I--FRANK STEPHENS

Life Areas of California

II--A. W. VOGDES

Address on Books Relating to Geology

Mineral Resources of California

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FAUNAS.

1, Humboldt.
2, Shasta.
3, Modoc.
4, Sacramento.
5, Foothill.
6, Sierra Nevada.
7, Alpine.
8, Clear Lake.
9, San Luis Obispo.
10, Santa Cruz.
11, San Jacinto.
12, San Diego.
13, San Bernardino.
14, Arctic.
15, Mojave.
16, Colorado Valley.
17, Island.

LIFE AREAS OF CALIFORNIA

BY

FRANK STEPHENS

Most people who have ascended mountains, on business or for pleasure, have noticed that there was a gradual change in the trees and other vegetation as height was gained, and some see that there is a system in this change. At a certain height in one mountain occurs a combination of trees, shrubs, plants, birds, insects and mammals, which combination is repeated in a general way on other mountains at a similar altitude, modified by local causes, such as soil, angle or direction of slope, nearness or remoteness of large bodies of water, height above base level and other conditions. Going higher, a change in the birds, trees, etc., occurs through the gradual disappearance of some species and the substitution of others until a new combination is formed. A similar combination is repeated in other mountains of the region in about the same order. Local causes modify these repetitions more or less, but the general similarity is sufficient to force the close observer to the conclusion that they are controlled by general natural laws. Within a few years much study has been given to the elucidation of these natural laws, and I will attempt to summarize some of the results of these investigations in California.

The causes controlling the geographical distribution of life are many, the most important being temperature, moisture, soil and light. We are accustomed to sum up three of these leading causes in the word climate.

The most important single cause of the varied distribution of life is heat: its quantity and daily and yearly range over a given area. Other conditions being equal, the warmer the climate of a locality is, the more luxuriant and varied its forms of life will be. A great

yearly or daily range of temperature unfavorably affects the life of an area by weeding out the forms most sensitive to such changes, on the principle of the "survival of the fittest".

The heat of a locality is affected by its latitude, altitude, direction of the prevailing winds, height above base level and slope exposure. Increase of latitude and altitude produce similar climatic effects, the higher area having a similar climate to that of the lower area situated a certain distance further from the equator. In other words, a traveler passing from the tropics toward the poles at sea level finds the climate steadily becoming colder; in climbing a mountain the same change is observed.

If the area of high altitude is great it is warmer than a small similar area at the same height and latitude, for the reason that the greater area conserves the greater amount of heat as daily received from the sun. It sometimes happens that the base level on one side of a mountain range is higher than that on the other side; in this case the higher level tends to raise the temperature and therefore the life zones on that side. A good illustration is the Himalaya Mountain range. The plain on the south side is several thousand feet higher than the plateau on the north side; in consequence of this difference of base level on the two sides the timber line and snow line are about three thousand feet higher on the north than on the south side. This is in direct opposition to the effect of latitude which would tend to lower the snow line on the north side. The Sierra Nevada Mountains are another illustration. The plateau on the eastern side is from three to four thousand feet higher than the San Joaquin and Sacramento valleys on the west side, and in consequence all the life zones are higher on the east side than on the west.

Slope exposure is another disturbing cause. A slope directly facing the sun is warmer than one facing away from it. This is very noticeable in many canyons running east and west in semi-arid parts of California, in which case the timber will be found growing considerably lower down on the side receiving the least amount of direct sunshine.

Prevailing winds coming directly from large bodies of water tend to cool the region contiguous and therefore lower the life zones.

The next most important agent in the distribution of life is moisture. The greater or lesser amount of moisture present in air and

soil strongly affects the vegetable growth of a locality; as animal life of a locality is practically dependent on the vegetation it is in that way affected by the proportion of moisture present. The amount of moisture of a region is regulated by its distance from large bodies of water, the direction of the prevailing air currents, and the height of intervening obstacles, such as mountain ranges. Most of the moisture present in the air originates in the evaporation of seas and other large bodies of water. The moisture laden air moving inland when cooled is unable to hold up all its moisture, which falls as rain. A high range of mountains will greatly cool the air currents passing over it and the heavy rainfall or snowfall resulting may abstract so much of the moisture from the air, that little is left for the region beyond the mountains, which thus becomes arid. The region of the Colorado and Mojave Deserts and the greater part of Nevada is an illustration of the drying influence which the Sierra Nevada Mountains exert on the air currents passing over them.

The quality of the soil is another factor in the quantity and character of the plant and animal life of a region. The carnivorous species of animals of a region subsist on the herbivorous species; these subsist on the leaves, stems, seeds or root of plants which draw their nourishment from the soil; therefore a richer or poorer soil has a considerable direct influence on such apparently remotely connected beings as the foxes or hawks that live in a region.

Dr. C. Hart Merriman has formulated certain laws of the distribution of life which appear to be based on sound reasoning from a sufficient mass of observed facts to assure their correctness.

"The northward distribution of animals and plants is determined by the total amount of heat—the sum of effective temperatures.

The southward distribution of Boreal, Transition zone, and Upper Austral species is determined by the mean temperature of the hottest part of the year."

If the North Temperate Realm was composed of sea and level land only, its life zones would nearly follow parallels of latitude around the northern hemisphere, deflected here and there by the effects of warm or cold ocean currents on the shores they wash. The presence of mountain ranges breaks up such uniformity of climate and renders the definition of life zones very difficult, nowhere more so than in California, where, in many mountains, island-like areas are detached from the main bodies of their zones or long

points project, or narrow bands curve to follow the sinuosities of the mountain sides. The peculiar topography of this state produces a variety of life zones which is probably equaled by no other similar area elsewhere. Bordered as California by the sea; traversed its whole length by a mountain range, in places carrying perpetual snow; possessing considerable areas lying below sea level; having a range of annual rainfall varying from 80 inches in the northwestern part of the State to 3 or 4 in the southeastern part, it offers the student of climatology and of the distribution of life facilities unsurpassed in any civilized country, and problems unknown in most other parts of the world.

Long ago geographers divided the earth's surface into five zones, giving them definite boundaries of certain parallels of latitude founded on astronomical considerations. Biologists have also divided the earth's surface into life zones and other divisions. These divisions seldom have very definite boundaries, but blend into one another.

For my present purpose I shall follow the division of the northern hemisphere into three Life Realms, as follows: The Arctic Life Realm, surrounding the north pole and passing southward to the northern limit of trees, or about the annual isotherm of 32 degrees; the North Temperate Life Realm, extending southward from the Arctic Life Realm to about the annual isotherm of 70 degrees; and a Tropical Life Realm. These Life Realms are subdivided into Life Zones as follows: An Arctic Life Zone, consisting of all the Arctic Life Realm; a Boreal Life Zone consisting of the upper or northern part of the North Temperate Life Realm south to about the summer isotherm of 63 degrees; a Transition Life Zone, consisting of that part of the same Realm bounded above or on the north by the summer isotherm of 63 degrees, and below or south by the summer isotherm of 70 degrees; an Upper Austral Life Zone lying between the summer isotherms of 70 degrees and 77 degrees; a Lower Austral Life Zone consisting of the remainder of the North Temperate Life Realm; and a Sub-Tropical Life Zone consisting of the northern part of the Tropical Life Realm. This covers but a small area in southeastern California. That part of the Arctic Life Zone in California is still smaller, consisting of a few small isolated areas on the highest mountain summits.

The distribution of life being affected also by the greater or less average amount of moisture present in a given area, and as this

average amount of moisture varies in portions of each life zone it follows that the distribution of life is not equal throughout a life zone. To give expression to the effects of the varying amounts of moisture in life realms and life zones they are divided in sections of variable size called regions, sub-regions and provinces. That part of the North Temperate Life Realm on this continent is known as the North American Region. That part of this region in western North America having a small annual rainfall is known as the Arid Sub-Region, and the part near the sea having a large rainfall is the Pacific Coast Sub-Region. The Arid Sub-Region has been divided into two provinces: the Sonoran Province consisting of that part in the Lower Austral and Sub-Tropical Zones; and the Campestrian, consisting of that part in the Upper Austral and Transition Zones.

I propose further subdividing the life areas of California into Faunas, to consist of areas of nearly equal temperature, moisture and soil, and the therefore a nearly homogeneous local assemblage of life forms. These will not be equal in either size or value, and are intended only to facilitate the study of distribution of species in California. The boundaries of Life Zones and Faunas as indicated on the accompanying map are only provisional; further study will necessitate numerous changes.

The Californian Arctic Fauna is that part of the Arctic Life Zone in California. A few species of plants constitute the only peculiarly Arctic life in California, as the areas are so small that animal life of strictly Arctic species has disappeared, with the possible exception of insects.

The Boreal Zone is forested nearly throughout its extent in California. The principal forest trees are the Foxtail Pine, White-barked Pine, Mountain Pine, Tamarack Pine, and Red Fir. The Californian mammals peculiar to this zone are the Gray-headed Pika, Mountain Beaver, Yellow-bellied Marmot, Belding Ground Squirrel, Alpine, Sierra Nevada and Alpine Chipmunks, Californian Pine Squirrel, Black Fox, Wolverine, Pine Marten and Ermine. Some of the birds breeding principally or exclusively in this zone are Sooty Grouse, White-headed Woodpecker, Williamson Woodpecker, Western Nighthawk, Calliope Hummingbird, Olive-sided Flycatcher Gray-eared Finch, White-crowned Sparrow, Lincoln Sparrow, Thick-billed Sparrow, Green-tailed Towhee, Audubon Warbler and Black-throated Gray

Warbler. The Californian part of the Boreal Zone may be called the Californian Alpine Fauna.

The Transition Zone is of considerable extent in northern California, but is of less extent in the southern part of the state, where it is limited to the sides and upper parts of the mountains, except that small part rising above about 7,000 feet altitude, which is Boreal. In most parts of the state the Transition Zone is well timbered, and is the great source of supply of wood and lumber in this state. The Yellow, Black and Sugar Pines, White Fir, Cedar and Redwood are characteristic of this zone. It contains a large number of species of birds and mammals, though few, perhaps none, are limited to it, nearly all its species being found in the adjoining zones, either above or below. Some of the birds breeding principally in it are the Californian Woodpecker, Blue-fronted Jay, Californian Purple Finch, Violet-green Swallow and Mountain Chickadee.

The Transition zone in California may be divided into several Faunas. The northeast part of the state, north of Honey Lake and east of Mt. Shasta, may be called the Modoc Fauna. It is a high broken plateau with some coniferous timber on the highest parts. A character of this Fauna is the abundant presence of sage brush *(Artemesia)*. South of the Modoc Fauna is a large area of the Transition Zone in the lower parts of the Sierra Nevada Mountains which may be called the Sierra Nevada Fauna. It is mostly well timbered, with Yellow Pine as the principal species. Those areas of the Transition Zone lying south of Lat. 35 degrees may appropriately take the name of the San Bernardino Fauna. Here also the Yellow Pine is a characteristic tree. The region about Mt. Shasta, north to Oregon and west to the low strip along the sea coast may provisionally take the name of the Shasta Fauna until its features are better known. I know nothing of this fauna personally and I can find very little published concerning its faunal conditions. A narrow strip along the seacoast from the Oregon line south to San Francisco may be called the Humboldt Fauna. This is a region of heavy rainfall and fogs, and a strong character is the presence of heavy redwood forests. A continuance of this narrow strip along the coast southward, including the Santa Cruz Mountains, and ending a short distance south of Point Sur, may take the name of the Santa Cruz Fauna. It presents similar characters to that of the Humboldt Fauna, but in a less marked degree.

The Upper Austral Zone lies next below or south of the Transition Zone. In many parts of the Upper Austral Zone a thick growth of several species of shrubs, collectively known as chapparral or chemisal, covers the hills. Forests are few and west of the Sierras are composed mostly of oaks, which east of the Sierras are replaced by Pinons and Junipers. The Gray-leafed Pine is common in this Zone in some places within the drainage of the San Joaquin and Sacramento valleys. The most characteristic mammals of the Upper Austral Zone are Pocket rats, two genera and several species, Pocket Mice of several species, Californian Grasshopper Mice, Striped Skunk, Gray and Island Foxes. The following species of birds find their upper or northern limits in this zone, Nuttall Woodpecker, Costa Hummingbird, Yellow-billed Magpie, Nelson Oriole, Lawrence Goldfinch, Black-throated Sparrow, Long-tailed Chat, Californian Thrasher and Black-tailed Gnatcatcher.

That part of the Upper Austral Zone lying on the west side of the Sierra Nevada Mountains, consisting of a long narrow strip along the sides of the lower parts of the mountains, may be called the Foothill Fauna. A broken region of moderate extent, bounded on the west by the Humboldt Fauna, on the north by the Shasta Fauna, on the east and south by the Sacramento Valley, may be called the Clear Lake Fauna. The region bounded on the west and southwest by the Santa Cruz Fauna and the Pacific Ocean, on the southeast by the Santa Ynez Mountains and on the northeast by the San Joaquin Valley may be called the San Luis Obispo Fauna. All the islands lying off the Southern California coast may be grouped together under the name of the Island Fauna. That part of the Upper Austral Zone south of the San Luis Obispo Fauna, and the Mojave Desert and west of the Colorado Desert may be called the San Jacinto Fauna.

The Lower Austral Zone includes most of the Mojave Desert, the San Joaquin and Sacramento valleys, and a strip along the coast from Santa Barbara to San Diego and southward. Over much of this area cactuses form a characteristic part of the vegetation. But few trees occur and these are found mostly along streams and in damp land. Much of this zone is very arid. Shrews are nearly wanting in this zone. Several species of bats find their northern limit in it, as do several species of ground squirrels. No species of tree squirrels or chipmunks (genera *Sciurus* and *Eutamias*) occur. Several species

of pocket rats and pocket mice and the Big-eared Fox are peculiar to this zone, the Gambel Partridge, Scott Oriole, Leconte Thrasher, Crissal Thrasher, Yellow-headed Tit and Plumbeous Gnatcatcher.

The large valley known as the Sacramento Valley (northern part), and San Joaquin Valley (southern part) may be called the Sacramento Fauna. The comparatively small area of Lower Austral Zone in the southwestern part of the state may be called the San Diego Fauna. In the eastern part of the state is a large area of arid plain, studded with small barren mountains, known as the Mojave Desert. It is principally Lower Austral Zone, but has a few tracts sufficiently elevated to reach the Upper Austral and a few very small areas of Transition Zone. This area north of the low Colorado Desert and west of the bottom lands of the Colorado River may be called the Mojave Fauna.

The Sub-Tropical Zone in California is confined to the bottom land along the Colorado River and west in the Colorado Desert, which is properly a part of the same bottom lands. Among the birds which do not breed above this zone and are found in this part of California are the Harris Hawk, probably the Audubon Caracara, Elf Owl, Vermillion Flycatcher, Abert Towhee and Cooper Tanager. This part of the Sub-Tropical Zone may be called the Colorado Valley Fauna.

AN ADDRESS

Before the San Diego Academy of Natural Sciences, on the Books Relating to Geology, Mineral Resources and Palæontology of California.

BY

ANTHONY W. VOGDES

In the early days the Science of Geology formed a part of Mineralogy, and subsequently, Physical Geology. The earliest writer to dignify the science was Dr. Saussure, in the year 1778. This great explorer of the Alps was the first to adopt a name for the science of Geology, instead of the old name of Cosmology.

The earliest account of the Geology of California, was that given by the Rev. William Buckland, in Beechey's Narration of a Voyage to the Pacific and Behring's Strait, in 1831. Dr. Buckland was born in Devonshire in 1784, and for many years held the chair of Geology at the University of Oxford. He was the founder of the museum of Geology of that University, and one of the founders of the Science of Geology. In the Volume on the Zoology, Dr. Buckland gives several references to the geology of the vicinity of San Francisco Bay, prepared from notes and collections of Lieut. Belcher, with a map of the headlands embracing San Francisco Bay. This early map indicates the several formations. Serpentine, sandstone, and jasper rocks are represented.

In the Geology of the Bay of San Francisco he gives an account of the Geology of San Francisco,—with notes of the earthquakes in 1806, also that of 1827.

In the report of the Exploring Expedition to the Rocky Mountains in 1842, Captain Fremont gives a few geological notes on California.

There are also notes regarding the geology of California in Emory's Reconnaissance from Fort Leavenworth, to San Diego, Califor-

nia, and in the report of Col. Cook's march from Santa Fe to San Diego, published in 1848.

In the U. S. Exploring Expedition, Vol. X, Geology, Prof. James D. Dana gives an account of the Geology of Shasta Mountains, also that of San Francisco Bay, with a description of the fossils of Astoria, Oregon, many of which are common to the Palaeontology of California.

Only 200 copies of this volume with its Atlas were published and it is one of the rarest works of California Geology.

During the year 1848-49, other expeditions and journals gave a few topographical and Geological notes; such as Capt. Johnson's expedition from Santa Fe to San Diego,—and Col Cooke's march of the Mormon Battalion.

With the discovery of gold in 1848, numerous notices appeared. The most important Reports were those by Dr. Tyson: Information in Relation to the Geology of California, Washington, 1850. This work contains articles on the Geology of the Sierra Nevada Mountains, also that of the Coast Range, with the geological structure of the Sacramento Valley; Gold regions of the Sierra Nevada,—the quicksilver mines, etc.

This work was republished with an introduction and an index, at Baltimore, in 1851.

The most important official document published at this date was the report of the Secretary of War, Part 2.

It contains a topographical memoir, with map of the Sacramento Valley, by Lieut. G. H. Derby, pp. 2-16, with Warner's reconnoissance of a route through the Sierra Nevada by the upper Sacramento, pp. 16-34.

Exploration of Monte Diablo, etc., by Lieut. Williamson.

The reports of the Secretary of War, 1850, contain an account of boring near Benicia, by Major Vinton, pp. 278-279.

T. Butler King's report on California, 1850, gives an account of the Geology of the Gold Regions.

House Doc. No. 17, 31st Congress, 1850, contains a letter from Col. Mason. This letter is the first official report on the discovery of gold in California. He gives a description of the country along the American river, and an historical account of the mining regions, also a description of the San Jose quicksilver mines. In the same docu-

ment there is an account of a tour made to the gold regions by Gen. Riley, pp. 785-792.

In 1857, Dr. James Hall, in the U. S. and Mexican Boundary Survey, gave a short description of the geology of Southern California, with a section of lignite bluff near San Diego.

Captain Aubrey, gives some notes of the route through the gold country on the head waters of the San Juan, Salinas, etc., in notes on route from near Tejon Pass, through Western New Mexico, and the Colorado to Santa Fe, in the fall of 1853.

In the publication of the Navy Department, House of Rep., Doc. 206, 42nd Congress, 1872, there is a report on the Mount Diablo coal mines of California, by B. F. Isherwood.

In the reports of Explorations and Survey for a railroad from the Mississippi to the Pacific, Volumes 3, 5, 6 and 7, contain geological information of California. Vol. 3, contains Jules Marcou's reports of routes explored near the parallel of 35 deg. North Latitude, with notes of geology of Los Angeles.

Vol. V, contains general observations upon the geology of the route, 35 and 32 parallels—Geological reports by Wm. P. Blake.

Chapter 1—San Francisco to San Joaquin River—Chapters 2 and 3, Fort Miller to Ocoya Creek, etc.; also chapters on the vicinity of Tejon, Mojave River, Los Angeles, San Bernardino, Colorado Desert, Warner's, Fort Yuma, San Francisco Bay, etc.

Prof. Louis Agassiz, describes and figures the fossil fish of Ocoya Creek, and Conrad, the fossil shells, including those from San Diego, and Monterey County, Colorado Desert, etc.

Vol. 6, contains reports by John S. Newberry, on the geology of San Francisco, Sacramento Valley, Western range of Sierra Nevada, also that of Pitt River and Klamath Basin. The Tertiary fossils collected were described by T. A. Conrad, from Santa Clara, Monterey County, Santa Barbara, etc.

Vol. 7, contains geological reports by Thomas Antisell—Geology of the Coast Range, also geology of the district from San Diego to Fort Yuma, etc.

Reports on Palaeontology, by T. A. Conrad—The fossil shells collected in California, by Wm. P. Blake, were also published in a pamphlet in 1855; also in final report in Vol. 1 of the Pacific R. R. Survey.

In the reports of the Mineral resources of the States and Terri-

tories west of the Mississippi, by J. Ross Brown and James W Taylor.

There are many notes on geological formation of the Pacific Coast, with resources in Gold, Copper, Quicksilver, etc. In that for 1867, there is an annotated catalogue of the minerals by Wm. P. Blake.

The report for 1868, contains a geographical and physical sketch of Lower California, by W. M. Gabb.

The reports for 1869-1875, by R. W. Raymond, contains many articles on minerals with a Geological map of the U. S., with several articles by A. W. Bowman, on Plieocene rivers, Geology of Plumas County, by J. A. Edman.

Petroleum in California, by F. A. Clark, etc.

The report of U. S. Mint for 1880-1900, contains statistics of the production of the precious metals.

The report of U. S. Coast survey for 1855, contains Observations on Geology of the Coast of California, from Bodega Bay to San Diego, by W. P. Blake.

The 10th U. S. Census, Vol. VI, Part 2, contains a general description of the geology of California, with reports on building stones of U. S., by Geo. P. Merrill, in Vol. X, 1884.

Notes on Iron Ore collected west of the 100 Meridian, by Bayard T. Putman, Vol. XV, 1886.

In the 11th U. S. Census Report, there are special reports on Gold, Silver, Quicksilver, Coal, Petroleum, etc.

In Lieut. George W. Wheeler's survey west of the 100 Meridian, Jules Marcou, has a special report on the geology of a portion of Southern California—Rep. of Chief of Engs., 1876, Appendix H.

The geological and mineralogical character of Southern California and adjacent regions are reported on by Oscar Loew —Appendix H^2, pp. 393-419, Geology of the mountain ranges from La Veta pass to head of Pecos, by A. R. Conklin.

In the preliminary report of Explorations in Nevada and Arizona in 1872, there are a few notes on the mining districts of California.

The report of 1877 contains a geological report on a portion of Eastern California, area examined, bounded on the north by Truckee and Washoe City, on the east by Mount Davidson range, and Como Mountains, and on the south by Job's Peak and Pyramid Peak, on the west by Truckee River.

In Hayden's Geological Survey, the 12th Report is the only one containing notes of California. Dr. White, described a *Productus giganteus* Martin, from McCloud's River.

In the contributions of the fossil Flora of the Western Territories, Leo Lesquereux describes several California fossil plants.

The Monographs, Statistical Papers, Annual Reports, and Bulletins of the U. S. Geological Survey, contain many papers on the Geology and Palaeontology and mineral resources of California.

The most important are those of J. S. Diller, on the Geology of Lassen Peak. The Quicksilver Deposits of the Pacific Slope, by George F. Becker.

Dr. White's papers on the Palaeontology of California in the Bulletins. The Earthquakes, by James E. Keeler, E. S. Holden, and Charles D. Perrine.

Contributions to the Cretaceous Palaeontology of the Pacific Slope, by F. W. Stanton. This bulletin describes the Knoxville beds; geographic distribution, local development in Tehama, Colusa, Lake, and Napa Counties, Mount Diablo, and other loccalities, etc.

There is also a paper by the same author on the Faunal Relations of the Eocene and Upper Cretaceous, in the 17th Annual Report.

The Mineral Resources, by David P. Day, to all the reports.

Reports on Geological maps of the U. S., by Jules Marcou and John B. Marcou.

Chemistry and Physics, by F. W. Clark.

The publications of the Smithsonian Institution, contains only two reports on the Geology. The first by Hitchcock, Illustrations of Surface Geology, 1857, pp. 107-108, on the erosions of the west side of the Sierra Nevada Mountains, and the second, by Geo. P. Merrill, on building and ornamental stones. Report for 1886.

The publications of the U. S. National Museum contain papers by W. H. Dall, of the fossils of the Coast Range, with a paper by Geo. P. Merrill, on onyx marbles, also notes on the Geology and Natural History of Lower California, etc.

The Geological Survey of the State of California was organized in 1853, by a resolution of the Senate, calling upon Mr. John B. Trask, for such information as he may possess, relating to the Geology of the State. Dr. Trask's report on the Geology of the Sierra Nevada or California range is a small pamphlet of 31 pp.—Sacramento, 1853.

The author gives a concise sketch of the geology and resources, from his reconnoissances of 1850-52, embraced within the 36th and 42nd degs. of North Latitude.

The second report was on the Geology of the Coast Mountains, Sen. Doc. No. 14, Sacramento, 1855. 95 pp. It contains description of the physical geography of the Coast Mountains and other geological information; Geology of San Bernardino Mountains, Stratified Rocks of San Bernardino chain, and plains of Los Angeles County, north of American River; mineral districts of the upper Sacramento Valley, Geology of northern Coast Mountains, etc.

The third report, by Dr. John B. Trask, on the Geology of the Coast Mountains and part of the Sierra Nevada—Assembly Doc. No. 9,1854. 92 pp., contains a description of the geology of Monte Diablo, Salinas Valley, Santa Cruz Mountains, Sacramento and San Joaquin Valleys, Position of the volcanic rocks to the Tertiaries, etc.

The final report on the Geology of Northern and Southern California, Assembly Doc. No. 14, 1856, contains 66 pp.

It contains a description of the physical geography of the Coast Mountains north of San Francisco Bay, etc.; Geology of Table Mountains, Tuolumne Co., California; rock of northern district, Shasta County, etc., etc.

In the Surveyor General's reports there are papers on Geology of part of Calaveras County—Doc. No. 5, Appendix F, 1855, with a report of a survey of a portion of the section boundary of California, and a reconnoissance of the old Carson and Johnson immigrant roads, in the Report of 1856.

The second Geological Survey of California, J. D. Whitney, State Geologist, consists of several addresses to the Legislature of California, with lectures on Geology. The final reports included the Yosemite Guide Books, in several additions; Catalogues of the Invertebrate fossils.

Palaeontology, in two Volumes ;

Geology, in two Volumes.

The first a report of progress an synopsis of the fields north, from 1860 to 1864, contains Geology of the Coast Range, Geology of the Sierra Nevada, with an appendix, Description of the Fossils of the Auriferous Slates of California, by F. B. Meek.

The second volume contains the Geology of the Coast Range.

Detailed description of Monte Diablo coal fields, Coal of Southern California, etc.

Notes on Geology of Lower California.

The other reports of this Survey include a Volume on Barometric

Hypsometry , with tables—Cambridge, 1874, with supplement in 1878.

Two Volumes on Botany, by W. H. Brewer, and Sireno Watson.

Two Volumes on Ornithology, with geological maps of San Francisco Bay; also map of California and Nevada.

To these reports should be added a report on the fossil plants of the auriferous gravel deposits, by Leo Lesquereux, and Auriferous Gravel of the Sierra Nevada, by J. D. Whitney, with the climate Changes of Late Geological Times: all published in the memoirs of the Museum of Comparative Zoology, at Cambridge.

The survey was stopped by the Legislature in 1874, permission having been given to the State Geologist by the Board of Regents of the University of California to continue the publications.

The California State Mining Bureau was created by an act of the Legislature, approved April 16, 1880, and Henry G. Hanks appointed by the Governor in 1880, as State Mineralogist.

The first Annual, Report, June 1st to Dec. 1st, 1880, contained analysis of clay from Placer County.

The second, Dec. 1st, 1880 to Oct. 1st, 1882, 288 pp., and 4 photographs, with appendix. This report contains various papers on mining, general geology, iron ores, mud volcanoes of the Colorado Desert, etc. The appendix has a paper on Forest Trees of California, by A. Kellogg; notes on hydraulic mining, etc., rare minerals recently found in the State, by Wm. P. Blake.

The miscellaneous publications include contributions to Geology and Mineralogy of California, by Wm. P. Blake, 15 pp., 1881; also a paper on the Milling of Gold Quartz, by M. Attwood, 20 pp., 1882.

Catalogues of the State Museum, Vols. 1 and 2, also catalogue of books and maps in the library of State Museum.

The 3rd Annual Report, for the year ending May 15, 1884, contains a report on the borax deposits.

The 4th Annual Report, for the year ending May 15, 1884, contains a general account of the Agricultural, and other resources, etc,,of California; also Catalogue of Minerals of California.

The 5th Annual Report, for the year ending May 15, 1885, 235 pp.;during this year the State Collection of Minerals was sent to the World's fair, at New Orleans, in charge of the State Mineralogist.

The 6th Annual Report, for the year ending June 1, 1886, Part 1: This report contains an article on San Diego Co., etc.

Henry G. Hanks resigned his office, May 13, 1886, and William Ireland waas appointed in his place.

The publications under William Ireland, State Mineralogist, consisted of the 2nd Part of 6th Annual Report, containing reports on the mines of Amador, Butte, and other counties.

Vol. 3, Catalogue of State Museum.

The 7th Annual Report, for 1887, contains articles on petroleum, asphaltum, and natural gas, etc., with a catalogue of fossils, by J. G. Cooper. This article forms Part 1 of the series; others were published in Bulletins.

The 8th Annual Report, for 1888, contains the mineral resources of the State, considered by counties.

Bulletin No. 1, a description of the desiccated human remains, by Winslow Anderson.

9th Annual Report, for 1889:

Contains articles on the Geology of the Islands off the Coast of California; account of San Diego County, etc.

The use of fossils to indicate mineral formation, by J. G. Cooper, etc.

The 10th Annual Report, for 1890:

Contains a geological map of the State, Geology of the Mother Lode, by H. W. Fairbanks.

Geological features of Placer, Nevada, Colorado Desert, Trinity, Orange Counties, etc.

During the year 1880, Vol. 4 of the Catalogues of the State Museum, with one on the Library, were issued.

The 11th Report, for two years, ending Sept. 15, 1892:

Contains special articles on Geology, including that of San Bernardino County.

Under the administration of J. J. Crawford, State Mineralogist, the following publications were issued, viz.:

The 12th Annual Report, for two years, ending Sept. 15, 1894. This report contains articles on the auriferous conglomerates, etc.; Geology of Ventura, Santa Barbara, and other counties, by H. W. Fairbanks.

This Report was followed by a number of Bulletins—Bulletin No. 2, Methods of Mine Timbering, with a second edition.

Bulletin No. 3, Gas and Petroleum-yielding Formations.

Bulletin No. 4, Catalogue of Fossils, Parts 2, 3, 4 and 5.

Bulletin No. 5, Cyanide Process; Catalogue of West North American Shells.

Bulletin No. 6, California Gold Mill Practices.

Bulletins Nos. 7 and 8, tables showing by Counties, the mineral productions of the State. No. 9, Mine Drainage Pumps, etc. No. 10, Bibliography of books relating to Geology of California, republished as Bulletin No. 30, including a list of the maps of California. No. 11, Oil and Gas-yielding Formations.

The 13th Report, for 1896, contains various articles on minerals, also mineral springs of the several counties, with appendix.

Under the administration of A. C. Cooper as State Mineralogist, th efollowing publications were issued:

Bulletins Nos. 12, 13, 14 and 17, showing by counties, the mineral productions of the State. No. 16, the Genesis of Petroleum. No. 17, the Mineral Productions of the State. No. 18, The Mother Lode regions, general geology of the gold belts, methods of mining, etc.

Bulletin No. 19, Oil and Gas-yielding Formations of California, with Atlas of Maps.

Bulletin No. 20, a compendium of the mining industry of the State, for the four years ending September, 1900.

Bulletins Nos. 21 and 22, relate to the mineral production of each county.

The State Mining Bureau has issued and has in preparationu several valuable papers showing the different mines in the several counties. These pamphlets include a map of each county.

The following has been published: Register of mines and mining with maps of Plumas, Calaveras, Siskiyou, Nevada, Lake, Placer, El Dorado, Shasta, San Bernardino, Tuolumne, Sierra, Los Angeles, Amador, and Trinity Counties.

There are also several special bulletins, such as Bulletin No. 23, reports on Copper; Bulletin No. 24, on Saline Deposits; Bulletin No. 27, on Quicksilver. Gold Production of Cal., 1848-1903.

In the Assembly Documents there are several papers relating to mines and minerals. The Transaction of the Agricultural Society, for 1863, gives a list of gold mines, pp. 101-118, with Mining Review for 1863.

Senate Doc. 16, Session 1866, Vol. 3, gives an account of California Marble, with Mining Review for 1865.

Senate Doc. 17, Session No. 3, 1867, gives an account of gold, silver, etc.

The State University has published Report on Mount Diablo, by S. B. Christy, in Report of President, of Universiey for 1877.

In the Reports of the Regents, there are papers on the genesis of the cinnabar deposits, by S. B. Christy; Berkeley, 1878.

List of earthquakes, Report for 1887.

Building Stones, Report for 1883.

List of printed maps, Bulletin No. 9, 1887.

The University has published three Volumes and part of another, under the title of University of California, Bull. Dept. of Geology. The Bulletins contain special reports on the Geology of Carmelo Bay; Geology of Angel Island, The Great Valley of California, Geology of Point Sal, Topographic Study of the Islands of Southern California.

Geology of Point Reyes Peninsula, The Berkeley Hills, Quaternary of Southern California, with several papers on minerals and fossils.

There is also a Bulletin of the type Specimen in the Geological Museum figured in Whitney's reports.

.. In the various scientific serials, many articles on California appeared, in a long list of some forty publications. We have only space to note in general the more important papers.

In the proceedings of the American Association for the Advancement of Science, Wm. P. Blake, writes on the Probable Age of the San Francisco Sandstone, in 1855.

Prof. Joseph Le Conte, in his address for 1893, discusses the theories of the origin of mountain ranges.

In the proceedings for 1895 and 1896, J. P. Smith, of Stanford University, notes the Carboniferous Strata of Shasta County and metamorphic series of that region.

In the American Journal of Conchology, there is a long controversy regarding the Cretaceous and Eocene formation of California, between Conrad, and Gabb.

Conrad refers the Tejon rocks to the Eocene, and Gabb, to the Upper Cretaceous.

In the American Naturalist, there are papers on the Glacial formations of the Pacific and Atlantic slopes.

Remarks on fossil shells of Colorado Desert, also a paper on the hillocks or mounds formation of San Diego, by Geo. C. Barnes, etc.

The American Geologist contains papers by Joseph Le Conte, on the Flora of the Coast Islands, Vol. 1, 1888.

Papers by J. S. Diller, on Lavas of the Sierra Nevada Mountains.

Geology of the Mother Lode, by Fairbanks; with a paper on the Eocene, Cretaceous and Carboniferous rocks of California.

There are also several articles by H. W. Turner on the Sierra Nevada and Coast Ranges.

In the first series of the *American Journal of Science*, as early as 1839, Conrad has an article on the elevation of California during the Tertiary epoch.

There is also an early account of the Cinnabar Mines, in 1848.

The gold discovery during this year, 1848, was reported upon by Rev. C. S. Lyman.

The Quicksilver Mines, and Earthquakes, were subjects of papers by Wm. P. Blake in 1854.

The Volcanic Springs of Colorado Desert, by John J. Le Conte, in 1855.

In the other *Journals*, for 1855-58, there are articles of the gold regions of California; also papers on the earthquakes, by Dr. J. B. Trask.

The leading papers in the *Journals* of 1859-65, are those of Lesquereux on fossil plants. Silliman's papers on Quicksilver Mines and Petroleum, with a notice of the Geological Survey of California, by J. D. Whitney.

In 1866-70, Whitney published a paper on the Borax of California. W. H. Brewer wrote papers on alleged discovery of an ancient skull, also one on gold-bearing rocks. Gabb and Conrad on the Cretaceous subdivisions of the California Geological Survey.

Blake, in Vol. 45, for 1868, refers the gold-bearing rocks of California to the Carboniferous age.

In Vol. 1, 1871, Clarence King publishes a paper on the discovery of actual glaciers on the Mountains of the Pacific slope.

Prof. Le Conte, papers on the theory of formation of great features of the earth's surface, appeared in Vols. 4 and 5, for 1872-73.

In the Volumes for 1873 to 1876, there are various papers on glaciers, lava flows, auriferous gravel deposits of Gold Bluff. Formation of Coast Ranges, by Joseph Le Conte; Age of the Tejon group, by J. G. Cooper, etc.

In the Volumes for 1878-80, Dr. Le Conte has an article on the

Structure and Origin of Mountains, with other papers on volcanoes about Lake Mono, and the old river beds, etc.

Vols. 24-25, for 1882-83, contains Le Conte's papers on Metaliferous Vein Formation.

Some notes on the Jurassic Strata of North America, by Charles C. White, appear in Vol. 29, for 1885.

George F. Becker, writes on the Cretaceous Metamorphic Rocks of California, Vol. 31, 1886. With another paper in same volume on the Texture of Massive Rocks.

There is an article by Joseph Le Conte, in Vol. 34, 1887, on the Flora of the Coast Islands of California, in which he discusses the physical changes af the Coast region, as indicated by the Flora and Fauna of the Coast Islands.

In Vol. 40, 1890, J. S. Diller writes on the Cretaceous Rocks of Northern California.

During the years 1893-95, several papers appeared in the *Journal*. One, on the so-called Wallala beds, by Fairbanks. Notice of the discovery of Devonian rocks, in California, by Diller and Schuchert, Vol. 47, 1894.

An auriferous conglomerate of Jurassic age, from the Sierra Nevada, by W. Lindgren, Vol. 48, 1894.

Lower Cambrian Rocks of Eastern California, by Charles D. Walcott, Vol. 49, 1895.

There is a notice of some Mesozoic plants from Oroville, by Fontain, in Vol. 2, 1896.

The Granitic Rocks of Pyramid Peak, by Lindgren, Vol. 3, 1897.

Also the papers by Fairbanks, on Contact Metamorphism, and on Tin Deposits at Temescal, in Vol. 4, for 1897.

In the publications of the New York Academy of Sciences, there is an article on the Infusorial Deposits, also a Catalogue of the Shells Collected at Panama, by C. B. Adams, published in the Annals of the Lyceums, Vol. V, 1852.

The Transactions of the American Institute of Mining Engineers, contains important mining notes regarding California, with the geographical distribution of mining districts in the United States, by R. W. Raymond, Vol. 1, 1873.

The Bulletins of the Geological Society of America, containing the following papers in reference to California:

1. Orographic Movements of the Rocky Mountains—Emmons.
2. Sandstone Dikes—Diller.
3. Structure of a Portion of the Sierra Nevada—Becker.
4. Antiquities from Under Tuolumne Mountains—Becker.
5. Early Cretaceous of California and Oregon—Becker.
6. Tertiary and Post-Tertiary Changes of the Atlantic and Pacific Coasts—Le Conte.
7. Geology of Mount Diablo—Turner.
8. Geology of Taylorville Region—Diller.
9. Jura and Trias at Taylorville—Hyatt.
10. Stratigraphy and Succession of the Rocks, Sierra Nevada—Mills.
11. Cretaceous and Early Tertiary—Diller.
12. Faunas of the Shasta and Chico Formations—Stanton.
13. Two Neocene Rivers of California—Lindgren.
14. Age of Auriferous Slates—Smith.
15. Trias and Jura of Western States—Hyatt.
16. Shasta-Chico Series—Diller and Stanton.
17. Geological Sketch of Lower California—Merrill.
18. Review of Geology of California Coast Range—Fairbanks.
19. Characteristic Features of Gold Quartz Veins—Lindgren.
20. Fauna of Shasta Group, Etc.—White.
21. Earth Crust Movements—Le Conte.
22 Precambrian Fossiliferous Formations—Walcott.
23—Ground Sloths—Merriam.
24. Drainage Features of California—Lawson.
25. Geology of Great Basin—Turner.
26. Sketch of Pedological Geology—Hilgard.
27. Sierra Madre, Near Pasadena—Claypole.
28. Origin and Structure of Basin Ranges—Spurr.
29. Drainage Features of California—Lawson.
30. Geology of the Great Basin in California and Nevada—Lawson.
31. Geological Section of the Middle Coast Ranges—Lawson.

The California Academy of Sciences, established in 1854, publishes a series of articles on the geology, fossils, mineral and other resources of California. The most important articles are the following:

The Natural System of Volcanic Rocks, by Baron Richthofen, Memories, Vol. 1.

The first Volume of the Proceedings for 1854-57, contains notes on fossils and earthquakes, also a paper on the mud volcanoes of the Colorado Desert.

Vol. 2, Earthquakes in California, in 1858-59, by Dr. Trask.

The 3rd Volume has several papers on fossils, notes on earthquakes, with a paper by W. P. Blake on oil regions in the Tulare Valley; also miscellaneous notices by the same author.

The 4th Volume gives notes on the ancient glaciers, with geology of the Coast of Oregon, etc.

The writers in the 5th Volume, are Whitney—Auriferous Gravel Deposits in Placer County. Davidson—Abrasions of the Continental Shores of Northwest America.

Chase—Artesian Wells of Los Angeles County.

Davidson—Auriferous Gravel Deposits.

Goodyear—High Sierra, South of Mount Whitney.

Le Conte—Great Lava Flood of the Northwest.

Dall—Tertiary Fossils.

Cooper—California Coal, with papers on the Pliocene, Miocene, Eocene and Tertiary formations of California.

The 6th Volume contains several papers by J. G. Cooper, on West Coast Pulmonata fossils and living, continued from Bulletin No. 8.

Notes on Geology of Lower California, by Lindgren.

There are no geological papers in the second Volume.

Volume 3, has an article on the flexure of rocks, by George H. Ashley.

A list of the books relating to the Geology of California, by Vogdes, with a note on discovery of *Proctus ellipticus*, in the Carboniferous of Shasta County.

Vol. 4, Pliocene Fresh Water Shells—Cooper.

Neocene Stratigraphy of the Santa Cruz Mountains—Ashely.

Fossil and Sub-Fossil Shells of the U. S.—Cooper.

The Washoe Rocks—Becker.

The 3rd Series of the proceeding contains Geology of Santa Catalina Islands—Smith.

Submerged Rocks of the Coast—Davidson.

Several papers by J. P. Smith, on Ammonites.

Tertiary Sea Urchins—Merriam.

Formanifera —Chapman.

Palaeontology and Stratigraphy of the Marine Pliocene, Vol. 3—Arnold.

There are many other scientific publications containing articles of value to the student of California resources, such as *Engineering and Mining Journal*, Harvard University publications, *Mining Magazine, Mines and Minerals*, *Nature*, Philadelphia Academy publications, etc., which, owing to the length of this address, can only be noted.

In the *Journal of Geology*, there are a series of articles by J. P. Smith, on the Carboniferous and Metamorphic Formation of Shasta County.

The Age and Succession of the Igneous Rocks of the Sierra Nevada—Turner. Vol. 3, No. 4, 1895.

Stratigraphy of Coast Ranges—Fairbanks. Vol. 3, No. 4, 1895.

Migration of Marine Invertebrates—Smith. Vol. 3, 1895.

Fauna of Independence Hill—Knowlton. Vol. 4, 1896.

Age of Auriferous Gravel—Lindgren. Vol. 4, 1896.

Classification Marine Trias—Smith. Vol. 4, 1896.

Topography of California—Drake. Vol. 5, 1897.

Geology, San Francisco, Peninsula—Fairbanks. Vol. 5, 1897.

Geology, Martinez Group—Merriam. Vol. 5, 1897.

Post-Pliocene Elevation of Inyo Range—Walcott. Vol. 5, 1897.

Pliocene Skull, of California, Table Mt.—Blake. Vol. 7, 1899.

Replacement of Ore Deposits, Sierra Nevada—Turner. Vol. 7, 1899.

Principles of Palaeontologic Correlation—Smith. Vol. 8, 1900.

Drainage Features of California—Lawson. Vol. 9, 1901.

Geology of Great Basin—Turner. Vol. 9, 1901.

Sketch of Geology, Salinas Valley. Vol. 9, 1901.

The West American Scientist, published in San Diego, contains New Cretaceous Fossils, No. 21, pp. 28-31.

Minerals and Mines of San Diego, No. 23, with several articles by Dr. L. G. Yates, on Fossil Botany.

In Zoe, there appears a short article on the Geology of Farallones, by Blankenship.

In Mofras' Exploration des Territoire de l'Oregon des Californies, etc., Paris, 1844, there is a notice of the bitumen near Los Angeles, on p. 337, Vol. 2.

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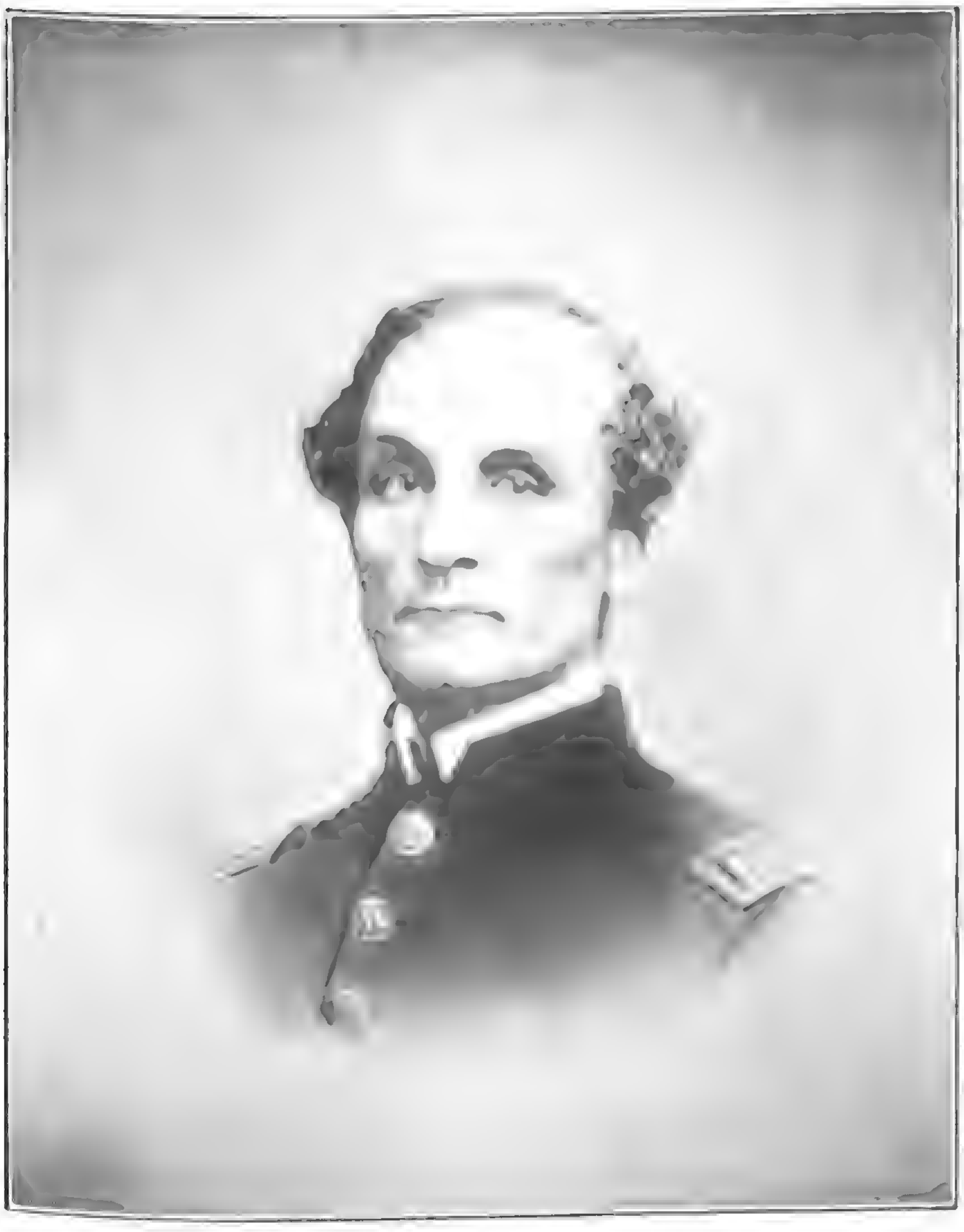


DOCTOR JOHN B. TRASK

First State Geologist of California

A BIBLIOGRAPHICAL SKETCH OF DOCTOR JOHN B. TRASK

FIRST STATE GEOLOGIST OF CALIFORNIA

BY

ANTHONY W. VOGDES

SAN DIEGO, CALIFORNIA

Doctor John B. Trask was born at Roxbury, Massachusetts, in 1824, and died at San Francisco, California, July 3rd, 1879, in the 55th year of his age. He was one of the charter members of the Academy of Natural Sciences of San Francisco and contributed many papers to the Academy. His last paper was read before the Academy February 19th, 1866; afterwards, though always interested in the welfare of the Academy, he ceased to take an active part, and devoted his time to the practice of medicine, in which he was professionally skilled, and remarkable for originality and independent thought.

Through him the medical professions of the Pacific coast were first made acquainted with the mode of preparation of Mentel's Aluminated solution and other valuable styptics.

Doctor Trask paid early attention to the medical flora of the Pacific and made known or discovered the virtues of such plants as *Yerba santa*, for rheumatism, etc., *Damiana*, a nerve tonic, and *Grindelia robusta*, for oak poisoning, and other plants.

The first Pacific medical journal published in California was edited by Dr. Trask, in conjunction with Dr. Wooster, under the title of the "Pacific Medical and Surgical Journal," in the year 1858. After some years of laborious editorial work the journal passed out of his hands.

Doctor Trask was licentiate of Yale University, passing examinations in Geology, Mineralogy, Chemistry, Medical Botany and cognate sciences, and was subsequently honored by the *ad eundem* degree in the year 1859.

He was also the subject of honorable recognition by various European and American scientific societies, with honorary degrees from Italian and German colleges, awarded for his researches and discoveries in Organic Chemistry, Mineralogy, Microscopy and Medical Botany.

Personally, Dr. Trask was remarkable for originality and independent thought, earnest and generous-hearted, free from the acquisitive instinct,

and always ready to serve those who needed his services, without money and without price; he had many opportunities for pecuniary advancement, but neglected them.

He was as careless in such matters as in his dress. Direct and blunt of manner, some thought him rough and rude of speech; he was, nevertheless, sympathetic and ever ready to lend a helping hand or do a kindly deed. He was a man of strong convictions and decided in his opinions.

He was connected with the Mexican Boundary Survey as Geologist of California and the State of Nevada, also State Geologist of California in the early fifties.

He served in the war as Assistant Surgeon of Volunteers.

LIST OF GEOLOGICAL AND PALÆONTOLOGICAL PUBLICATIONS:

Dr. John B. Trask contributed to the California Academy of Sciences the following papers:

1—Description of new species of Naiades from Sacramento River; Proc. Cal. Acad. Sci., vol. 1, p. 27–29, 1855; *Anodonta Randalli*, *A. triangularis*, *A. rotundovata*. The second paper describes species from the Yuba River, *Alasmodon yubæensis*.

2—Description of *Ammonites Batesii;* Proc. Cal. Acad. Sci., vol. 1, p. 39, 1855.

3—Description of Fossil Shells; Proc. Cal. Acad. Sci., vol. 1, p. 40, 1855; *Chemnitzia papillosa*, *Tornatella elliptica*, *Murex fragilis*, *Fusus Barbarensis*, *F. robustus*, *F. rugosus*.

4—Earthquakes in California from 1812 to 1855; Proc. Cal. Acad. Sci., vol. 1, p. 85, 1856.

5—Descriptions of new species of Ammonite and Baculite from the Tertiary rocks of Chico creek; Proc. Cal. Acad. Sci., vol. 1, p. 92, 1856; *Ammonite Chicoensis*, *Baculite Chicoensis*.

6—Description of three new species of the genus Plagiostoma from the Cretaceous rocks of Los Angeles; Proc. Cal. Acad. Sci., vol. 1, p. 93, 1856 (plate); *Plagiostoma Pedrona*, *P. annulatus*, *P. truncata*.

7—On Earthquakes in California in 1856; Proc. Cal. Acad. Sci., vol. 1, p. 102, 1856.

8—On the direction and velocity of the Earthquake in California January 9th, 1857; Proc. Cal. Acad. Sci., vol. 1, p. 109, 1857.

9—On some new Microscopic Organisms; Proc. Cal. Acad. Sci., vol. 1, p. 110, 1857. In which he establishes the new genus *Leptosiagon* for certain forms attached to Algæ of Santa Barbara.

10—New species of Zoophytes; Proc. Cal. Acad. Sci., vol. 1, p. 112, 1857. In which the author describes nine new species from the Bay of San Francisco and adjacent localities.

11—Earthquakes in California during the year 1857; Proc. Cal. Acad. Sci., vol. 1, p. 121, 1858.

12—Earthquakes in California during 1858, 1859 and 1860; Proc. Cal. Acad. Sci., vol. 2, pp. 39 and 90, 1859-60.

13—Earthquakes in California in 1863 and 1864; Proc. Cal. Acad. Sci., vol. 3, p. 131, 1864.

14—Earthquakes in California from 1800 to 1864; Proc. Cal. Acad Sci., vol. 3, p. 131, 1864. Also published as a pamphlet at San Francisco 1864, 26 pp.

15—Earthquakes in California during 1864; Proc. Cal. Acad. Sci., vol. 3, p. 190, 1865.

16—Earthquakes in California during 1865; Proc. Cal. Acad. Sci , vol. 3, p. 239, 1866.

By resolution of the State Senate, passed March 26, 1853, Dr. Trask was called upon for such information as he may possess relative to the Geology of California and productive resources of the State. This report, of which only 2,000 copies were printed, is entitled:

1—Report of 1853, Geology of the Sierra Nevada or California Range, by John B. Trask, Sacramento, 1853, 31 pp.

It contains a sketch of the Geology and Mineral resources of the Eastern valleys of the Sacramento and San Joaquin, and to the Coast line within 41st and 42nd degrees of north latitude, from personal observations made during the years 1850-52.

Reviewed Mining Mag. 1853, vol. 1, pp. 6-23.

2—Report on the Geology of the Coast Mountains, embracing their Agricultural resources and Mineral productions, also portion of the Middle and Northern Mining Districts, by Dr. John B. Trask, State Geologist, Senate Doc. No. 14, Sacramento, 1855, 95 pp.

This report contains a description of the physical geography of the Coast Mountains. Geology of the Coast Mountains. Tertiary rocks of the Coast Mountains, Primitive rocks of the Coast Mountains. Volcanic rocks of the Coast Mountains. Geology of the San Bernardino Mountains, Stratified rocks of the San Bernardino chain of Los Angeles. Artesian borings. Soil and productions of Los Angeles. Mineral productions of Los Angeles. Country north of the American River. Mineral district of the Upper Sacramento Valley. Geology of the northern mountains. Local geology of the Northern Coast Mountains. Carboniferous limestone of the eastern part of Shasta County. Trinity County. Structure of the Sacramento Valley. Tertiary rocks and other deposits of the Sierra Nevada. Placer Mining. Quartz veins. Quartz Mines, with description of the mines and statistics.

3—Report on the Geology of the Coast Mountains and part of the Sierra Nevada, embracing their industrial resources in agriculture and mining, by John B. Trask, State Geologist, Assembly Doc. No. 9, 1854, 92 pp.

Contains a description of the Geology of the Monte Diablo range. Salinas Valley, from Point Pinos to the Nacimiento River. Santa Cruz Mountains. Structure of the valleys of the Sacramento and San Joaquin.

Review of the geological changes in the Coast Mountains and Monte Diablo ranges. Classification of the rocks of the Coast Mountains and Monte Diablo ranges. Position and relation of the Volcanic rocks of the Tertiaries. Volcanic rocks preceding the Tertiary era. Most recent volcanic rocks of the Coast Mountains. Changes of level and river terraces. Soils of the Santa Clara valley and shores of the Bay of San Francisco. Valley of the Salinas. Soils of the Salinas, Pajaro Valley, Livermore Valley. Mineral resources of the Coast Mountains. Mineral districts, embracing parts of the counties of Nevada, Placer, El Dorado and Calaveras. Quartz veins and their relative age in California. Character and position of the older veins below the surface. Present government of metallic veins. Description of the mines, with a list of gold mines.

4—Report on the Geology of Northern and Southern California, embracing the Mineral and Agricultural resources of those sections, with Statistics of the Northern, Southern and Middle Mines, by Dr. John B. Trask, Assembly Doc. No. 14, Session of 1856, 66 pp.

Contains a description of the Physical geography of the Coast Mountains, lying north of the Bay of San Francisco. Geological structure of the Coast Mountains. Mineral character of the Primitive rocks of the Coast Mountains. Soils of Petaluma County. Plains west of the Sacramento River. San Bernardino. Geology of Table Mountain, Tuolumne County. Carboniferous rocks of the northern district. Salines of the Upper Sacramento Valley. Description of mines, etc. Analyses of Saline waters from Lick Springs, Shasta County. Gold mines in operation in 1855. Table of altitudes.

5—Report on the Geology of the Sierra or California Ranges, by John B. Trask; Pharmaceutical Journal, vol. 14, 1855, pp. 20–24.

MOLLUSKS AND BRACHIOPODS COLLECTED IN SAN DIEGO, CALIFORNIA.

BY F. W. KELSEY.

For the benefit of collectors of Mollusca and Brachiopoda, the author has compiled, as nearly as possible, a complete list of recent marine species to be found at San Diego, California.

The species listed have been collected within a district bounded by a a coast line not exceeding twenty-five miles in length, and in but a few instances going beyond a depth of two hundred fathoms.

San Diego is so situated as to afford special advantages to the collector of mollusks, as a great variety of collecting ground is accessible within a limited area, and the climate is so mild as to make collecting not only possible, but pleasant at all times of the year.

San Diego Bay affords an unusually interesting as well as prolific field for the conchologist, owing to the variety of ground awaiting his conquest.

At extremely low tides the nature of the ground uncovered ranges through all stages from a black, oozy mud, at the head of the bay, to the white beach sand at its entrance.

The grass flats opposite La Playa, are found well stocked with ever-varying sea life, and it is extremely interesting to note the changes in the molluscan population, as one species after another finds its way into the sheltered portions of the bay, becoming numerous today and tomorrow disappearing again.

On the Government Reservation, at the northern end of the bay, at a point about midway between Quarantine Station and Ballast Point, is a colony of rock borers, several species of which inhabit the sandstone left bare at middle tide; while still lower, among the moss-covered rocks, we find numerous Chitons and several species of Ocinebra, Muricidea, Pleurotoma and Odostomia.

The coarse gravel of Ballast Point contains its share, but gives it up only after hard labor; for the toothsome clam seems to be aware of the fact that he is popular, and the collector generally earns the savory dinner which he carries home in his basket.

The rocks of the Government Jetty are alive with rock dwellers, including many species of Littorina, Chlorostoma, Acmaea, Purpura,

Haliotis, Crepidula and others, while the ribbon kelp attached to the rocks carries several species that find shelter among its leaves.

The "marine ways," too, contribute their share of treasures, some of which, however, are introduced, as many small schooners from the southern coast come here to have the grass, barnacles and other foreign matter scraped off their hulls. This material furnishes a shelter for small mollusks, some of which are found among the debris.

Probably the most interesting method of collecting, and without doubt the one most costly, both in money and in labor, is securing the shells by means of the dredge and trawl. Both Dr. Fred Baker and I have done a great deal of this during the past five years, and have quite thoroughly covered an area of about thirty square miles of water, in the form of a semi-circle, with the entrance to San Diego harbor as a center.

The area so covered ranges from five to seventy fathoms in depth, and the species obtained have been quite numerous, including several new ones, and many others quite rare.

Personally I have dredged, with a good deal of care, all portions of the bay having over three fathoms of water, and have obtained very satisfactory results.

In the following list, which contains 554 species and named varieties, over 500 are at the present time in the author's collection, while the remainder are in the collections of Dr. Fred Baker, the Marine Biological Association of San Diego, and the National Museum at Washington, or are listed from C. R. Orcutt's list, published in the Proceedings of the National Museum in 1885; Philip P. Carpenter's list, published in 1872, and various publications mentioned in the explanatory notes.

The author has received the valuable assistance of Dr. William Healey Dall, Dr. Paul Bartsch and Dr. Fred Baker, in the identification of species.

The Nudibranchs are taken from a list prepared by Professor MacFarland, of Stanford University.

The list has been arranged alphabetically for ready reference, but for further convenience an index of genera and sub-genera has been provided, the same being arranged in the order adopted by Tryon in his Structural and Systematic Conchology.

Acanthochites avicula,
Var. diegoensis..... Pils.
Acmaea asmi..... Mid.
depicta ..... Gld.
Found on eel grass in sheltered localities.
incessa ..... Hds.
instabilis.. ..... Gld.

Acmaea mitra .. ..Esch.
paleacea .....Gld.
Dead shells, numerous on beaches.
patina .....Esch.
pelta .....Esch.
pelta, var. elevata.....Esch.
pelta, var. nacelloides.....Dall.
On ribbon kelp at Government Jetty.
persona.....Esch.
rosacea .....Cpr.
This species is quite rare here, although it is occasionally dredged or thrown upon the shore among drift.
scabra.....Nutt.
scabra, var. limatula .....Cpr.
Admete gracilior.....Cpr.
Dr. 52 fathoms.
Adula falcata.. .....Gld
stylina..... Cpr.
Beautifully marked little rock borers, having a rich brown epidermis.
Aeolis iodinea .....Cpr.
opalescens ..... .Cpr.
Aesopus myrmecoön.....Dall.
Dr. 5 fathoms.
chrysalloideus .....Cpr.
Dr. 5 fathoms.
Alaba oldroydi.....Dall.
supralirata .....Cpr.
Alabina turrita .....Cpr.
Aldisa sanguinea .....Cooper
Alvania purpurea .....Dall.
Amiantis callosa.....Conr.
One of the most beautiful of our bivalves; rare in San Diego, but occasionally found on sand beaches.
Amphisphyra subquadrata .....Cpr.
Dr. 15 fathoms.
Amphissa corrugata.....Rve.
undata.....Cpr.
Dr. 50 fathoms.
versicolor ... .Dall.
Amphithalamus inclusus.....Cpr.
Collected by Henry Hemphill, and mentioned in Bulletin of the Southern California Academy of Sciences, November, 1905.
Anomia lampe .....Gray
Found occasionally on rocks, but very difficult to obtain in good condition, owing to the tenacity with which the delicate lower valve clings to the rock.

Aplysia californica ..... Cooper
A good example of an interesting class of mollusks, whose shell, when present, is concealed in the back of the animal, and can only be produced by dissection. This is the largest known species of sea hare.

Arca gradata ..... Sby.
Formerly known as Barbatia gradata, found attached by byssus to under side of mossy rocks at low tide.

solida ..... Sby
Dr. 13 fathoms.

Assiminea californica ..... Cooper

Asthenothaerus villosior ..... Cpr.
Dr. 5 fathoms. A delicate little bivalve, with a strong orange band around the edge of both valves; found abundantly in shallow dredging.

Astrelium inaequale ..... Mart.

Avicula sterna ..... Gld.
Introduced. Found at the "Marine Ways," where vessels from the south have been scraped and shells have been among moss and barnacles.

Axinea intermedia ..... Brod.
Dr. 10 fathoms.

Barleeia haliotiphila ..... Cpr.
Found concealed among barnacles, moss, etc., on large Haliotis shells.

subtenuis ..... Cpr.

" var. rimata ..... Cpr.

Bittium armillatum ..... Cpr.
Dr. 11 fathoms.

asperum ..... Cpr.
Dr. 5 fathoms.

interfossa ..... Cpr.
Dr. 12 fathoms.

quadrifilatum ..... Cpr.
Found plentifully on mud flats, at low tide.

rugatum ..... Cpr.
Dr. 50 fathoms.

Boreotrophon avalonensis ..... Dall.
Dr. 52 fathoms.

disparilis ..... Dall.
Proc. U. S. Natl. Museum, No. 1032, page 712.

eucymatus ..... Dall.
Proc. U. S. Natl. Museum, No. 1264, page 547.

Bulla nebulosa ..... Gld.
Found very plentifully on mud flats, at low tide, or crawling leisurely through soft mud in shallow water.

quoyi ..... Say.
Rare, but occasionally found at False Bay.

Bursa californica .....Hds.
=Ranella californica, Hds.
Occasionally taken in fishermen's nets, or when spawning, in sand and mud of sandspits at the mouth of False Bay.
Cadlina flavomaculata .....MacFarland
marginata.....MacFarland
Cadulus californicus.....Pils.
Dr. 160 fathoms.
fusiformis .....Pils.
Dr. 60 fathoms.
nitentior .....Cpr.
Dr. 5 fathoms.
Caecum californicum.....Dall.
crebricinctum.....Cpr.
Dr. 15 fathoms.
glabrum.....Mont.
magnum.....Stearns.
Dr. 15 fathoms.
orcuttii.....Dall.
Found under rocks, at low tide, at Pacific Beach and on Point Loma. These, like Caecum californicum, are generally found in colonies
Calliostoma annulatum .....Mart.
canaliculatum .....Mart.
" var. parvum .....Williamson
gemmulatum .....Cpr.
gloriosum .....Dall.
splendens .....Cpr.
supragranosum .....Cpr.
Dr. 10 fathoms.
tricolor.....Gabb.
turbinum .....Dall.
The Calliostoma are found in considerable numbers nestling among the grass on the mud flats, at low tide. The last species is mentioned in the Proceedings of the U. S. National Museum, Vol. XVIII, p. 8.
Callistochiton crassicostatus.....Pils.
decoratus .....Cpr.
palmulatus .....Cpr.
" var. mirabilis .....Pils.
Calyptræa mamillaris.....Brod.
Dredged.
Cantharidus (Halistylus) pupoideus.....Cpr.
Dr. 5 fathoms.
Capulus californicus .....Dall.
Discovered by Mrs. Oldroyd on the shell of the Pecten diegoensis, which is, I believe, its only habitat.

Cardita subquadrata. ... .Cpr.
=Lazaria subquadrata.
Cardium corbis ....Mart.
Rare, although found in considerable numbers farther south.
procerum. .....Sowb.
This cardum, although formerly found alive here, is now only found in a sub-fossil condition on the shore of Spanish Bight.
quadrigenarium.....Conr.
Cavolinia inflexa ....Lesueur
Dr. 600 fathoms.
tridentata .....Gmel.
Dr. 120 fathoms.
trispinosa .....Lesueur
Dr. 400 fathoms.
Cerithidea californica..... .....Hald.
Formerly listed as Cerithidea sacrata, Gld. Found in great numbers on mud at middle tide, and on salt marshes.
californica, var. hyporhyssa..... .....Berry
Described in Nautilus, Vol. XIX, No. 12.
Cerithiopsis assimilata .....C. B. Ads.
columna .....Cpr.
metaxae ....Della Chiaje.
Dr. 5 fathoms.
munita .....Cpr.
Dr. 8 fathoms.
purpurea..... .....Cpr.
tuberculata .... Mont.
Dr. 10 fathoms. These small forms, often found in drift, are very difficult to determine without the aid of a good glass.
Chaetopleura hartwegii .....Cpr.
lurida, Var. prasinata.....Cpr.
Dr. 75 fathoms. My specimen, found on a rock, drawn up on lines of fishermen.
nuttallii ....Cpr.
Chama exogyra.....Conr.
pellucida ....Sowb.
Quite common on rocks, often growing side by side, and only distinguishable to a casual observer by the difference in direction of the spiral turn of the upper valve.
Chione excavata..... ....Cpr.
fluctifraga ....Sby.
simillima .....Sby.
succincta .... Val.
Chlamydoconcha orcutti.....Dall.
A rare bivalve, discovered by Mr. Orcutt at False Bay. The shells are entirely concealed within the whitish, spongy portions of the animal.

Chlorostoma aureotinctum .....Fbs.
brunneum .....Phil.
funebrale .....A. Ads.
" var. subapertum .....Cpr.
gallina .....Fbs.
" var. tinctum.....Hemp.
pfeifferi .....Phil.
pulligo .....Mart.
regina.....Stearns
Nearly all the species of Chlorostoma are found in large numbers among the rocks at middle tide, and although inclined to colonize, several species are often found in the same locality.

Chorus belcheri .....Hds.
Dredged. Quite common; generally drawn up in nets of fishermen.

Chromodoris californiensis.....Bergh
macfarlandi .....Cockerell
porterae .....Cockerell
universitatis .....Cockerell

Chrysallida aequisculpta .....Cpr.
helga .....D. & B.
pumila.....Cpr.

Chrysodomus eucosmius.....Dall.
Proc. U. S. Natl. Museum, No. 1032, page 709.

Circe margarita.....Cpr.
Dr. 15 fathoms.

Clathurella canfieldi .....Dall.
Dr. 12 fathoms.
lowei.....Dall.
Dr. 35 fathoms.

Clidiophora punctata.....Cpr.
Dr. 10 fathoms. Live shells are rare, but single valves are often washed ashore after storms at Pacific Beach.

Clio pyramidata.....Raug.
Dr. 400 fathoms.

Columbella (astyris) aurantiaca .....Dall.
Dr. 3 fathoms.
carinata .....Hds.
gausapata.....Gld.
hindsii .....Rve.
penicillata .....Cpr.
subturrita .....Cpr.
tuberosa .....Cpr.
variegata .....Stearns
Dr. 3 fathoms.

Conus californicus.....Hds.
Common, among rocks at low tide.
Cooperella subdiaphana .....Cpr.
Formerly known as Oedalia, and Oedalina subdiaphana. Cpr.; found in mud, on flats, at low tide.
Corbula luteola.....Cpr.
" var. rosea.....Williamson
Dr. 5 fathoms.
Crassatella marginata .....Cpr.
Dr. 12 fathoms.
Crassinella varians .....C. B. Ads.
Dr. 15 fathoms.
Crenella columbiana.....Dall.
Dr. 50 fathoms.
divaricata .....Orb.
Dr. 50 fathoms.
Crepidula aculeata.....Gmel.
adunca.....Sby.
This shell is found on the backs of other shells, and, like Capulus californicus, is marked by a beautiful pink color, unlike most of the other crepidulae.
arenata .....Brod.
dorsata .....Brod.
dorsata, var. lingulata.....Gld.
excavata .....Brod.
lessonii .....Brod.
navicelloides .....Nutt.
Generally found inside the orifice of larger shells.
navicelloides var. explanata .....Gld.
onyx .....Sby.
rugosa.....Nutt.
Found in large numbers on other shells, notably on Bulla nebulosa and Conus californicus.
unguiformis .....Lam.
Crucibulum spinosum.. .....Sby.
Cryptomya californica.....Conr.
Cumingia californica .....Conr.
Found with Platyodon cancellatus, in soft sandstone, into which they seem to have burrowed like Pholads.
Cuspidaria californica.....Dall.
Dr. 50 fathoms.
Cylichna albida.....Brown
attonsa .....Cpr.
Dr. 56 fathoms.
Cypraea spadicea .....Swains.
This, our only local Cypraea, is found rarely, at False Bay.

Cythara brannerí.....Arnold
Cytherea fordi.....Yates
Dr. 50 fathoms. In National Museum collection.
Dentalium neohexagonum.....Sharp & Pils
Dr. 5 to 8 fathoms.
vallicolens.....Raymond
Dr. 62 fathoms.
Diala marmorea.....Cpr.
Diaululua sandiegensis.....Cooper
Diplodonta orbella.....Gld.
Besides finding this shell in its cleverly constructed nest of mud, with tubes covering the siphons, I have found it cosily nested in the deserted shells of bivalves, like the Semele rupium, with a cushion of the same muddy nature, which fits the shell and prevents friction with the hard walls outside.
Donax conradi.....Desh.
culter.....Hanley
navicula.....Cpr.
Doriopsis vidua.....Bürgh.
Doris alabastrina.....Cpr.
saudiegensis.....Cpr.
sanguinea.....Cpr.
Drillia cancellata.....Cpr.
Dr. 12 fathoms.
hemphilli.....Stearns
Dr. 4 to 5 fathoms.
incisa.....Cpr.
Dr. 30 fathoms.
inermis.....Cpr.
moesta.....Cpr.
Found plentifully on rocks at Quarantine, among green moss.
montereyensis.....Stearns
penicillata.....Cpr.
torosa.....Cpr.
" var. aurantia.....Cpr.
Dunkeria gracilenta.....Cpr.
laminata.....Cpr.
Dr. 8 fathoms.
Engina carbonaria.....Rve.
Dr. 13 fathoms.
Ensis californicus.....Dall.
Erato columbella.....Mke.
vitellina.....Hds.
Ervilia castanea.....Mont.
Ethalia invallata.....Cpr.
Dr. 6 to 8 fathoms.

Ethalia supravallata.....Cpr.
Dr. 6 to 8 fathoms.
Eulima bistorta .....Van.
Dr. 15 fathoms.
fuscostrigata .....Cpr.
Dr. 6 fathoms.
hastata .....Sby.
Dr. 3 fathoms.
micans .....Cpr.
Dr. 3 to 5 fathoms. Found quite commonly in shallow dredging.
rutila .....Cpr.
Dr. 2 to 3 fathoms.
solitaria .....C. B. Ads.
My specimens were among moss on large abalone shells.
Eulithidium substriatum..... Cpr.
A very beautiful little shell, resembling Phasianella compta, Gld.; var. pulloides, Cpr., but more globose and very thin.
Fissurella volcano .....Rve.
Very common on rocks at all points along the coast.
Frieleia halli.....Dall.
Dr. 100 fathoms.
Fusus kobelti.....Dall.
Dredged.
Gadinia reticulata..... Sby.
Gemma gemma.....Totten
Dr. 50 fathoms.
Gibbula optabilis .....Cpr.
parcipicta .....Cpr.
Dr. 50 fathoms.
Glottidia albida.....Hinds.
This little shell in many ways resembles a growing plant; the leaf-like valves come up through the mud, while the long appendage strikes down like a root to support the coming plant.
audebarti .....Brod.
Dr. 12 fathoms.
Glyphis aspera ..... Esch.
densiclathrata .....Rve.
inaequalis .....Sby.
Haliotis assimilis.....Dall.
corrugata .....Gray
cracherodii .....Leach
" var. californiensis.....Swains
splendens .....Rve.
=H. fulgens, Phil.
Haminea vesicula..... Gld.
virescens .....Sby.

Heterodonax bimaculatus.....D'Orb.
This shell is found in a great many beautifully colored varieties, ranging from pure white to dark purple.
Hinnites giganteus.....Gray
Hipponyx antiquatus .....Linn.
cranoides .....Cpr.
tumens .....Cpr.
Hopkinsia rosacea.....MacFarland
Nautilus, Vol. XVIII., page 131.
Ianthina trifida.....Nutt
This beautiful Pacific species is not rare, frequently being washed ashore after storms.
Isapis fenestrata .....Cpr.
Dr. 8 fathoms.
obtusa .....Cpr.
Dr. 8 fathoms.
Ischnochiton clathratus.....Rve.
conspicuus .....Cpr.
Jeffreysia alderi.....Cpr.
translucens.....Cpr.
Kellettia kellettii .....Fbs.
Siphonalia kellettii.
Kellia laperousii.....Desh.
" var. chironii.....Cpr.
suborbicularis.....Mont.
Lacuna solidula .....Lov.
unifasciata .....Cpr.
" var. aurantiaca .....Cpr.
Laila cockerelli .....MacFarland
Nautilus, Vol. XVIII., page 131.
Lamellaria diegoensis.....Dall.
Rarely found among grass at low tide.
stearnsii .....Dall.
Laqueus californicus .....Koch.
Dr. 108 fathoms.
Lasea rubra.....Mont.
" var. subviridis.....Cpr.
Numerous colonies of these ruddy little bivalves are found at low tides clinging to the rocks like a crust of little jewels.
Leda cuneata .....Hovley
Dr. 50 fathoms.
conceptionis .....Dall.
Dr. 62 fathoms.
hamata .....Cpr.
Dr. 56 fathoms.
taphria .....Dall.
Dr. 40 to 60 fathoms.

Lepidopleurus mertensi.....Conr.
rugatus. .....Cpr.
veredentiens .....Cpr.
Lepton meroëum.....Cpr.
Leptothyra bacula .....Cpr.
carpenteri.....Pils.
paucicostata.....Dall.
Lima orientalis.....Ad. & Rve.
Limatula subauriculata.....Mont.
Dr. 52 fathoms.
Liocardium elatum .....Sby.
substriatum .....Conr.
Liotia acuticostata .....Cpr.
fenestrata ... .Cpr.
Lithophagus aristatus.....Dillwyn.
attenuatus .....Desh.
plumula.....Hanley
This genus consists of rock-boring bivalves that are only obtained by the exercise of much labor.
Littorina planaxis.....Nutt.
scutulata.....Gld.
Loligo stearnsii.....Hemp.
Lottia gigantea .....Gray
This limpet seems to love the dashing of the waves, and where the sea is wildest, there we find it in abundance on the rocks.
Lucapina crenulata.....Sby.
The great keyhole limpet is at times quite abundant among the rocks at low tide, where its black, slug-like mass slowly drags itself through the tangles of sea-weed.
Lucapinella callomarginata.....Cpr.
Quite rare, only a few specimens having been found here alive.
Lucina annulata.....Rve.
californica .....Conr.
nuttallii .....Conr.
Lunatia lewisii .....Gld.
Dr. 12 fathoms. A variety of the above is found here which so closely resembles Lunatia draconis as to be almost undistinguishable.
Lyonsia californica.....Conr.
Dr. 5 fathoms.
inflata .....Conr.
nitida.....Gld.

Macoma inconspicua..... .....B. & S.
indentata ....Cpr.
" var. tenuirostris..... ....Dall.
inflatula ....Dall.
Dr. 20 fathoms.
nasuta..... ....Conr.
secta ....Conr.
yoldiformis..... ....Cpr.
Dr. 20 fathoms.
Macron lividus .....A. Ads.
Very common on the moss-covered rocks of Point Loma.
Mactra californica ....Conr.
dolabriformis ....Conr.
falcata ....Gld.
nasuta..... ....Gld.
Malletia californica..... .....Dall.
Dr. 36 fathoms.
faba.. .....Dall.
Keep's West American Shells, page 23.
Mangilia angulata ....Cpr.
Dr. 10 fathoms.
fuscoligata ....Cpr.
hamata ....Cpr.
merita ....Gld.
Dr. 5 fathoms.
nitens ....Cpr.
Dr. 8 fathoms.
subdiaphana..... ....Cpr.
Dr. 5 fathoms.
variegata ... .Cpr.
Marginella jewettii..... ....Cpr.
Dr. 6 fathoms.
pyriformis..... ....Cpr.
Dr. 5 to 6 fathoms.
regularis ....Cpr.
Dr. 3 fathoms.
varia ....Cpr.
Megatebennus bimaculatus..... .....Dall.
Melampus olivaceus..... .....Cpr.
Very numerous on the salt marshes kept moist by high tides, but seldom covered by water.
Mesalia californica..... ....Dall.
Dr. 52 fathoms.
subplanata .... Cpr.
Dr. 100 fathoms.
tenuisculpta ... .Cpr.
Dr. 3 to 5 fathoms.

Metis alta..... Conr.
Formerly known as Lutricola alta, Conr.

Milneria minima ..... Dall.

Miodon prolongatus..... Cpr.
Dr. 50 fathoms. Proceedings of U. S. Natl. Museum, Vol. XIII, page 217.

Miralda californica..... D. B.
notabilis..... C. B. Ads.

Mitra maura..... Swains.
This beautiful mitra, only rarely found alive on Point Loma.

Mitromorpha aspera..... Cpr.
filosa ..... Cpr.

Modiolus capax..... Conr.
opifex ..... Say.
politus ..... Verrill.
Dr. 56 fathoms.
rectus ..... Conr.

Monia macrochisma..... Desh.
Formerly known as Placuanomia macrochisma, Desh, a rare but handsome shell, showing rich color markings.

Monoceros engonatum ..... Conr.
Found in large numbers among rocks at Government Jetty.
engonatum var. spiratum ..... Blv.
lugubre..... Sowb.
pauciliratum ..... R. E. C. Stearns.
Not uncommon in shallow pools, at middle tide, at Pacific Beach.

Mopalia hindsii var ..... Dall.
muscosa..... Gld.

Mumiola cincta..... Cpr.
turricula ..... De Folin.

Murex carpenteri..... Dall.
Nautilus, Vol. XII., page 123.
incisus..... Brod.
trialatus..... Sowb.
Rare and generally covered with green limey incrustation.

Muricidea barbarensis..... Gabb.
foveolata ..... Hds.
These are rare, but a few fine specimens of the banded form have been found near Quarantine.

Mytilimeria nuttalli..... Conr.
Mytilus bifurcatus... ..... Conr.
californicus ..... Conr.
Myurella simplex..... Cpr.

Nassa cooperi .....Sby.
" var. mendica .....Gld.
fossata.....Gld.
insculpta.....Cpr.
Dr. 56 fathoms.
perpinguis .....Hds.
Very common, showing great variety of color, including some fine banded forms.
tegula .....Rve.
Navanax inermis.....Pils.
Nettastomella darwinii .....Sby.
Quite abundant in rocks at La Jolla, but so frail as to render it difficult to secure unbroken specimens.
Neverita recluziana ..... Petit.
Norrisia norrisii .....Sby.
A beautiful species, generally found in the ribbon kelp that fringes the reefs on Point Loma, formerly known as Trochiscus norrisii, Sby.
Nucula bellotii.....A. Ads.
Dr. 52 fathoms.
castrensis.....Hds.
Dr. 60 fathoms.
exigua .....Sby.
Dr. 15 to 20 fathoms.
Nuculina munita .....Cpr.
50 fathoms.
Nuttallina californica .....Nutt.
scabra .....Gld.
Obeliscus conicus.....C. B. Ads.
Ocinebra circumtexta.....Stearns
" variety aurantia .....Stearns
gracillima .....Stearns
interfossa .....Cpr.
" var. atropurpurea .....Cpr.
" var. muricata .....Cpr.
painei. .....Dall.
Dr. 75 fathoms. Beautiful specimens of this rare shell have been found by the author on a rock, hauled up on the lines of fishermen.
pauxillus .....A. Ads.
poulsoni .....Cpr.
Octopus punctatus.....Gabb.
Odostomia amaura.....D. & B.
americana .....D. & B.
eucosmia .....D. & B.
This species and the following from the Bulletin, Southern California Academy of Sciences, Vol. IV., No. 8.

Odostomia grammatospira .....D. & B.
gravida ..... Gld.
montereyensis.....D. & B.
nuciformis .....Cpr.
subturrita.....D. & B.
tenuis .....Cpr.
tenuisculpta, var.....Cpr.
turritominia.....D. & B.

These minute mollusks are generally found in colonies, among or under rocks, at low tides, and in many cases cannot be determined without a lens.

Olivella biplicata .....Sby.

Often found in great numbers at low tide; the colors ranging from pure glossy white, through light and dark gray, to dark brown.

boetica .....Cpr.
intorta.....Cpr.

Dr. 12 fathoms.

Ommastrephes gigas ..... D'Orb.
Onphalius fuscescens..... Phil.
Oscilla aequisculpta..... .....Cpr.
insculpta..... .....D. & B.
Ostrea amara.....Cpr.
conchaphila .....Cpr.
lurida .....Cpr.
" var. expansa ..... Cpr.

The various species of Ostrea are found in considerable numbers on rocks, bottles, cans, pipes, and timbers, at low tide.

Ovula deflexa, var. barbarense..... .....Dall.

Dredged. Generally found on a species of yellow gorgonia.

Panopea generosa..... .....Gld.

Rarely found; burrowing in sand and mud to a depth of two feet or more. Formerly known as Glycimeris generosa, Gld.

Parapholas californica .....Conr.
Parthenia amianta..... .....Dall.
Pecten aequisulcatus ..... Cpr.
diegoensis..... .....Dall.

Dr. 8 fathoms. This fine species is occasionally pulled up by fishermen in their nets, and formerly called Pecten floridus, Hds.

latiauritis ..... Conr.
" var. paucicostatus .....Cpr.
monotimeris..... .....Conr.

These two species are very common, sometimes a single kelp plant having hundreds on its leaves.

vancouverensis ....Whit.

Dr. 50 fathoms.

Pedipes unisulcatus .....J. G. Cooper.
liratus .....Cpr.
Periploma argentaria..... .....Conr.
discus .... Stearns.
Dr. 10 fathoms.
Petricola carditoides..... .... Conr.
" var. californica ....Conr.
denticulata..... ....Sby.
ventricosa .....Desh.
Phacoides approximatus..... ....Dall.
Dr. 12 to 35 fathoms.
californicus .....Conr.
richthofeni..... .. ..Gabb.
tenuisculpta .....Cpr.
Dr. 4 fathoms.
Phasianella compta..... ....Gld.
" var. punctulata.....Cpr.
pulloides.. .....Cpr.
This pretty shell can generally be found in considerable numbers on the grass at low tide.
Philobrya setosa ....Cpr.
Dr. 20 fathoms. Also known as Bryophila setosa.
Pholadidea ovoidea ....Gld.
penita ....Conr.
sagittata .....Stearns
These fragile species are rock-borers and are difficult to obtain, but make pretty cabinet specimens. Found near Quarantine and at La Jolla.
Pholas pacifica .....Stearns
Platidia anomioides.....Scacchi.
Dr. 50 fathoms.
Platyodon cancellatus ....Conr.
Plectodon scaber..... ....Cpr.
Dr. 35 fathoms.
Pleurophyllidia californica .. ..Cpr.
Pleurotoma carpenteriana ....Gabb.
Dr. 60 fathoms.
catalinae.. ....Raymond
Dr. 60 fathoms.
perversa..... ....Gabb.
Dr. 82 fathoms.
santarosana.. .....Dall.
Dredged.
stearnsiana ....Raymond
Dr. 25 to 40 fathoms.
tryoniana.....Gabb.
Dredged.

Pomaulax undosus.....Wood.
Dr. 7 fathoms. A large, rough, conical shell, often thrown ashore after heavy storms; frequently carries smaller shells among moss which adheres to its epidermis.
Priene oregonensis.....Redf.
Dredged.
Protocardia centifilosa.....Cpr.
Dr. 50 fathoms.
Protothaca laciniata. ..... Cpr.
staminea .....Conr.
tenerrima .....Cpr.
This genus was formerly listed as Tapes.
Psammobia edentula..... Gabb.
californica ..... Conr.
Not common, but occasionally found at a depth of a foot or more at False Bay. The last species has formerly been listed as P. rubroradiata.
Psephidia ovalis..... Dall
Dr. 50 fathoms.
Pteronotus festivus ..... Hds.
Pterorhytis foliatum ..... Gmel.
nuttallii .....Conr.
This genus formerly listed as Cerostoma.
Puncturella cooperi ..... Cpr.
Dr. 56 fathoms.
cucullata .....Gld.
Dr. 56 fathoms.
Purpura muricata ..... Hds.
ostrina .....Gld.
Dredged.
saxicola .....Val.
This species found abundantly among stones of Government Jetty, and furnish a fine illustration of variety in form and color marking.
Pyramidella californica.....D. & B.
Rictaxis punctocaelata..... Cpr.
Listed as Rhextaxis punctocaelata in Keep's "West American Shells."
Rissoa acquisculpta .....Cpr.
compacta .....Cpr,
Rissoina bakeri .....Bartsch.
Nautilus, Vol. XVI., No. 1.
kelseyi ..... Dall.
Dr. 7 fathoms. Nautilus, Vol. XVI , No. 8.
Rupellaria lamellifera ..... Conr.
Dr. 8 fathoms.
Sanguinolaria nuttalli.....Conr.

Saxicava arctica ..... Linn.
rugosa..... Linn.
These little bivalves, found among rocks, are very irregular in form—no two seeming to follow the same plan of structure.
Saxidomus nuttallii ..... Conr.
The young of this species has been known as Saxidomus aratus, Gld.
Scala ballastriata ..... Cpr.
Dr. 15 fathoms.
crebricostata ..... Cpr.
Dr. 20 fathoms.
crenatoides..... Cpr.
hindsii ..... Cpr.
" var. tincta ..... Cpr.
lowei ..... Dall.
Dr. 40 fathoms.
sawinae ..... Dall.
Dr. 55 fathoms.
Scissurella kelseyi..... Dall.
Nautilus, Vol. XVIII., page 124.
Semele decisa ..... Conr.
incongrua..... Cpr.
Dr. 5 to 10 fathoms.
pulchra ..... Sby.
Dr. 8 fathoms.
rubropicta ..... Dall.
Dr. 3 fathoms.
rupium ..... Sby.
Fine specimens of the last species are found occupying the deserted burrows of rock-borers in the rocks at La Jolla.
Septifer bifurcatus ..... Rve.
Serpulorbis squamigerus..... Cpr.
Serridens oblonga.. ..... Cpr.
This interesting little bivalve was found by the author nestling in the mantle of the Ischnochiton conspicuua. It was listed by Carpenter as Pristophora oblonga, named from a single valve in 1866.
Sigaretus debilis..... Gld.
Siliqua lucida ..... Conr.
Siphodentalium quadrifissatum ..... Cpr.
Dr. 15 fathoms.
Siphonaria lecanium..... Phil.
Solariella johnsoni ..... Dall.
nuda..... Dall.
Dr. 400 fathoms.
peramabilis ..... Cpr.
Dr. 60 fathoms.

Solemya occidentalis .....Desh.
Dr. 50 fathoms.
valvulus .....Cpr.
Solen rosaceus.....Cpr.
sicarius .....Gld.
Sphenia fragilis.....Cpr.
ovoidea .....Cpr.
Dr. 5 fathoms.
Spiroglyphus lituella.....Mörch.
Spisula catilliformis.....Conr.
hemphilli.....Dall.
planulata .....Conr.
Formerly listed as Mactra.
Tagelus californianus .....Conr.
subteres .....Conr.
This genus = Solecurtus.
Tellimya tumida.....Cpr.
Dr. 51 fathoms.
Tellina bodegensis.....Hds.
buttoni.....Dall.
Dr. 5 fathoms = Angulus obtusus, Cpr.
carpenteri.....Dall.
Dr. 5 to 50 fathoms = Angulus variegatus. Cpr.
lamellata.....Cpr.
Dredged. Proceedings of the U. S. Natl. Museum, Vol. XXIII., page 301.
meropsis .....Dall.
= Tellina gouldi, Cpr.
santarosae .....Dall.
Dr. 12 fathoms.
Terebra specillata .....Hds.
Dr. 10 fathoms.
Terebratalia occidentalis.....Dall.
Dredged.
transversa .....Sby.
Dredged.
Terebratulina caput-serpentis.....Linn.
Dr. 50 fathoms.
" var. unguicula.....Cpr.
Dr. 20 fathoms.
Thalotia caffea.....Gabb.
Thecacera velox.....Cockeaell
Journal of Malachol, Vol. VIII., page 87.
Thracia curta.....Conr.
Thyasira barbarensis.....Dall.
Dr. 56 fathoms. Cryptodon barbarensis.

Tivela stultorum.....Mawe.
= Pachydesma crassatelloides, Conr.
Tornatina carinata.....Cpr.
cerealis.....Gld.
culcitella.....Gld.
Dr. 3 to 56 fathoms.
eximia.....Baird
Dr. 56 fathoms.
harpa.....Dall.
inculta.....Gld.
planata.....Cpr.
" var. attonsa.....Cpr.
Trachydermon dentiens.....Gld.
Transenella tantilla.....Gld.
Dr. 10 fathoms = Psephis tantilla, Gld.
Tresus nuttalli.....Conr.
= Schizothaerus nuttallii
Triforis adversa.....Mont.
Tritonia palmeri.....Cpr.
Trivia californica.....Gray
solandri.....Gray
This beautiful shell is rare, but fine examples have been found at La Jolla and Point Loma.
Truncatella californica.....Pfr.
stimpsonii.....Stearns
Turbonilla aurantia.....Cpr.
Dredged.
castanea.....Cpr.
chocolata.....Cpr.
Dr. 12 fathoms.
gracilior.....C. B. Ads.
Dr. 20 fathoms.
kelseyi.....D. & B.
laxa.....Dall.
lowei.....Dall.
Dr. 12 fathoms.
nuttingi.....D. & B
oldroydi.....D. & B.
tenuicula.....Gld.
" var. subcuspidata.....Cpr.
torquata.....Gld.
Dr. 10 to 20 fathoms.
tridentata.....Cpr.
Turiccula bairdii.....Dall.
Dr. 500 fathoms.

Turritella cooperi .....Cpr.
Tylondina fungina .....Gabb.
A brilliant orange-colored mollusk, with its horny shell, is found at times at La Jolla.
Venericardia gouldii .....Dall.
Dr. 822 fathoms. Collection of National Museum, Washington, D. C.
ventricosa .....Gld.
Dr. 62 fathoms.
Vermetus centiquadrus .....Val.
Bulletin So. California Academy of Sciences, Vol. IV., No. 8.
Vermicularia fewksii .....Yates.
Dr. 50 fathoms.
Verticordia ornata .....Orb.
Dr. 50 fathoms.
Vitrinella complanata .....Cpr.
subplana .....Cpr.
Dr. 6 to 8 fathoms.
Volvula cylindrica .....Cpr.
Williamia vernalis .....Dall.
Xylotrya pennatifera .....Blain.
setacea .....Tryon.
stutchburyi .....Jeff.
Yoldia cooperi .....Gabb.
Dr. 10 fathoms.
montereyensis .....Dall.
Dredged.
Zirphaea crispata .....Linn.

INDEX TO GENERA

NOTE ON THE GENUS HALIOTIS

With a Description of a New Variety

BY HENRY HEMPHILL

The genus Haliotis consists of quite large ear-shaped shells, brilliantly iridescent internally, and when the foreign matter that frequently accumulates on the outer surface is properly removed, most of the shells show a highly-colored exterior.

So far as we know at present the South Seas in the vicinity of Australia, and the adjacent islands, appear to be the metropolis of the genus, for there the greatest number of the known forms are found.

Woodward, Adams and Tryon recognize in their works on Conchology about 75 species.

In the later monograph of this genus by Pilsbry it seems that there have been described and named about 150 species. Dr. Pilsbry recognizes among them about 60 valid species, and 14 varieties worthy of a name, with several that he could not identify by the descriptions alone. The rest he places in the synonomy of the others.

The geographical distribution of the genus may be summed up as follows: Australia and adjacent islands, 30 species; Ceylon, Mauritius and Eastern Seas, 3; West Coast of Africa, 1; Cape of Good Hope, 3; Cape Verde Islands, 1; Mediterranean Sea and British Islands, 1, with two varieties; Gulf Stream, 1; Galapagos Islands (?), 1; Cape Horn Region, 1 and one variety; Philippine Islands, Japan and China, 7 or 8; West Coast of North America, from Alaska south to the Gulf of California, 5 and one variety.

The localities of about 16 species are unknown. None have been found on the west coast of America south of the Gulf of California, and not a single specimen has yet rewarded the researches of the collector along the east coast of America, from the Arctic regions to Cape Horn, except the one species and its variety already credited to the Cape Horn region.

From the above record of its distribution, it will be seen that the genus has succeeded in circumnavigating the globe, though greatly reduced in the number of species as it wanders away from its metropolis or the Australia region.

Since the publication of Pilsbry's monograph of the genus Haliotis. Dr. R. E. C. Stearns has published and described a new variety of Haliotis, which he characterizes and names *Haliotis fulgens*, variety *Walallensis*. This variety was discovered a few years ago on the coast of Mendocino county, California, near Gualala, by Mr. Rivers. Dr. Stearns remarks of this shell as follows:

"This variety differs from the type in its more elongate and flattened form, its constantly finer spiral threading, and its paler nacre. The concentric lamellation is sometimes undeveloped on the young shells. It has the same number of holes as the type.

"The above may be regarded as the extreme northerly expression of *H. fulgens* which has not heretofore been credited to any part of the coast north of Point Conception. From that point to Gualalla is an immense jump, about 320 nautical miles."

While the holes or perforations on the left dorsal side of the shells of the genus Haliotis may be of generic value, or a distinguishing character that serves to separate it from the genus Gena—a smaller but a similar shell without perforations—the number of holes is of no specific value whatever, as will be seen by the following examination of a large number of specimens, both young and adults, of *Haliotis cracherodii* (Leach):

Number of holes, 5 to 9.—Carpenter.

Number of holes, about 8.—Pilsbry.

Dr. Stearns remarks of the number of holes in *H. cracherodii*, as follows:

"Thirty-seven individuals gave a total of 236 complete holes, an average of about 6½. One individual had had only 2, two had 4, while five had 9, approaching the insular form known as *Californiensis* (Swainson). All of the foregoing were adult shells."

An examination of 27 adult shells of *H. cracherodii* (Leach) by myself gave the following result in the number of holes:

Three had 5 holes;
Four had 6 holes;
Seven had 7 holes;
Seven had 8 holes;
Eight had 9 holes;
One had 10 holes.

An examination of 85 young shells of this same species, varying in size from one-fourth of an inch to two inches in length, gave the following variations in the number of perforations:

Two had 3 holes;
Twenty-one had 4 holes;
Forty-four had 5 holes;
Sixteen had 6 holes;
Two had 7 holes.

The smallest individual of the above lot, one-fourth of an inch long, had four holes; the largest, about 2 inches in length, had six holes; but there did not appear to be any regular increase in the number of holes in proportion to the size or age of the shells.

Further examination and close study of these young shells reveals the fact that when the young creature emerges from the egg, the nucleus, or first whorl of its shell, is white in color and without sculpturing or holes. About the time one whorl is added to this embryonic shell the holes and sculpturing appear, and at the same time the little shell, in some instances at least, assumes a dirty brick-red color, but soon changes into the normal shading of brown or blue, while a few shells before me are of a beautiful shade of dark green.

The holes or perforations are arranged in a serial row on the left dorsal side of the shell, and are a little tubular until the shell attains about 2 inches in length. They are generally circular in form, but oblong holes frequently appear with the circular ones in the same individual. The sculpturing consists of a few oblique or curved radiating ridges passing from the nucleus to the holes, over which there passes from eight to twelve wavy spiral threads, a little corded sometimes by the sharp striæ of growth.

The interstices formed by the intersecting ridges and spiral threads often show as deep pits, and especially so in certain shades of light, which gives that part of the little shell near the nucleus a reticulated appearance and adds much to its beauty. With the increase of age and size these sculpture characters change greatly, and even disappear altogether on many of the adult shells. Frequently, however, the spiral threads of the young can be traced on the back of the adults, as low, obscure ribs, wavy or corrugated, and in a few instances the whole back of the shell is covered with obscure corrugations, giving such shells quite a distinct aspect.

Haliotis cracherodii (Leach), var. *californiensis* (Swainson).

The shells of this interesting variety found on Guadalupe Island, Lower California, are peculiar.

The perforations are smaller, more numerous, generally circular, resembling gimlet holes in a piece of wood, closer set together, while the entire row is often higher up on the back of the shell than in the normal or typical shells of *H. cracherodii.*

This combination of characters conspire to give these shells quite a distinct aspect of their own, and notwithstanding that there are numerous intermediates between the extreme forms of these shells and the typical *H. cracherodii,* I think it well for the purposes of study and the illustration of variation to retain Swainson's name, *Californiensis,* for those shells with the small holes without regard to their number on a single

shell, and not jumble together under one name shells so diverse in these characters.

By the kind permission of Miss Cooke, of the World Shell Store, here in San Diego, I have had the privilege of examining the large lot of this variety collected by the late Captain Geo. D. Porter, on Guadalupe Island, Lower California, that are now in her possession.

Three hundred and twenty of these shells show the following variation in the number of holes:

One had 4 holes;
Five had 6 holes;
Twenty-four had 7 holes;
Thirty-two had 8 holes;
Thirty-one had 9 holes;
Sixty-three had 10 holes;
Seventy had 11 holes;
Sixty-five had 12 holes;
Twenty-six had 13 holes;
Two had 14 holes;
One had 15 holes.

Miss Cooke reports finding 12 specimens in this same lot with 16 holes, but these were packed away and not accessible at this time.

The shells average a little smaller and a little thinner than *H. cracherodii*, while the form is more circular, generally. The color of the epidermis varies from a very dark blue, or black, to a yellowish blue and passes through various light and dark shades of brown.

Unfortunately there were none among the lot examined smaller than about three inches long, and these, with adults or larger shells, were well worn in the region of the spire, with the early sculpture characters destroyed.

There is evidence enough, however, on the half-grown and adults among this lot to warrant the assertion that the sculpturing is similar in the young state or on the young shells of this variety, to the typical or normal *H. cracherodii*.

With this knowledge of the variations of the holes and sculpturing of the shells of *H. cracherodii*, we may now briefly consider its mutations in the opposite direction.

Haliotis cracherodii, var. *holzneri* (Hemphill).

I have before me three shells that, while they possess all the characteristics of *Haliotis cracherodii*, they are without perforations, and there is no evidence on these shells that they ever had any holes. Thus they have lost the most important generic character that separates the genus Haliotis from that of the genus Gena, which has smaller but similar shells in every respect except the perforations, which are absent. These

three shells then show the intergrading of these two genera, and are of much importance when taken or considered in connection with the multitude of similar facts already known, and serves to shake our faith in the present methods of classification, specie and genera making. However this may be, these shells are unusually high and arching, as well as narrow and oblong, with the spire much nearer the posterior margin, than any other specimens of *H. cracherodii* that I have examined of the same size.

The spire of all of these shells is well worn, and consequently the sculpturing of the early stages of growth is lost, but there is sufficient evidence on the body of them, similar to that found on the adults of *H. cracherodii* to warrant the assertion that the sculpturing is the same on both forms.

The measurements of these shells are as follows:

Largest specimen—Length 4½, width 3½, height 1¾ inches.

Medium specimen—Length 4¼, width 3⅛, height 1½ inches.

Smallest specimen—Length 4, width 2⅞, height 1½ inches.

Habitat, coast of Lower California.

Mr. Frank Holzner, of San Diego, to whom I dedicate this interesting and very important variety, recently placed these shells in my hands for study and description. They were fouud in a lot of shells received by him from the lower coast, and he very considerately laid them aside for future cousideration. He informs me that he has, at different times, received about a dozen similar shells from the coast of Lower California.

Prof. F. W. Kelsey, of the Commercial College here in San Diego, has already published a note on this variety in *Vol. XVIII, page 67*, of *The Nautilus*, in which he calls it a "freak," and I am indebted to him for one of his excellent photos of the medium-sized specimen. I add a list of all the known forms of our West Coast Haliotis:

Haliotis gigantea, var. *kamtschatkana* (Jonas).

Haliotis rufesuns (Swains).

Haliotis corrugata (Gray).

Haliotis corrugata, var. *assimilis* (Dall.).

Haliotis fulgens (Phillippi).

Haliotis fulgens, var. *walallensis* (Stearns).

Haliotis cracherodii (Leach).

Haliotis cracherodii, var. *californiensis* (Swainson).

Haliotis cracherodii, var. *holzneri* (Hemphill).

THE GENUS ENCRINURUS

Its History, Its Species, Its Proper Division in the Family of Trilobites

—BY—

A. W. VOGDES

OF SAN DIEGO, CALIFORNIA

Specimens of this Trilobite were known almost 200 years ago; the first to Herrmann, who, in his Maslographia, plate 9, fig. 50, represents a tail of this genus, with six nodes on the axis and nine pleurae; he names it *Pectunculites marmoreus trilobus imbricatus*. This book was published in the year 1711. For copy of original see plate 3, fig. 10.

Some fifty years afterwards Linné, in Act. Reg. Acad. Sci. Holmiens, p. 22, plate 1, fig. 3, gave a figure of a specimen from Gotland, under the general name for all Trilobites, that of *Entomolithus paradoxus*. For copy of original see plate 3, fig. 11.

The author illustrates a tail with 9 pleurae and 20 axial joints; they are notched at the sides: this species served for the type of Wahlenberg's *Entomostracites punctatus*.

Other authors, such as Lehman, Novi Comm. Acad. Sci. Imp., vol. 10, plate 3, fig. 10, and Wilckens, Stralsundishes Mag., vol. 4, 1769, p. 267, plate 3, fig. 12, gave illustration of the pygidium, but without generic or specific description.

Wilckens has the credit of placing the fossil under the Crustacea. He copies Herrmann's figure and names the fossil "*Entomolithum Branchiopodis cancriformis marini.*"

Under the general term of Trilobus, Brunnich Nye Samling, af det Kong. Danskse Vidensk. Skrifker, vol. 1, 1781, p. 394, gave a specific name to the fossil now known as *Encrinurus punctatus*.

The author remarks: "Of the two very imperfect fossils I found in a soft yellowish limestone from Bohemia, I find across the fossil body impressed spotted joints, which are sufficient to distinguish it from other species. The size of it seems to vary greatly, as my limestone contains one small and one very large tail; each has 18 joints."

Wahlenberg, in his Petrificata telluris Svecanae Upsaliae, 1818, p. 32, plate 2, fig. 1*, not fig. 1 (*Calymmene Blumenbachi*), under the general name of *Entomostracites punctatus*, figures a specimen from Gotland.

Brongniart, who was the first author classifying the Trilobites, in his excellent work Hist. Nat. Crust. Foss., 1821, places this fossil under his genus Calymmene, naming it *Calymmene variolaris*, p. 14, plate 1, figs. 3 a-b.

Burmeister Org Trill., p. 114, and other authors, refer Brongniart's plate 1, figure 3a, to *Encrinurus punctatus*, and his fig. 3b to *E. variolaris*. The first is an extended specimen, with the genal angles prolonged into spines; the second a rolled up specimen, in which the genal angles are not extended into spines.

The characteristics of the pygidia are amply sufficient to separate the two common species. *E. variolaris* has 9 axial joints, interrupted in the middle by one or two isolated nodes on each joint, with 7 pleurae, and the axis is not extended into a long caudal spine, as in *E. punctatus*.

The Rev. Dr. Buckland, Geol. & Mineral Bridgw. Treat., vol. 2, 1837, copies Brongniart's figure, plate 1, fig. 3a, on plate 64, fig. 6, under the new name *Asaphus tuberculatus*.

Dalman Palæden, 1826, p. 234, plate 2, fig. 2a-b, gives figures of Gotland specimens No. 6, *Calymmene punctata*, and corrects the error of Wahlenberg's reference to plate 1, fig. 1* (the head of *Calymmene Blumenbachi*, to this species).

Murchison, Syst. Silurian., plate 23, fig. 8, illustrates *E. punctatus*, and on plate 14, fig. 1, an entire specimen of *E. variolaris* erroneously figured with 13 thoracic segments.

Emmrich De, Tril. Dis., 1839, p. 20, describes under the genus *Phacops variolaris* a species with the posterior angles of the head produced into short horns, a common characteristic of the other species, *Encrinurus punctatus*.

As late as the year 1840, the then known two species of this genus were classified under the genera Asaphus, Calymmene and Phacops. Eichwald at this date proposed that of Cryptonymus for the generic name (Sil. Syst. Esthlands, 1840, p. 71). The author placed such specie as *Calymmene punctata* and *C. variolaris*, including in the new genus *C. Woerthi C. parallelus*, now classed under the genus Cybele. The author, in substituting his abandoned name of Cryptonymus (proposed Obser. Geog. Zool. per Ingram. Marique Baltice, 1825, p. 44, there used for eight species, now classed under the genera Asaphus and Illaenus), simply pointed out his generic types without giving a generic description.

This name should stand under the strict rule of priority, for at least such species as *Encrinurus punctatus* or *E. variolaris;* and it was so used by Angelin in his Palaeont. Scand., in which he gave a description of the genus.

Eichwald, Bull. Soc. Imp. Sci. Moscow, 1855, claims priority and gives a history of the generic names.

The same author also remarks, Die Urwelt Russlands, 1840, p. 22: "I found also in Odinsholm fragments of other species, viz: *Calymmene variolaris* Brong. (at that date both *E. punctatus* and *E. variolaris* were classed under the name of *C. variolaris*), which belongs to the genus Cryptonymus. * * * I discovered near Reval an interesting small species of Cryptonymus, which has a tail similar to *Calymmene punctata*, Dalm.

Emmerich, Zur Naturgesch. der Trilobiten, 1844, p. 16, gives the following description of his new genus Encrinurus. The name was taken from the resemblance of the tail to a Crinoid stem., Der schwan and Encrinites:

"Eyes smooth, the glabella inflated and club shaped, the tail with many ringed axis and few pleurae.

"*E. punctatus* Wahl. is so different from all other trilobites that it is entitled to form a separate genus; it unites the clavate glabella of the Asaphus, and has the facial suture and eyes like Calymmene. * * On account of its peculiar shaped pygidium, I have given it the above name."

The author includes *E. punctatus* and two of Portlock's species, *Amphion multi-segmentatus* and *Ogygia rugosa*.

This description, like that of Eichwald, only points out its type. Almost all the authors on Trilobites have used it, with the exception of Angelin, Eichwald and Vogdes.

To retain both genera Emmrich's Encrinurus might be used for *E. punctatus* for a group of species having the genal angles of the head produced into spines, the pygidium, with a many jointed axis, terminating in a long caudal spine or blunt point with 9-10 plurae, such as—

Encrinurus punctatus Brunn, Ordovician and Silurian of Norway, Sweden and England.
——Vigilans Hall .....Silurian of New York.
——Seebachi Schmidt.....Ordovician of Russia.
——Schisticola Tornquist.....Ordovician of Sweden.
——ornatus Hall.....Silurian of New York.
——sex-costata Salt.....Ordovician, North Wales, &c., &c.

And the genus Cryptonymus for Eichwald's second type *E. variolaris* Brong., in which the genal angles of the head are not prolonged into spines. The pygidium has few axial joints and few pleurae. Such as—

Encrinurus variolaris Brong.....Silurian of England.
——expansa Haswell .....Pentland Hills, England.
——obtusus Angelin.....Reg. E Sweden.
——laevis Angelin .....Reg. D Sweden.
——Bowningi Foerste.....Silurian, Australia.
——Indianensis Kindle.....Silurian, Indiana.

Under which we have included the species described under the genus Cromus Barrande.

The Trilobites described under Encrinurus are as follows:

AFRICAN.

Encrinurus cresta-galli Woodward, Quart. Jour. Geol. Soc., vol. 29, p. 32, plate 2, figs. 6 and 7, referred by Lake to Phacops, Devonian.

NORTH AMERICAN.

Encrinurus elegatulus, Billings, Cat. Sil. Foss Anticosti, p. 62. Probably a species of Cybele..... Ordovician.
——vigilans, Hall, Palaeont. N. Y., vol. 1, p. 245, plate 65, fig. 2a-h .....Trenton.
——raricostatus, Walcott, 31st Rep. N. Y. State Mus., p. 69.....Trenton.
——vannulus, Clarke, Geol. Minnesota Palaeont., vol. 3, p. 709..Trenton.
——cristatus, Clarke, " " " " p. 741..Trenton.
——tuberculosus, Collie, Bull. Geol. Soc. Amer., vol. 14, p. 218, plate 14, fig. 3; same term used by Buckland for a species of this genus Bridw. Treat., 1837 .....Trenton.
——deltoides, Shumard, Geol. Missouri, p. 198, plate B, fig. 10...Silurian.
——Trentonensis, Walcott, 31st Rep. N. Y. State Mus., p. 68...Trenton.
——nereus, Hall, 20th Rep. N. Y. State Mus., p. 375, plate 21, fig. 15 .....Niagara.
——Egani, Miller, Cinn. Soc. Nat. Hist., vol. 2, p. 254, plate 15, fig. 1 .....Niagara.
——ornatus, Hall, Palaeont N. Y., vol. 2, p. 297, plate 66A, fig. 1a-e.....Clinton.
——Threcheri, Foreste, Bull. Denison Univ., vol. 2, p. 101, plate 8, fig. 26 .....Clinton.
——Americanus, Vogdes, Des. new species Clinton group, p. 1...Clinton.
——Indianaensis, Kindle, Geol. Indiana, vol. 28, p. 482, plate 24, figs. 14-15.....Niagara.
——phlyctainodes (Green), Miller, Cat. Amer. Foss, 2nd Ed., p. 574..... .....Niagara.
This species which Dr. Green, Amer. Jour. Sci., vol. 32, p. 167, compares with *Calymmene variolaris* Brong., Hall refers it to Lichas, Paleont N. Y., vol. 2, p. 314, plate 70, figs. 2a-b, c..... .....Niagara.

AUSTRALIAN.

Encrinurus Barrandei, DeKonick, Resch. Pal. Foss. Sud. Aust., p. 151, plate 1, fig. 1 .....Silurian.
Cromus Murchisoni, DeKonick, Resch. Pal Foss. Sud. Aust, p. 55, plate 1, fig. 9 .....Silurian
Encrinurus Bowningi, Foerste, Bull. Denison Univ., vol. 3, p. 122, plate 13, fig. 7..... ...Silurian.

——Mitchelli, Foerste, Bull. Denison Univ., vol. 3, p. 124, plate plate 13, figs. 2, 3 and 20 .....Silurian.

UPPER ALPS.

Eucrinurus Novaki, Fresch. Zeitschr. Deutsch. Geol. Ges., 1888, p. 735, plate 29, figs. 5-9.....Silurian.

BOHEMIA.

Cromus Beaumonti, Barrande, Sil. Syst. Bohéme, vol. 1, p. 826, plate 43. figs. 6-14.

——Bohemicus, Barrande, Sil. Syst. Bohéme, vol. 1, p. 828, plate 43, figs. 15-17.

——transiens, Barrande, Sil. Syst. Bohéme, vol. 1, p. 828, plate 43, figs. 18-19.

—intercostatus, Barrande, Sil. Syst. Bohéme, vol. 1, p. 824, plate 43, figs. 1-5.

Novak Bohm. Ges. Wissensch Jahrg., 1885, refers all of these species to the older genus, Encrinurus.

ENGLISH.

Encrinurus expansa, Haswell, Geol. Pentland Hills, p. 36, plate 4, fig. 4.

——punctatus, Brunn., 1781, Besk. Trilobiten, p. 394, England Wenlock, Dudley, Upper Ludlow, &c., Ordovician of Sweden, Norway, Russia, Silurian of Gotland.

——multi-segmantatus, Portlock, Geol. Londonderry, p. 291, plate 3, fig. 6..... ...Ordovician of Tyrone, Ireland.

——Stokesi, McCoy, Pal. Sil. Fossils, Ireland, p. 46, plate 4, fig. 15.

——sex-costata, Salter, Mem. Geol. Sur, vol. 2, plate 1, fig. 10 Llandeilo Flags..... .....North Wales.

——variolaris, Brongniart, Crust. Foss., plate 1, fig. 3b, not 3a, Wenlock Limestone, Dudley, &c.....England.

——fallax, Reed, Quart. Jour. Geol. Soc., vol. 55, p. 751, plate 49, figs. 9, 12 ....Irish Silurian.

RUSSIAN.

Encrinurus Seebachi Schmidt, Ostbal. Sil. Trilobiten, p. 229, plate 14, fig. 16–26 .....Ordovician.

Also E. obtusus Ang., E. punctatus Brunn., E. mulsi-segmentatus, Portl.

SCANDINAVIAN.

Encrinurus, obtusus, Angelin Pal. Scand., p. 3, plate 4, fig. 9, Gotland Reg. E.

——lævis, Angelin, Pal. Scand., p. 4, plate 4, fig. 10, West Gotland Reg. D.

——striatus, Angelin, Pal. Scand., p. 89, plate 41, fig. 13.....Reg. D-E.

——schisticola, Törnquist, Sv. Geol. Under, Ser. C, No. 66, p. 23, plate 1, figs. 15-17.

Also E. punctatus, Silurian of Gotland.

GROUP OF SPECIES WITH 23–33 AXIAL JOINTS IN PYGIDIUM.

Encrinurus punctatus..	.....(Entire)	23–30	axial joints,	9	pleurae.
——Stockesi, McCoy	.....(Entire)	28	" "	12	"
——Trentonensis, Walc	.....(tail)	23	" "	9	"
——Barrandei, DeKon	..... (head & tail)	25–26	" "	9	"
——multi-segmentatus, Portl	(tail)	32	" "	9–10	"
——striatus, Ang.	.....(tail)	.....not known	" "	10	"
——tuburculosus, Collie	.....(tail)	25	" "	8	"
——deltoides, Shum	.....(tail)	24	" "	7	"

GROUP OF SPECIES WITH 20 AXIAL JOINTS IN PYGIDIUM.

Encrinurus sexcostatus, Salter	(Entire)	20	axial joints,	6	pleurae.
——Americanus, Vogd..	..... (tail)	20	" "	5–6	"
——ornatus, H. W....	(tail, Ohio specimen)	...20	" "	7–8	"

GROUP OF SPECIES WITH 16-18 JOINTS TO PYGIDIUM.

Encrinurus nereus, Hall	.....(tail)	18	axial joints,	8–9	pleurae.
——Egani, Miller	.....(Entire)	18	" "	6	"
——Threcheri, Foerste	.....(tail)	18–20	" "	7–8	"
——raricostatus, Walc	..... (tail)	16	" "	6	"
——vannulus, Clarke	.....(Entire)	14–16	" "	6	"
——lævis, Ang	.....(Entire)	14	" "	8	"
——schisticola, Tornq	.....(Entire)	14–16	" "	7–8	"
——Bowningi, Foerste	.....(Entire)	18	" "	10	"
Encrinurus vigilans, Hall	.....(Entire)	18	axial joints,	9	pleurae.

GROUP OF SPECIES WITH 9–15 AXIAL JOINTS IN PYGIDIUM.

Encrinurus variolaris, Brong.	(Entire)	.....	9–10	axial joints,	7 pleurae.
——expansus, Haswell	.....(Entire)	14	" "	8	"
——fallax, Reed	.....(Entire)	12–14	" "	5–6	"
——obtusus, Ang	.....(tail)	12	" "	10	"
——Indianensis, Collie	...(head and tail)	...15	" "	10	"

The species may be grouped as follows:

ENCRINURUS.

1. Encrinurus punctatus, Stockesi, Trentonensis, Barrandei.
2. E. vigilans, Seebachi.
3. E. sexcostatus, deltoides.
4. E. multi-segmentatus, striatus.
5. E. Nereus, ornatus, Egani, Threcheri, Americanus.
6. E. raricostatus, vannulus.

CRYPTONYMUS.

7. E. variolaris, expansus, obtusus, lævis.
8. Bowningi.

9. E. Indianensis, tuberculosus.
10. E. schisticola.
11. Encrinurus (Cromus) Beaumonti, transiens, Novaki, Murchisoni.
" " intercostatus, Bohemicus.
12. E. Mitchelli, fallax.

Encrinurus punctatus, Brunn.

Syn. Entomolithus paradoxus, Linné, 1759, Act. Reg. Acad. Sc. Holm., p. 22, plate 1, fig. 2, Pygidium, with 9 pleurae, 20 or more axial joints.
Trilobus punctatus, Brunn., Kjobenh. Sellsk. Skrivt. nye Samml., vol. 1, p. 394; no illustration.
Entomostracites punctatus, Wahlenb., Petrif. telluris Svecanae., p. 32, plate 2, fig. 1, not fig. 1*.
Calymmene variolaris, Brong., Crust Foss., plate 1, fig. 3a, not fig. 3b, which represents E. variolaris.
——punctatus, Dalman, Palaeaden, p. 234, plate 2, figs. 2, a, b.
————Murch., Sil. Syst., p. 661, plate 23, fig. 8a-b.
Phacops variolaris, Emmrich, Diss., p. 20.
Asaphus, tuberculatus, Buck., Bridgw. Tr., plate 46, fig. 6.
Encrinurus punctatus, Emmrich, Neus Jahrb., p. 42.
——Stockesii, McCoy, Syn. Sil. Foss. Ireland, p. 46, plate 44, fig. 15.
——punctatus, Corda, Prodr. Tril., p. 91, fig. 55.
Cybele punctatus, Fletcher, Quart. Jour. Geol. Soc., vol. 6, p. 403, plate 32, figs. 1–5.
Encrinurus punctatus, Salter, Mem. Geol. Sur. Dec. 7, plate 4, figs. 15–16.
——Kuotr., Verh. Min. Ges. zu St. Pet., 1847, p. 299, plate 8, fig. 4a, b, c, e. f, g.
——Hoffman, Verh. Min. Ges. St. Pet., 1857–58, p. 35, plate 3, fig. 3a-e.
——Nieszkowski, Archiv. Nat. Liv. Ehst Kurl, p. 4, plate 3, figs. 6–7.
——Baily, Fig. Char. Brit. Foss, p. 67, plate 23, fig. 2.
——Steinhardt, Prenss. Tril., p. 57, plate 4, fig. 15.
——var calcareus, Salt., Nicholson & Etheridge Sil. Foss. Girvan Dist., p. 108 and 205, plate 10, fig. 7.
——punctatus, Etheridge, Jour. Roy. Soc. N. S. Wales, vol. 14, p. 3, plate 1, figs. 11 and 12.
——Schmidt, Ostb. Sil. Tril., p. 225, plate 14, figs. 11–13; plate 15, fig. 18.
——Roemer, Lethæa Palaeoz, plate 17, fig. 8.
——Novak, Bohm., Ges. Wissensch Jahrg., 1885, p. 5, plate 1, figs. 1–8.
——Roemer, Lethæa erratica, 1885, plate 7, fig. 21.
——Foerste, Bull. Denison Univ., vol. 2, p. 102.
————Proc., Boston Soc. Nat. Hist., vol. 24, p. 269, for E. ornatus, H. & W., E. Threcheri Foerste.
——Wigan, Zeitschr., Deutsch Geol. Ges. 1888, p. 91, plate 10, fig. 23.
——Foerste, Geol. Ohio, vol. 7, p. 531.
——Trentonensis, Walc., 31st Rep. N. Y. State Mus., p. 68.
——punctatus, Vogdes, Mong. genera Zethus, &c., p. 18, plate 1, figs. 1–5 and 17; plate 2, figs. 5–8; plate 3, figs. 15 and 16.

Encrinurus, Emmrich, 1844.

Diagnosis: The cephalic shield is semi-lunar, with the genal angles produced into long spines.

Glabella clavate; surface of the glabella and cheeks tuberculated.

Obscure glabella furrows.

Thorax with 11 segments; pleurae not grooved; tips notched.

Pygidium triangular; axis of many joints, 18-23-30; centre marked by a single row of nodes and terminating in a long caudal spine.

Pleurae, 8-10-12.

ENCRINURUS PUNCTATUS, Brunn. Plate I, figs. 1–18; Plate II, figs. 23–24.

Range, Ordovician of England, Sweden, Norway and Russia, &c.
Silurian of Gotland, Sweden.

Description: The general form ovate, nearly twice as long as wide. The head is bounded by a thick marginal border, which is narrow at the glabella and ornamented with two rows of tubercles.

Glabella clavate and gibbous, overhanging with 3 indistinct lateral furrows; large frontal lobe.

The facial sutures commence on the exterior margin of the head, just above the genal angles, and run in an oblique direction to the large pedunculated eyes, over their base, near the middle of the cheeks, then converge to the front of the glabella; they then turn suddenly, at an angle of 90 degrees, downward, and running parallel in a vertical direction to the marginal edge, which they cut, and converging, combine into a rostal suture.

The fixed cheeks are triangular, and separated in front by the vertical suture, convex and tumid.

Free cheeks are prolonged at their genal angles into spines.

The occipital furrow is continuous; occipital ring broadest in the centre, which is smooth, but has a node at each extremity.

Hypostoma ovate, obscurely granulated, surrounded by a sinuated margin, connected by its pointed end with the head. The wings are short and triangularly pointed. A furrow runs from each side up to one-third part of its length, which runs vertical, and its end not visible in the posterior thickened part, a small, obtuse continuation is seen.

Thorax with 11 segments. Pleurae without grooves, notched at their ends, but not spined; surface tuberculated. The axial joints are somewhat narrower than the pleurae. Spines occur on the 7, 9, and 10 axis joints.

Pygidium triangular, terminating in a caudal spine, the axis tapering posteriorly to an acute end, which has from 23–30 distinct side notches; the centre is smooth, with 7 prominent nodes: between the 1–3 nodes 2 notches appear; the 3–4 nodes have 4 notches; 4–5 nodes, 5 notches; 6–7 nodes, 5 or 6 notches appear.

The numerical arrangement of these nodes is not inviolable.

Pleurae 8, with a central row of tubercles.

Some Ludlow specimens have the glabella narrower, and but 4 nodes down the axis of the tail. (Salter.)

The variety called *arenaceus* Salt. differs only in the abrupt ending of the tail, which has not the long caudal spine of *E. punctatus*, but the terminal joint of the axis of the tail is deflected and blunt.

ENCRINURUS VIGILANS, Hall. Plate III, figs. 17, a, g. From Trenton Limestone of New York.

The head is more than semi-lunar in form, with its genal angles produced into long spines extending to the tail. The glabella is not lobed The front lobe is thickened and marked with 2 rows of tubercles. Eyes facetted, prominent.

Thorax with 11 segments; the axis has on every second joint a node or short spine.

Pygidium triangular, with 9 pleurae, every alternate one being ornamented with a node. Axis of 18 joints, every third one being marked by a node.

The specimen has only 18 axial joints in the tail, and a longer spine to the genal angles of the head, than the type E. punctatus, and should be compared with *E. Seebachi*, Schmidt.

ENCRINURUS ORNATUS, Hall & Whitfield. Plate III, figs. 15, 15a.

The authors refer *Cybele punctatus*, Hall, Pal. N. Y., vol. 2, p. 297, plate 66a, figs. 1a-e, to this species. Pal. Ohio, vol. 2, p. 154.

The Clinton specimens from New York have a subcresiform head, with the genal angles produced into spines extending to the fourth thoracic segment. Glabella clavate, also tuberculated; plate 66a, fig. 1, shows two lateral furrows. Thorax with 11 segments.

Pygidium triangular; no caudal spine shown in illustrations. Axis of 20 or more joints, notched at the sides, centre with row of 6 nodes, located on the 1st, 4th, 8th, 13th, 17th, 20th axis joints.

Other specimens from Clinton, at Lockport, have 7–8 pleurae, with 5 nodes on the axis of the tail, viz: on the 7th, 11th, 15th, 19th and 23d joints. These nodes occur at variable intervals, but with sufficient irregularity to discredit the value of such features for specific distinctions.

Pleurae 7–8, marked with a central row of 3 or more tubercles.

The Ohio species, *E. ornatus*, is of larger size; it has 20 axial joints, 7 pleurae in the tail, with 5 nodes on the 2nd and 5th joints, the three others having three segments between each node.

ENCRINURUS THRECHERI, Foerste.

In the Proc. Boston Soc. Nat. Hist., vol. 24, p. 269, the author places this species with Hall's E. ornatus under E. punctatus.

The species has 13–18 axial joints and 7 pleurae in the pygidium, with nodes on the 5th, 8th, 11th, 12th, 15th and 18th joints.

ENCRINURUS TRENTONENSIS, Walcott. Syn. *E. punctatus.*

This species from the Trenton Group of Wisconsin was described from the pygidium; it has 23 axial joints, with nodes on the 3rd, 6th, 10th, 14th, 18th and 22nd, with 9 pleurae.

ENCRINURUS NEREUS, Hall. From Niagara Group, Racine, Wis.

This species, described from a tail, has 18 axial joints and 8–9 pleurae. The rings of the axis are distinct and not notched at the sides.

ENCRINURUS EGANI, Miller. From Niagara Group at Joliet, Illinois. Plate III, fig. 13.

The genal anges are spined; glabella clavate and gibbous; projects in front beyond the narrow rim. Thorax 11; segments grooved.

Pygidium a little wider than long, with caudal spine.

Axial joints 18, with centre row of 4 nodes on the 4th, 7th, 11th and 14th joints. Pleurae, 6.

This group of species from the Clinton Group, consisting of *E. ornatus and Threcheri with Egani*, and *Nereus* from the Niagara Group, vary slightly in the number of axial joints, 18 to 20; and in the pleurae from 6 to 9: all of these species probably belong to the same species, and should take the older name, that of *E. nereus*, Hall.

Encrinurus Americunus, Vogdes, from the Clinton Group of Georgia, which has 20 axial joints and 5 or 6 pleurae, belongs to the same group.

ENCRINURUS SEX-COSTATA, Salter. Plate II, figs. 1–12.

Cybele sex-costata, Salter, Mem. Geol. Sur., vol. 2, pt. 1, plate 8, fig. 10, not fig. 9, 1848.

Zethus sex-costata, McCoy, Synops. Pal. Foss. Woodw. Mus., fasc. 1, p. 156.

Encrinurus sex-costata, Salter, Mem. Geol. Sur., Decade 7, plate 4, figs. 1–11.

——Brit. Pal., Rocks & Foss, Appendix A, 1855, p. iv. plate 1G, figs. 6–7.

——Nieszkowski, Archr. Nat. Liv. Ehst. Kurl, 1857, p. 80.

——Vogdes, Mong. genera Zethus, &c., p. 25, plate 3, figs. 1–12.

General shape, broad ovate head, and tail convex; body rather flat; head triangular; genal angles produced; the front rounded, gibbous and overhanging. Glabella pyriform; it overhangs the margin; there is a strong furrow which runs across the front of the glabella, separated from it by a thick, prominent ridge (fig. 3a); it has three short lateral furrows.

The cheeks, though convex, are much less so than the glabella, and bear the eyes in the middle, the surface pitted with fine granules. The free cheeks have their outer margin thick and separated by a furrow, with the genal angles produced into spines.

The posterior margin has a strong neck furrow continued along it. Thorax with 11 segments; each pleurae is nearly semi-cylindrical, with a row of 3–4 tubercules along its centre; tips bilobed.

Pygidium triangular, wider by one-third than the length, with obtuse rounded anterior margin. Axis with 20 joints extending across it, but

the upper one-third becomes flatter, and the rings are effaced along the middle. No nodes along the smooth central portion.

Pleurae 6, strongly indicated, divided from each other by narrow, deep furrows; ends squarish and obtuse. The upper four pleurae are free, but the two others are fused with those from the opposite side and extend in a very blunt point beyond the tip of the axis.

Llandeilo Flags, North Wales.

ENCRINURUS DELTOIDES, Shumard, Geol. Missouri, p. 198, Plate B, fig. 10.

Cryptonymus deltoides, Vogdes, Mong. genera Zethus, &c., p. 21.
Encrinurus deltoides, Foerste, Bull. Denison Univ., vol. 2, p. 102.
————Keyes, Geol. Missouri, vol. 4, Palaeont, p. 229.

The description of this species was drawn from a pygidium, Silurian of Cape Gardeau, Mo.

Pygidium subtriangular; width greater than the length. Axis flattened, convex, with 24 axial joints; the first 4 or 5 are entire, the others are interrupted in the middle of the axis and bear several very small granules. Pleurae, 8.

This species is related to E. sex-costata, Salter, from which it differs in the greater number of pleurae and axial rings.

ENCRINURUS BARRANDEI, DeKonick, Resch. Pal. Foss. Sud Aust, p. 51, Plate I, fig. 8.

——Trans. Mem. Geol. Sur. N. S. Wales, Palaeont, No. 6, p. 40, plate 1, fig. 8.

Head and tail only known from Yarralumla.

The head is similar to *E. punctatus;* it is, however, a little broader; the glabella less convex. The occipital furrow faintly marked; genal angles are rounded.

Pygidium subtriangular, slightly broader than long. The axis has 25–26 joints, not tuberculated. Pleurae 9, smooth; no caudal spine.

ENCRINURUS MITCHELLI, Foerste, Bull. Denison Univ., vol. 3, p. 124, Plate XV, figs. 2, 3 and 20.

The author illustrates the glabella fixed, and free cheeks, thorax and tail. The thorax has 12 segments. Pygidium 9–10; pleurae smooth, and 28 axial joints, notched at the sides, with a central row of nodes. No caudal spine indicated. Silurian of Australia.

ENCRINURUS SCHISTICOLA, Tornquist, Sv. Geol. Under. Ser. C, No. 66, p. 23, Plate I, figs. 15–17.

The author illustrates the glabella, part of the thorax and tail.

The head has the genal angles produced into short spines. The pygidium triangular, with a caudal spine. Axis 14–16 joints, extending across it, with a central row of nodes. Pleurae, 7–8; first 5 obtusely rounded, the last 2 spinous. Surface granulated.

Dist. of Siljan Dalecarlia.

ENCRINURUS SEEBACHI, Schmidt, Obsbal. Sil. Tril., p. 229, Plate XIV, figs. 16–26; Plate XV, figs. 21–23.

The author illustrates the entire species in parts from Wesenberger.

The genal angles of the head are produced into long spines, almost to the last segment of the thorax, as in *E. vigilans*, Hall. The glabella and cheeks coarsely granulated.

Thorax with 11 segments. The axis has a spine on the 7th, 9th, 10th and 11th joints.

Pygidium triangular in shape. Axis 30–32, axial joints extending across it. No nodes. Pleurae 9; not tuberculated.

Hypostoma the same as that of E. punctatus.

ENCRINURUS MULTI-SEGMENTATUS, Portlock.

Amphion multi-segmentatus, Port., Geol. Rep. of Londonderry, p. 291, plate 3, fig. 6 a-b.
Ampyx? baccatus, Port., Geol. Rep. of Londonderry, p. 262, plate 3, fig. 11.
Encrinurus multi-segmentatus, Salt., Mem. Geol. Sur., Dec. 7, Encrinurus, p. 7.
———Nieszk., Mong. Tril. Ostseeprov., p. 609 (ex. pt.)
———Schmidt, Untersuch Sil. Form. Erkl., p. 190 (ex. pt.)
———Roemer, Foss. Fauna V. Sandewitz, p. 75, plate 8, figs. 7, a, b, c.
Cryptonymus multi-segmentatus, Vogdes, Mong. genera Zethus, p. 29.
Encrinurus multi-segmentatus, Schmidt, Ostbal. Sil. Tril, p. 227, plate 14, figs. 14–15; plate 15, figs. 19–20.
Tornq., Sv. Geol. Under., Ser. C, No. 66, p. 24, plate 1, figs. 18–19.
——Roemer, Lethaea erratica, plate 4, figs. 14, a.

The author figures the pygidium (plate 3, figs. 6-a, b) and the head as *Ampyx baccatus*, plate 3, fig. 11.

The following is the original description:

Characters: "Axial segments very narrow and numerous, 28 being enumerated as far as the last side segment, and still continuing through very minute, to the very apex. A small, lozenge-shaped caudal plate. Side segments, 12 on each side, exclusive of the false segment. They are rounded and slightly bent or raised at their extremities; no punctures or marks of any kind."

Dr. Roemer Foss., Fauna von Sadewitz, p. 75, plate 8, figs. 7, a, b, c, illustrates a head and tail, which he refers to this species; fig. 7-a of the head has the genal angles prolonged into short spines; fig. 7-c of the tail, exhibits side notches on the axis and a smooth centre; no ornamentations

The same author referred *Encrinurus striatus*, Ang., to this species as a synonym.

The Irish species will easily be distinguished by its large, coarsely tuberculated head and many ribbed tail. The crest of large tubercles on the glabella are parted in the middle along the front of the glabella.

ENCRINURUS FALLAX, Reed, Quart. Jour. Geol. Soc , vol. 50, 1899, p. 753, Plate XLIX, figs. 9–12.

The author illustrates an entire specimen of a young individual; also the head and tail of an adult; from County Waterford, Ireland.

The head shield broadly semi-circular, strongly convex. Glabella convex, subcylindrical, slightly broader in front than at the base; not inflated in front or overhanging the margin. Three pair of short lateral furrows. Frontal lobe twice the length of the anterior pair of lobes; not overhanging them laterally; it is rounded in front, where it is encircled by a marginal furrow, which runs into the deep and strong axial furrow. A narrow tuberculated, almost horizontal border, is thus marked off from the anterior end of the glabella, as in E. Seebachi, Schm. Fixed cheeks, convex; elevated genal angles, bent down. Eye lobe large and elevated.

The facial suture curves backwards and outwards from the front of the glabella to the 2nd lateral furrow, where the eye is situated; from this point it bends slightly outwards, and running nearly parallel to the posterior margin in front of the genal angles. Surface ornamented with small tubercles.

Thorax with 12 segments. Axis convex; each ring has a median, raised, rounded ridge, ornamented with tubercles; narrow, flat, articulating band on the anterior and posterior margins. A conspicuous nodule is seen on each side of the axis, as in *Calymmene Blumenbachi*. Pleurae with medium tuberculated ridge; free ends bluntly pointed. Pygidium with 12–15 axial joints; only the first 9 or 10 rings are entirely across the axis; sometimes only the first four. The axis ends in a bluntly pointed extremity. The anterior joints have each four tubercles The 1st pleurae, 3 tubercles; 2nd, two or three; 3rd, two, and the 4th and 5th, one or two each. The first pleurae are strong, without furrows, and curve regularly backwards; the 5th and 6th pair are weaker, and run nearly straight backwards.

The author compares the species with *E. sex-costatus*, Salt. It has not the overhanging glabella of that species; the lateral furrows of the glabella are different; cheeks are tuberculated, not pitted; number of axial joints in the pygidium is less; pleurae curve back more strongly, and ornamented with tubercles. Salter's species has smooth pleurae.

Remarks.—The facial sutures, the glabella, 12 thoracic segments, ridged pleurae, also the pygidium, all point to Cybele or a prototype of that genus.

A similar species from Australia, described as *E. Mitchelli*, by Foerste, has the ridged pleurae and 12 thoracic segments; also the conspicuous nodules on each side of the axis of the thorax, with a similar tail, but it has a greater number of axial joints (28) and pleurae (9–10). The cast now before me from Bowning does not indicate tubercles.

CRYPTONYMUS, Eichwald, 1840.

Diagnosis: Head semi-circular; genal angles rounded, not produced into spines, as in E. punctatus. Glabella gibbous and overhanging, with obscure furrows. Eyes prominent; smooth. Thorax with 11 segments. Pleurae without grooves, notched at ends. Pygidium triangular, convex, and rounded at the end, with 9–15 joints and few pleurae (7 or more).

In typical *Encrinurus punctatus*, &c., the axial joints of the tail have a single row of nodes; in *Cryptonymus variolaris*, &c., the axial joints two or more rows.

CRYPTONYMUS VARIOLARIS, Brong., Plate III, figs. 8–9.

Not named Parkinson Org. Rem., vol. 3, plate 17, fig. 16.

Illustrates a head and part of thorax, inflated glabella, with large tubercles.

Calymmene variolaris, Brong., Crust. Foss., p. 14, plate 1, fig. 3-b, not 3-a.
——Murch., Sil. Syst., p. 655, plate 14, fig. 1 (entire).
Cybele variolaris, Salter, Mem. Geol. Sur., vol. 3, plate 1, p. 344.
——Fletcher, Quart. Jour. Geol. Soc., vol. 6, p. 403, plate 32, figs. 1–5.
Zethus variolaris, McCoy, Pal. Foss. Woodw. Mus., p. 157.
Encrinurus variolaris, Salter, Mem. Geol. Sur., Dec. 7; Encrinurus, p. 7, plate 4, figs. 13 and 14.
Cryptonymus variolaris, Vogdes, Mong. genera Zethus, &c., p. 21, plate 1, figs. 6–10; plate 3, figs. 13–14.

Description: Head triangular, gibbous, one-half as long as wide, tuberculated. Glabella gibbous and overhanging, spherical, with a short neck; the inflated glabella has not an anterior row of tubercles, as in E. punctatus.

Glabella furrows obscured by the size of the tubercles. Eyes large, smooth. Occipital ring smooth. Genal angles rounded, with prominent tubercle in place of spine. Thorax with 11 segments. Pleurae without furrows and notched at ends. Pygidium with 9–12 axial joints; each joint frequently interrupted in the middle by one or two isolated nodes. Axial grooves distinct; not notched at their sides, as in *E. punctatus*. Pleurae 7, bent down; not spinous, but prominent at the ends; no terminal caudal spine.

English species, Wenlock Limestone, &c., known as the Strawberry-headed Trilobite.

CRYPTONYMUS EXPANSA, Haswell, Sil. For. Pentland Hills, p. 36, plate 4, fig. 1.

Glabella pear-shaped, rounded in front, narrow behind, with 2 glabella furrows extending on each side one-fourth its width, studded with about 28 small tubercles. Fixed cheeks, convex; triangular genal angles rounded; eyes lateral, projecting; thorax with 11 segments. Pygidium

bent down; axis smooth in the centre, with transverse marking at the sides; 14 joints; 8 pleurae.

This is a doubtful species of Cryptonymus, but placed here on account of its characteristic tail.

CRYPTONYMUS OBTUSUS, Ang., Pal. Scand., p. 3, plate 4, fig. 9.

Cryptonymus obtusus, Vogd., Mong. genera Zethus, p. 22.
Encrinurus obtusus, Pompecki, Tril., Fauna Westpreuss, p. 39, plate 5, figs. 25, 25-a.
——Wigand, Zeitschr. Deutsch. Geol. Ges. 1888, p. 92, plate 10, fig. 24.

This species was described from a tail and part of the thorax from Reg. E. Gotland.

The pygidium is triangular; axis with 12 joints, notched at the sides, with a row of central nodes; pleurae 10.

Pompecki, plate 5, figs. 25 and 25-a, show 14 joints, with 10 pleurae. The anterior border of the hypostoma is very much produced in the species (see Limdstrom Visual Org. Tril., plate 4, fig. 15.) Plate 3, fig. 14.

ENCRINURUS RARICOSTATUS, Walcott, Adv. sheets 31st Rep. N. Y. State Mus., p. 16, 1877; p. 69 of the report, 1879.

Encrinurus raricostatus, Safford & Vogdes, Proc. Acad. Nat. Sci., Phila., 1887, p. 167, fig. in text.
Cryptonymus raricostatus, Vogdes, Mon. genera Zethus, &c., p. 27.
Encrinurus raricostatus, Clarke, Geol. Minnesota, vol. 3, p. 740.

Pygidium subtriangular, convex; length and breadth about equal. Axial not very prominent, with 16 joints. Pleurae 6.

A similar species from the Trenton Limestone of Wisconsin was described by Clarke, Geol. Minnesota, vol. 3, p. 739, as *Encrin. vannulus.* The author illustrated the head, thorax in part, and pygidium. The axis of the tail has 14 or 16 joints, with the first 6 or 7 joints extending across it; the others are notched at the sides. Pleurae 6.

CRYPTONYMUS LAEVIS, Angelin, Pal. Scand. p. 4, Plate IV, fig. 10, Reg. E. Gotland.

——Vogdes, Mong. genera Zethus, &c., p. 22, plate 2, fig. 10.
——Wigand, Zeitschr. Deutsch. Geol. Ges., 1888, p. 92, plate 10, fig. 25.

The author figures an entire specimen. The genal angles of the head are rounded, and the surface coarsely tuberculated. Thorax, 11 segments. Pygidium triangular, with 7 smooth pleurae; axial joints 14, notched at the sides; centre smooth.

The hypostoma has its anterior margin prolonged, which characteristic marks the species. (Lindstrom Visual Org. Tril., plate 4, fig. 16). See plate 3, fig. 16.

ENCRINURUS BOWNINGI, Foerste, Bull. Denison Univ., vol. 3, plate 22.

The author illustrates the glabella only, which he compares with E. Barrandei, DeKon.

The glabella is inflated, clavate, covered with large tubercles. In a specimen from Bowning, N. S. Wales, now before me, the thorax has 11 segments; it does not show the ends of the pleurae. Pygidium one-third wider than long; it has 10 pleurae. The axial joint, 18 or more; the first 10 are entire and extend across the axis to opposite the 8th pleurae; the other notched at the sides; the centre is smooth and ornamented by 4 nodes on the 2nd, 3rd, 6th and 9th joints.

ENCRINURUS TUBERCULATUS, Collie, Bull. Geol. Soc. Amer., vol. 14, p. 418, Plate LIX, fig. 3, Oct. 19, 1903.

This name used by Buckland for a species, Bridgw. Treatise, 1837, for the species now known as *E. punctatus*.

Encrinurus Indianensis, Kindle, Geol. Indiana, vol. 28, p. 482, plate 24, figs. 14–15, 1904.

The Indiana specimen exhibits the glabella, fixed cheeks and tail; the genal angles apparently terminating in short spines; the pygidium elongate-triangular, convex, with 15 axial joints extending across it, each joint ornamented by 3 to 5 nodes. Pleurae 10 (fig. 15, plate 24, only shows 8 or 9.)

The Pennsylvania specimen has 25 axial joints, with 3 nodes on each joint; 8 pleurae.

The number of axial joints and pleurae vary so much in species of this genus, that this slight variation discredits the value of such features for specific identification.

Remarks on the genus Cromus Barrande :

Certain species, which Barrande has placed under his genus Cromus Novak (Ges Wissensch Jahrg, 1886) has referred the older genus Encrinurus, on account of the direction of their facial sutures, which are the same in both genera. They are :

CROMUS BEAUMONTI, Barr. Sil. Syst. Bohéme, p. 826, Plate XLIII, figs. 6–14.

In which the genal angles of the head are rounded off; the glabella 4-lobed; pygidium 15–20; axial joints with 1–4 tubercles on each ring; pleurae 12 tips, rounded. See plate 2, figs. 13–15.

CROMUS BOHEMICUS, Barr, Sil. Syst. Bohéme, p. 828, Plate XLIII, figs. 15–17.

In which the genal angles of the head are rounded off; pygidium 20; axial joints 12; pleurae ends ending in spines. See plate 2, figs. 20–21.

CROMUS TRANSIENS, Barr, Sil. Syst. Bohéme, p. 828, Plate XLIII, figs. 18–19.

In which the tail is triangular; pleurae 10–12; ends rounded off; axis 12–14; from 2–5 tubercles on each ring. See plate 2, figs. 16–19.

CROMUS INTERCOSTATUS, Barr, Sil. Syst. Bohéme, p. 824, Plate XLIII, figs. 1–5.

In which the head and tail is spined with 20–28 axial joints; pleurae 12–16; all from Reg. E. See plate 2, fig. 22.

All the species are characteristic of the typical Cryptonymus in having their genal angles of the head rounded off; pygidia with few joints, 12–20; and few pleurae, 10–12–16, without the long caudal spine common to those species which we have classed under Encrinurus. The replacement of fine granules, in place of coarse tubercles, gives a better view of the marking of the glabella, and exhibit 4 lobes on each side.

The pygidia of *C. Beaumonti* and *C. transiens* are those of Cryptonymus, although the head of *C. intercostatus* has the genal angles spined. It exhibits only the variation common to all the genera.

The pygidia of *C. intercostatus* and *Bohemicus* have the ends of the pleurae spinous with the Encrinuridæ; they are notched at the end. There is a general tendency of all Trilobites with semi-cylindrical pleurae, to extend themselves into spinous terminations, and should only have specific value.

Törnquist exhibits a species, *E. schisticola*, from Dalecarlia, which has the terminal pleurae of the tail spinous. We also note that the tubercles on the axis of the tail vary in number from 1–5; in the centre the tendency is to become enlarged. This characteristic is more in keeping with species of Cryptonymus than in Encrinurus, which has only the central row of nodes.

In tracing these spinous forms from the Ordovician to the Silurian, we notice that each group begins its history in notched segmentation. This form of pleurae develops into spinous form; becomes more abundant at the culminating of the group, reached in Cromus intercostatus; afterwards the genus becomes extinct in the higher Silurian beds.

ENCRINURUS NOVAKI, Frech, Zeitschr d. Deutsch Geol. Ges., 1887, p. 735, Plate XXIX, figs. 5–9 of Cromus Beaumonti.

CROMUS MURCHISONI, DeKoninck Rech. Foss. Pal. Sud. Aust., p. 55, Plate I, fig. 9.

The species is distinguished from all others by the shape of the glabella and depth of the furrows which separate it from the fixed cheeks.

Explanation of Plate I.

Encrinurus punctatus.

Fig. 1. The head enlarged.

Fig. 2. The head and part of the thorax enlarged.

Fig. 3. The pygidium enlarged.

Fig. 4. Side view of the pygidium enlarged.

Fig. 5. Interior view of the pygidium enlarged.

Photographic copies of Kutorga's plate 8, figs. 4 a-f, with an alteration of the anterior course; facial sutures.

Fig. 6. Full grown specimen.

Fig. 7. Adult specimen.

Fig. 8. The pygidium, upper fig. of the 10th segment, with spine.

Fig. 9. Under side of head, showing hypostoma; lower fig.; eye magnified.

Fig. 10. The hypostoma; the tip is slightly recurved.

Photographic copies of Fletcher's plate 32.

Fig. 11. The hypostoma, after Lindstrom's plate 4, fig. 5.

Fig. 12. The hypostoma, front and side view—after Lindstrom's plate 4, figs. 12 and 13.

Fig. 13. The hypostoma enlarged, a sinuated margin: b, cucullate base; c, the points of the extended base of attachment.

Photographic copies of Salter's plate 4.

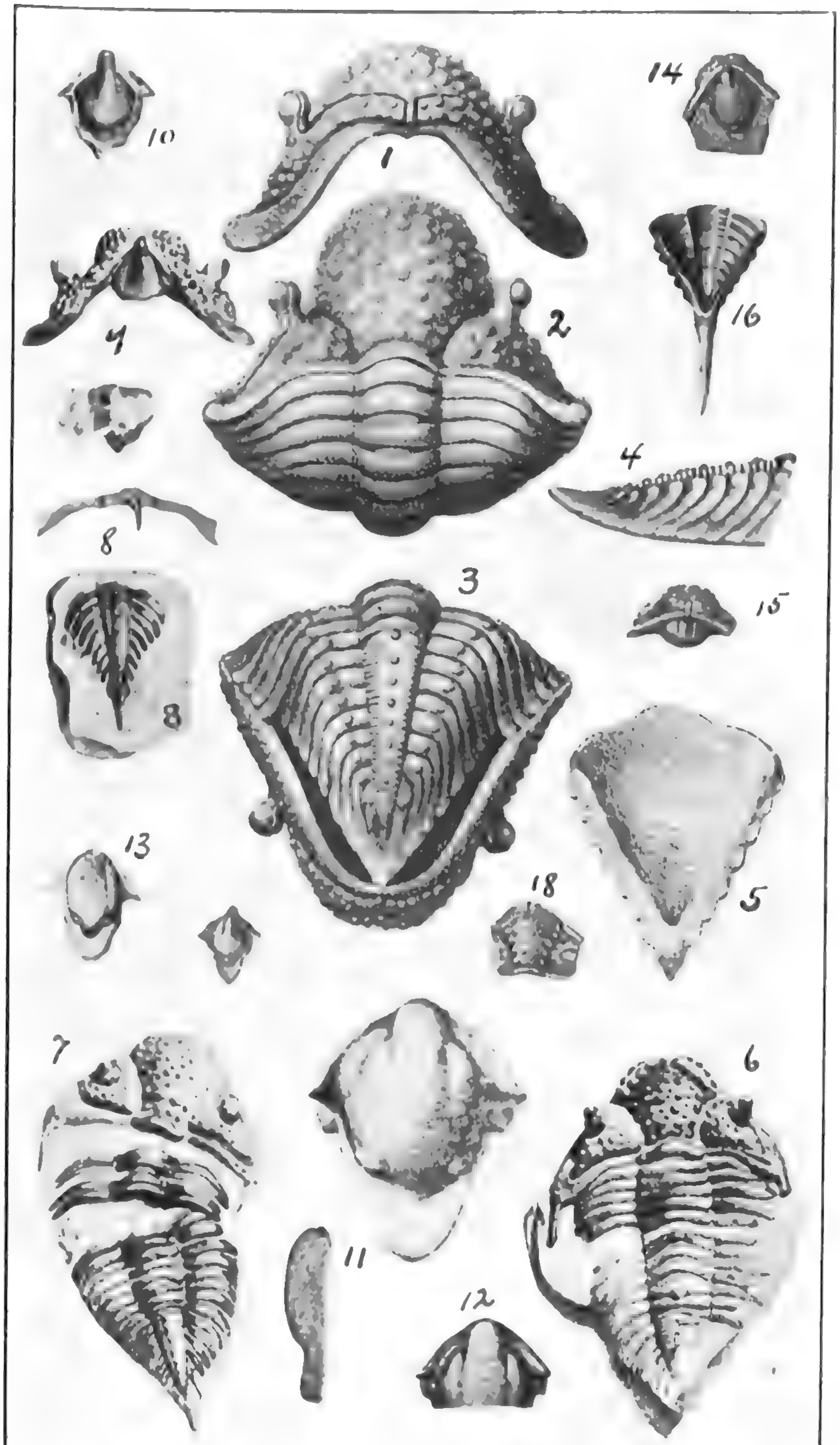
Fig. 14. The head, showing anterior course of facial sutures and hypostom—aafter Schmidt's figures.

Fig. 15. Front view of the head.

Fig. 16. Under view of the tail, somewhat enlarged to show the incurved scabrous margin which unites the lateral ribs of the tail; their free points are seen projecting beyond it—after Salter's plate 4, fig. 15.

Fig. 17. The hypostoma.

Fig. 18. The glabella and fixed cheek; shows anterior course of facial suture.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Explanation of Plate II.

Encrinurus sex-costatus, Salter.

Fig. 1. A rolled up specimen; from Rhiwlas.

Fig. 2. A view showing the 11 thoracic segments.

Fig. 3. Anterior view of the head and tail, showing the raised ridge of the anterior branches of the facial suture.

Fig. 4. Side view.

Fig. 5. Head cheeks and glabella, showing pitted surface.

Fig. 6. Magnified view of glabella, showing tuberculated and granulated surface of glabella, with 3 lateral glabella furrows.

Fig. 7. A thoracic segment enlarged: at a, the fulcral point; b, the facetted, and c, the blunt, indented tip of the segment.

Fig. 8. Side view of the pleurae in a coiled state; at a, one of the facetted surfaces is seen.

Fig. 9. The pygidium.

Fig. 10. Part of the same magnified, to show the scabrous surface.

Fig. 11. Variety of the pygidium, with 7 pleurae; also fig. 12.

Photographic copies of Salter's plate 4, figs. 1–12.

Fig. 13. Encrinurus (Cromus) Beaumonti, Barr. The head.

Fig. 13-a. The under side of the head.

Fig. 14. Side view of the head.

Fig. 15. Anterior view, showing course of facial sutures.

Fig. 16. Encrinurus (Cromus) transiens, Barr. Glabella and fixed cheeks.

Fig. 17. Side view.

Fig. 18. The hypostoma.

Fig. 19. Front view of the hypostoma.

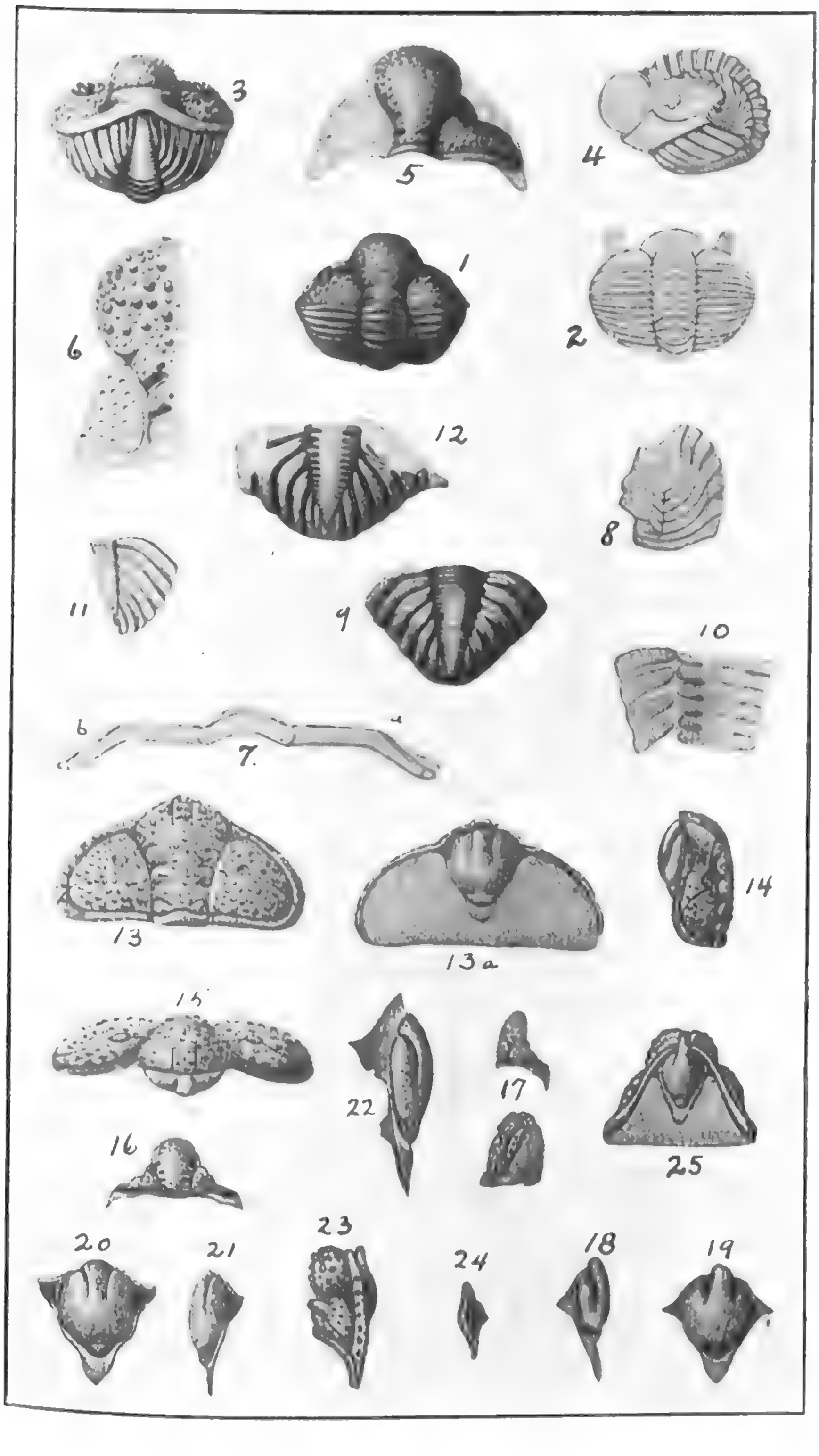
Fig. 20. Encrinurus (Cromus) Bohemicus, Barr. Front and side view of the hypostoma.

Fig. 21. The same.

Fig. 22. Encrinurus (Cromus) intercostatus, Barr. The hypostoma.

Fig. 23. Encrinurus punctatus. Side view of head.

Fig. 24. Side view of hypostoma.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Explanation of Plate III.

Cryptonymus variolaris, Brong.

Fig. 1. A young specimen.

Fig. 2. Rolled up specimen.

Fig. 3. The head and thorax. The segments are slightly bent backwards; it shows the sharpened front edge, and notched termination of the pleurae.

Fig. 4. A rolled specimen, nearly full-grown.

From photographic plates of Fletcher's plate 32.

Fig. 5. Head, showing anterior course of facial suture—after Salter.

Fig. 6. The same: a, side view; a-a, facial suture.

Fig. 7. Side view—after Fletcher.

Fig. 8. Shows front part of head and hypostoma after Fletcher.

Fig. 9. Under side of the pygidium.

Fig. 10. The pygidium—after Herrman's illustration, 1711.

"*Pectunculites marmoreus trilobus imbricatus.*"

Fig. 11. The pygidium—after Linné's figure, 1759. Entomolithus paradoxus.

Fig. 12. Pygidium of *E. multi-segmentatus*, Portl.—after Roemer.

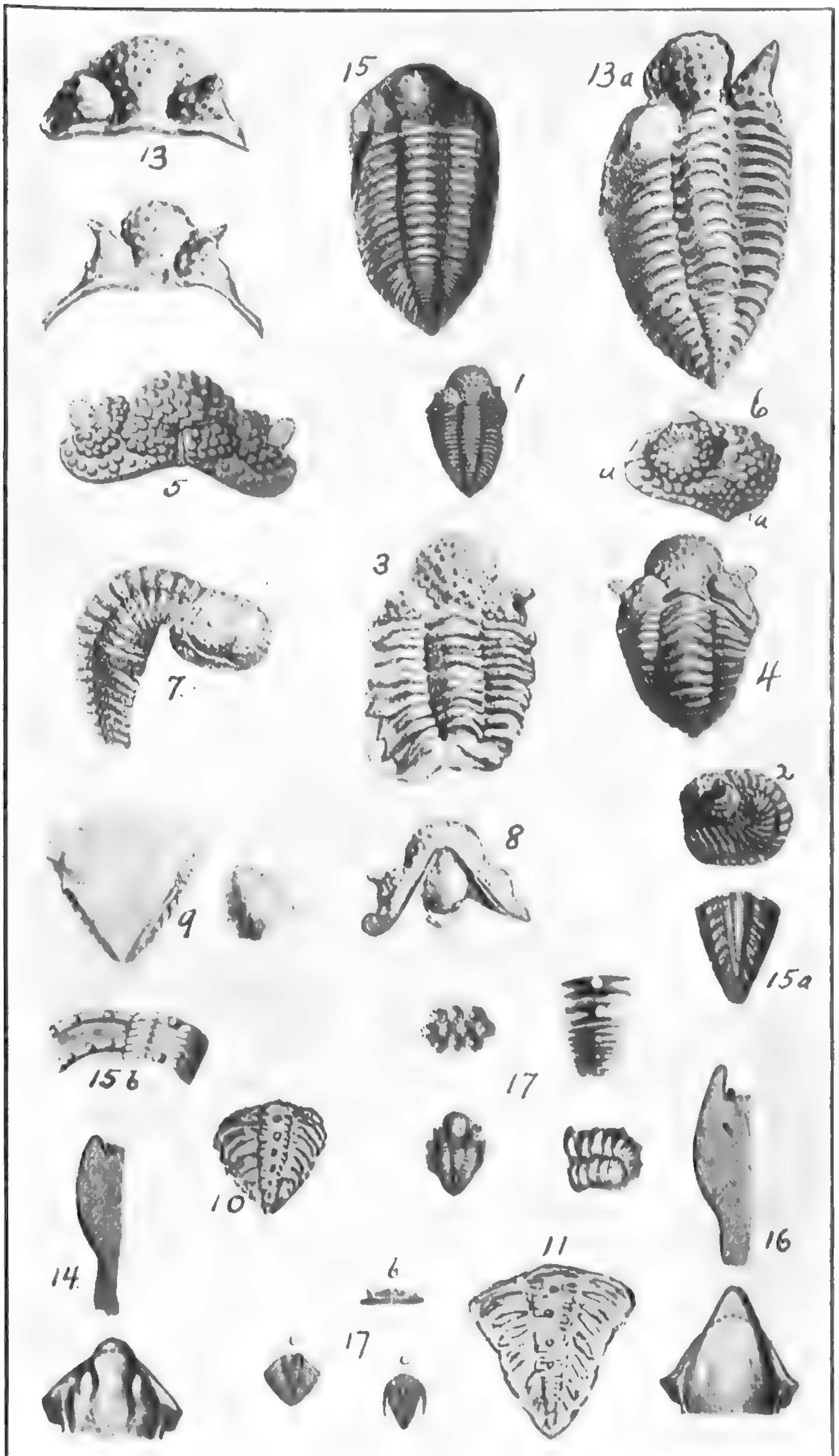
Fig. 13. Encrinurus Eagani, Miller—after Miller's plate.

Fig. 14. Hypostoma of *E. oblusus*, Ang.; front and side views.

Fig. 15. Encrinurus ornatus, Hall & Whitfield; from Clinton, Gr. N. Y. after Hall's plate.

Fig. 16. Hypostoma of *E. Leavis*, Ang.; front and side views.

Fig. 17. Cybele vigilans, Hall, Trenton, a-g, N. Y.—after Hall's plate.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Photographing "Red Snow" in Natural Colors.

TRANS. SAN DIEGO SOCIETY OF NATURAL HISTORY
Vol. 1, No. 3. 1911. Pp. 85-113

"RED SNOW" (*SPHÆRELLA NIVALIS*)

on Lambert Dome, Tuolumne Meadows, Yosemite, July 19, 1911. Photographed in colors from nature by Ford A. Carpenter, U. S. Weather Bureau

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The Honey Ants of Point Loma

BY PERCY LEONARD

Ever since Llave first described a Mexican honey ant in 1832, these insects have been more or less before the public notice, and yet there are many obscure points to be cleared up in respect to their habits.

The following notes are a contribution to the subject, and are based upon nearly a year's observations of these ants, both in the wild state and in captivity.

In opening up a nest of honey ants, we are liable to meet with six distinct phases. Firstly, and most numerous are the workers, the undeveloped females which occur in three sizes, the majors, the minors, and the minims; and the so-called "queens", who exercise no regal power, but are simply the egg producers and mothers of the community. They have deprived themselves of their wings and inhabit the darkest recesses of the nest. Next come the virgin females, adorned with gauzy wings of great beauty, and lastly, the almost brainless males, likewise provided with wings. (Fig. 1.)

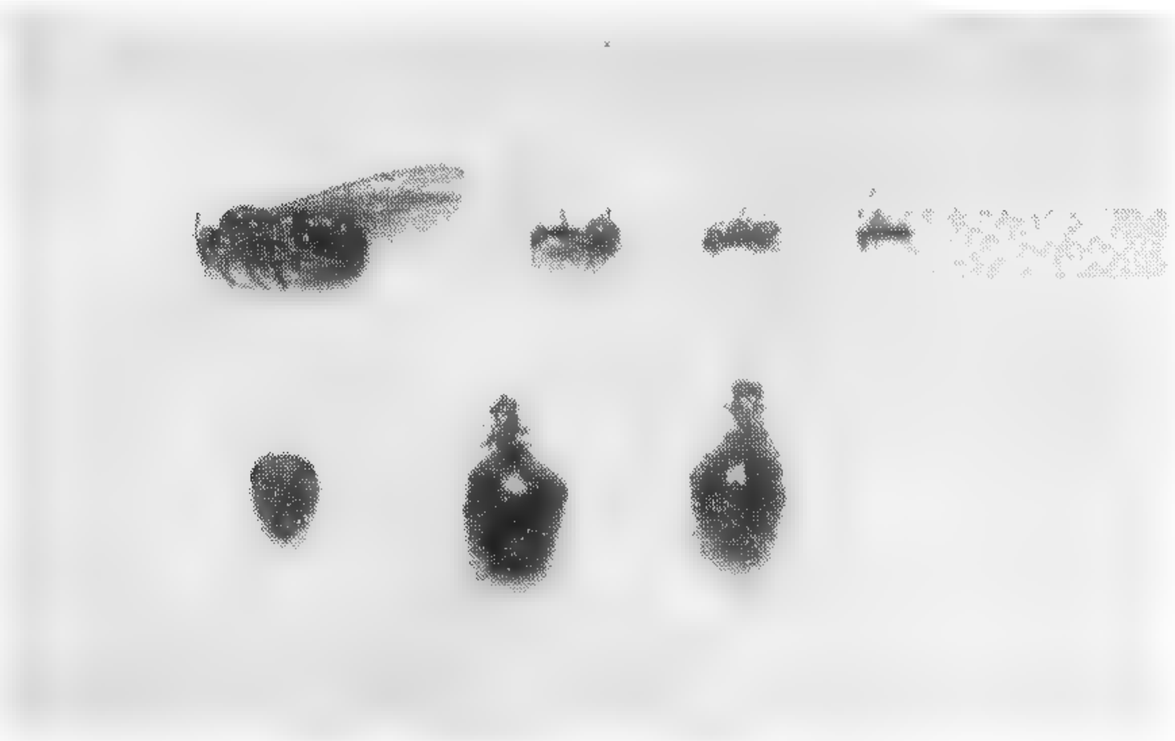

Fig. 1. Winged female of Myrmecocystus mexicanus mojave. Major, minor and minim workers. Two replete majors and a nodule brought out of the nest.

Besides these we find the repletes, which are not, however, a distinct phase, but are simply workers (usually majors) whose crops are so distended with honey as to justify their generic name Myrmecocystus (i. e., ant bladders). These ants have evolved their distinctive habit with reference to climatic conditions. In the Californian springtime the hills are covered with flowers and flowering shrubs. The juicy shoots of many plants are also infested with aphides, which excrete the "honey dew". These insects use only a part of the sweet sap sucked from the growing shoots, the surplus being excreted, and

the foraging ants lap it up from the surface of the leaves, or directly from the excretory orifice of the aphides. The quantity of syrup thus produced is extraordinary. As an extreme case we may mention an aphis living on the sugar maple which excretes forty-eight drops in twenty-four hours.*

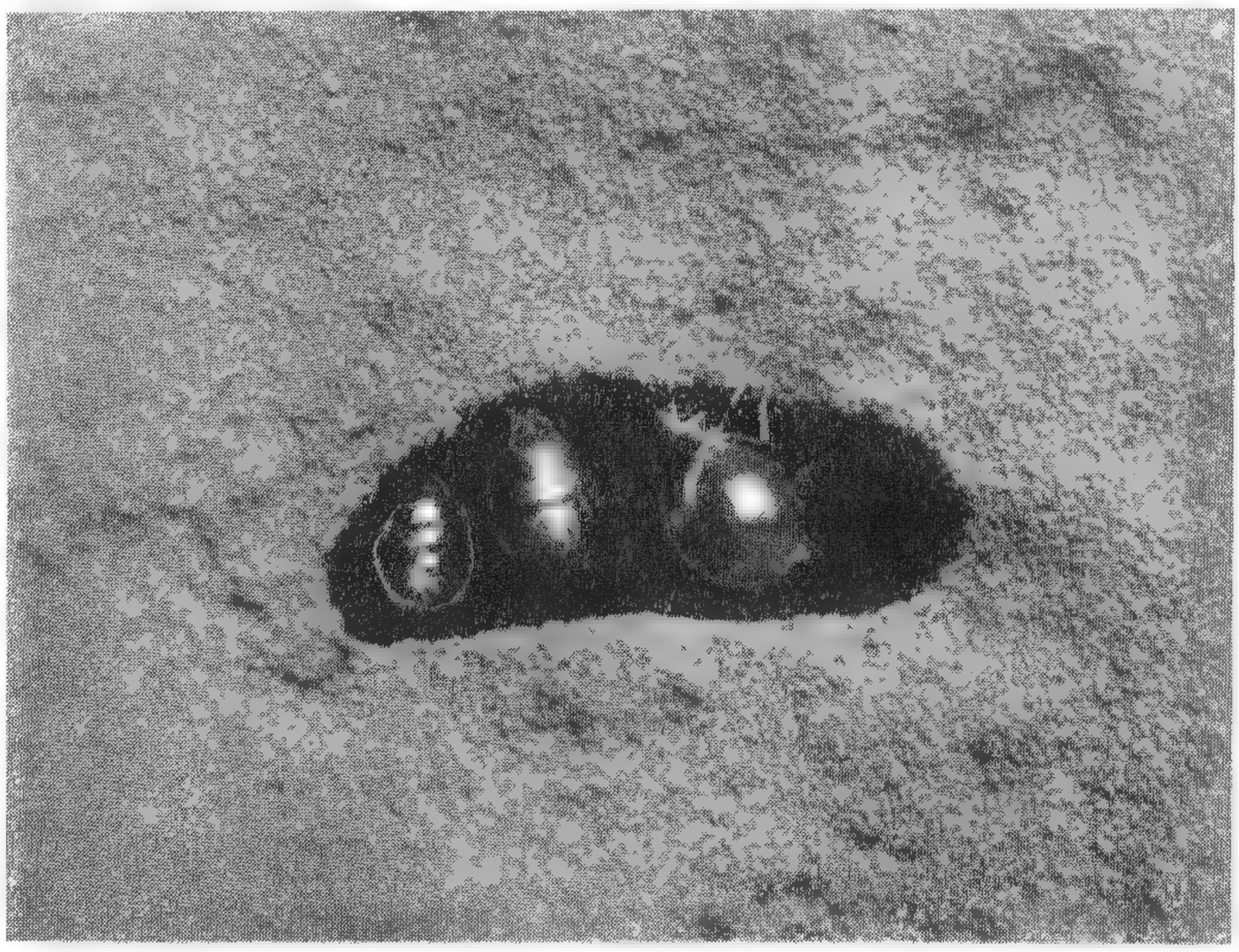

Fig. 2. Replete majors hanging from the ceiling of subterranean honey vaults.

During the season of plenty, a certain number of the workers, usually majors, are set aside to store up the supplies collected by their foraging sisters. They hang motionless from the vaulted ceilings of the underground chambers (Fig. 2), and are always ready either to relieve a returning collector of the contents of her crop or to regurgitate a drop or two to feed a hungry member of the community. The swallowed honey is not "consumed"; but simply stored. It remains in the crop, and is returned to the mouth in the same condition as when first swallowed. A minute quantity is of course passed on to the stomach proper, for the sustenance of the individual, but the crop contents are available for the use of the community "on demand".

The tendency to active exertion, common to ants, is held in abeyance, and the patient replete resigns herself to the monotonous occupation of serving as a simple container for the fluid wealth of the community.

During the dry season, the whole community depends upon the honey stored in the repletes, supplemented by dead bees, wireworms and other insects. The replete when appealed to by the antennae of another ant opens her mandibles to their fullest extent, and the recipient sucks up the honey with mandibles almost shut. In two or three minutes the meal is over, and it is usual for the party served to lick

*Ants, Their Structure, Development and Habits. Page 341.

the replete all over, and massage the abdomen, as she is powerless to perform her own toilet. The crop, which expands to fill almost the entire gastric cavity, has no glands discharging into it, and as its walls are composed of non-absorbent chitine,* it is to all intents and purposes as cleanly a container for fluids as a glass bottle.

MYRMECOCYSTUS MEXICANUS MOJAVE

Early in March, 1910, some boys of the Raja Yoga School at Point Loma, San Diego, brought me some honey ants. Their gasters looked like partly deflated bladders or half-dried raisins. This was because their honey contents had been almost exhausted by the winter consumption of the nest, and the spring blossoms having not yet opened no fresh supplies were available.

It is a golden moment in the myrmecologist's career when, with a few blows of a mattock on the hard, tough, sandstone subsoil, he lays open the honey vaults. In the bright sunshine the repletes glitter like jewels. They look like highly-polished amber beads, clear and translucent, as they hang from the domed ceilings. So firmly do they cling that only one or two are dislodged by the shock of the mattock. Many of the workers huddled together, like frightened sheep, in one of the chambers, and made no effort to defend their citadel, but, doubtless, they were paralyzed by the sudden glare. All the chambers and passages were spotlessly clean and absolutely free from smell. Although they look quite helpless, the heavily laden repletes are perfectly well able to regain their position in the dome when shaken to the floor. Wm. M. Wheeler comments on the need of keeping the nest dry to prevent the crumbling of the walls and to prevent the growth of moulds on the repletes.† My observations, continued daily for nearly a year, have convinced me that they actually *prefer* a moist soil. I have found many chambers of repletes about four inches below the surface of the flower beds, in a garden which is repeatedly irrigated during the summer months. A wild nest under observation was situated at the bottom of a steep bank where it received not only its own rainfall but the surface water shed by the adjoining slope. The soil crumbles very readily when moist, and how the nest escaped disaster is not very apparent, nevertheless, it appears to be a strong and populous formicary.

At first it seems almost incredible that these ants, whose mandibles cannot pierce a plum skin or the rind of a pear,‡ should be able to

*Ants, Their Structure, Development and Habits. Page 33.
†"Honey Ants, with a Revision of the American Myrmecocysti." Page 380.
‡Ants, Their Structure, Development and Habits. Page 177.

drive tunnels in the hard sandstone subsoil. The sandstone, however, must appear to the ants as lilliputian masonry, the stone being represented by the sand grains, the mortar by the yellow clay which binds them together. It is not a question of cutting through the tiny blocks of silica, it is only necessary to moisten the clay matrix with saliva and remove the loosened grain. Lafcadio Hearn's statement that ants can bore tunnels in the solid rock is therefore seen to be misleading. Wm. M. Wheeler states his belief that the relatively large nest opening is an adaptation for increasing the ventilation.† My own view, based upon observation, continued for many months, is that the large entrance is required for the removal of nodules of iron encountered while excavating. During the hot weather of July and August the entrance was almost entirely blocked up with little clods; but when the first autumnal rain fell, softening the soil and favoring excavation, the hole was enlarged to a size somewhat greater than that of a ten-cent piece (which measures eighteen millimeters, in diameter). (See fig. 3.) Six or eight workers unite their efforts to drag out a nodule. Each grasps it on its equatorial line with her mandibles, and their bodies radiate outwards from this center like the spokes of a wheel Those in front drag, while those behind push, and after very heavy exertions the heavy burden is deposited outside the entrance. To allow egress for a team of eight workers surrounding a nodule necessitates a commodious gangway. The constant stream of ants circulating through the galleries is probably sufficient to prevent the accumulation of stagnant air. The nursery chambers are invariably situated in the upper

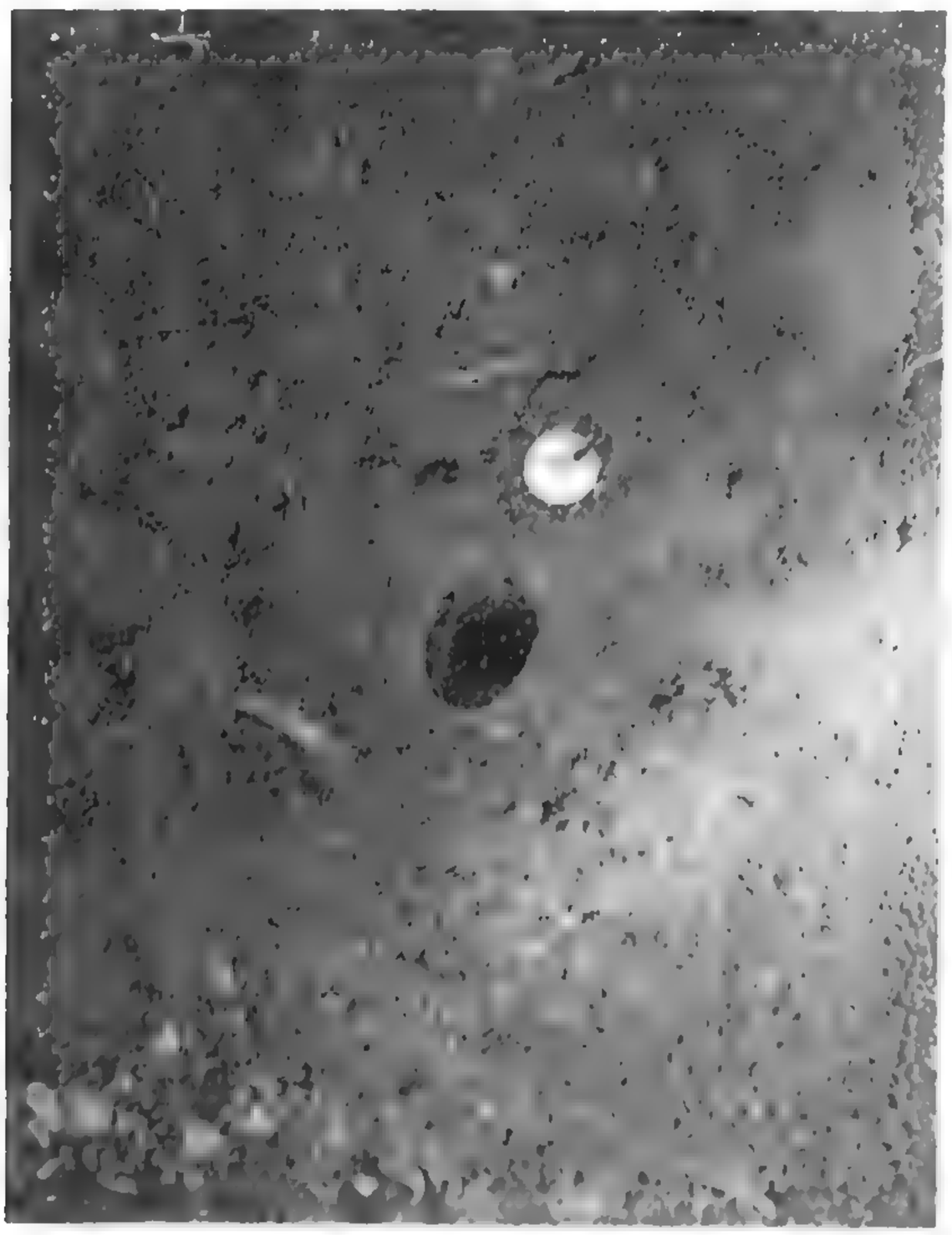

Fig. 3. Nest entrance of Myrmecocystus mexicanus mojave, with a ten-cent piece (18 mm. dia.) for comparison. A winged female lies on the coin.

†Ants, Their Structure, Development and Habits. Page 375.

portion of the nest, and one may sometimes see a worker carrying a cocoon outside the nest as if to give it an airing.

One usually associates ants with dry weather and sunshine, but these ants come out only at night. A thick fog drifts in from the ocean spangling the scanty grass blades with glittering drops. The landscape is shrouded in darkness; but the little circle, illuminated by the lantern, is a scene of bustling activity. A constant stream of amber-colored ants pours out of the entrance hole, each carrying a small pellet of sand-grains in her mandibles. Some leave their burden just outside, others laboriously plod as far as three or four feet before they drop their load and hurry back for another. The underground workings are being extended almost every day in the year. I have seen the ants at work at 9 p. m. in the pouring rain and at a temperature as low as 44° Fahr. They do not leave their holes until about half an hour after sunset. Thus they escape the birds and the lizards, their only enemies being the night-prowling toads, and ant lions.* If we smear a little honey on a piece of glass, it is quickly surrounded by 40 to 50 ants, who climb upon each other's backs to reach the tempting fluid. In two or three minutes they are loaded to the limit of their capacity, and then they stagger off towards home. They are perfectly ready to regurgitate, when appealed to on their way by a hungry comrade. The ant's antennae, in which the "contact-odor" sense resides, are constantly being cleaned to free them from dust, which must dull their sensibility. The eggs and larvae are continually being licked over, probably as a sanitary precaution to prevent the growth of moulds, to which they are very subject in the damp recesses of the nest.

As evidence of individuality in character I give the following anecdotes.

An ant had fallen into the moat surrounding my artificial nest and was rescued in a moribund condition, and laid upon the surface of the island. Two of the workers came up, inspected the sufferer and passed by without the slightest effort to help. Presently a minor worker arrived and showed the liveliest concern.

For many minutes she vigorously kneaded the patient's gaster, and worked the stiff legs until at last the half-drowned ant revived.

On another occasion, after a team of six workers had deposited a nodule outside the nest opening, one major stayed behind and by strenuous exertion dragged the load one-third of an inch further away. Its exact location was a matter of absolute unimportance; but the major's notions of exactitude had to be satisfied.

*Since writing, my nest was raided by driver ants (Eciton sumichrasti) on June 12th, 1911. The invaders poured into the nest and emerged carrying larvae. They were repulsed by spraying them with kerosene oil. "The ant's most dangerous enemies are other ants, just as man's most dangerous enemies are other men."—Forel.

For more than nine months I was unable to get the least indication as to the source of their honey. Occasionally foraging ants would drag a dead bee or other insect into the nest; but I could never find any foragers returning with distended crops.

On March 16th, 1911, however, it seemed as if the whole population was on the move, and streaming up and down the trunk of a neighboring pepper tree (schinus molle). An examination of the tree by daylight showed a quantity of blossoms, but I could find only one or two scale insects. My captive ants greedily lapped up the nectar from these flowers. I have found these ants "milking" the aphides upon roses and carnations at night. It is probable that almost all the wild flowers are visited by the foraging ants. I know they get nectar from the "rattlesnake weed" (Euphorbia setiloba), the honey plant (Echium simplex, a cultivated flower), and the blossoms of that fragrant wild shrub, Ceantothus cuneatus. As evidence of the stay-at-home habits of these ants, I can certify that a honey plant was in full bloom twenty-seven feet away from their nest and yet it was three weeks before the foragers discovered it.

The honey stored in a replete of average size I found to weigh 0.1885 of a gramme, and if we take McCook's figure of 600 repletes in a nest of the horti-deorum variety* to be approximately true of M. M. Mojave, this would give us 113.10 grammes, or a grand total of about a quarter of a pound of honey. Small though it may appear to us, I fancy that the knowledge of a share in this provision imparts a certain dignity to every individual member of the nest.

These ants do not display such a wolfish eagerness to acquire chance scraps of food, as is shown by other species, who live from hand to mouth. To show the inoffensive character of the ants under consideration, I may mention that once a troop of little black ants (Darymyrmese pyramicus var. niger) gathered round to lap up some honey which I had put at the nest entrance, but there was no resentment expressed towards them.

When watching the nest at night one may sometimes see crickets hop about among the ants who cover the ground outside the entrance; but no notice is taken of these intruders, and they hop away in a leisurely manner. Once I saw a tiny cricket emerge from the nest among the moving throng of ants, and markedly differentiated from his companions by his sudden, jerky action of progression. He skirmished about for a minute or two and then retreated down the hole. Evidently he was one of the "pets" of the nest.

Among the solitary insects, such as the flies, the moths and beetles, only a very small percentage of their numerous offspring ever reach

*"Nature's Craftsmen." Page 104.

maturity, owing to parental neglect. Among ants, under favorable conditions, the infant mortality is practically nil, so that if every female produced eggs the population would very soon outrun the means of subsistence. It has been very plausibly suggested that the ants regulate the supply of "queens" by rearing a selected number of female larvae on a full diet, while the great majority of them are so insufficiently nourished that their reproductive organs never develop. The feminine trait of taking delight in nursing the larvae survives, however, in its full strength in these stunted females, and they devote themselves passionately to the care of the little, white, semi-translucent grubs, which resemble a crook-necked squash in general form. I think I have never looked into my artificial nest at any time during the day or night without seeing the nursing ants employed in caring for the larvae.

On October 28th, 1910, I caught a worker near my wild nest who was carrying about a cocoon in her mandibles. I placed her upon the island nest, where a quantity of other workers were wandering about, not yet having begun to excavate tunnels. There arose immediately a tremendous competition to nurse the cocoon. The lucky possessor was constantly surrounded by eager applicants for the privilege. Sometimes they showed their impatience by stamping violently on the ground or jerking their bodies forward in their uncontrollable desire to caress the helpless pupa. A few days afterwards the covering was stripped off, and the pale, unfinished infant was carried to and fro without a moment's peace, as one ant after another acquired possession of it. Every worker wanted to be good to it and in the end it died, killed by kindness. If the care of the luckless pupa had been entrusted to one nurse all would have gone well, but by a perversion of the nursing instinct a tragedy resulted.

On October 16th, 1910, after the first real rain of the winter season, I noticed a number of ants peeping out of their hole in great excitement. To produce the effect of nightfall I inverted a box over the entrance. On raising the box after a few minutes I saw the ground alive with ants and among them a virgin queen, which I secured. This is the first capture of this phase of M. M. Mojave. The general coloring and markings remind one of a wasp. (Fig 1.) Although many nests have been searched, only two queens of this species have been found.

During the hot dry spell of weather at the end of August, 1910, the ants stayed underground. The entrance was almost closed with little clods of earth, which seems to show that the extraordinary large nest opening is needed not so much for ventilation as to afford egress for ants removing nodules.

For some time I had noticed ants come out of the nest carrying what seemed to be the corpse of ants in their mandibles. I casually noted that they dropped their burdens and returned to the nest. Later on, I discovered that these burdens were *live ants*, and that when deposited, both parties plodded away in opposite directions without showing the slightest trace of emotion. Other observers who have witnessed similar occurrences have thought them to be a kind of play; but what I saw was much too solemn to be called a frolic. I would suggest that the ants carried out were "callows", that is ants newly emerged from the chrysalis, and that after being allowed to harden their shells for some days in the shelter of the nest they were thus formally introduced to the outside world as a hint that they might now undertake the regular work of the nest.

Professor Wheeler has established the fact that it is only "callows" which are capable of becoming repletes. Once an ant gets thoroughly matured and hardened it appears to lose the elasticity required in order to allow of the enormous distention of the crop which characterizes the replete. An ant in process of becoming distended

Fig. 4. Five replete majors of Myrmecocystus mexicanus mojave posed on a string.

to the proportions of a replete can never be confounded with a replete who has fed away her store and is slowly collapsing to her normal condition. In the former case the gaster is tense and more or less spherical (Fig 4), in the latter the skin is corrugated into folds and the segments stand out as ridges.

MYRMECOCYSTUS MEXICANUS

These ants have never been found in the United States until 1910, and our discovery of a nest on Point Loma was the third reported occurrence of this species in the year.

On November 6th, I dug up a nest in a soil composed of disintegrated shale. They are hardly distinguishable to the casual observer from the preceding species, except by a slightly darker color.

Fig. 5. Winged females of Myrmecocystus mexicanus. Partially deflated replete majors, males, and major, minor and minim workers.

There were many semi-repletes moving about the galleries (Fig. 5), and about eight laying females.

When opened up, the resulting hole was only three feet deep and two feet in diameter—evidently a new nest. The laying females, in pleasing contrast to the queens in a beehive, are very friendly and spend hours with their heads together, caressing one another with their antennae. On January 30th, 1911, I found a solitary female in a little hole in a bank. The excavation could not have been more than a day or two old. Had she been undisturbed, in due time a new colony would have been produced by her unaided efforts.

Shortly after I had established an island nest in a basin and had moistened the earth, a minor worker was struck with the idea of sinking a shaft. Accordingly she scratched away at the soil, using her fore legs just like a terrier. Her energy was so infectious that a major joined her, and presently a minim was drawn into the undertaking. Ants digging in pure sand are obliged to remove it grain by grain, but the slightest admixture of clay permits the formation of pellets thus enormously economizing labor. The loose dirt is first scraped into a heap under the ant. The gaster is then curved forward and downward as in the act of stinging* and the front pair of legs is used to pat the earth against the opposing lower surface of the gaster. The loose soil granules are thus packed into a solid pellet, which is seized in the mandibles and carried out. When digging a gallery against the inner wall of a glass tumbler, the digging consists for the most part in tugging at the sand grains and detaching them by main force. The gallery is afterwards enlarged to give passage room for the females. One of the nests under observation had its entrance

*N. B. No ant of the Subfamily Camponitinae, to which the genus Myrmecocystus belongs, possesses any sting. They have a large poison bag, the contents of which are used to spray their enemies and their prey.

against the edge of a level slab of smooth concrete, so that the circular area over which the ants deposited their excavated soil was divided into two parts; one extended over a flower bed, the other over a surface of cement.

Every day the concrete slab is swept, so that on any given morning the loose earth is exactly half of the total amount brought up during the preceding night. On January 24, 1911, the radius of the circle of debris was 7 feet, 4 inches. The night had been calm, so that in sweeping up the deposit I am sure that I collected no wind-borne particles. The weight was 23.6489 grammes, and by doubling this figure we get the total output of loose dirt for the night. When poured into a cubic inch measure it almost exactly filled it. Under favorable conditions, therefore, these ants can excavate nearly two cubic inches in a night. During a colder night, a few days previous, the radius of the circle was only 4 feet 8 inches. Quite early in the evening, some ants will be seen travelling to the very circumference of the circle, passing by bare spaces where we might imagine they would be perfectly justified in getting rid of their load.

Prof. Wheeler, in speaking of repletes, remarks that they "are of course imprisoned for life"; but I have found my ants gradually resume their original figure when their contents are exhausted. In the nest I excavated November 6th, 1910, there were two or three dozen semi-replete majors whose gasters were no larger than those of the fertile female's and who could walk about quite freely. Others had apparently been entirely emptied, owing to the lapse of time since the spring honey harvest and their gastric segments were in a distressing condition of misfit. They did not overlap smoothly, but

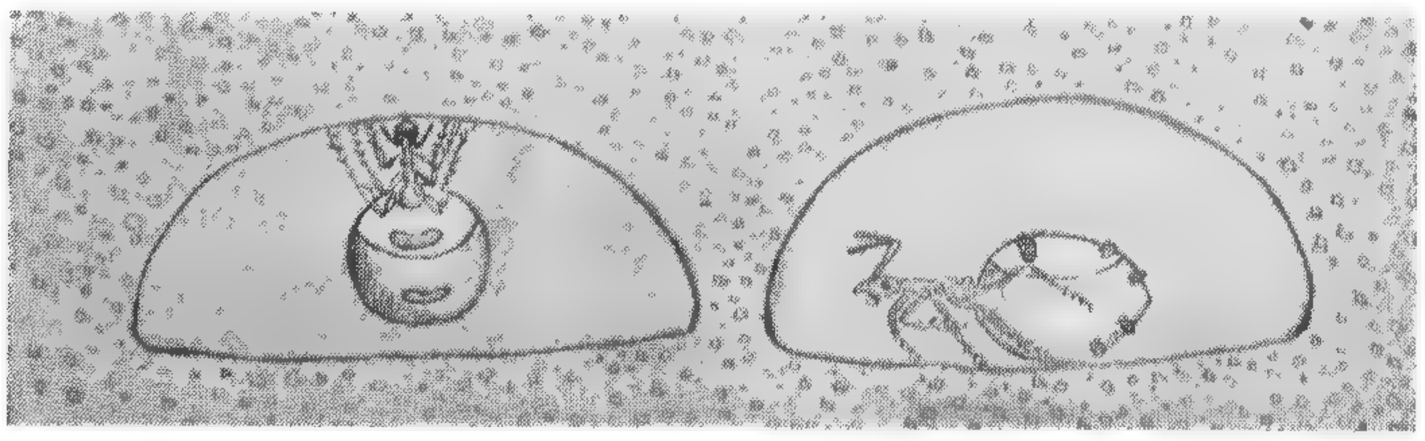

Fig. 6. Replete major of Myrmecocystus mexicanus unable to regurgitate honey while hanging, and who has to assume a recumbent posture before she can feed her sister workers.

were warped and twisted out of shape. But another course is open to a replete who finds her honey content diminishing. *She may swallow air* and thus maintain her size. (Fig. 6.) This is done by both M. M. Mojave and the present species. In my artificial nest I found a full-sized major replete three-quarters full of honey, and

with an air bubble occupying the upper region of the crop. I stinted supplies of honey to bring about diminution of her stock, and as she fed away her store the air bubble increased, until it filled three-quarters of her capacity, while the remaining quarter of honey lay in the lowest part of the crop.

I now frequently found her lying on the floor of the little grotto where she lived, with six or eight workers gathered around to be fed. The reason for her recumbent posture is at once apparent. So long as she was hanging from the ceiling, the air bubble occupied the upper portion of the crop, and her efforts to regurgitate honey could only result in an escape of the imprisoned air; but if she lay upon her side, or ventral surface, on the principle of the spirit level the air rose to the highest point of the gastric wall and then any contraction of the proventriculus, or pumping stomach, forced the honey out at the mouth. Contrary to the observations of McCook on the horti-deorum variety, I have found that these ants very economically lap up the honey contents of dead repletes, after depositing the heads and thoraces in the moat round their nest. It was very amusing to watch the workers of this species feeding their larvae with eggs. The nurse holds the egg in her jaws and squeezes it into the mouth of the helpless baby, who shows great eagerness to be fed. After the larva has got what it can, the nurse cleans out the shell, and regurgitates the remnant into the larva's mouth. Frequently the nurse sticks an egg on to the back of the larva's neck by saliva, so as to have it ready for the next feeding time.

Although these ants have no stings, they can spray some poisonous fluid into the wounds made by their mandibles, from a gland situated in the tip of the gaster. Two caterpillars, an inch and a half long and a quarter of an inch in diameter, succumbed to the spray in a few minutes, and were dragged down into the nest for food. It is quite common to find dead insects, termites, flies, etc., lying among the larvae, and in wild nests and among captive communities it is usual for two or three repletes to hang from the ceilings of the nursery chambers. Sometimes the larger larvae remain for a long time with their heads thrust into the thoraces of dead flies, devouring the muscular tissue.

The high development of ants is shown by the long period of helpless infancy and absolute dependence upon the care of the nursing workers. Although they lie upon the bare earth of their caves, they are protected from actual contact with the soil by stiff bristles which are set in their soft skin, and which allow of a free circulation of air all round them. Living as they do in damp subterranean caverns they are peculiarly liable to be attacked by various moulds, and it is

for this reason that the nurses are indefatigable in licking their charges to remove the spores from which these vegetable parasites take their rise. Larvae isolated from the attentions of the workers very quickly succumb to these exhausting growths. It is probably due to the need of a certain amount of ventilation that the larvae are usually found in the upper chambers, thus presenting a parallel with the case of the short-tailed field vole (microtus agrestis), of England. The ordinary retreat of these rodents is a burrow situated far below the surface; but their young are reared in a nest of split grass, built upon the very surface of the ground. They are exposed to innumerable dangers, of course; but a litter of six or eight young mice would probably be suffocated if confined in a deeply situated nursery.

As showing the preference of these ants for moist surroundings, I may mention that for some months I kept a colony upon a porous earthenware saucer inverted in a basin of water and completely covered by a mound of clay and sand. When I eventually broke up the formicary, I found that the chambers and galleries had all been hollowed out in the soil immediately above the damp earthenware surface, the saucer itself forming the floor. The higher and drier portion of the mound had not been inhabited at all.

PRENOLEPIS IMPARIS

fs found here in great abundance, and is common from the Atlantic to the Pacific. We will content ourselves, therefore, with merely recording its occurrence. It ascends the blue gum, (eucalyptus globulus), and may be found by the dozen resting half hidden among the fragrant anthers.

MYRMECOCYSTUS MELLIGER FOREL

The typical form has not yet been found here, but a variety which appears to be intermediate between varieties testaceus and semirufus has been identified by Professor Wheeler.

MYRMECOCYSTUS MELLIGER LOMAENSIS

Another variety or sub-species has been found here, only previously reported from Riverside and Whittier by Mr. Quayle.

This ant is strictly diurnal in its habits, and has been seen feeding upon the white flowers of mesembryanthemum aequilaterale.

In an artificial nest these ants were fed with a drop of bee's honey in a leaf. Instead of greedily lapping it up, as the first two species here treated of would have done, they became violently agitated. They flung themselves upon the honey and sprayed it with their poison,

snapping at it furiously with their mandibles, and it was some time before they realized that it was good for food. Is it possible that being diurnal in their habits they have a perennial feud with honey bees when they compete with them for the contents of the nectaries of flowers, and that the smell of the honey forcibly suggested bees to their minds, and provoked the customary hostilities? Whereas the honey bees require a hollow tree and household furniture in the shape of waxen cells for rearing brood or storing honey, the ants can carry on their lives with nothing more than food, and a few cubic feet of soil. They use no implements, utensils nor bedding, and the sole garment they require is the swaddling gown of woven silk that wraps them in the pupal state. Ants have no personal ambition. The only end they have in view is to cover the earth with colonies of their own particular species, and urged by this remote, impersonal desire they spend their lives in ceaseless toil. The instinct which impels the ants' unselfish labor is probably as irresistible as that which forces human beings to pursue their personal advantage. The personality of ants appears to be dissolved, and every individual seems to act as if it was the agent for that nameless, universal will that urges on the slow advance of cosmic evolution. Without compulsion or direction their social life is carried on in perfect harmony. Each ant is a law to herself; but as the aim of all is identical, a spirit of perfect harmony prevails. The ants have shown the possibility of a perfect communal life, and have proved that individuals can be incited to the maximum of effort with the minimum of personal advantage, and that the little states based on unselfish sisterhood are supremely fitted to survive in the struggle for existence.

This paper would be incomplete without an expression of grateful acknowledgement to Professor William Moreton Wheeler for his kindness in identifying the various species of ants to which reference has been made. Without this help in naming specimens, and the assistance derived from his correspondence, the production of the paper would have been indefinitely delayed.

The illustrations are from plates prepared expressly to illustrate the text, and are the work of the Lomaland Photo and Engraving Department, Loma Homestead, Point Loma, San Diego, California.

It may be of interest to note that I have in my possession specimens of replete Honey Ants collected at Coronado, San Diego, in 1890, by Dr. F. E. Blaisdell, formerly a member of the San Diego Society of Natural History. They evidently belong to the species Myrmecocystus mexicanus, but whether to the pure type, or to one of the sub-species or varieties, it is impossible to determine, owing to their defective state of preservation.

Descriptions of Some Varieties of Shells, with Short Notes on the Geographical Range and Means of Distribution of Land Shells

BY HENRY HEMPHILL

The study of variation among Mollusks involves the consideration of the laws of life, if one desires to understand or ascertain the cause or causes that produces all this great diversity that we see in every department of nature.

Briefly, life as I understand it, consists of energy moulding matter into form and of expressing through those forms, not only the objects of life, but also the properties of matter.

An organism is a specialized portion of energy and matter, separated from the great mass, and endowed with organs that have functions for performing special work necessary in the economy of the creature, all of which act in harmony with the class to which the organism belongs.

Development is the fundamental law of growth, and nature's great working basis in organic evolution, and should be the working basis of every student of her laws.

Diversity, or variation as it is frequently called, is the detail work of development and evolution, if we can separate the action and meaning of these two closely related terms.

The fundamental law of equilibrium presides over all of nature's laws. It is dual in its activities; radiates, so to speak, from a common center in opposite directions, and adjusts diversity by developing opposite varieties of equal weight, quality value and importance in each class of organisms, and generally maintains or keeps the union or unity of nature complete.

MUREX CARPENTERI TREMPERI, HEMPH.

Murex carpenteri, Dall., has been described as, of a "livid brown color, pinkish towards the apex and whitish around the aperture". I have in my collection one specimen dark reddish brown in color, with a dash of white along the columellar side of the aperture; an-

other with the body ashen white, shading off darker on the varices, and another one of the typical coloring.

Recently I have seen in the very fine collection of Dr. R. H. Tremper of Ontario, Cal., a magnificent series of this and other deep water shells, from the Santa Barbara channel, and perhaps the best collection of these shells extant, in good condition and artistically arranged to please the eye. Among the lot there is a series of Murex carpenteri, about typical in form and coloring, with the addition of three white revolving bands, that expand in width as they pass toward the outer edge of the foliated varices, and show on three of the spire whorls. There are three broad, thin varices on the specimen before me, the edge of the last broken by five rather broad, circular indenta-

Plate 1.—Murex carpenteri tremperi.—Hemphill (Enlarged.)

tions, separated by four broad, rather short, chisel-shaped digitations, curved upward at the ends. The somewhat large basal indentation forms about two-thirds of a regular circle, is one-fourth of an inch across, its edge thickened and regularly reflexed, except next to the long, curved and well-covered canal. The body and varices are quite smooth, except the last varix, which is roughened on the lower side by wavy, file-like striae.

These beautiful shells were dredged in the Santa Barbara channel, off Newport, by Dr. R. H. Tremper, who kindly gave me a specimen and to whom I dedicate this beautiful variety.

OCINEBRA STEARNSI, HEMPH.

The general outline of this small shell is diamond shape, with the side points rounded off. It is composed of six turns or whorls. The

nucleus or embryonic whorls, are white, rather rough, and consist of about two turns. The next whorl has flat sides and a square-edged shoulder and is divided by a small revolving groove into two revolving nodulus riblets with shallow pits, in the interstices. The antepenultimate and penultimate whorls are convex in form and divided into three revolving nodulus riblets by two revolving grooves, with deep, rounded pits in the interstices. The convex body-whorl comprises nearly two-thirds the entire length of the shell with similar sculpturing as that of the two preceding whorls, and with the pits more conspicuous above, than below the periphery of the body-whorl. The suture is distinct and well impressed. The outer lip is very much thickened for such a small shell, its outer edge being faintly denticulated by the revolving ribs and grooves, the inner edge just within the aperture bearing 5-denticles. The form of the aperture is oval, slightly pointed below; canal short and covered. The base of the columella is creased by an umbilical slit. The color is light or dark yellow or brownish, plain or with a single white revolving band at the periphery of the body-whorl, covering one and sometimes two of the revolving riblets.

Length, 18; breadth, 8 mm. Habitat, Monterey, Cal.

This small shell has the general form of O. gracillima, Stearns; the coloring of O. lurida as well as that of O. gracillima, and some varieties of interfassa, but may be readily separated from other members of the lurida group by the pitted sculpturing. I dedicate it to the late Dr. R. E. C. Stearns, in return for many favors of a similar kind.

HELIX VAR. SONOMAENSIS, HEMPH.

Shell rather small, greatly depressed, umbilicated, of a yellowish or buff color, whorls 5½, slowly increasing in size, the last flatly convex beneath, and not excavated around the umbilicus; umbilicus large and deep; suture distinct; aperture rather small, nearly quadrate in form and bearing on its columellar portion a long oblique tooth; peristome slightly reflected, crowding but not covering any portion of the umbilicus, and bearing on its inner side two small denticles, one on the basal, and the other near its upper termination.

Great diam., 8; height 2½ mm.

Great diam., 7; height 2½ mm.

Habitat, near Healdsburg, Sonoma County, Cal.

The larger size, more depressed form, lighter color, and larger umbilicus, will serve to separate this variety from the other known forms of Helix (triodopsis) loricata Gld.

TONITES (CONULUS?) WASCOENSIS, HEMPH.

Shell small, smooth, shining, transparent, perforate, consisting of 4½ or 5 convex whorls—the last a little more tumid than the penultimate whorl; striae of growth very fine, hardly perceptible under a strong pocket lens; suture distinct, well impressed; aperture moderately narrow, semilunar; outer lip simple, acute, not falling at its upper termination; columellar portion of the shell, very convex; base of shell convex, hardly excavated around the umbilicus; umbilicus small and deep.

Great diam., 2; height 1 mm.

Habitat, Wasco County, Oregon; also near Salem, Oregon.

This small shell seems to be new. It has the aspect of Tonites chersennellus Dall., but is about half the size of that shell, with about the same number of whorls. The aperture is narrow and resembles that of L. capsella Gld.

HELIX WALKERIANA, HEMPH.

Shell umbilicated, glaubosely convex, rather thin and somewhat transparent, of a reddish brown or chestnut color; spire elevated with an obtuse apex, or with a sharp pointed apex on the narrow, tall forms; whorls 5½ convex, the last well rounded above and below, descending a little in front, bearing a well defined chestnut-colored revolving band just above the periphery, margined by two light yellowish or horn-colored zones or bands, all three of about equal width. These bands are rarely absent, but when the central band is absent

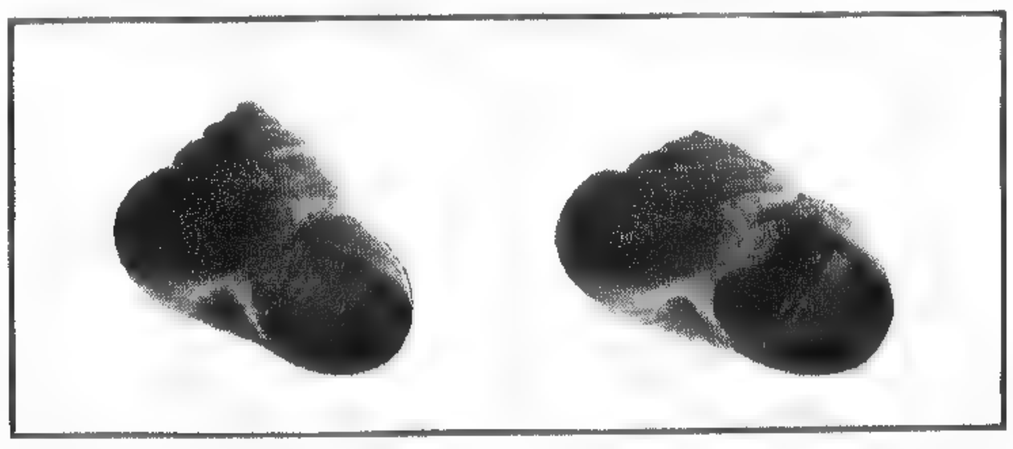

Plate 2—Helix walkeriana—Hemphill. (About natural size.)

the marginal bands coalesce and form a faint light revolving zone. I found but one shell with all the bands absent.

The sculpturing consists of rather coarse oblique file-like striae of growth cut by numerous, rather fine, well impressed but irregularly spaced revolving grooves, forming in some instances parallelograms or little squares, and numerous rude, rather coarse granules, that occasionally coalesce and are arranged along the striae of growth or are scattered over the upper surface of the body whorl. Below the

periphery this sculpturing becomes much modified, and disappears near the umbilicus. The suture is distinct and well impressed; aperture, subcircular and large; peristome simple, very slightly reflected, its ends approaching the basal or columellar end, crowding and half covering the rather small umbilicus.

Great diam., 26; height 20 mm.
Great diam., 25; height 18 mm.
Great diam., 20; height 14 mm.

A very elevated shell measures:

Great diam., 20; height 20 mm.

Two depressed shells measure:

Great diam., 23; height 19 mm.

Two small shells measure:

Great diam., 19; height 15½ mm.
Great diam., 18; height 14½ mm.

Habitat, San Luis Obispo, Cal.

HELIX VAR. MORROENSIS, HEMPH.

This variety of walkeriana differs from the typical form, in having the revolving grooves obsolete, or extremely faint, and more profusely granular.

Great diam., 29; height 18 mm.
Great diam., 22; height 16 mm.
Great diam., 18; height 15 mm.

Habitat, San Luis Obispo County, Cal., among brush and rocks.

This shell and its variety are extremely interesting forms, when one reads and interprets their combinations of characters intelligently. It combines the form, file-like striae of growth, open umbilicus and general aspect of Helix ramentosa Gld., with the glaubose (not typical form), open umbilicus, file-like striae of growth, and the revolving grooves of the typical H. ayresiana Newc.

I dedicate this shell to Mr. Bryant Walker in recognition of his valuable services in the study of conchology.

CIRCINARIA VAR. KELSEYI, HEMPH.

Shell umbilicated, greatly elevated, of a yellowish horn-color; whorls about 5 convex above and below, gradually enlarging, the last sloping rapidly to the periphery; spire greatly elevated, with a medium pointed apex; striae of growth oblique, rather fine; suture distinct but not very deeply impressed; aperture somewhat effuse, roundly oval; peristome simple, a little thickened, outlined by a rim of dark brown epidermis, the ends approaching and joined by a thin parietal callus; umbilicus deep and quite narrow.

Great diam., 15; height 12 mm.
Great diam., 16; height 9 mm.
Great diam., 17; height 10 mm.

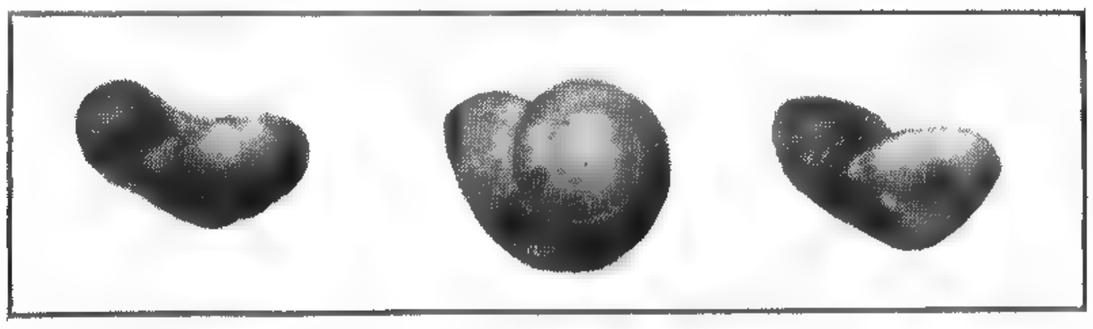

Plate 3—Circinaria var. kelseyi—Hemphill. (Natural size.)

Habitat of the most elevated shell, San Mateo County.

Habitat of the other two shells, San Luis Obispo County, Cal.

I dedicate this variety of Prof. F. W. Kelsey of San Diego, Cal., who has taken much interest in the study of shells, and whose photographs of shells are nearly perfect.

HELIX VAR. AVALONENSIS, HEMPH.

Shell sub-lenticular, deeply unbilicated, whitish horn-color. Whorls 5 or 5½, flatly convex above, more rounded beneath, with a sharp carina at the periphery, which becomes obsolete on the last half of the body-whorl of the single mature shell that I have. The sculpturing, under a strong pocket lens, on the nuclear whorls, consists of fine rib-like striae of growth, regular in form and arrangement, that after two or three turns become obsolete and are superseded on the following whorls by very small revolving granular riblets, one of which rapidly develops into a sub-carina with the aid of the pinch of the peripheral carina, making the shell bicarinate as in Helix hemphilli, Newc. The revolving riblets above and beneath vary considerably in strength, number and arrangement.

The whole surface of the shell, except the nuclear turns, is covered with fine, sharp striae of growth, and rather rough indentations that divide the surface of the shell into irregular sections. Beneath the surface is smoother, but under a strong pocket lens, the sharp striae of growth and the revolving riblets give that portion of the shell the exact aspect of Helix haydeni, Gabb. The suture is distinct and well impressed and after three or four turns shows the upper part of the carina as a sutural riblet.

The umbilicus is moderately broad and deep, and in very young shells, it is defined by a blunt carina, but does not appear in the adult shell. The peristome is simple and acute, its upper termination not falling. The aperture is nearly a complete circle, but in immature specimens its outer margin is made angular by the peripheral carina.

Great diam., 14; height 8 mm.

Habitat, Santa Catalina Island, Cal.

The presence of a colony of land shells, living on Santa Catalina Island today, belonging to the strigosa group, whose metropolis at the

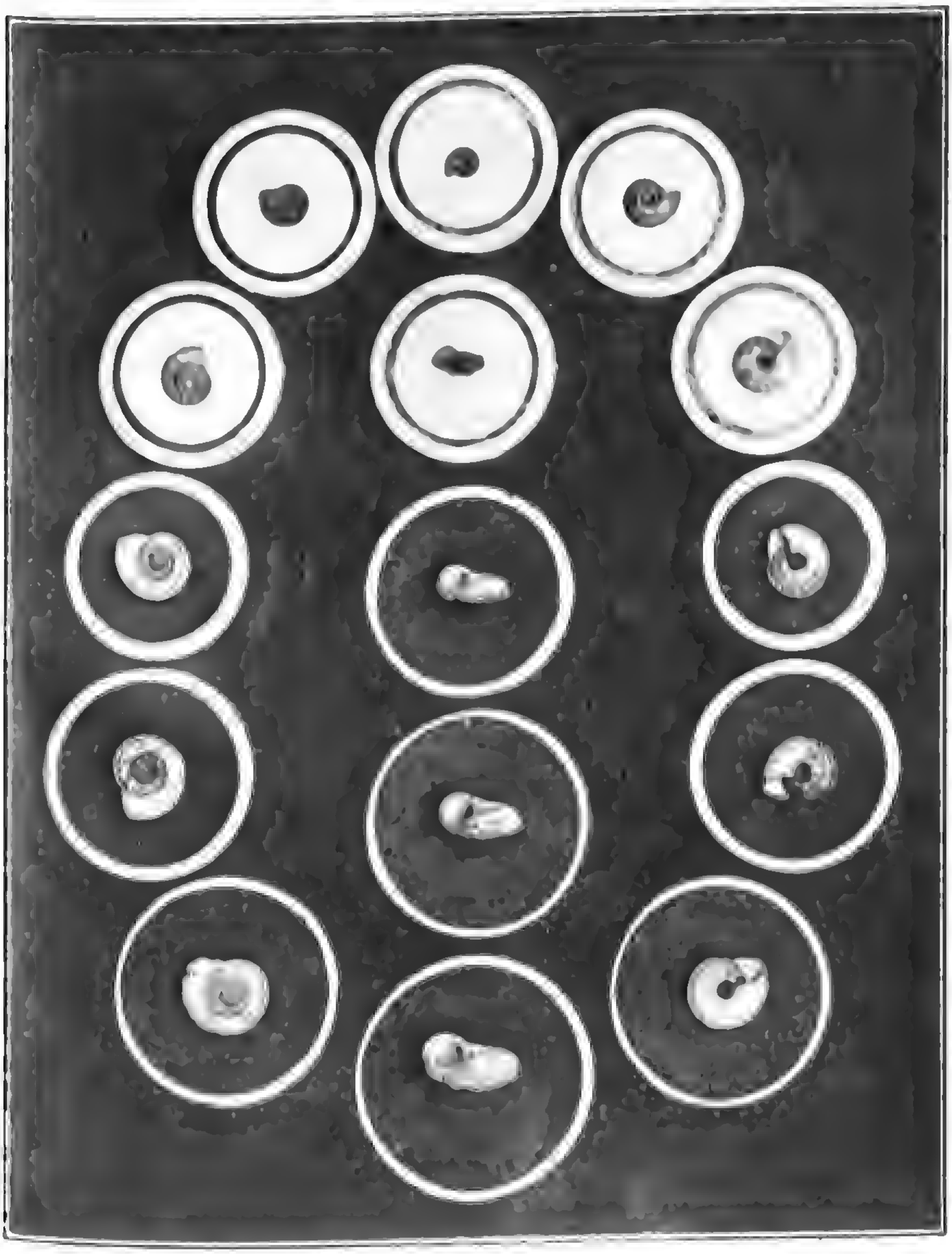

Plate 4.—Helix var. avalonensis.—Hemphill.

present time is several hundred miles distant and northward from this island, at an elevation of from four to eight or ten thousand feet above the sea level, with a great stretch of desert-like country intervening

between the coast and the metropolis of this group of shells, calls for some explanation and remarks on the geographical range, and the means of distribution of such slow-moving creatures.

Undoubtedly in the early history of the continent, it has been elevated and submerged several times above and below the sea level, before the land assumed its present state or condition. The great abundance of marine fossils in the various stratas of rocks in every part of the country, inland as well as along the coast, and in the low valleys as well as on the high mountains, confirm this statement.

Perhaps, after many hundreds of centuries had passed, and during the miocene or about the middle of tertiary times, the continent became comparatively quiet, and when the great lake system of the interior had become well established, and dense forests and rank vegetation had become well developed, and served as food for the great herbiverous creatures of that time, whose fossil remains are found in almost every part of the continent, whose bodies became, in turn, the food of the huge carniverous amphibians that lived in the lakes and low marshy land at that time, and were probably the terror of their day, and whose fossil remains are the wonder of men at the present time.

It is quite possible that land shells and probably Helix strigosa, or its progenitor of large size, may have occupied the higher and dryer areas of the land, as it does today, and became widely distributed by the floods and drainage system of that time, Santa Catalina Island, with the other islands of the Santa Barbara group, were probably high landmarks of a broad range of mountains, at that time, and extended many miles in a northerly and southerly direction, and probably spread out many miles beyond San Nicolas, the outermost island of the Santa Barbara group.

Perhaps, during the latter part of miocene times, this colony of the strigosa group and the other land shells that are peculiar to these islands today, occupied high areas on these mountains. At the close of the miocene period great volcanic disturbances occurred again, when this Santa Barbara range, as it may be called, went down below the sea, leaving the eight islands standing above the turbulent waters, as monuments or tombstones to mark its burial place, where these stranded colonies of land shells have continued to exist but have become somewhat modified in form. Fossil land shells of the present living forms, indicate considerable age and seem to support these assertions and suppositions.

About the time that this western range of mountains became submerged, another and perhaps the last general elevation of the continent took place, when a hundred volcanoes on its western slope,

belched forth a flood of lava that formed high ranges of mountains and laid the rocky floors of many valleys in its flow to the lower levels, and perhaps during this great upheaval the limestone bedrock of the Mississippi and adjacent valleys was pushed up to its present height, out of the sea, which its marine fossils indicate.

At this time it is possible that part or all the continental mountain ranges were raised to their present elevations, probably higher, in which time and the adjustment of the earth's crust to the new order of things after these upheavals, may have made some minor changes.

With this general elevation of the land the barriers that held the waters of the great internal lake system of that time were broken, the water rapidly drained off and the rush of floods cut the river channels that form the drainage system of the continent, which the storms and floods subsequently have completed as we have it today.

As the geographical range of land shells is a question of considerable importance to conchologists, I wish to call especial attention to the rivers and drainage system of the continent, as the principal avenue and means of distribution of these slow-moving creatures.

Little study of the map of North America will show that all the principal rivers that form the drainage system of the continent have their source in the district formed by, or near, the union of the states of Idaho, Montana, Wyoming, Utah and Nevada. These rivers flow to the Arctic ocean at the north, to the east and south, into the Atlantic, to the southwest, the west and northwest into the Pacific ocean, and curious enough, this district, the source of all these rivers, is also the metroplis of all the genera of the universally distributed American land shells. I have collected in this district myself, the following genera: Succinea, Vitria, Tonites, Circinaria, Helicodicus, Patula or Pyramidula, Polygyra, Vallonia, Pupilla, Cochlicopa, Polygyrella, Hemphillia and Prophysaon.

The last three genera, however, are confined in their geographical range to the western slope of the continent so far as we know at the present time.

There is little doubt in my mind, that the universally distributed genera and species have been scattered over the continent principally by the drainage system.

During heavy storms and great floods, whole colonies, as well as individual shells, are washed into the streams with the woodland debris and carried far away from their native haunts in the higher areas of the mountain districts, to the lower levels of the valleys, where lodgments are made, and colonies are formed, perhaps after many failures, but in the course of time become permanently established and spread over the adjacent territory.

Here under the constant stress of changed conditions in the environment, principally perhaps, by the chemical affinities contained in the food and atmospheric conditions, the progeny of the newly established colonies become modified wholly or in part as the adjustment of the organism to its environment demands and requires.

This manner of distribution by the drainage system has been going on for ages, and is still scattering the slow-moving creatures over the face of the land, and it is not strange and no wonder that we meet with similar shells, high up on the mountains, low down in the valleys, far up in the cold north, away down in the hot south, back in the effete east, out in the wide west, as well as on the beautiful islands of the sea.

Photographing "Red Snow" In Natural Colors*

BY FORD A. CARPENTER

On July 13th, 1911, as we were encamped on the shores of Lake Merced in the Little Yosemite Valley, the advance party of the Sierra Club returned with the news that "red snow" was visible for many miles over the Vogelsang pass. At the campfire that evening, Dr. C. A. Kofoid, professor of zoology at the University of California, gave an informal talk on *protococcus nivalis*, or, according to the new nomenclature, *sphaerella nivalis*, popularly known as "red snow". He called attention to the fact that this phenomenon was unusual even in the mountains of the Sierra Nevada, and that the members of the Sierra Club were fortunate in having the privilege of viewing this interesting species of algae. Dr. Kofoid's talk aroused the anticipation of the members so that it was discussed in many of the detached groups as they clambered over the Vogelsang trail early the next morning on their 20-mile jaunt to the Tuolumne Meadows.

It was not at all remarkable, however, that with the magnificence of the panorama spread before them on approaching the rugged Vogelsang Pass, that the phenomenon of colored snow was almost forgotten. In fact, our party first noticed it while following in the trail broken by the pack animals. The trail led through several miles of deep snow into which the pack train plunged heavily at every step. Several of the hoof-prints were splotched with red as if the snow crust had cut the mule's feet and dyed the snow with drops of blood. Then it dawned upon us that we were witnessing that alpine curiosity, *sphaerella nivalis*. The place where the first *sphaerella nivalis* was observed was in the nearly perpetual snowfields on the saddle of the Vogelsang Pass. This Pass has an altitude exceeding 10,000 feet and the surrounding peaks and crests are rugged and forbidding. Owing to the length of the day's march the party could not linger on the trail, but tramped steadily forward to that night's camp at the Tuolumne Meadows.

*See frontispiece.

It was on the summit of Lambert Dome, which is the dominant feature of the Tuolumne Meadows, that the photograph which accompanies this article was taken. Lambert Dome is a solid mass of granite, rising a thousand feet above the Tuolumne River that skirts its base. It is a rock which has withstood the grinding of the glaciers of the past, and shows on its crest glaciated patches polished to a mirror-like surface. While the Sierra Club was in camp across the river at the Tuolumne Meadows, Lambert Dome was the objective point of many short climbs. It was during one of these excursions that patches of *sphaerella nivalis* were found. To quote from my note-book under date of July 16th:—"On the west side of Lambert Dome are patches of 'red snow'. It looks as if carmine ink has been spilled over the snow. The snow-drift, splashed with red, is in the immediate foreground, the tall pines on one hand, and the precipitous sides of the Dome on the other inclose a vista of deep green tree-tops and meadow, through which meanders the silvery Tuolumne River. The purple foothills flank the snowy glacier-scarred peaks that pierce the sky: the whole is overhung with slowly drifting cumulus clouds." It was under these picturesque circumstances that the first photograph of "red snow" was ever made in natural colors.

One of the most prominent members of the 1911 outing of the Sierra Club was Dr. W. L. Jepson, of the botanical department of the University of California.

Upon request he furnished me this memorandum on *sphaerella nivalis:* "'Red snow', *protococcus nivalis*, or according to the latest nomenclature, is *sphaerella nivalis.* The cells are spherical and have no power of motion in the frozen snow, but in the summer, when the snow melts, the cells become vegetatively active, increase in size, and, after the fashion of the simple algae, divide into usually four, or six, or eight (or even two daughter) cells. These daughter cells escape from the original cell, and by means of rotating hairs at one end, they have the power of motion through the melted film of water, which fills the spaces between the particles of snow on a warm summer's day. The cells secure their nourishment partly from the water, and partly from the atmospheric dust which always lies on the snowfield, and which becomes dissolved in the film of melted snow."

The color-plate of *sphaerella nivalis*, which forms the frontispiece of this volume of the transactions, is a direct reproduction from the original photograph made by the Lumiere process in natural colors. The apparatus used in making this autochrom was a 3¼x5½ camera fitted with a No. 1, Series III, double anastigmat, F 6.3, 6 inch focus, diaphragmed down to f24. The autochrom was given an exposure of 6 seconds. This relatively long exposure was necessary on account of

the yellow-orange rayfilter which was fitted to the lens in order to equalize the intensity of the light and compensate for the predominating actinic effect of the violet and blue rays. The plate was developed in a metroquinone solution, cleared in potassium permanganate and reversed by re-development in the monomethyl-para-amidophenol sulphate and hydroquinone.

Six years ago the writer exhibited before the San Diego Society of Natural History several direct-color photographs of still life such as fruit, flowers, etc., but at that time the process required an extremely long exposure through thick color filters, which made it impractical for landscape photography. One of the photographs shown at that time was a study of a few clusters of Tokay and Muscat grapes; this picture required an exposure of 40 minutes through the orange-red filter, and proportionate exposures when using the green and violet filters.

In the Lumiere process the procedure is rendered very simple and the speed is only about two hundred per cent. greater than in ordinary photography. Through the courtesy of the brothers Lumiere the following outline of the process is given herewith: "Autochrom plates differ from ordinary plates as follows: Interposed between the sensitive coating and the glass is a thin layer of transparent miscropical starch grains, dyed *orange-red*, *green and violet*, spread without overlapping, and mixed in such proportion that the layer appears colorless when examined by transmitted light, and absorbs but a small percentage of the light received. The sensitive coating is extremely thin, and made of a special fine-grained panchromatic emulsion. When such a plate is exposed in the camera, the glass side towards the lens, the light, before reaching the sensitive coating, passes through the colored starch grains, which act individually as minute screens, each one absorbing all colors but its own. A microscopical selection takes place, and after development there is found under each grain a corresponding black spot, reduced silver of a density proportionate to the amount of color received and transmitted by this particular grain. Were the plates fixed at this stage, the picture when examined by transmitted light, would show only the colors complementary to those in the original, since the true colors are masked by the black spots beneath the grains. But when the reduced silver is dissolved in the permanganate solution, the image is reversed: the opaque image under each grain becomes translucent and transmits colored light precisely of the same hue as the light transmitted by the grain when the plate was exposed in the camera: in other words the color is reconstructed just as it was decomposed during exposure."

While the bibliography of *sphaerella nivalis* includes the writings of the ancient Greek philosophers, Swiss geologists, arctic explorers,

geographers, and modern cryptogramic botanists, it should not be inferred that "red snow" is of common occurrence in alpine regions. In fact, there are not a few Alaskan explorers and mountaineers who have never encountered this phenomenon. Mr. Samuel B. Parish, one of the oldest botanists in the state of California writes that although he has botanized over the greater portion of the state he has not had the fortune to see *sphaerella nivalis*. Mr. Frederic G. Plummer of the United States Forest Service and Geographer of the United States, says, "Although this phenomenon has often been reported by arctic explorers and I have seen it in the alpine regions of Washington and Oregon, it is the first time to my knowledge that it has been seen by a reliable observer as far south as central California. I would be glad to know if there is any reliable record that 'red snow' has been found in still lower altitudes."

In the third century before Christ, Aristotle mentions "red snow" in his "Meteorologics"; Saussure in the eighteenth century hinted at its true cause, Sir John Ross, in his voyage of discovery in the arctic regions in 1819, mentioned finding deep banks of "red snow" on the eastern shores of Baffin's Bay extending for miles; six years later Parry made detailed entry in his journal of observing large tracts of "red snow". In fact, the literature on the subject is quite extensive. Through the suggestion of Dr. Frederic V. Coville, botanist of the United States Department of Agriculture, Dr. Marshall A. Howe, of the New York Botanical Gardens, prepared for this article a complete bibliography of *sphaerella nivalis* as follows:

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