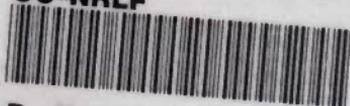


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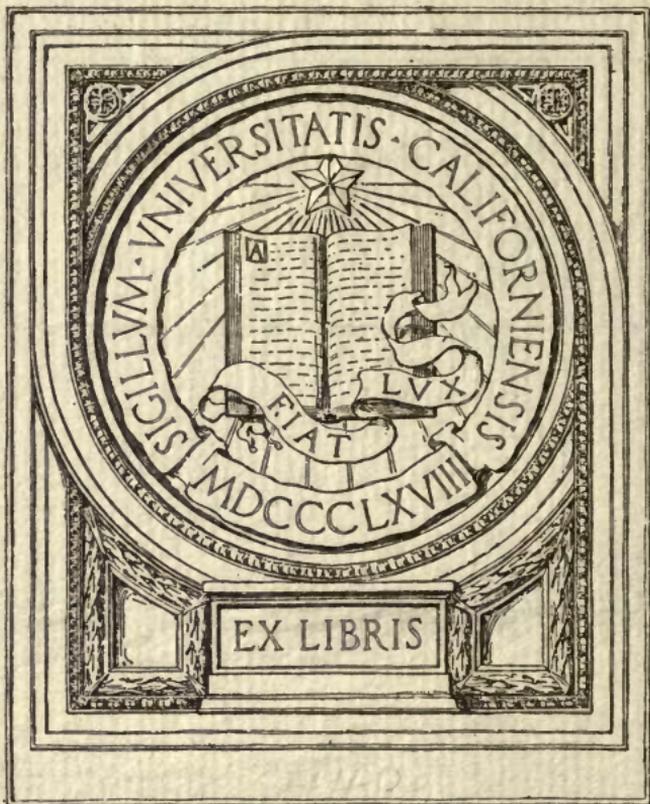
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SIGNIFICANT  
FEATURES IN THE  
HISTORY OF LIFE  
ON THE PACIFIC  
COAST

*By* JOHN C. MERRIAM

*Professor of Palaeontology and Historical Geology  
University of California*

UNIV. OF  
CALIFORNIA

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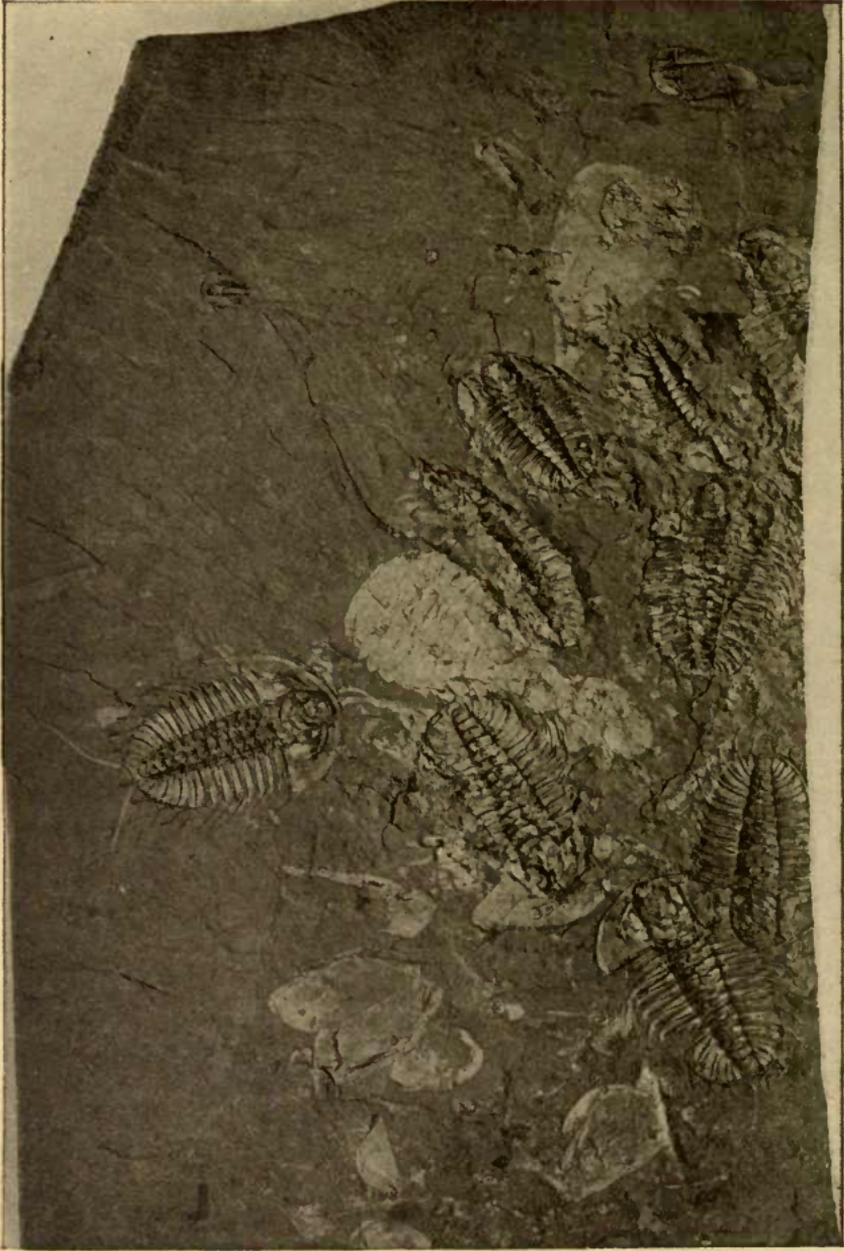
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**PLATE IX**  
**Cambrian Fossils**  
**From Near**  
**Mount Wapta,**  
**British Columbia.**  
**There Were**  
**Fourteen Species**  
**of Trilobites**

**and**  
**Other Crustaceans**  
**on the Slab**  
**From a Portion**  
**of Which**  
**the Photograph**  
**Was Taken.**

Photographed  
From a Specimen  
in the United States  
National Museum,  
Through Courtesy of  
Charles D. Walcott,  
Secretary of the  
Smithsonian Institution.



# SIGNIFICANT FEATURES IN THE HISTORY OF LIFE ON THE PACIFIC COAST

BY JOHN C. MERRIAM

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*Historical Geology, University of California*

**I**NTRODUCTION.—There are many significant features in every phase of West Coast palaeontology, but in certain aspects the history of life in this region is as yet imperfectly known, and little of world interest has been contributed. For a considerable portion of the earlier history of the lower animals we have here only a meagre record compared with that of the Atlantic Coast. Our story of the plants is largely that of the later periods. Of the age of amphibians we have no amphibian record. Of the wonderful world history of the great reptile class we know but a limited portion of the record of two groups. In the evolution of mammals we lack entirely the long record of Eocene time. After subtraction of the factors which are poorly represented there is much remaining, and it is to the features which are here unusually well expressed that the visitor will naturally be attracted.

**THE HISTORY OF PLANTS.**—Our knowledge of the history of the plant kingdom in the Pacific Coast region is much less advanced than that of many groups of animals. Of the plant life from the older or Palaeozoic formations very little is known on the western border of the continent, and not until we reach the next great division, the Mesozoic, do we find material which has attracted especial interest. The oldest well-known flora is that of the Jurassic period of the Mesozoic described from Oroville in California, Thompson Creek in Oregon, and other localities. In this group are many ferns, cycads, and the strange ginkgos now almost extinct. It includes many types known also in Jurassic areas of the Old World.

The Cretaceous flora is especially well represented in the great thickness of deposits of this period in the northern end of the Sacramento Valley in California. It contains many ferns, cycads, conifers, and a few of the higher flowering plants. Ginkgos are not known, but are found in a later flora. Almost without exception the Cretaceous

## FEATURES IN HISTORY OF LIFE ON PACIFIC COAST

Figure 11.—GEOGRAPHIC SITUATION OF IMPORTANT LOCALITIES AT WHICH FOSSIL REMAINS ARE FOUND IN THE WEST COAST REGION. On the map on the opposite page a square dot indicates the occurrence of vertebrates, a circular dot invertebrates, and a triangular dot plants.

- |   |   |
|---|---|
| 1. Field, Cambrian invertebrates                                  | 31. Marysville Buttes, Eocene invertebrates                               |
| 2. Nanaimo, Cretaceous invertebrates                              | 32. Chalk Bluffs, Tertiary plants   |
| 3. Swauk, Eocene plants   | 33. Hawver Cave, Pleistocene mammals                                      |
| 4. Roslyn, Eocene plants  | 34. Knoxville, Cretaceous invertebrates                                   |
| 5. Carbonado, Eocene plants                                       | 35. Ione, Tertiary plants and invertebrates                               |
| 6. Vader, Eocene invertebrates                                    | 36. Virgin Valley and Thousand Creek, Tertiary mammals                    |
| 7. Montesano, Tertiary invertebrates                              | 37. Astor Pass, Pleistocene mammals                                       |
| 8. Astoria, Oligocene invertebrates                               | 38. Elko, Tertiary invertebrates and mammals                              |
| 9. Pittsburg, Oligocene invertebrates                             | 39. West Humboldt Range, Triassic invertebrates and reptiles              |
| 10. John Day, Tertiary mammals and plants                         | 40. Cedar Mountain, Miocene mammals                                       |
| 11. Crooked River, Oligocene mammals                              | 41. San Pablo Bay, Tertiary invertebrates and plants, Pleistocene mammals |
| 12. Fossil Lake, Pleistocene mammals                              | 42. Mount Diablo, Tertiary invertebrates and plants                       |
| 13. Payette, Tertiary plants                                      | 43. Merced, Pleistocene and Pliocene invertebrates                        |
| 14. Aspen Ridge, Lower Triassic invertebrates                     | 44. Santa Clara, Pliocene plants  |
| 15. Coos Bay, Miocene invertebrates                               | 45. Coalinga, Tertiary invertebrates and mammals                          |
| 16. Port Orford, Tertiary invertebrates                           | 46. Inyo County, Cambrian invertebrates                                   |
| 17. Roseburg, Tertiary invertebrates                              | 47. San Luis Obispo, Tertiary invertebrates                               |
| 18. Thompson Creek, Jurassic plants                               | 48. Kern, Miocene invertebrates   |
| 19. Klamath Mountains, Cretaceous invertebrates and plants        | 49. Ricardo, Pliocene mammals   |
| 20. Shasta County Limestones. Triassic invertebrates and reptiles | 50. Barstow, Upper Miocene mammals  |
| 21. Samwel Cave, Pleistocene mammals                              | 51. Manix, Pleistocene mammals  |
| 22. Potter Creek Cave, Pleistocene mammals                        | 52. Rancho La Brea, Pleistocene mammals                                   |
| 23. Kennett, Devonian invertebrates                               | 53. San Pedro, Pleistocene invertebrates                                  |
| 24. Eel River, Pliocene invertebrates                             | 54. Santa Ana Mountains, Cretaceous and Tertiary invertebrates            |
| 25. Horsetown, Cretaceous invertebrates                           | 55. Carrizo Creek, Tertiary invertebrates                                 |
| 26. Elder Creek, Cretaceous invertebrates and plants              | 56. Fort Tejon, Eocene invertebrates                                      |
| 27. Chico, Cretaceous invertebrates                               |   |
| 28. Oroville, Jurassic plants                                     |   |
| 29. Plumas County, Carboniferous invertebrates                    |   |
| 30. Plumas County, Silurian and Jurassic invertebrates            |   |

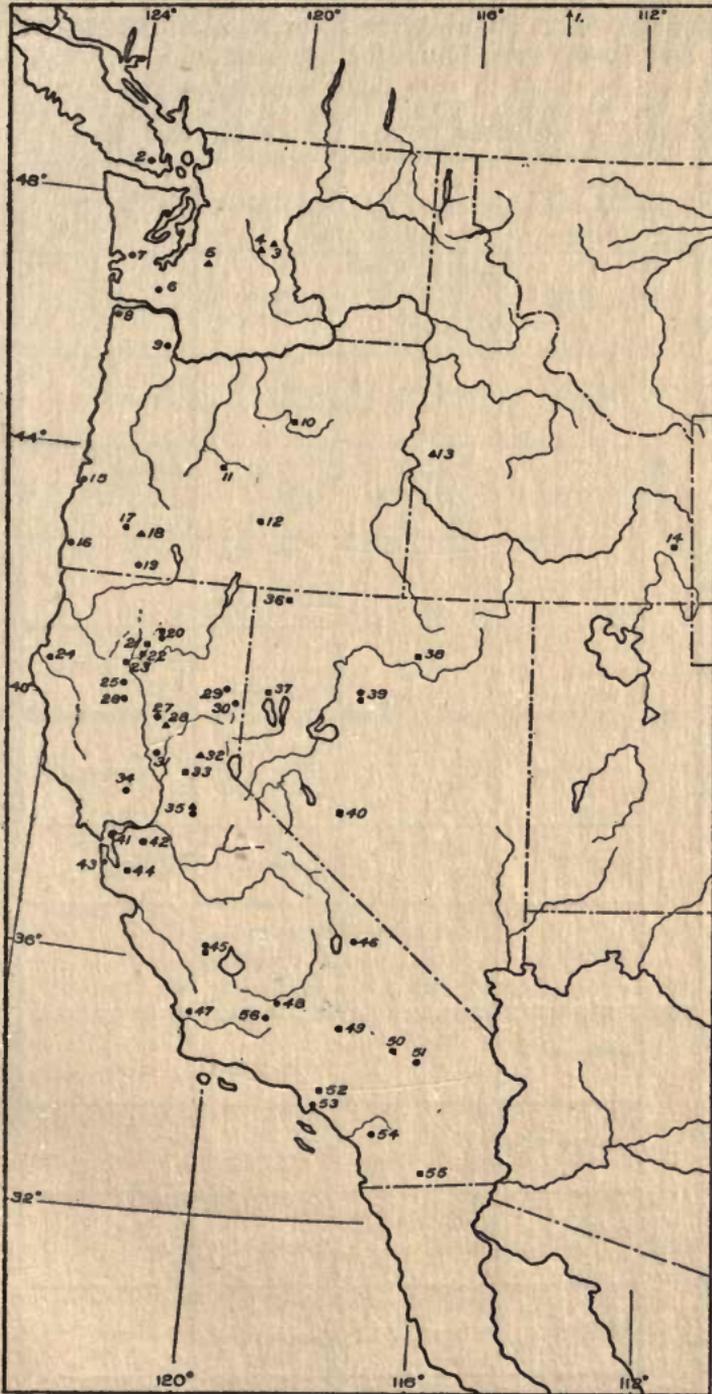


Figure 11

Geographic situation of important localities at which fossil remains are found in the West Coast region. Legend for locality numbers on opposite page.

# GEOLOGIC OCCURRENCE OF LOCALITIES FOR WEST COAST FAUNAS AND FLORAS OF ESPECIAL SIGNIFICANCE IN A STUDY OF THE HISTORY OF LIFE.

All localities listed in this table appear on the map, Figure 11, on Page 90. The nature of the material at each locality is indicated in the legend for this map.

Time Divisions		Vertebrates	Invertebrates	Plants
Eras	Periods			
Cenozoic	Pleistocene	Rancho La Brea Potter Creek Cave Samuel Cave Fossil Lake	San Pedro Merced	Rancho La Brea
	Pliocene	Thousand Creek Ricardo	Merced Purissima	Santa Clara
	Miocene	Barstow Virgin Valley Mascall	San Pablo Mount Diablo Coalinga Kern	Mascall Auriferous Gravels
	Oligocene	John Day	Astoria San Lorenzo Mount Diablo	
	Eocene		Tejon Martinez	Puget Group Clarno Ione
Mesozoic	Cretaceous		Elder Creek Chico Martinez Santa Ana	Upper Sacramento Valley
	Jurassic		Plumas County	Oroville Thompson Creek
	Triassic	Shasta Lime- stones West Humboldt Range	Shasta Lime- stones West Humboldt Range Aspen Ridge	
Palaeozoic	Permian		Shasta County	
	Carboniferous		Shasta County	
	Devonian		Kennett	
	Silurian		Plumas County	
	Ordovician			
	Cambrian		Field, B. C. Inyo	

## FEATURES IN HISTORY OF LIFE ON PACIFIC COAST

plants belong to species not known in the Jurassic flora of this region. In a few areas of the West Coast, as at Vancouver Island, remains of Cretaceous plants accumulated in sufficient quantity to form coal beds.

In the Eocene period, following the Cretaceous, plant life was more abundantly preserved than at any other time in the history of the Pacific Coast region. It was during this time that the greater part of the West Coast coal was deposited, largely through accumulation of remains of coniferous plants. There is good reason to believe that conditions were unusually favorable during this time both for accumulation of coal and for abundant growth of plants over wide areas of low-lying land. The Eocene flora is especially well known from the coal mines of the Puget Group in western Washington, from the Swauk and Roslyn beds of eastern Washington, from the Upper and Lower Clarno beds of eastern Oregon, and from the Ione formation of the eastern border of the Sacramento Valley in California. At least two phases of this flora are known. The earlier or Cherry Creek phase of the eastern Oregon flora contains a considerable percentage of ferns and is more closely related to the Cretaceous flora than is the Upper Clarno of Bridge Creek, Oregon. In the upper flora walnut, birch, alder, oak, maple and sycamore make up a large percentage of the plants, and ferns are not known.

From strata of the Oligocene period a very few plants are known in the uppermost John Day beds of eastern Oregon.

The flora of the West Coast in Miocene time is well shown at a number of localities. In the Mascall Middle Miocene of the John Day region very abundant remains represent about eighty species. Included among these plants are the following types: willow 9 species, oak 7 species, elm, magnolia, tulip tree, sycamore, acacia, maple 8 species, sequoia 3 species, yew, scouring rushes, and a ginkgo. A flora resembling that of the Mascall beds is found in eastern Washington and in several other regions of the West. The flora of Corral Hollow in middle California is referred to the Upper Miocene. The splendid flora of the Auriferous Gravels from the Sierra foothills of middle California has been generally recognized as Miocene, though Knowlton who has most carefully studied it notes also a relationship to the Eocene. Recent work has shown the presence of an Eocene marine fauna in beds thought by many to represent the same period as formations containing the Auriferous Gravel plants.

## FEATURES IN HISTORY OF LIFE ON PACIFIC COAST

The plants of the last two periods preceding the present, that is the Pliocene and the Pleistocene, are relatively little known, though scanty materials have been obtained from formations of both periods.

**HISTORY OF INVERTEBRATE FAUNAS.**—The unusually thick series of sediments in the Pacific Coast region presents an exceptional opportunity for the study of life zones of invertebrates. The marine faunas of a number of the periods are at least as well represented here as in any part of the world, and some of the faunas are of unusual importance. In the western region the faunas of the Silurian and Devonian are not relatively significant. Jurassic faunas are known, but are of relatively small importance. The Carboniferous and Permian are represented by abundant remains at a number of localities. The Cambrian, Triassic, Cretaceous, Eocene, Oligocene, Miocene, Pliocene, and Pleistocene are all known by faunas of unusual interest which may well attract the attention of the palaeontologist.

Cambrian faunas are found at a number of localities in the western region, among those of importance being the occurrence of Lower Cambrian in Inyo County, California, and the extraordinary Cambrian faunal representation of southern British Columbia. The occurrence at Field, in British Columbia, is among the most important of the Cambrian localities of the world. The wonderful preservation of the specimens makes possible unusually satisfactory studies on this fauna. The slab shown in Plate IX illustrates the nature of the material.

Silurian rocks are known in Plumas County, California. A Devonian fauna has been obtained from limestones exposed along the upper Sacramento River at Kennett. Carboniferous exposures of importance appear in Shasta County, California, where great thicknesses of shales and limestones contain in places an abundant fauna.

Of the whole Pacific Coast section there is no division in which the invertebrate life is of greater interest, or presents a greater variety of forms than the Triassic of Idaho, Nevada, and California. Through the work of Professor James Perrin Smith these faunas have been exhaustively investigated, and a part of the result of this work has already appeared in the publications of the United States Geological Survey. By far the most interesting phase of the Triassic life represented in these rocks is found in the nautilus-like molluscs of the ammonoid group, which are known by a great number of specimens representing many genera and species, and showing a remarkable state of preserva-

## FEATURES IN HISTORY OF LIFE ON PACIFIC COAST

tion. In a study of the material available important results have been obtained which bear on the evolution of the cephalopods, and on the whole biological question of mode of evolution. In a number of cases these faunas exhibit close relationship with those of the Triassic of other portions of the world, and make possible important studies on the geographic distribution of animals, and on climatic changes during Triassic time. Extensive materials representing the West American Triassic invertebrates are deposited in the palaeontologic collections of Stanford University.

The rocks of the Cretaceous period are of great geographic extent and of unusual thickness. At Elder Creek in the northern portion of the Sacramento Valley, California, a measured section has been studied which approximates 30,000 feet in thickness. Three important faunal zones, the lower or Knoxville, the middle or Horsetown, and the upper or Chico, have been recognized. Abundant material representing all of these zones has been described by W. M. Gabb, by Dr. T. W. Stanton, and by F. M. Anderson. Good collections are available at Stanford University and at the University of California. The Knoxville division is by many considered to represent the Jurassic rather than the Cretaceous. Excellent material from Cretaceous faunas is also known at many other localities in the West, as in the Klamath Mountains on the border line between Oregon and California, the Blue Mountains of eastern Oregon, at Martinez and Mount Diablo near San Francisco, and in the Santa Ana Mountains in southern California.

The marine Eocene of the Pacific Coast has one of the best represented and best known of the later faunas. At least two divisions are recognized, the lower or Martinez and the upper or Tejon, in both of which a large number of species are reported. The Martinez fauna is found in the southern portion of California, and possibly as far north as Washington. The generally recognized Tejon fauna ranges the whole length of the Pacific Coast region and serves as one of the characteristic bases for reference in stratigraphy. The Martinez fauna is well known at Mount Diablo near San Francisco. The typical locality of the Tejon is at the southern end of the San Joaquin Valley in California.

Oligocene faunas are found in Oregon and Washington, and have more recently been described from middle California.

In the Miocene an unusual wealth of invertebrate material appears in Oregon, Washington, and Cali-

## FEATURES IN HISTORY OF LIFE ON PACIFIC COAST

ifornia. Especially in western Washington and southern California there are enormous thicknesses of beds referred to this period. At least three distinct divisions of the Miocene can be made on the basis of the faunas, and this number will doubtless be greatly increased by further study. In the immediate vicinity of San Francisco Bay excellent sections of the Miocene can be studied, but the thickest sections are represented in the southern portion of the state. In the vicinity of Coalinga good exposures of the Miocene may be seen with the Eocene and Pliocene.

Important Pliocene occurrences are those in the Merced series near San Francisco, where a splendid section of approximately 5000 feet is exposed. Good faunas are seen again at Purisima south of the Merced region, and in the Etchegoin formation near Coalinga, on the western side of the Great Valley of California.

In Pleistocene time the sea had retreated to the outermost border of the continent, but deposits of great thickness were laid down at some localities. The fauna is abundantly represented in many sections. The best known Pleistocene of the West Coast is that of San Pedro in southern California. The fauna of this locality has been admirably described in a memoir by Dr. Ralph Arnold. According to this description the lower portion of the San Pedro Pleistocene represents a cold-water stage, while the upper San Pedro was laid down under conditions of somewhat higher temperature. In addition to the abundant invertebrate fauna of the upper San Pedro, there have recently been found in these beds a number of vertebrate remains, which contribute important information bearing on the general problem of time correlation among the Cenozoic deposits of the western region.

**HISTORY OF THE VERTEBRATES.**—The relatively large area covered by a thick mantle of strata deposited in a sea in the region west of the Sierra-Cascade Range has given large opportunity for the preservation of marine invertebrates, and the probabilities of preservation of vertebrates, excepting fishes and marine forms of the higher groups, are relatively small.

In the Great Basin Province no marine invertebrates are found in rocks of later date than the Jurassic period, and following this time fresh-water and land-laid deposits presented large chance of entombment of the higher types of vertebrates. For these reasons the history of the Pacific Province is known largely in terms of the stages of develop-

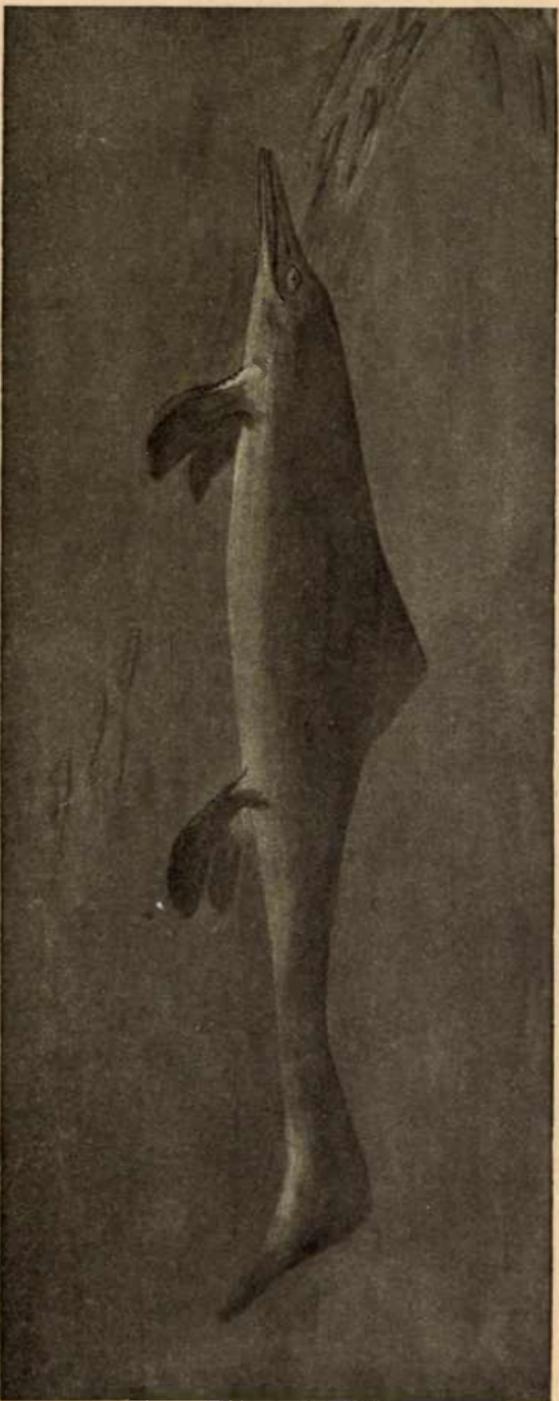


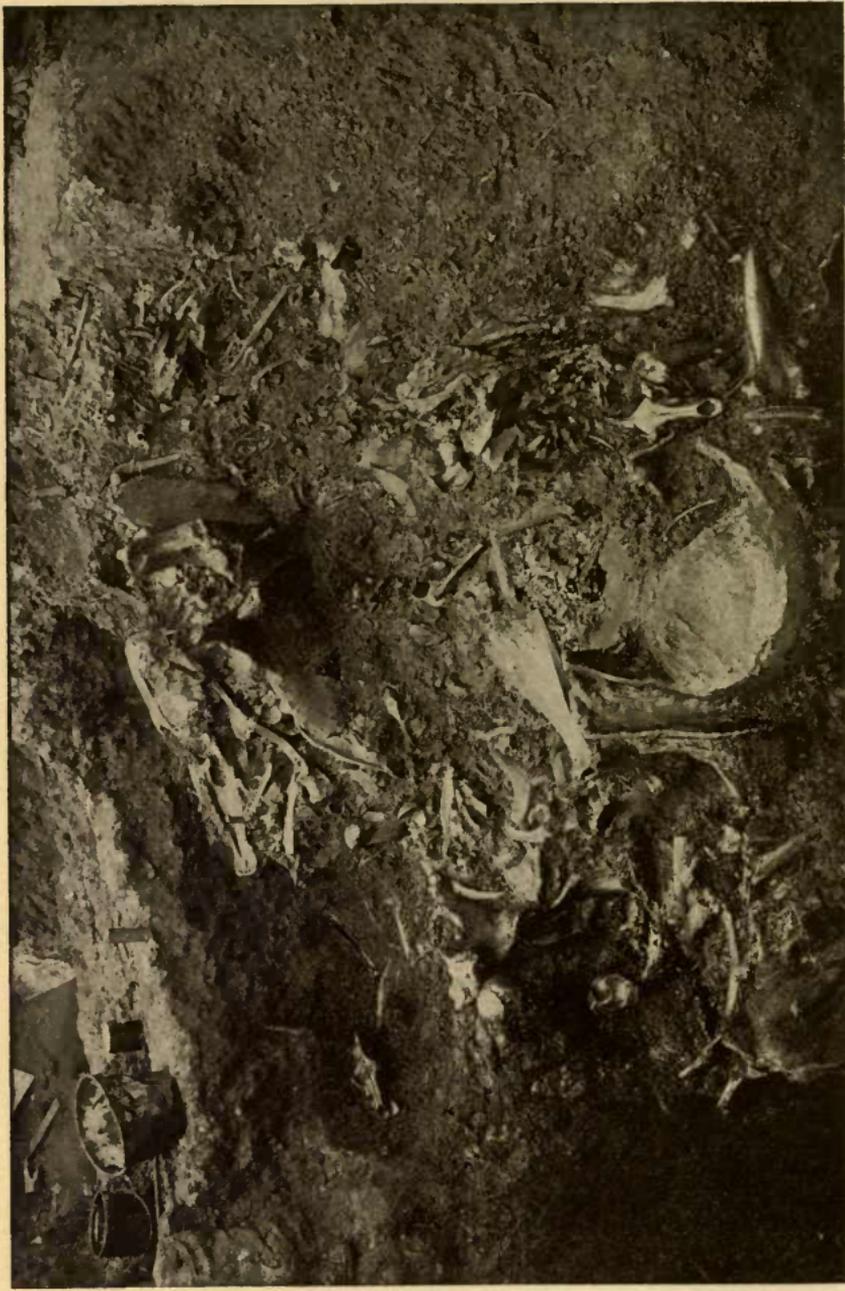
PLATE X  
Reconstruction of  
*Cymbospondylus*  
*petrinus*, the  
Characteristic  
Ichthyosaur, or  
Fish-Lizard, of the  
Middle Triassic  
Limestones in the  
West Humboldt  
Range, Nevada.  
Length in Life  
Approximately  
Thirty Feet. This  
Animal Was a Rep-  
tile Specialized  
for Life in the Sea.  
Drawn in 1907 by  
Mrs. Grace Ballantine  
Under the Direction of  
John C. Merriam.

PLATE XI

One of the  
University  
of California Pits  
at Rancho La Brea.  
The Numerous  
Bones in View Had  
Not Been  
Removed From Their  
Original Positions  
When This Photograph  
Was Taken.

This Picture Shows  
Skulls of Four  
Sabre-Tooth Tigers,  
Four Large Wolves,  
Parts of the  
Skeletons of  
Four Ground-Sloths,  
Four Skulls of the  
Extinct Horse and  
Bison, and Limb Bones  
of the  
Camel and Mastodon.

Photographed by  
John C. Merriam.



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ment of the lower animals, and a considerable portion of the Great Basin history is interpreted in terms of the succession of vertebrates.

**FISHES AND AMPHIBIANS.**—Dr. David Starr Jordan has assembled all available information on the fossil fishes of California in two papers in the University of California Publications in Geology. The earliest described forms are rare cestraciont sharks from the Triassic of California and Nevada. Rare remains of sharks, and scales of the more modern teleost or bony fishes, occur in the Cretaceous. A few imperfect fishes have been obtained in the fresh-water Eocene of the John Day region of Oregon, and at Elko, Nevada. In the marine Eocene of the Pacific Province scattered teeth of sharks appear with fragmentary material of the higher fishes. From the Oligocene scattered remains are known, but no satisfactory collection is available. The most important fish fauna of the western region is known from the marine Miocene occurring along a large part of the west coast. As yet no satisfactory collection of this Miocene fauna has been brought together. The Miocene fish fauna includes numerous types of sharks and skates, with forms like the herring and mackerel. Other groups of the higher fishes are known by many scattered bones and a few fairly preserved skeletons. In the Pliocene and Pleistocene many fish bones have been obtained, but the faunas as a whole are very imperfectly known.

As yet the Amphibia are known from the western region only by the remains of a peculiar toad recently described from the asphalt deposits of Rancho La Brea.

**REPTILES.**—The study of the great groups of extinct reptiles, constituting so important a portion of the palaeontologic story of the earth, has been limited in the western region to the history of certain marine reptiles of the Triassic period, representing the first of the three divisions of the age of reptiles.

In the Lower Triassic, vertebrates are known only by remains of primitive fishes. Middle Triassic beds are exposed both in Nevada and in northern California, but vertebrate remains are described only from the limestones of western Nevada. In the West Humboldt Range near Lovelocks, Nevada, marvelously preserved skeletons of Middle Triassic ichthyosaurs or fish-lizards have been found, associated with rare remains of another marine reptile group as yet only imperfectly known. Several ichthyosaur specimens from this region are now on exhibition at the University of California. The ma-

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terial is sufficiently complete to permit a tentative reconstruction shown in Plate X.

In the Upper Triassic limestones, reptilian remains are also well represented, but are known only from the exposures in northern California. Bones have been found representing the ichthyosaurs and another marine group, the thalattosaurs, peculiar to California. While numerous fragments have been obtained from these deposits, the skeletons are nearly all imperfect and do not show the wonderful preservation of the Middle Triassic specimens from Nevada.

The history of the ichthyosaurs represented in the Middle and Upper Triassic of the western region furnishes one of the most interesting studies of evolution thus far known in the story of this group. The Middle Triassic forms are much more primitive in every respect than those of the Jurassic, and show less advanced specialization of the limbs, tail, eyes, and teeth for life on the high seas. The Upper Triassic types are also relatively primitive, but are intermediate between the Middle Triassic and the Jurassic stages of evolution.

It is worthy of note that of all the multitude of kinds of marine reptiles known to have lived elsewhere on the earth in the Jurassic and Cretaceous periods, that is, in the second and third of the three divisions of the great age of reptiles, only two or three indeterminate fragments have been found in the extensive exposures of rocks of these periods in the Pacific Coast and Great Basin regions. One specimen from the Cretaceous of California is doubtfully considered to represent a plesiosaur, a long-necked reptile very abundant in the seas of the world in Cretaceous time.

**BIRDS.**—Fossil remains of birds are among the most uncommon of the relics preserved in the rocks, and can be expected in relatively few localities. In the western region remains of bird bones have been found in several formations. Dr. L. H. Miller has summarized all of our information on the distribution and history of this group in a paper in the University of California Publications in Geology.

No birds are known from the western region in beds older than the Oligocene, from which a single bone has been obtained at Vancouver Island, British Columbia. In the Miocene several fragments are known from Nevada, from the Mohave Desert of California, and one from marine deposits at Los Angeles. In the Pliocene the material is similarly scanty and imperfect.

The Pleistocene bird fauna of the West is excep-

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tionally rich, exceeding in quantity of material that of all other regions of America. This fauna is known from the deposits of Fossil Lake, Oregon; Potter Creek Cave, Samwel Cave, and Hawver Cave of California; Rancho La Brea, California; and the marine Pleistocene of San Pedro. By far the most abundant remains are those obtained at Rancho La Brea. From this locality thousands of perfectly preserved specimens have been secured.

The Pleistocene fauna as described by Dr. Miller contains a large percentage of extinct species, some of which belong to genera no longer in existence. A number of the forms, as the peacock-like species, *Pavo californicus*, of Rancho La Brea have relationships with Old World types.

Probably the most interesting of all the Pleistocene birds recently described is the giant *Teratornis*, a form with a skull somewhat like that of the condor, but with a narrow beak of the eagle type. It reached gigantic size and was evidently larger than the great California condor. Remains of *Teratornis* occur in portions of the deposit at Rancho La Brea which seem to have formed relatively late, and it is not impossible that this creature lived on into the present period, and was known to early man of this region. Condors and eagles of numerous species were represented, among them the existing California condor and a number of extinct eagles.

THE HISTORY OF MAMMALS.—Remains of extinct mammals are found in considerable abundance in the Cenozoic fresh-water and land-laid formations of the bad-lands regions in the Great Basin Province. In the Pacific Coast Province mammals have until recently been known sparingly excepting in the deposits of the latest period, the Pleistocene. The occurrences of greatest importance in the Basin Province are the John Day, Crooked River, and Fossil Lake beds of eastern Oregon; the Washtunca Pleistocene of eastern Washington; the Virgin Valley, Thousand Creek, Cedar Mountain, and Astor Pass localities of Nevada; and the Barstow, Ricardo, and Manix localities of the Mohave Desert in southeastern California. West of the Sierra-Cascade range we find a few marine mammals in the great series of marine sediments, but the most important occurrences are the asphalt deposits of Rancho La Brea, and the Pleistocene caves of northern and middle California. Several mammal faunas in association with the marine series near Coalinga, California, furnish information of unusual significance in working out the problem of age determination of the West Coast faunas and formations.

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MAMMALIAN FAUNAS OF THE GREAT BASIN PROVINCE.—Within the limits of the Great Basin Province the most important series of mammalian faunas is that in the John Day region of eastern Oregon. In this area the Cenozoic section from the base upward comprises the Clarno Eocene, John Day Oligocene, Lower Miocene Columbia lava flows, Mascall Middle Miocene, Rattlesnake Pliocene, and terrace deposits of the Pleistocene. All of these formations, excepting the lavas, contain remains representing the extinct life of this region. The Eocene has an abundant flora but contains no remains of mammals. Mammal remains are found in all of the formations above the Eocene.

The mammal fauna of the John Day Oligocene includes a little more than one hundred species, of which an unusually large number of forms belong to the cat and dog groups. Of the dog family there are at least 18 species distributed among 9 genera. Of the cats there are at least 10 species, representing 4 or 5 genera referred to the sabre-tooth group. Numerous primitive horses belong to the genus *Miohippus*. Rhinoceroses are represented by the two-horned *Diceratherium* and the hornless *Aceratherium*. The gigantic pig-like *Elotherium* is known by a number of fine specimens. Smaller pigs of the peccary type are not uncommon. The most abundant remains in all of this fauna are those belonging in several genera of the characteristic even-toed ungulates, the oreodons. Primitive camels are well known, especially in the upper portion of the series.

The fauna of the Mascall Middle Miocene is less satisfactorily known than that of the John Day, and contains a considerable variety of horses belonging in at least three genera, of which the three-toed *Merychippus* is the most common and characteristic type. The camels are much larger and more specialized forms than those of the John Day. The members of the cat and dog families are all different from those of the John Day.

The Rattlesnake Pliocene fauna is imperfectly known. It contains horses of the *Neohipparion* and *Pliohippus* groups, approaching in many respects the type of structure in modern horses. There is also a very large camel, a rhinoceros, and a large peccary.

The Pleistocene fauna of the John Day is not well known, but contains the remains of elephants of a very modern type.

On the northern border of the Nevada region are two important series of mammal beds known as the Virgin Valley and Thousand Creek formations. The

## FEATURES IN HISTORY OF LIFE ON PACIFIC COAST

former contains a fauna like that of the Middle Miocene Mascall of the John Day region. The fauna of the Thousand Creek beds is entirely different from that of the Virgin Valley formation and most closely resembles the Pliocene life of the John Day region. In the Thousand Creek fauna are a number of peculiar types not previously known in America, including certain twisted-horned antelopes which in many respects resemble some of the living African forms, and correspond approximately in the type of their horns to certain widely distributed antelopes of the late Miocene and early Pliocene of Europe and Asia.

Next to the John Day region of eastern Oregon the most important succession of mammalian faunas in the Great Basin Province is found in the Mohave Desert. At least three faunas are known in the badland deposits of this region.

The oldest mammal-bearing beds of the Mohave Desert are the extensive deposits of the Barstow formation near the town of Barstow. This fauna represents an Upper Miocene stage not known elsewhere in the region west of the Wasatch. The Barstow fauna includes about thirty species among which the most common forms are three-toed horses of the *Merychippus* type, camels of two groups, primitive deer-antelope, four-tusked mastodons, dogs of the heavy-jawed *Aelurodon* type, and large tortoises.

A second faunal stage, evidently occurring in a second geologic formation of the Mohave Desert, appears in the splendid exposures at Ricardo on the western side of the El Paso Range, and facing the foot of the Sierras. The Ricardo fauna contains mammalian types of the same groups as those represented at Barstow, but many of the genera and nearly all of the species are different and of more specialized stages. The Ricardo fauna is most closely related to that of the Lower Pliocene. It contains several forms, especially the horses of the *Hipparion* group, which closely resemble species found in fossil beds of the Old World.

A third fauna of the Mohave is found in the Pleistocene of Manix Lake, near Manix station on the Salt Lake Railway in the eastern part of the desert. The mammalian remains at this locality are scattered and fragmentary, but represent the most satisfactory assemblage of Pleistocene forms known in the Mohave Desert area. They include two horses of the genus *Equus*, two extinct camels, a proboscidean, an antelope, and several birds. A number of fresh-water molluscs are also found here.

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**FAUNAS OF PLEISTOCENE CAVES.**—A number of important discoveries of rich mammal-bearing Pleistocene deposits have been made in caverns situated in the limestone regions of the mountains of northern and eastern California. The faunas obtained in these caves have contributed much to our understanding of the history of mammalian life on the Pacific Coast.

Potter Creek Cave, in Shasta County, furnished a fauna comprising more than fifty species, of which approximately one-half are extinct. Included in this fauna are the great bear *Arctotherium*, a bear of more modern type related to the black bear, a puma, a large extinct lion, an extinct wolf, and fragmentary material representing the deer, mountain goat, ground sloth, bison, camel, mastodon, elephant, extinct horse, and a goat-like animal known as *Euceratherium*. Samwel Cave, also in Shasta County, contained a fauna differing to some extent from that of Potter Creek Cave. The great bear is absent, and there is present another peculiar goat-like animal known as *Preptoceras*.

Hawver Cave near the town of Auburn, on the overland line of the Southern Pacific Railway, was discovered by the late Dr. J. C. Hawver, through whose interest much material of scientific value has been brought to light. The collections from this locality comprise a number of extinct mammalian forms, but investigation of the fauna as a whole has not been completed.

**RANCHO LA BREA.**—The deposits of fossil skeletons in the Pleistocene asphalt beds of Rancho La Brea constitute one of the most interesting features in the history of life on the Pacific Coast. The unusual nature of the accumulation, the vast quantity of material, the marvelously perfect preservation, and the great variety of life represented all serve to mark this locality as one of the most important occurrences of remains of the life of a past period known in America. The site of the excavations is about seven miles from the middle of the city of Los Angeles and is within a stone's throw of Wilshire Boulevard, a fine automobile road between Los Angeles and Santa Monica. The locality can be reached by automobile in twenty minutes from the central part of the city.

The bones are found at Rancho La Brea in asphalt pits or chimneys which are the vents through which oil and gas have escaped from great reservoirs of oil located far below the surface. The geologic history of this region indicates that bending or breaking of the strata has permitted the oil and

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gas to escape. Since the first accumulation of the asphalt, there has been very frequent trapping of animals coming in contact with the sticky pools. Wherever oil is exuded at the present time we find birds, gophers, squirrels, dogs, and even cattle frequently entangled. This process has led to the accumulation of great quantities of remains of animals in times past. In many of the pits the bones are found massed and matted together in enormous numbers. Literally hundreds of thousands of specimens have been obtained from these deposits. The photograph shown on Plate XI illustrates a typical occurrence in one of the University of California excavations. The great number of specimens are shown in place, exactly as found.

The representation of ancient life at Rancho La Brea comprises numerous species, the total number amounting to considerably more than one hundred forms. These include an extinct bison, an extinct antelope, an elephant, a mastodon, extinct species of horse and camel, a sabre-tooth tiger, a giant cat closely related to the existing lion, great numbers of extinct wolves and coyotes, a gigantic bird with characters to some extent intermediate between the eagle and condor, many condors, vultures, owls, eagles, hawks, and a great variety of other birds and mammals. There are also remains of toads, and snakes, insects, thousand-legged worms, many leaves, and twigs of large plants, and even considerable parts of tree-trunks with the attached limbs.

The bones are all as perfectly preserved as though buried within the past few years; they can be assembled in complete skeletons which may be multiplied to hundreds in the principal collections. Several of the animals represented in such abundance at Rancho La Brea were known only by rare or fragmentary material before the discovery of this deposit, so that the opportunity for study offered in the Rancho La Brea collection is unusual.

The wonderful Rancho La Brea fauna obtained from the asphalt pits comes from deposits accumulated in the Pleistocene period, which preceded the present day by many thousands of years. As oil and asphalt are constantly being exuded from the soil in this region, it is natural that in some localities deposits of the present day, and stages between the present and Pleistocene, may be associated with the older deposits of Pleistocene time.

Good specimens representing the principal animals of Rancho La Brea are to be seen at the Museum of History, Science and Art in Los Angeles, and at the University of California in Berkeley.

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**PREHISTORIC HUMAN REMAINS.**—Among the most interesting west-American occurrences of actual human bones which have made some claim to antiquity are the famous Calaveras skull, certain stalagmite encrusted human bones from Stone Man Cave near Potter Creek Cave in northern California, and the recently discovered human skeleton from Pit Ten at Rancho La Brea. The Calaveras skull is now generally held to have come from a cave deposit, in which it may have been entombed for many years. This widely known specimen, monographed by Professor Whitney, and ridiculed by Bret Harte in his well-known ode to a Pliocene Skull, is evidently not the skull that was placed in a mining shaft for the purpose of perpetrating a joke on the miners. The remains in Stone Man Cave were covered with a considerable layer of stalagmite and may be very old, but it is not possible to make certain of their age. The specimen found at Rancho La Brea was associated with a fauna which is mainly Recent. The peculiar nature of the occurrence in asphalt chimneys at Rancho La Brea makes difficult any definite determination of age from occurrence alone.

In the San Francisco Bay region human remains are abundant in great shell-mounds at Shell Mound Park in Emeryville, and at Ellis Landing near Richmond. These mounds have been partially buried by gradual up-building of the surrounding marsh, coincident with a depression of the region which carried the bases of the mounds from an original position above the sea to a situation many feet below mean tide level. The remains in these mounds are certainly very old measured in terms of years, but they are very young geologically, and belong to the present or Recent period.



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