers of the corallites, and especially in the structure of the wall, which consists of concentrically added layers of sclerenchyma, with an open reticulate structure appearing in some parts.

The described species are *Monilopora crassa* (M'Coy) N. and E. from the Carbonic limestone of Great Britain and Ireland and *M. antiqua* Whiteaves from the middle Devonian of Canada. To these I add *M. beecheri* from the lower Carbonian of Indiana.

Closely related to Monilopora is the new genus Ceratopora. This is represented by three species, *C. jacksoni*, sp. nov., *C. distorta*, sp. nov., and *C. dichotoma*, sp. nov., from the Hamilton shales and limestones of western New York and the Falls of the Ohio. Monilopora and Ceratopora, each represented by several species, form a natural association, and the features which they have in common separate them from other Palaeozoic corals. Ceratopora appears earlier than Monilopora and is less specialized in structure. For these two genera the family Moniloporidae is proposed.

Moniloporidae, fam. nov.

Compound, branching coralla, composed of cylindrical or funnel-shaped corallites, which either remain connected by their visceral cavities, or become separated within by the disposition of continuous layers of sclerenchyma. Tabulae absent. Walls thickened by the addition, internally, of concentric layers of sclerenchyma which either are closely applied or leave variously shaped cavities or lacunae between successive layers. Septa absent, or represented by costae and by trabeculae. Asexual reproduction by basal and lateral gemmation. Range from Devonic to Carbonic.

MONILOPORA Nich. and Eth. Jr.

Geol. mag., 1879, vol. 6, p. 293.

Description. Corallum compound, increasing by lateral gemmation; commonly attached to foreign objects of support. Septa absent or represented by faint marginal striae or flutings on the interior of the calices. Visceral chamber of corallites open and free from tabulae. Wall extremely thick, exhibiting in section, for the most part, a distinctly fibrillated appearance, from being composed of successive concentric layers. Concentric lamellae of the wall frequently separated, so as to include a series of distinct interspaces or lacunae, which are approximately parallel to the axis of the visceral chamber, and which are crossed at right angles by numerous delicate cross-bars or trabeculae of sclerenchyma, forming a reticulate structure.

The characteristic features of this genus are: the open central cavity, free from tabulae; the concentric lamellae of the wall; and the reticulate structure, which in the type species "* * * seems to be sometimes partially developed in the basal portions of the corallum, but is essentially and principally, if not altogether, present in that portion of the wall which forms the actual cup of each corallite." (Nich. and Eth. Jr., loc. cit. p. 295.)

Type. *Monilopora crassa* (M'Coy).

Range and distribution. This genus has been found in the lower Carbonian rocks of Europe and North America, and recently in the middle Devonian of North America.

MONILOPORA CRASSA (M'Coy).

Jania crassa M'Coy, Synops. Carb. limestone foss. Ireland, 1844, p. 197, pl. 27, fig. 4.

Cladochonus (*Jania*) *crassus* M'Coy, Ann. and mag. nat. hist., 1847, ser. 1, vol. 20, p. 227.

Cladochonus crassus M'Coy, Ann. and mag. nat. hist., 1849, ser. 2, vol. 3, p. 134. (Listed.)

Cladochonus crassus M'Coy, British Palaeozoic fossils, 1851, p. 85.

Cladochonus crassus Morris, Cat. British fossils, 1854, ed. 2, p. 49.

Cladochonus crassus Rofe, Geol. mag., 1869, vol. 6, p. 352, fig. 2, 3, 4, 4a.

Monilopora crassa Nich. and Eth. Jr., Geol. mag., 1879, vol. 6, p. 293, pl. 7, fig. 2, a–f.

Monilopora crassa Nich., Tabulate corals of the Palaeozoic period, 1879, p. 223, fig. 32 a–f.

Description. "Irregularly dichotomous; branches thick, conical, short; slender at their origin, expanding rapidly; surface smooth."

"This is by much the largest species of this group I have seen; it is common in the shales of several localities; it most nearly resembles the *J.* (*Jania* = *Cladochonus*) *bacillaria*, M'Coy, from which it differs in the great thickness and conical form of the branches. Length of specimens usually from one to two inches; length of branches about three lines; diameter of branches at base usually about one line, at extremity one line and a half." (M'Coy.)

This description was evidently made from free growing specimens. From one to three branches are given off from the earlier corallites. This species is frequently found growing around a crinoid stem, and Rofe has made some interesting observations on the effect which such attachment produces on the crinoid column. According to him, a local enlargement or swelling is caused, by the growth of the coral, in the affected portion of the crinoid stem, which grows so as to enclose the coral, until finally the apertures of the corallites alone are visible.

Rofe also discovered the reticulate structure of the wall, but Nicholson and Etheridge were the first to recognize its import. The presence of this structure, and the absence of tabulae, caused them to take this species out of Cladochonus, and erect for it Monilopora. According to their figures, the reticulate structure is well developed in the wall just about and below the expanded calyx. The lacunae are of nearly equal width with the subequal partitions, and the trabeculae are disposed at short and very regular intervals.

Formation and locality. This species is at present known only from the Carbonic limestone of Great Britain and Ireland.

MONILOPORA BEECHERI, sp. nov. Plate 1, figs. 2, 3. Plate 2, figs. 1–5.

Description. Corallum regularly branching or forming a confused mass of intergrown tubes, which branch and repeatedly unite, the calices opening in all directions. Tubes expanding rapidly towards the calyx, below which they give off one or more lateral buds. Adjoining corallites frequently united by their walls.

Walls thick, especially in the lower portions of the corallite, consisting of numerous concentric lamellae, between which the reticulate structure appears. The lacunae are subequal, but the lamellae separating them are more irregular, and as a rule thicker than those of *M. crassa*. The trabeculae are also more irregularly disposed.

This species differs from the described and figured forms of *M. crassa* in the larger size of its corallites, the more confused growth of the agglomerated masses, and the greater length and more regular budding of the simple branches. The internal differences appear to be the irregularities of the reticulate tissue, which is also much less frequently developed. From *M. antiqua* it differs chiefly in the surface features, and in the thickness of the wall, which in that species is stated to be "rather thin."

This species, like the European *M. crassa*, frequently grows around crinoid stems. It is commonly found on the stems of Platycrinus, which is an abundant genus in the rocks in which this coral occurs. When thus attached, it takes on a surprisingly irregular colonial form, calices budding out on all sides. In one of the specimens figured (Pl. 1, figs. 2, 3) the calices point upwards and downwards, as well as outwards in all directions. This would seem to indicate that it grew on the crinoid stem while the latter was erect, and that the coral was attached around the stem at some distance above sea-bottom, thus allowing free expansion of the corallites in every direction.

The regular coralla give off calices at definite intervals, these calices pointing upwards and outwards on all sides. From this it appears, that the regular coralla grew upright, unsupported except basally (Pl. 2, figs. 1–3). The more usual method of growth, however, seems to have been by irregular budding, which resulted from the attachment of the young coral to the crinoid stem. Such an attached individual would not require the regular growth, which is necessary in the free corallum to maintain proper balance, and hence the attached corallum can put out buds promiscuously.

With increasing age, the individual corallites become separated from each other internally, by the extension of the sclerenchyma over the pore through which the young polypite was connected with the parent.

Formation and locality. From the calcareo-arenaceous Platycrinus beds of the Keokuk group, lower Carbonian, Crawfordsville, Indiana.

Named in honor of Prof. C. E. Beecher of Yale university. Types in the collection of Yale university museum, New Haven, Conn., and in the collection of the Museum of comparative zoology, Cambridge, Mass.

Monilopora antiqua Whiteaves.

Monilopora antiqua Whiteaves, Contrib. Can. pal., 1898, vol. 1, pt. 5, p. 364, pl. 48, figs. 1, 2, 3, 3a.

This species was described from the Hamilton group of Thedford, Ontario, where it is said to be not uncommon. It is the first and only species so far described from rocks below the Carbonic, in this country, and none have been noted at so low a horizon elsewhere.

Dr. Whiteaves states that the species is "at first attached to and either wholly or partially encircling foreign bodies, but apparently free and ramose ultimately." Like the other species it is found chiefly on crinoid stems, "completely enveloping them, except at the ends, and throwing out corallites in all directions." This method of growth therefore may be regarded as characteristic of the genus. Free branches occur in this species as in those from the Carbonic rocks, and in them occurs the zigzag, alternate arrangement of the corallites found in the other species. A method of growth, not yet observed in the other species, is shown (Whiteaves, loc. cit., fig. 2) where a partially attached specimen spreads out into a "thin, nearly flat, sub-circular lateral expansion, with all the corallites springing from its upper surface, and the lower surface consisting of a concentrically wrinkled epitheca."

The surface of the corallites "* * * is minutely granulo-striate and marked by irregularly disposed and very minute granules, tubercles, or low, interrupted longitudinal ridges, with equally minute grooves or channels between them." This feature readily distinguishes the species.

The occurrence of this species in Hamilton strata is of great interest, as showing that the family, as at present constituted, was fully differentiated in Mesodevonian time.

Ceratopora, gen. nov.

(Ety.: κέρας = a horn, πόρος = pore.)

Description. Corallum compound, increasing by lateral gemmation; erect or prostrate, seldom attached above the base. Septa represented by costae and by spinous trabeculae projecting from the inner walls. Calyx deep, funnel-form, thin walled, and continued downwards in a narrowing tube, formed by the thickening of the walls through the addition, internally, of concentric layers of sclerenchyma and the formation of coarse cysts. Tabulae absent. Surface formed by a wrinkled epitheca.

Type. *Ceratopora jacksoni*, sp. nov.

Range and distribution. This genus is at present known from the middle Devonian, Hamilton group, of western New York and the Falls of the Ohio.

Ceratopora differs strikingly from other Palaeozoic corals, except Monilopora, with which it agrees in the open character of its visceral cavities, in the presence of trabeculae, and in the manner of thickening the walls by concentric additions of sclerenchyma from within. It differs from Monilopora in the absence of reticulate structure in the walls, and in the presence of very coarse cysts. These latter, as seen in cross-section (Pl. 2, figs. 7–12) are formed by successively added layers of sclerenchyma, the later-formed layers overlapping the earlier. Sometimes a single cyst occupies more than half the circumference of the corallite, but this is not frequent. The cysts are usually long, as shown in the longitudinal sections (Pl. 2, figs. 7 and 11).

The trabeculae are of the nature of gently tapering spines, projecting from the inner surfaces of the lamellae into the free spaces. In well-preserved specimens, the inner walls of the calices and visceral cavities are seen to be thickly studded with these spines, which project at right angles from the walls. In form, they are slender, conico-cylindrical, broad at the base and tapering at first rapidly, and then move gently to a point. In a number of silicified specimens of *C. dichotoma* and *C. distorta* from western New York, the trabeculae appear as hollow tubuli, and where they have been destroyed, a series of pores marks their former position (Pl. 3, figs. 11, 14, 15).

The hollow character of the trabeculae in the silicified specimens is probably due to the method of preservation; nevertheless, this feature indicates what is probably the true relation between the trabeculae and the walls. The former appear to be local elevations of the latter, or, again, the walls appear as if formed by the lateral expansion of the bases of the trabeculae. This relation of the lamellae of the wall to the trabeculae is well shown in the cross-sections of *C. jacksoni* (Pl. 2), where the lamellae are seen to bend inwards to form the trabeculae.

The trabeculae are commonly short, usually projecting only part way across the lacunae, but occasionally they are long enough to project across from wall to wall, thus presenting, on a larger scale, the character seen in Monilopora. More rarely a trabecula projects beyond the next added lamella, which then envelops it with an additional layer of sclerenchyma (Pl. 2, fig. 9).

In the calices, the trabeculae are arranged in parallel vertical rows, of which from sixteen to twenty have been counted in different specimens of *C. distorta*. In the procumbent portion of *C. dichotoma*, the rows of trabeculae gradually diverge, new ones coming in between, until they reach the calyx, where they are disposed in parallel vertical rows (Pl. 3, fig. 14). At the bases of the new corallites the trabeculae are especially numerous, projecting from all sides across the pore connecting the bud with the parent. In old individuals of *C. dichotoma*, and in adult individuals of *C. distorta*, the trabeculae cover most of the pore. In *C. distorta* the orifice becomes closed over during the course of further growth, the polypites thus becoming separated. After this, the wall thus formed is commonly thickened by the addition, on both sides, of new layers of sclerenchyma. This separation of originally conjoined polypites probably takes place in *C. jacksoni*, although it has not been observed. In *C. dichotoma*, the polypites apparently remain united throughout life.

Ceratopora jacksoni, sp. nov. Pl. 1, fig. 1. Pl. 2, figs. 6–10.

Description. Corallum erect, frequently and irregularly branching; corallites cylindrical, or slightly trumpet-shaped. Surface formed by a coarsely wrinkled epitheca, and showing longitudinal ridges or costae. Cavity of the calyx funnel-shaped, continued as a cylindrical central tube, which seldom occupies more than one third of the diameter of the corallite. Cysts coarse, irregular, arranged semi-concentrically, with frequent spine-like processes or trabeculae projecting from the lamellae of the wall.

The branching of this species is such as to produce an irregular arborescent form, indicating that the corallum grew upright. The corallites seldom grew perfectly cylindrical and erect, almost always having a more or less sinuous or irregular outline. The new buds were usually given off at an oblique angle.

Twelve zooids occur on the type specimen (Pl. 1, fig. 1), but additional ones probably existed on the broken basal portion of this specimen.

Formation and locality. This species is common in the Hamilton (lower) shales of Eighteen Mile Creek and vicinity in Erie County, N. Y. It also occurs in the Marcellus shales and limestones at Lancaster, Erie Co., N. Y. Named in honor of Dr. Robert T. Jackson of Harvard university.

Ceratopora distorta, sp. nov. Pl. 3, figs. 1–13.

Description. Corallum erect or prostrate, frequently and irregularly branching. Corallites irregular in outline, often much distorted, cylindrical when perfect. Basal portion of corallites usually more or less constricted; calicinal portion frequently inflated. Lines of growth irregular, costae faint. Buds diverging at all angles, connected with the parent internally during the earlier stages of growth.

Cysts moderately coarse, trabeculae numerous, well developed, and disposed in vertical rows, of which from sixteen to twenty have been counted in different individuals.

This species is much smaller than *C. jacksoni*, and has a much more irregular growth. When the corallum grows prostrate, the under side is usually more or less flattened, and not infrequently irregular, subradiciform epithecal prolongations occur, as if for attachment (Pl. 3, figs. 1, 3, 6, 13). In a few cases, the corallum has been found growing upon foreign bodies, and in some of these, where the corallum was attached to a specimen of Taeniopora, its flattened under side conformed accurately to all the irregularities of surface of the bryozoarium, even to the extent of reproducing the pores in reverse. When prostrate, the lines of growth became oblique, and the calyx turned upward, as is characteristically the case in *C. dichotoma*. In one of the specimens (Pl. 3, figs. 9, 10) a single bud is given off, some distance below the calyx; this bud assumed a triangular form, with a ridge or carination along the center, — features eminently characteristic of the next species.

Regularly developed individuals approach in appearance that of small specimens of *C. jacksoni* (Pl. 3, fig. 5), the branches becoming smooth and circular in cross-section.

While the branching is usually irregular, it occasionally becomes verticillate (Pl. 3, fig. 4), a number of branches being given off at the same level. Occasionally, however, the growth is so irregular as to produce a conglomerate mass resembling the usual manner of growth of Monilopora (Pl. 3, fig. 7).

Internally the corallites remain connected by a pore, usually until well advanced in age, when the pore may become closed. This, however, may also occur in young individuals, but it is not very common. The closing begins by the increase in size and number of the trabeculae which fringe the pore, the further effectual separation being accomplished by the deposition of lamellae of sclerenchyma.

Ontogeny. The young corallite is irregularly conical much resembling the initial tube of Aulopora. This resemblance is strengthened by the attached character of the young corallite (Pl. 3, figs. 12, 13, the latter separated from the object to which it was attached). No trabeculae or cysts have been observed in the young individuals below the first bud, but these appear higher up in the initial corallite. From the initial tube lateral buds arise, in the same manner as in Aulopora, the new corallite retaining, for a time at least, its connection with the old one through the mural pore. The cysts and trabeculae are well developed in the second corallite.

Abnormal deformations. Deformations occur in the early stages of growth as well as in the later ones. Plate 3, fig. 2, shows a specimen in which the first bud took a downward direction of growth, probably through the separation of the initial corallite from its object of support. This corallite continued to grow in this abnormal direction, finally growing past and over the initial point of the first corallite and coalescing with it.

Formation and locality. This species occurs in calcareous beds of the Hamilton group at Canandaigua Lake, N. Y. Collected by Prof. C. E. Beecher. Types in the collection of Yale university museum. A number of specimens of this species from the Falls of the Ohio, probably from limestones of the Hamilton group, are in the collection of the Massachusetts institute of technology.

Ceratopora dichotoma, sp. nov. Pl. 2, fig. 11–12. Pl. 3, figs 14–16. Pl. 4, figs. 1–18.

Description. Corallum free above the base, prostrate, lower surface of tubes flattened, upper surface rounded or abruptly sloping, with a carination along the middle. Cross-section of the lower portion of the tube subtriangular. Tubes gently and regularly increasing in diameter towards the aperture, before reaching which, in adult individuals, they are abruptly bent upwards, so that the calyx opens at right angles to the longitudinal axis of the tube. Calyx frequently deep, circular in cross-section.

New tubes given off in pairs, from the baso-lateral angles, diverging at right angles, and each in turn giving off a pair of tubes. Seen on the flattened side, the corallites appear to divide dichotomously. Surface formed by a thick, wrinkled epitheca. Cysts moderately coarse, best developed in the larger specimens. The cysts frequently change the triangular inner section of the procumbent portion of the tube to nearly circular, by cutting off the carination and the lateral angles.

Trabeculae numerous, arranged in regular rows; most prominent on the walls of the calyx. In the procumbent portion of the tube the rows of trabeculae gradually diverge forwards, new ones coming in between the older rows. The connecting pore between corallites is usually thickly studded with trabeculae.

This species might at first be taken for an Aulopora, but is readily distinguished by its free, though prostrate habit, its triangular cross-section, the carination along the center, the abruptly upward bending calyx, and the regular dichotomous branching. Internally the cysts and trabeculae form distinctive characters. From *C. jacksoni* and *C. distorta* it can be distinguished by its regular form and manner of branching, and by the carination along the middle of the upper side.

Ontogeny. Only the later stages in the development of the corallum have been observed. These later stages have not been found on an initial corallite, except as indicated by the lines of growth, but they can be seen in the secondary corallites. Inasmuch, however, as each corallite repeats the history of the initial one, excepting the earliest stages, we may gain a knowledge of the development of the whole corallum — with the exception of the earliest stages — by the study of the last formed corallites.

Almost from the beginning, as far as known, the characteristic ridge or carina appears along the center of the upper portion of the procumbent tube. It is probable, that in the very young initial corallite this carina is wanting, especially if this young individual was attached to some foreign object of support. On this point, however, observations are entirely wanting. The aperture of the immature tube is oblique, the lower wall of the tube projecting farthest forward, and ending in a gently rounded anterior lip. The lines of growth indicate this to be true of very young individuals, and it is also seen in the distal end of the last formed immature corallites (Pl. 4, figs. 2–5). The same character is shown in adult specimens by the lines of growth, which form a sharp reentrant over the carina, pass obliquely forward over the sides, and describe a gentle forward curve on the flat face. This manner of growth indicates that the immature polyp bent upwards at the oral end after the manner of some modern Bryozoa and sedentary worms, a habit which became permanent in the adult individual, resulting in the upward building of the final portion of the tube. The resulting crowding of the polyp against the upper edge of the orifice of the procumbent tube may have been a cause in the formation of the carina. The supposition, that the pressure of the polyp against the upper frontal edge of the corallite is responsible for the carina, seems to be borne out by the fact, that on the upturned calyx the carina gradually dies away, so that at the rim of the ordinary calyx there remains scarcely a notch to mark its position. This would be explained by the gradual diminution of the pressure, which finally ceased after the calyx had reached a certain height. The fact, that away from the margin, where the pressure no longer existed, the internal section of the tube became circular through the addition of layers of sclerenchyma, also indicates that the marginal pressure had a close connection with the formation of the carina. An important factor in the formation of the carina, was undoubtedly the friction of the polyp against the upper edge of the procumbent tube during contraction and expansion, and the crowding on the withdrawal of the polyp into the tube. In this respect the carina may be compared to the plications and groovings on the columellar lip of gastropod shells (see Dall., Trans. Wagner free inst., vol. 3).

When the polyp has reached maturity, and gives off its buds, a broadening of the anterior portion of the tube occurs. This is followed by an extension of the lateral angles and an upward building of the median frontal portion or lip (Pl. 4, fig. 8). As the calyx of the parent tube grows upward and the lateral angles grow outward, the front and sides meet, closing over the lateral extensions and converting them into tubes. The various steps are well indicated by the lines of growth on the well-preserved specimen figured from Eighteen Mile Creek (Pl. 4, figs. 9, 10).

It is evident, from the geometrical growth of the corallum, that some of the polypites forming the inside branches must eventually interfere with each other. In a nearly perfect specimen from Eighteen Mile Creek (Pl. 4, fig. 1) the two corallites approaching each other are apparently young individuals which have not yet reached the calyx-building stage. Even before they can reach this stage, they must meet, when one of several things may happen. The stronger branch may put out normal buds, preventing the weaker one from budding. The corallites may cross each other in different planes, each giving off normal branches. Finally the two corallites may coalesce. This last method of settling the difficulty seems to have occurred, as indicated by intergrown specimens. In one specimen (Pl. 4, fig. 11) the weaker polypite on the left put forth one short bud only, the left one, while the stronger polypite on the right put out two buds, at a somewhat distorted angle. The shorter of these buds from the right united with the single bud from the weaker member on the left, the resulting tube apparently being traversed by a continuous canal. In another specimen (Pl. 4, fig. 12) the branch from the left was also the weaker or younger one, the branch from the right in this case succeeding in putting forth two normal buds, while the branch from the left put forth a very short bud on the left which was soon enveloped by the calyx of the stronger branch. The two calices appear to have been united by the tube of this bud. It is interesting to observe, that in the complete specimen (Pl. 4, fig. 1) the branch from the left is also the shorter one (the specimen is represented in the figure as seen from the flat under side, and hence with parts reversed), and that hence the branch from the right would have succeeded in putting forth its buds, before the branch from the left had reached maturity. A union, similar to that of the other specimens, would probably have taken place, had growth continued. It should be noted that in all these cases the branch approaching from the right is the left branch, when considered with reference to its maternal corallite, while similarly the branch approaching from the left is the right branch of its maternal corallite.

Abnormal deformations. Deformations which are not due to the normal method of growth, as in the case of the interfering corallites, are chiefly due to abnormal interferences, which caused irregular growth, and to injuries and the repairing of the injured portion. Plate 4, fig. 13, shows an irregularity of budding probably due to some external interfering influence; Pl. 4, fig. 14, shows a single bud only, the left one having either been broken away or not developed. In either case the normal opening was completely closed. What appears like a pathologic growth, resulting probably from injury to the polypite, is shown in Pl. 4, fig. 15; here the left branch ends with a sudden constriction and a short conico-tubular prolongation, which terminate the branch while still in an adolescent condition. The injury to the polypite apparently caused a diminution in growth power, and hence in the power of secreting the corallite. The result was the diminutive end, and the loss of the power to give out buds and build a normal calyx. Another case of irregular growth, which seems to have been due to early injuries is that represented in Pl. 4, fig. 16. In this specimen a marked irregularity appears in the procumbent portion of the tube which seems due to an injury and a breaking of the tube, with a subsequent reparation. The normal calyx of the tube is low, and from it proceed two normal buds, one on each side. What is clearly a later addition to the calyx appears above the normal rim of the calyx, arising from it in a manner similar to that shown in many rugose corals, and which is commonly attributed to a rejuvenescence of the polyp. From this second calicinal ring a bud is given off on the right, which rests directly on the corresponding bud of the normal calyx, two buds thus appearing on one side of the calyx and one on the other. The explanation of this anomaly seems to be, that the normal right-hand branch suffered an injury, which may have extended even to the central polypite, so as to cause a temporary cessation of growth. With the resumption of growth, a new bud was put forth in place of the injured one.

A specimen which throws considerable light on the relationships of the two species *C. dichotoma* and *C. distorta* is represented in Pl. 4, figs. 17, 18. This is attached to a branch of the bryozoan *Taeniopora exigua*. The older portion of this corallum probably represents an initial tube, though this cannot be proved, since the earliest portion is broken away. What remains of the first tube has the characteristic form of attached specimens of *C. distorta*, including the epithecal prolongations. A carination runs along the length of the tube, but, owing to the twisting of the tube, it has a sinuous outline. The cross-section of the tube is roughly circular, there being no flattening on the under side as in normal individuals. Except for the carination, this portion of the corallum is indistinguishable from an attached corallum of *C. distorta.* The tube terminates in a normal upturned calyx, at the base of which two buds are given off. The left-hand bud is irregular, round in section, and much distorted. It is broken away near the base. The right-hand bud is normal, triangular in section, with a normal carina along the center, and lines of growth mostly sloping forward, though sometimes approximating those of *C. distorta.* The branch ends with a normal adolescent opening which, however, is somewhat more vertical than in ordinary specimens. A notch in the right-hand lower margin of the opening indicates that the branch was about to give out buds. This normal branch is attached in places to the Taeniopora, showing below impressions of the surface features of the bryozoan. Taken in connection with the abnormal specimen of *C. distorta*, Pl. 3, figs. 9, 10, which shows characters of *C. dichotoma*, the close relation of the two species becomes well established.

Formation and localities. This species is common in the soft Hamilton shales of Eighteen Mile Creek and vicinity in western New York. It there occurs in the lower Moscow and the upper portion of the lower shales. The specimens usually occur on the lower surface of the shale laminae, their calices deeply embedded in the shale, and only the flat lower portion exposed (Pl. 4, fig. 1).

The species also occurs in limestones of the Hamilton group at Canandaigua Lake. It occurs here in a silicified condition, and shows many structural details. The specimens from Eighteen Mile Creek were collected by the author, those from Canandaigua Lake by Prof. C. E. Beecher.

General Observations.

The general form and manner of budding in the various species described form a pretty reliable index to the manner of growth in each. The three species of Monilopora, when not attached to foreign objects of support (i. e. crinoid stems), grew erect and unsupported, as is indicated by the regularity with which the calices were given off on all sides (Pl. 2, fig. 2). In Ceratopora a different method of growth is indicated for each species. *C. jacksoni* has corallites with a circular cross-section, indicating free growth. This is further shown in the type specimen by the tree-like character of the whole corallum, the branches diverging from the trunk on all sides, bending outward and upward. The arrangement seems to have been such as would secure the greatest stability to a top-heavy structure. *C. dichotoma*, a type which rested on the bottom, shows a manner of growth which induced the flattening of the lower surface of the corallum. In muddy bottoms, such as probably formed the normal habitat of this species, the flat resting-surface of the corallum prevented sinking into the mud. The calices of the adult individuals at the same time turned upwards, and were frequently long, so that the polypite was kept well above the mud on which its corallite rested. The normal circular section of the tube occurs in the last built, free projecting calices, indicating that the flattening of the side on which the corallite rested was primarily a dynamic feature. This supposition is borne out by the fact, that in *C. distorta*, which has normally a circular cross-section, with an erect growth, one side is occasionally flattened, the indications being, that the corallum rested on the flattened side (Pl. 3, figs. 9 and 10). It is also strengthened by the peculiar form of the attached specimen referred to *C. dichotoma* (Pl. 4, figs. 17, 18), in which the flattening does not appear in the older corallite, a subcircular cross-section, with irregular prolongations occurring. The similarity of this portion of the corallum to an attached specimen of *C. distorta* is very marked. *C. distorta* is intermediate in form, and probably was in habitat between *C. jacksoni* and *C. dichotoma*, and with sufficient material a series connecting the two extremes could probably be arranged.

The origin and nature of the reticulate structure in Monilopora seem to be explained by the similar though less perfectly developed structures of this character in Ceratopora. The trabeculae of Monilopora are more numerous and more regularly disposed, at the same time being much shorter than those of Ceratopora. In both genera the trabeculae may be regarded as of the same nature as septa growing from the walls of the cysts, towards the visceral chamber. The addition of new lamellae over the trabeculae occurred at intervals, as the polyp prolonged its tube and contracted in its lower portion. From the newly added lamellae new trabeculae arose.

Phylogeny. In *Ceratopora distorta* we have a form intermediate in structure between *C. dichotoma* and *C. jacksoni*, and a species therefore which more nearly conformed to the characters of the radical of the three species than either of the other two. In the young of *C. distorta*, we may with a reasonable degree of accuracy, suppose to have typified the young of each of the three species, as well as the characters of the proximal radical. As already remarked, the young of *C. distorta* closely resembles the initial tube of an Aulopora. It is true, that the absence of trabeculae in the young of *C. distorta* is not absolutely proved, the two specimens which have come under observation being insufficient to establish this point. The thickening of the walls and the formation of cysts are clearly secondary features, not occurring in the young, so that, even if the trabeculae are present, the relation between the two genera is not a very distant one. The similarity in all the determinable points of structure extends even to the manner of budding, which is aulopo-roid, and to the habit of fixation in early life. If we are warranted, as it seems we are, in regarding this similarity of form and structure as indicative of relationship, we are furnished with a clue to the probable origin of the family Moniloporidae. It seems very probable that Nicholson's suggestion, that Monilopora represents a branch of the Auloporidae, is correct, and true of the family, the immediate connection being through the more primitive species of Ceratopora.

Monilopora is probably not a direct descendant of any of the known species of Ceratopora, though following them in the geologic record. It is probable, that when the numerous corals of the western Devonian coral reefs are studied in detail, intermediate species will be discovered, which will establish the genealogy of Monilopora more precisely.

I take pleasure in acknowledging my indebtedness to Prof. Charles E. Beecher, of Yale university, who generously placed many of the fossils herein described unreservedly at my disposal.

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PLATE 1.

Fig. 1. *Ceratopora jacksoni.* Type, nat. size. — A bud, extending away from the plane of the paper, is not shown. Hamilton shales, Eighteen Mile Creek, Erie Co., N. Y. Author's coll.

Figs. 2, 3. *Monilopora beecheri.* Opposite sides of a specimen in the collection of Yale university museum growing upon the stem of a Platycrinus. Calices project in all directions. Nat. size.

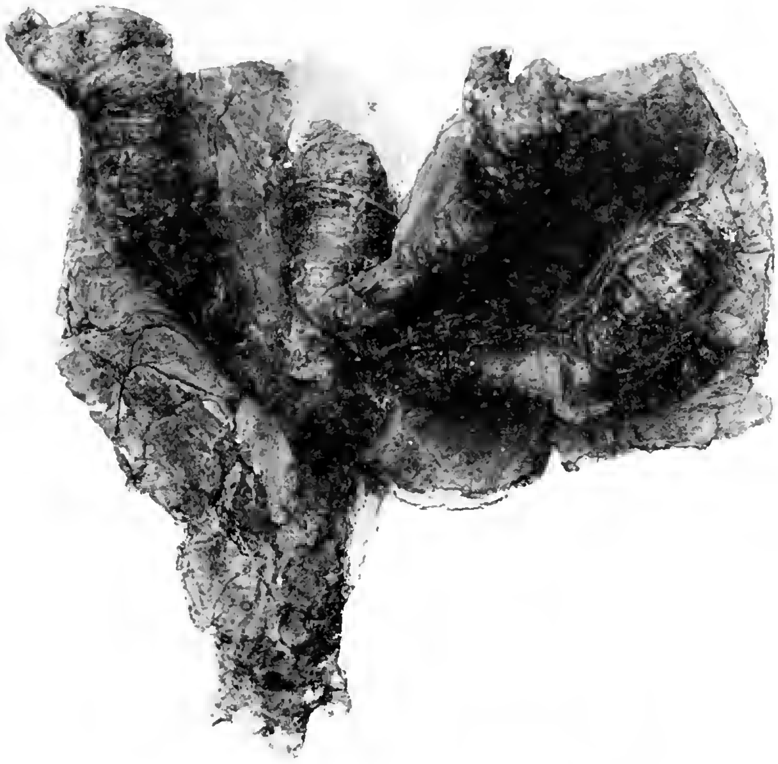

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PLATE 2.

Figs. 1–5. *Monilopora beecheri.*

Fig. 1. A young corallum of regular growth, showing the manner of budding. Nat. size.

Fig. 2. An older corallum of regular growth, showing the very regular budding in opposite directions. Slightly reduced.

Fig. 3. A corallum showing irregular branching. Nat. size.

Fig. 4. Enlargement of a cross-section, showing the lamellose character of the wall and the reticulate structure formed by the subequal division of the lacunae by the trabeculae. From a camera drawing, ×5.

Fig. 5. A still further enlargement of a portion of the preceding section, showing the character of the lamellae and trabeculae. From a camera drawing.

Figs. 6–10. *Ceratopora jacksoni.*

Fig. 6. From the surface of a limestone slab, showing the curved corallites and the distant manner of branching. Stafford limestone, Lancaster, Erie Co., N. Y. Nat. size.

Fig. 7. Longitudinal section of a branch, showing the elongated character of the cysts, the manner of addition of the lamellae, and the character and disposition of the trabeculae. From a camera drawing, ×5.

Fig. 8. A cross-section of a corallite, showing a small central tube, numerous cysts, and numerous long trabeculae. The section through the bud on the right is eccentric, and does not show the true relation of the bud to the central tube and cysts of the main branch. From a camera drawing, ×5.

Fig. 9. Another cross-section, showing cysts and trabeculae. The main tube is on one side of the center, and shows several short spines projecting into it. From a camera drawing, ×5.

Fig. 10. Longitudinal section of a calyx, showing a recently formed bud fully connected with it internally. The lamellose character of the wall and the manner of addition of the new lamellae are shown in the section. Below the calyx the tube is narrowed by the formation of cysts. From a camera drawing, ×2½.

Figs. 11, 12. *Ceratopora dichotoma.*

Fig. 11. Longitudinal section of the procumbent portion of a corallite from the Hamilton shales of Eighteen Mile Creek, showing the lamellose character of the wall, the cysts, and the trabeculae. From a camera drawing, ×5.

Fig. 12. Transverse section of the procumbent portion of a corallite from Eighteen Mile Creek, showing the change from a subtriangular to a circular internal section. From a camera drawing, ×7.

1–3 Coll. Yale univ. mus., 4–5 Coll. Mus. comp. zool., Cambridge, 6–12 Author's coll.

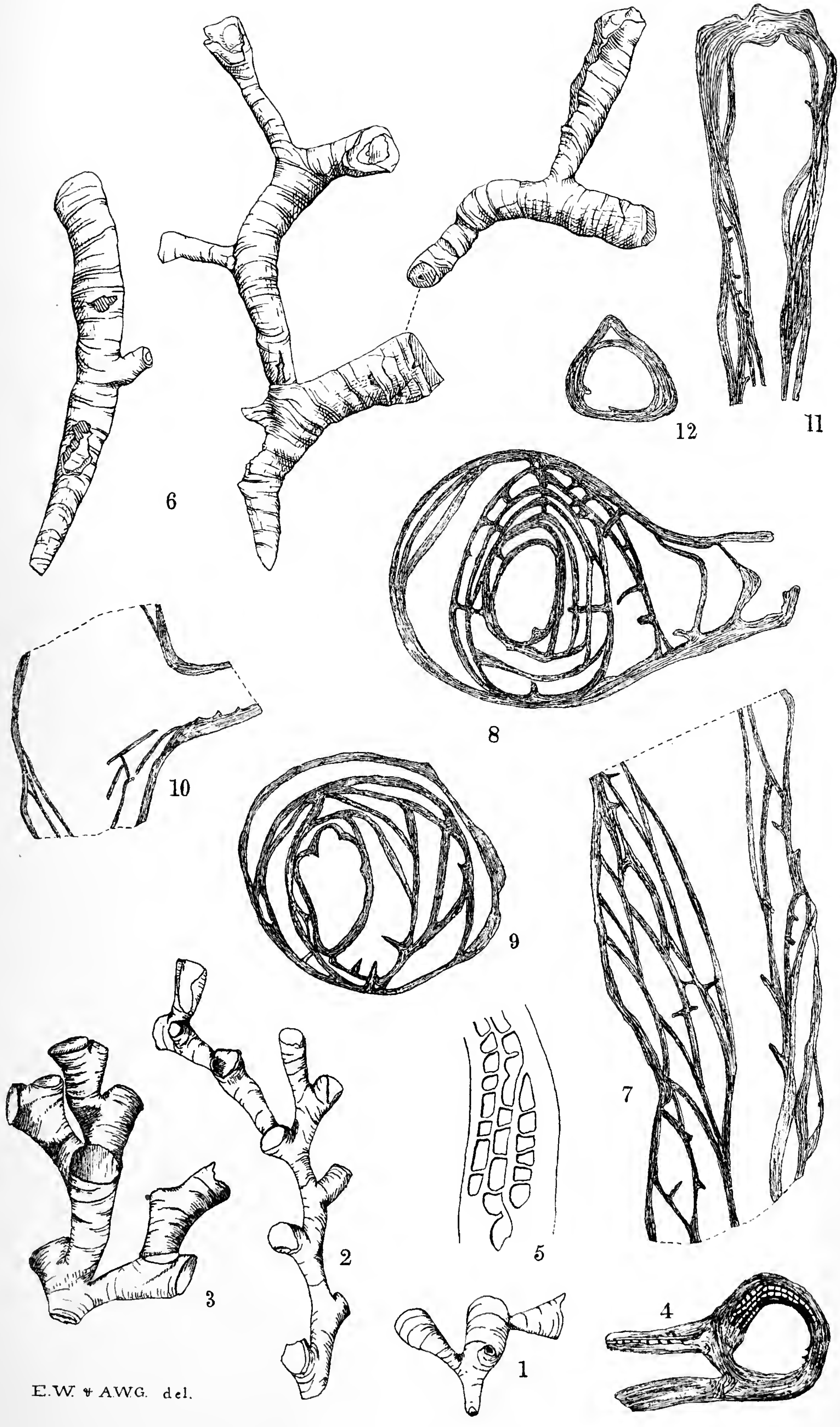

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PLATE 3.

Figs. 1–13. *Ceratopora distorta.*

Fig. 1. Showing the normal form and method of branching, as well as the radiciform epithecal prolongations. ×1¾.

Fig. 2. Showing abnormal growth in the first bud. ×1¾.

Fig. 3. Showing irregularities of the corallites. ×1¾.

Fig. 4. With verticillate buds. ×1¾.

Fig. 5. Unusually regular specimen with cylindrical corallites. ×2⅝.

Fig. 6. Showing clustered branching and irregular growth. ×1¾.

Fig. 7. Showing irregular clusters resulting from profuse and irregular budding. ×2⅝.

Fig. 8. A corallite showing irregularities of the tube and bud, and in the broken portion the characteristic cystose structure. ×2⅝.

Figs. 9, 10. Two views of a procumbent specimen, showing the flattened lower side, carination, and manner of budding of *C. dichotoma.* ×2⅝.

Fig. 11. A portion of the inner wall of Fig. 8, much enlarged, showing the character of the spines or trabeculae.

Fig. 12. Young individual, showing initial tube and first bud, — attached to the shell of a Stropheodonta. ×3½.

Fig. 13. Young individual, showing initial tube and several buds. Originally attached to a frond of Taeniopora. ×3½.

Figs. 14–16. *Ceratopora dichotoma.*

Fig. 14. Enlarged to show the disposition of the trabeculae in diverging rows on the floor of the calyx. ×5¼.

Fig. 15. Trabeculae or septal spines greatly enlarged, showing their hollow character in silicified specimens. The tops of the spines are broken away. (Compare Fig. 11.)

Fig. 16. Showing an apparent double character of the tube, due to the great size of the cysts. Also the character of the calyx, and the pore connecting the calyx with the bud. ×2⅝.

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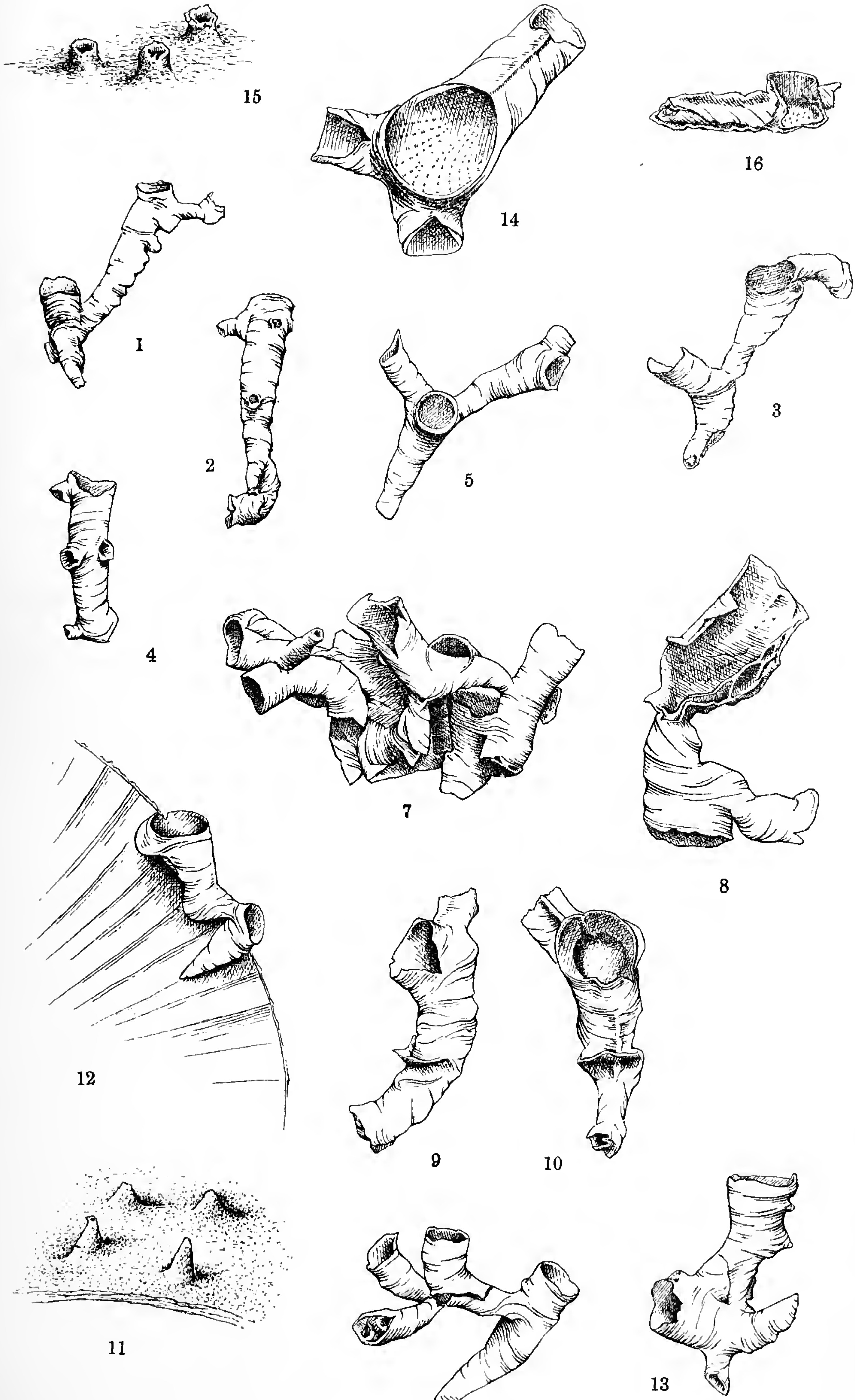

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PLATE 4.

Figs. 1–18. *Ceratopora dichotoma.* (Compare also Plates 2 and 3.)

Fig. 1. From the soft shales of the Hamilton group at Eighteen Mile Creek, N. Y., showing five generations of corallites. The specimen is embedded in the shale, the flat "lower" surface alone showing on the under side of the shale lamina. Slightly enlarged.

Fig. 2. From the limestone of Canandaigua Lake, showing three generations of corallites. The first and second generations show strongly developed calices; the corallites of the third are immature, those on the left showing normal adolescent terminations. $\times 1\frac{3}{4}$.

Fig. 3. The right bud broken away, and the left one showing a normal adolescent termination, though somewhat broken. $\times 2\frac{5}{8}$.

Fig. 4. With only the calyx of the first corallite remaining, and showing on the right bud a somewhat imperfect, though normal adolescent termination. $\times 2\frac{5}{8}$.

Fig. 5. Similar to Fig. 4, showing a nearly perfect adolescent termination on the right bud. $\times 2\frac{5}{8}$.

Fig. 6. An average specimen, showing a well-developed calyx and two broken buds. $\times 2\frac{5}{8}$.

Fig. 7. Lateral view of an average specimen, showing the height of the calyx and the manner of change of the diagonal lines of growth to a horizontal position in the calyx. $\times 2\frac{5}{8}$.

Fig. 8. Showing the beginnings of the calyx in the formation of an upward-turning frontal lip, and the lateral broadening preparatory to budding. $\times 2\frac{5}{8}$. (Compare Figs. 9 and 10.)

Fig. 9. Lateral view of a specimen from Eighteen Mile Creek, showing the directions of the lines of growth on the procumbent tube and the bud, and the change to a horizontal position on the calyx. $\times 3\frac{1}{2}$.

Fig. 10. Front view of the same specimen, showing, by the lines of growth, the upward-turning frontal lip, which finally merges into the calyx wall. $\times 3\frac{1}{2}$. (Compare Figs. 7 and 8.)

Figs. 11, 12. Showing the intergrowth of two corallites meeting near the center of the corallum. $\times 4$. Compare Fig. 1.

Fig. 13. Showing an irregularity in the angle of divergence of the right bud. $\times 2\frac{5}{8}$.

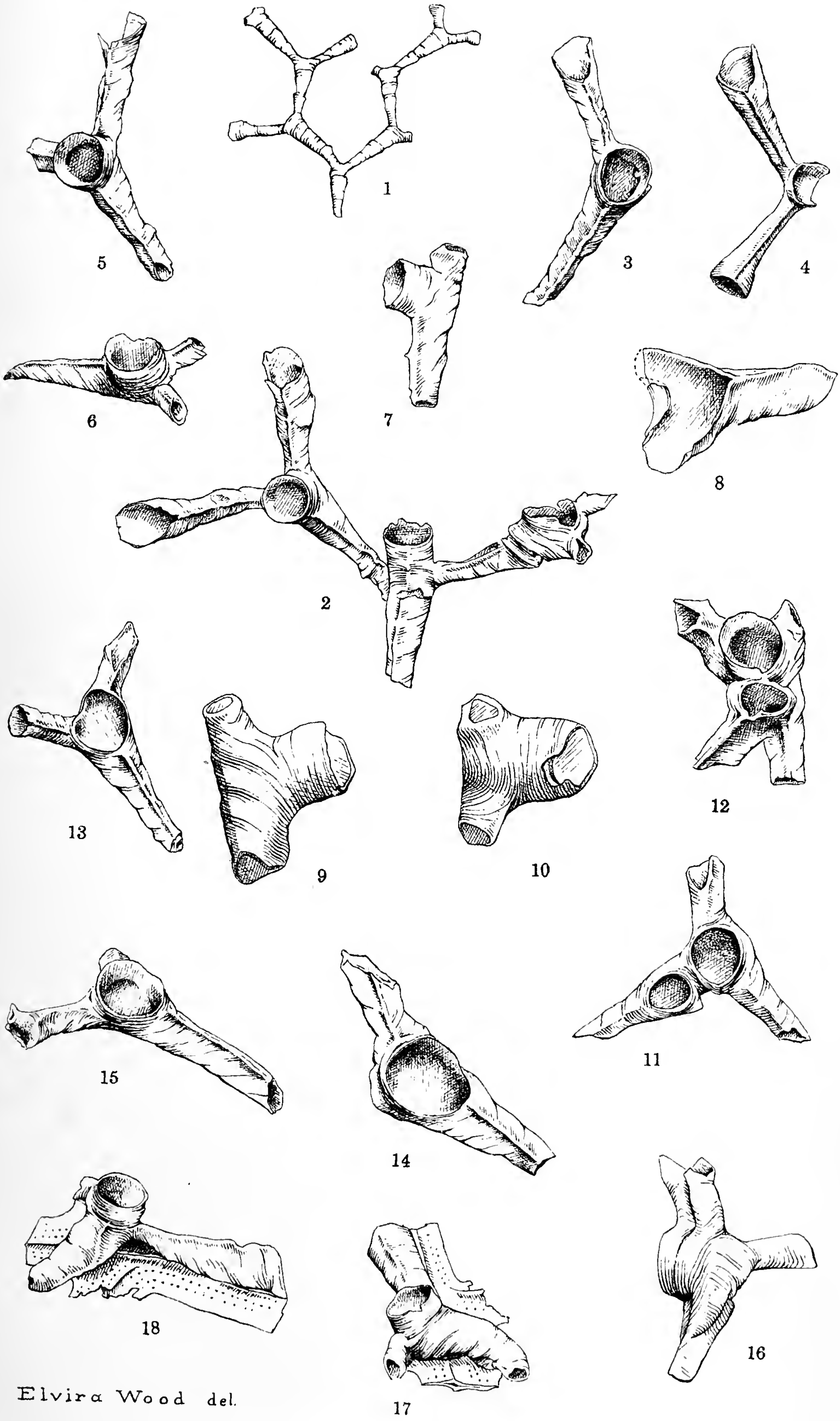
Fig. 14. Left bud either atrophied or broken away, and the scar healed over. $\times 3\frac{1}{2}$. (Compare Pl. 3, figs. 9, 10.)

Fig. 15. Indicating an injury to the left polypite which caused the contraction of the tube into a terminal cone. $\times 3\frac{1}{2}$.

Fig. 16. Showing a repaired injury in the lower portion of the tube, and a rebudding on the right side after the destruction of the first bud. $\times 3\frac{1}{2}$.

Figs. 17, 18. Two views of an attached specimen, showing features characteristic of *C. distorta.* $\times 3\frac{1}{2}$.

1, 9–10, Author's coll., 2–8, 11–18, Coll. Yale univ. museum.



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