NATVRE AND SCIENCE ON THE PACIFIC COAST

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PLATE I

Mount Shasta, California. A Rare Cloud Formation Over This Volcanic Peak (Elevation 14,162 Feet), Which Stands at the Head of the Central Valley of California.

NATURE & SCIENCE ON THE PACIFIC COAST

A GUIDE-BOOK FOR SCIENTIFIC TRAVELERS IN THE WEST. EDITED UNDER THE AUSPICES OF THE PACIFIC COAST COMMITTEE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

ILLUSTRATED WITH NINETEEN TEXT FIGURES, TWENTY-NINE HALF-TONE PLATES AND FOURTEEN MAPS

PAUL ELDER AND COMPANY
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1915

DEDICATED TO

JOHN MUIR

MAN OF SCIENCE AND OF LETTERS
WIDELY TRAVELED OBSERVER OF THE WORLD
FRIEND AND PROTECTOR OF NATURE
UNIQUELY GIFTED TO INTERPRET
UNTO OTHER MEN HER
MIND AND WAYS

The words of the dedication are those used by President Benjamin Ide Wheeler of the University of California in conferring the degree of Doctor of Laws upon John Muir, May 14, 1913

INTRODUCTORY NOTE

THE *Pacific Coast region of the United States contains many distinctive natural features and much unique material for scientific research. Many of the problems presented here are peculiar to the West, but in their larger aspects they have a significant bearing upon fundamental questions of world-wide concern both in the field of natural science and in the relation of these problems to the affairs of men. However interesting western materials may be, the traveler wishing to know of them has little time for study, and sources of information which might be used are frequently scattered or inaccessible.*

Recognizing the need for ready information on nature and science in the West, the Pacific Coast Committee of the American Association for the Advancement of Science has considered it desirable in this year of the two expositions celebrating the opening of the Panama Canal to bring together in hand-book form concise data upon matters of general interest for the use of travelers in this region. A special committee was appointed to assemble the material and to enlist the assistance of men well informed upon the subjects to be discussed. The descriptions contained in this book have been prepared with care by specialists, and the volume is addressed to all travelers in the West who wish to know the significant features of the land through which they pass.

The sub-committee charged with the preparation of this guide-book desires to express its sincere appreciation of the generous aid of the contributors. To many others who have assisted by supplying illustrations, maps, and information upon facilities for travel, the committee is also greatly indebted. Only wide co-operation such as has been accorded could make possible the completion of an undertaking of this character. The volume is presented with the hope that it may increase the value of the journey for those who visit the Pacific Coast for the first time and that it may be of service also to the people residing within the region which it describes.

Sub-Committee in Charge:

JOHN C. MERRIAM, *Chairman,*
H. FOSTER BAIN,
VICTOR H. HENDERSON,
VERNON L. KELLOGG,
JOSEPH GRINNELL, *Editor.*

March 20, 1915.

CONTENTS

CONTENTS PAGE

CONTENTS PAGE

ILLUSTRATIONS

MAPS

NATURE AND SCIENCE ON THE PACIFIC COAST

THE APPROACHES TO THE PACIFIC COAST

BY FREDERICK J. TEGGART
Associate Professor of Pacific Coast History, University of California

The name "California" antedates the discovery of the territory to which it is now applied. It seems to have been created by a Spanish romancer to signify an island lying beyond the Indies, remarkable alike for its women and its gold—a last effort, apparently, to find a home upon the map for the Hesperides and their golden apples. Viewed from Europe, indeed, California was the most remote, the farthest of all lands, and some remnant of the wonder of the voyages of Bran, of Hercules, and of Pantagruel even yet lingers about the westward Thule.

Now, however, that Europeans have actually reached and settled this ultimate coast, the outlook changes, and we may survey the efforts of the long line of adventurous explorers from a new point of view. To appreciate the significance of these endeavors it is necessary to disabuse one's mind of the idea, expressed in its accepted form by Bishop Berkeley, that the expansion of the nations follows the path of the setting sun. This idea may suitably interpret the experience of the nations that border upon the Atlantic, but in no circumstances could it have originated upon the shores of the Pacific Ocean. For as we stand here facing the Orient the old conception of a westward line of advance gives place to another view—that of civilization spreading east and west from some original seat in eastern Asia, traversing the world in opposite directions, and drawing at length to a new focus on this opposite side of the globe. From this standpoint the picture is not merely that of Spaniards, English, French, and Dutch crossing the Atlantic Ocean and founding settlements upon its American seaboard; it includes the far more arduous struggles of these same Europeans to find a way around the land masses of America and Asia. What is of equal importance, moreover, is that this newer outlook includes also the sight of oriental peoples overflowing into the great emptiness of the west, and the spectacle of Russians making their way with an irresistible sweep across Asia, to leave, above high-water mark as it were, the wreckage of a

"Ross" or Russian fort upon the banks of a Russian River in California.

Indeed, the reflective student can never lose sight of the fact that Asia has always tended to overflow eastward. Migrations remote in time have stamped their impress upon the native population of the American side of the ocean, and it may even be to this source that the American Indian owes his origin. Again, whether or not the land of Fusang is to be identified with Mexico, this interpretation of the Chinese story of Hiu Shen has at least a suggestive interest in the history of the Pacific. Hiu Shen was a Buddhist missionary from Cabul who appeared in 499 A. D. at King-Chow on the Yang-Tse. To the emperor Wu Ti he brought presents from Fusang—thought to be the land of the agave or century-plant—and the record of his voyage was incorporated in the imperial annals. It is, indeed, no more than might have been expected that the extraordinary zeal of the Buddhist missionaries should have brought them in the fifth century to America; and while linguistic scholars continue to disagree, others may, for the time, accept the story as an additional illustration of the fact that waves caused by upheavals in the life of Asia break ultimately upon the American shore. So, too, the advance of the Russians across northern Asia in the sixteenth century reached Alaska, through the discoveries of Vitus Bering, by the middle of the eighteenth; and it is of interest to observe that there were moments in the opening years of the nineteenth century when it seemed as if the Pacific was about to become a Russian sea. Later still, the inauguration of steamship communication across the Pacific Ocean showed how easily the Chinese overflow might set towards the California coast, while today an immigration problem presents itself that acts of Congress may prove inadequate to solve.

The North Atlantic shores of America are dominated by European civilization. Granted the discovery of eastern North America, the way there from Europe lay open for all who cared to take it. The interest of Atlantic Coast history lies in the vicissitudes of the settlers in their struggle with nature, and in the varying relations they have maintained with sovereign powers in Europe that could not be brought to take the settlers' view of the problems of a new land.

The interest of Pacific Coast history is altogether different. Far from being easily accessible to Europe, California was, in the first instance, to be reached only by dint of extraordinary efforts; and the present routes hither have been created by engineering works of unprecedented magnitude. The land is remote, and for the maintenance of connections, even with the country of which politically it forms a part, all the mechanical resources of western civilization are necessary. Once here, moreover, the man of European descent finds himself looking out upon an alien and incomprehensible Asia. So the dominating consideration in the affairs of the Pacific Coast is that here a detached outpost of European civilization finds itself face to face, in perpetuity, with the Orient. It is unnecessary to dwell upon the fact that from the point of view of anthropogeography the coasts of the Pacific—Asiatic and American—constitute a unit. The seas unite, the land masses separate, men. Here before us lies the ocean, easily traversed; there behind us rises the great mountain barrier, threaded only by occasional passes, separating us from the eastern part of the continent. Considered in terms of humanity at large, the situation is artificial; we close an avenue in the face of millions, and open a path by which only tens arrive. The significance of this anomaly is unmistakable: Europeans, having by their daring and alertness won a title to a coast which would seem to be the natural area for the overflow of Asia, propose to hold it as the frontier of their own civilization. The supreme difficulty of this attempt should not be underestimated. The ingenuity of the European has abridged distances by means of railroads and canals, and so has made his position here seemingly tenable. On the other hand, his inventiveness has placed steamships at the disposal of his competitors, and, while the land on this side remains unfilled, the millions in Asia do not decrease.

It is obvious that the study of history inevitably forces upon us a realization of the circumstances in which European man finds himself placed when he undertakes to hold the western border of the Pacific Ocean; but history itself does not seek to elucidate the future; it takes account only of the steps by which the present situation has come to be as it is. From the point of view of the history of occidental peoples, the juxtaposition of west and east upon the Pacific is the outcome of the hardihood and adventurous spirit of successive generations of European seafarers and frontiersmen.

In whichever direction one looks out from Europe, California lies beyond an ocean and a continent. To reach it from Europe, therefore, it would be necessary to pass around—either to the north or to the south—one of the two great land masses of the globe. Less than four years after Columbus discovered the New World, John Cabot, sailing a Bristol ship, reached the coast of Labrador (1497), and from that time onward the English nation seemed committed to the task of finding a northwestern passage to the Pacific Ocean. Untiring explorers matched themselves in vain, however, against the ice, until 1907, when the Norwegian Amundsen completed his four years' voyage by sailing into San Francisco Bay. (His ship now rests within a stone's throw of the ocean in Golden Gate Park.) As early as 1553, English ships were sent to try out the possibilities of a northeastern route, but again the accomplishment of the voyage was long deferred, being effected by the Swedish Nordenskjöld in the *Vega* in 1879.

The recommendation of the northeast and northwest passages would have been their shortness—had they been practicable. Of the open sea routes, that by the Cape of Good Hope had been made known by the voyages of Bartholomew Diaz (1487) and Vasco da Gama (1498), but its extreme length has always left it out of consideration as a way of getting to the American Pacific Coast. In 1520, Magellan discovered the strait named after him, and in 1578 Drake followed the southwestern route into the Pacific Ocean. Drake's voyage may be said to have opened the Pacific to Europeans of every nationality, while his visit to California in 1579 pointed out what remained the only feasible sea route to the coast for three centuries and a third.

The path thus indicated by hardy voyagers, prepared to lose two-thirds of their number on the way, was no practicable road for colonization; and hence the European foothold on the Pacific Coast had to await the long and arduous process of interior exploration.

As might be supposed, the earliest land-approach was not across the American continent at its widest part. The first knowledge of the California coast was a sequel to the conquest of Mexico. The efforts of Cortés, persistent as they were, can scarcely be called successful. The ships for the voyage had to be built upon the Pacific side, and the two he sent out in 1532 never returned. In 1533, the *Concepción* and *San Lázaro* discovered the extremity of the peninsula, but were otherwise unfortunate. The expedition of 1535, led by Cortés himself, landed at the bay of Santa Cruz, possibly La Paz, but failed in the purpose of establishing a colony. Finally, the supreme effort of Cortés, the expedition under Francisco de Ulloa in 1539, succeeded so far as to explore the Gulf of California to its head and the outer coast of the peninsula for about half its length. The viceroy, Antonio de Mendoza, next took up the burden of northward exploration. To co-operate with Coronado in the search for the famous Seven Cities of Cibola he sent Hernando d'Alarcón, in 1540, by sea to the head of the gulf. Mendoza had no better fortune than Cortés in discovering fabulous lands and cities, but by his next venture, the expedition of Cabrillo and Ferrelo in 1542, the California coast was explored to Cape Mendocino. The return of Ferrelo marks the conclusion of the first period of California exploration.

Whatever the policy of Spain may have been at any time in regard to the northern Pacific Coast, her activities upon it may be traced in practically every instance to the movements of foreigners. Even the explorations of Cortés, inevitable as they would appear, seem to have been influenced by his discovery in 1524 that a foreign-built ship—presumably Portuguese from India—had been wrecked upon the Jalisco coast. It was, similarly, the voyage of Drake, followed by that of Cavendish in 1588, that impelled the Spanish government to a new burst of energy. The voyages of Sebastián Vizcaíno in 1596 and 1602 were the Spanish response to the English incursions into the Pacific Ocean. Vizcaíno was directed to search for a harbor that would serve as a refuge or port of call for the Philippine ships on the return voyage from Manila, and to discover the strait that was supposed to lead to the Atlantic Ocean. On the second voyage he reached the vicinity of Cape Blanco (without finding the strait) and visited and described the ports of San Diego and Monterey, but a hundred and sixty-five years were to elapse before the government was moved to act upon his recommendation that these places should be occupied.

The council that met in the City of Mexico in 1768 to take measures for the occupation of Alta California recognized as the reason for the undertaking the approaches of foreign powers towards this unoccupied territory. To Joseph Gálvez, visitador-general—one of the most remarkable figures in American history—and the other members of the junta it seemed as if the English, French, Russians, and Dutch were converging upon California from the four corners of the earth. The records of the council show that consideration was given to the Russian advance eastward across Asia, and to the French progress overland from Canada; to the activities in the Pacific Ocean of the Dutch who arrived by way of the Cape of Good Hope, and of the English who came round Cape Horn.

The danger was in no sense chimerical. In the first half of the eighteenth century such famous sailors as William Dampier, Woodes Rogers, George Shelvocke, and Lord Anson (1740) had, at different times, lain off the coast of Lower California in watch for the Manila galleon. During the sixteenth century the Russians had advanced from the Ural Mountains to Kamchatka; and in 1741 Bering had sailed to explore the coast of Alaska. Between 1737 and 1746 three English expeditions had renewed the effort to find a northwest passage, with the deliberate intention that "if a discovery should be made of this passage, a considerable settlement should be made in California." Meanwhile the French advance from Canada across the American continent had reached its farthest point west in La Vérendrye's discovery of the Rocky Mountains in 1743. Following the Treaty of Paris in 1763—which had witnessed transferences of colonial territory on a colossal scale—the European powers set themselves to the systematic exploration of the unoccupied parts of the earth. Thus Byron, Wallis and Carteret, and Cook all sailed for the Pacific between 1764 and 1768, while the Russians sent out Krenitzen and Levashef, in 1768-69, on an expedition that the Empress Catherine had set on foot in 1764.

The occupation of Alta California in 1769 was but one of a number of steps taken by Spain, in face of this general advance of European nations, to protect her outlying possessions against aggression. The decision having been made, Gálvez took charge of despatching the necessary forces. These, under command of Gaspar de Portolá, were divided into four parts—two going by sea and two by land. In June, 1769, San Diego was occupied and a year later a post was established at Monterey. The experience of this expedition showed the hazard involved in maintaining communication between Mexico and Alta California by sea, and the impracticability of the land route up the length of the Baja California peninsula. In these circumstances, Juan Bautista de Anza was directed, in 1773, to survey a route overland to California by way of the Gila and Colorado rivers. This having been accomplished, he was further authorized in 1774 to convey a party of soldiers and settlers for the purpose of taking effective possession of the Bay of San Francisco; with the result that a presidio was established there in 1776. The new land route from the south, though difficult and uninviting, might have led to noteworthy results, but owing, almost immediately, to the incompetent management of the Chevalier de Croix, comandante-general of the frontier provinces, the Indians on the Colorado revolted in 1781, killing some members of an expedition then on its way to the new settlements. With this incident the attempt to approach California from the south was effectively blocked, and the prospect of any extensive colonization from Mexico and the south was at an end.

Henceforward the problem of an approach to California narrows down to the discovery of a route across the continent. Owing to the elimination of the French from North America by the treaty of Paris, the exploration of the continent between 1763 and 1803 was conducted by the rival traders of the Hudson Bay Company and the Northwest Company of Montreal. In 1769, Samuel Hearne was sent out by the former, and before his return in 1772 had reached the Arctic Ocean at the mouth of the Coppermine River. The activities of the Montreal company did not rise to importance until after the American Revolution. In 1789, Alexander Mackenzie explored to its mouth the river that bears his name, and four years later completed the first overland journey across the continent by reaching the Pacific Ocean, opposite Queen Charlotte Island, on the 22d of July, 1793.

It was not Mackenzie's route, however, but the more southerly one of Lewis and Clark that proved to be the long-sought substitute for a northwest passage. Following immediately upon the purchase of Louisiana from Napoleon, Lewis and Clark, at the orders of President Jefferson, made their journey overland, by way of the Missouri and Columbia rivers, between 1804 and 1806. With the acquisition of Louisiana, the American frontiersman promptly overran this vast new territory, and passed unheeding the ill-defined boundaries of the Mexican possessions. By the end of the third decade of the nineteenth century the pioneer, in the person of Jedediah Smith, had entered California.

The contrast between the Spanish and English methods of colonization is nowhere more apparent than in the respective approaches of the Spaniard and American to California. Not so much as a solitary wanderer had traversed Alta California when, in 1769, a military expedition was sent out to occupy San Diego and Monterey. On the other hand, the personal initiative of the English-speaking adventurer has carried him across the continent—across an ocean and a continent—and has more than once created embarrassment for the government to which he owed allegiance. So, in Texas, Oregon, and California, the United States appears as following with hesitation the leadership of an insignificant number of westward-moving frontiersmen. Following this leadership, however, the European advance to the Pacific has been consolidated by the completion of the overland railroad in 1869, and of the Panama Canal in 1914.

It is due to the personal initiative of many generations of Westerners—the Pilgrim Fathers among the number—that the West now confronts the East across the open space of the Pacific Ocean. At every step in the approach to the present situation two great difficulties have been continually growing clearer: it is irksome for a government to admit that the sparse population of a far-lying outpost may intrude itself into the complexities of international policy; it is hard for the man on the frontier to remember always that territory not fully occupied in proximity to overpopulated lands must needs be filled up.

SPANISH SETTLEMENTS ON THE PACIFIC COAST

BY CHARLES E. CHAPMAN
Sometime Traveling Fellow in Pacific Coast History, N. S. G. W., University of California

THE only enduring Spanish settlements on the Pacific Coast north of Mexico were those of California. Yet they have an interest greater even than that of their own idyllic charm, for they bore an important relation to the history of the entire northwest coast, and indeed to that of the United States.

From the first, after Cortés had reached the Pacific in 1522, Spain was one of the principal contenders for the far northwest. The Cabrillo-Ferrelo voyage (1542-3), that of Vizcaíno (1602-3), and the occasions when the Manila galleon passed the California coast on the way to Acapulco were the only known voyages of Spaniards to our Pacific Coast prior to the occupation by them in 1769. Yet there was little that Spain more keenly desired than to possess herself of that coast. There was an almost continuous stream of royal decrees calling for its conquest, and considerable expenditure of treasure to that end, though not until 1769 were permanent establishments made. Spain became just strong enough in California to keep out the casual voyagers of other nations. She did not develop her holdings in such a way as to lead to discovery of gold. Had she done so, it is doubtful whether the United States would now have a foothold on the Pacific Coast. With the development of California would have come a like advance farther north. Spain could not have held the land, and the United States would not have been strong enough to take it, but a stronger European power than Spain could have entrenched herself and remained.

Spain's failure to reach California earlier, and to develop it after 1769 was due primarily to her European entanglements and her poverty. From the moment that Pedro III of Aragon (1276-85) started on a career of conquest in Italy, Spain's retention of her yet undiscovered colonies was doomed. All went well until the sixteenth century; then, wars in Europe for possessions outside of the Iberian Peninsula began to call for more funds than Spain itself could supply. The Americas were drained and projects of development or conquest became secondary to Spain's policy in Europe.

Yet, by a fortunate accident, viewed from the standpoint of the United States, development of California under Spain was narrowly averted. What California most needed was communication with the outside world. Natural resources there were in plenty, but everything else was lacking, settlers with families, domestic animals, seeds for planting, and manufactured articles of every variety. Existing routes from San Blas, Mexico, by sea direct or by way of Baja (Lower) California were never adequate to supply the needs of California. One other possibility remained, that of opening a route overland from Sonora, Mexico. This was done in 1774, resulting in a pronounced advance of the California settlements. But the old difficulty, lack of funds or unwillingness to apply them in so distant a part of her realms as Sonora, caused Spain to lose the advantage of this route only seven years after it was opened. Weak establishments had been made on the California side of the Colorado River opposite what is now Fort Yuma. Ill-provided for by Spain they became an annoyance to the Indians of that vicinity, who in 1781 destroyed both settlements. No serious attempt was ever made again by Spain to reopen the Sonora route to California. Thus the colonies in California had to go ahead with what they had, supplemented to some extent by shipments from San Blas and by illicit traffic with foreign ships.

This then is the meaning that lies behind the picturesque life of Spanish California. Had there been no 1769 or 1781, there would have been no 1848, insofar as that marks California's formal entry into the Union. Spain would almost inevitably have discovered gold, but for the Yuma massacre, although she might not have reaped the benefit for herself. But, these things did not happen, and California and the entire Coast were held by Spain and Mexico, as it were in trust, for later delivery to the United States.

There were five principal elements in the social and administrative organization of Spanish California: the presidios, pueblos, ranchos, missions, and Indian tribes. The last named were connected with each of the other four, but also existed in great numbers beyond the pale of Spanish settlements. It has been estimated that there were 700,000 Indians in California when the Spaniards first came. This figure may be too high, but the number was certainly very great, far in excess of what it was at later periods or is today. To hold them in check there was a total Spanish population of little more than 3000 at its greatest and less than 1000 during the crucial days of the eighteenth century. Under Mexico, population increased, but there were certainly not more than 10,000 people of white race in California at the time of its acquisition by the United States.

It is usual to speak of California's early history as if it were all summed up in the missions. This is due, perhaps, to the fact that the mission ruins are almost the only tangible remains from that period, and also that the mission fathers left more records of their works than did the others. In fact, the backbone of the establishments here as elsewhere in Spanish colonies was the military element, whose principal manifestation was the presidio. Each mission also had its guard, usually a corporal and six soldiers, quite enough to keep the Indians in subjection, but a very necessary part of the mission establishment.

There were four presidios, San Diego (1769), Monterey (1770), San Francisco (1776), and Santa Bárbara (1782), the most important being Monterey, whose commander was also civil and military governor of the province.

Around each presidio, but more especially at Monterey, centered the life of the colony. Towns grew up around the presidios, ranch owners came there to visit, foreign traders stopped to enjoy California hospitality, and close at hand there was in each case a mission. Life was one continuous round of hospitality and social amenities, tempered with vigorous outdoor sport. There were no hotels in California. Every door was open, and food, lodging, a fresh horse, and money, even, were free to the guest, whether friend or stranger. No white man had to concern himself greatly with work, and even school books were a thing apart. Music, games, dancing, and sprightly conversation—these were the occupations of the time—these constituted education. Also men and women were much in the open; all were expert horsemen, could throw a lasso, and shoot unerringly, even the women, accomplishments which fitted their type of life, and made hunting a general pastime. When foreign ships came, there were balls and the gayest of festivals, nor were these visits the only occasion for that type of entertainment.

This happy life was possible because there were Indians to do the work. Virtual slavery existed, sometimes by direct bargain with a chief for members of his tribe, or by willing submission of the Indians who found themselves better clothed and

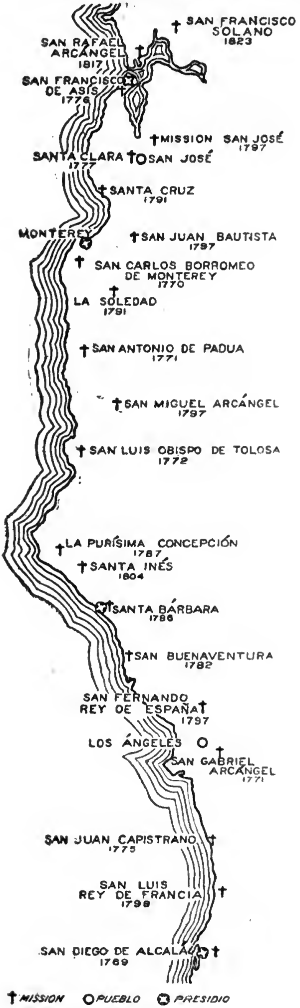


Figure 1

Spanish settlements in California. The dates of the founding of the two pueblos and of the four presidios are given on pages 11 and 12.

fed than in their tribal mode of life, and with perhaps greater personal liberty and less work than at the missions.

Aside from those at the presidios there were but two pueblos proper, San José (1776) and Los Angeles (1781). Another on the site of Santa Cruz, Branciforte, had a brief existence. The inhabitants at San José and Los Angeles were regarded as of lower social rank than those at the presidios, and indeed many of them had but a small proportion of Spanish blood, being part Indian or part negro. They, too, enjoyed an idle life, although somewhat more addicted to gambling and other forms of vice than others in the colony.

The private rancho was not in accord with the aims of the Spanish government, which desired Spanish settlers in remote provinces like California to live in communities. But it grew to be a recognized institution, getting official sanction under certain restrictions, as that it should not exceed three leagues in extent or infringe upon the territories of missions, pueblos, or Indian towns. Under Spain there were probably not more than twenty such grants, these usually being made to retired officers of the presidial aristocracy. Under Mexican rule the number increased to about 600, a single individual being allowed to own as many as eleven square leagues. There the proprietor with his family lived a life of ease and plenty, surrounded by numerous servants, and there he entertained as lavishly as did those of the towns. Occasionally the proprietor rode over his land to see his animals, for grazing was the only great industry of the ranchos. There was no agriculture nor even dairying of any consequence. Mission fathers thundered against the rancheros, claiming that they were invading mission territory, and causing dissatisfaction among mission Indians, but their protests were without avail.

The missions* came to be almost completely self-sufficient establishments, having not only the mission church, but also mission flocks and herds, gardens and fields, warehouses, dormitories, etc. The object of the fathers was to civilize and Christianize the Indians. But the Spanish kings employed missions primarily as an effective agency of conquest, to which conversions and the mission system among the backward peoples conduced. In theory the lands and personalty of missions belonged to the Indians, to whom they were to be turned over when the Indians were sufficiently civilized and Christianized to leave the mission and take up settled life. The length of time before this could happen was supposed to be but a few years, but in fact the day of emancipation never came. The Indians of California were unable to compete with a civilized race; the attempts to civilize them were from the first hopeless.

In the early years the Indians were treated with great kindness. Later, when danger of an Indian uprising was no longer a dread possibility, kindness was tempered by correction, whether by the lash or by imprisonment, it being recognized by the authorities of that day that instruction of Indians and punishments to them were inherently inseparable. The Indians were virtually slaves of the missions. They spent most of the daylight hours at work, and the rest of their time, whether at church service, eating, sleeping, or play, was planned for them by mission rules. Nor were the missionaries able to check the appalling death rate of the Indians, for at the missions as elsewhere more died than were born. Perhaps, in a measure, they put off the fatal

* Not including the ill-fated Purísima Concepción and San Pedro y San Pablo of the Colorado and mission visitas (Indian towns near a mission, to some extent under authority of the missionaries), there were twenty-one missions in California, all established by the Franciscans of the College of San Fernando, Mexico. (See text fig. 1, and Pl. II.)

day; certainly when the missions were, at length, discontinued the emancipated Indians in great part rapidly passed away. The spirit of the days of Serra, first father-president of the missions, seems to have waned as the years wore on, for the missionaries drove a thriving trade with foreign ships, which was against the law. In this they were not alone, but were the most successful, for theirs were the largest flocks and herds, and tallow and hides the chief products sought by foreign traders. But let it be said that they were distinctly a part of the delightful life in California, for none were more hospitable than the mission fathers of the Camino Real.

If they failed to do the impossible, to civilize the Indians in the time available, they did make Christians of them, and have left an impress upon California art, literature, and sentiment. But in some respects their greatest service was that they helped to hold the land for Spain.

Such was California under Spain, beside which Acadia and Utopia were unattractive, a dream life for over half a century. But, like dreams, it had to have its awakening, and, almost as evanescent as they, has disappeared, save only for scattered records and the mission ruins. With the independence of Mexico came freedom of trade, increase in the number of ranchos, and entry of foreigners, notably the Americans. It was then a brief race to the discovery of gold. That came in 1848, and the scene changed as if touched by a magic wand. By that time America was ready. Today, as she looks forth upon the Pacific from California, Oregon, Washington, and Alaska, she is still more ready. If the world's future problems are to lie around the Pacific, and if the United States is to play a leading part in them, we may well look back in gratitude to Spanish California, which gave us the chance.

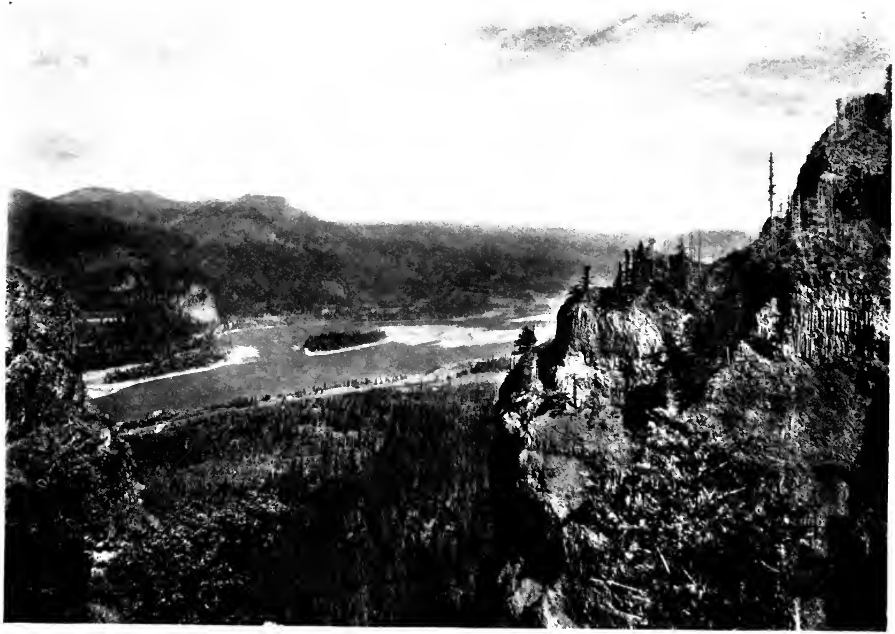
For the reader who would like to get a general survey of early California history, in a fairly readable book of one volume, the works of Richman, McGroarty, Norton, and Mrs. Gertrude Atherton may be mentioned, all recent publications. The older but more voluminous historians, Greenhow, Hittell, and Bancroft, still rank, however, as the best, although it is also true, as often stated, that the history of California "is yet to be written." But those who may read the narratives of eye witnesses, as for example in the works of Richard Henry Dana, Alfred Robinson, Walter Colton, Alexander Forbes, and William Heath Davis, will get more of the atmosphere of early California than can possibly be conveyed by any writings of a later day.

PLATE II

Mission San Carlos
Borromeo
de Monterey. This Was
the Scene of the
Labors of Junípero Serra,
and Other Fathers-
President of California.
The Mission
Was Originally Located at
Monterey,
But in 1771 Was Moved to
Carmelo, and
Is Now Popularly Known
as the
Carmel Mission.

PLATE III

The Gorge of
the Columbia River. This
Is Cut Through a
Great Lava Plateau of
Tertiary Age,
Which Extends Over the
Greater Part of
Eastern Oregon and
Southeastern Washington.
Mt. Adams
in the Distance
Is a Volcanic Peak
12,470 Feet in Height.
View From
St. Peter's Dome, Thirty
Miles From Portland,
Looking East.



HISTORICAL SKETCH OF THE PANAMA CANAL

BY RUDOLPH J. TAUSSIG
Secretary, Panama-Pacific International Exposition, San Francisco

THE water highway westward from Europe which Columbus set out to find over four hundred years ago, but could not because it did not then exist, has now become a reality through the skill, ingenuity and labor of man. For all practical purposes the surmise of the fifteenth century will become true that the ocean to the west of Europe and to the east of Asia is the same body of water—the interposition of the continents of North and South America being merely an incident en route.

Columbus died in the belief that he had reached the coast of Asia; and long after Balboa discovered the Pacific Ocean in 1513, the search for the so-called "Secret of the Strait," the short and direct route to Cathay, was continued. The discovery of the Pacific Ocean, the conquest of Mexico by Cortez, De Soto's discovery of the Mississippi River, may all be attributed to this effort. As early as 1523, only thirty-one years after the discovery of America, Cortez, while still searching for the strait, was convinced of the desirability and practicability of creating the strait if it did not exist. In 1529, Alvaro de Saaveda Ceron, a cousin of Cortez, had prepared plans for the construction of a canal where Balboa had crossed the isthmus. It is therefore safe to say that the idea of constructing the Panama Canal is almost as old as the discovery of America itself. It may be of interest to note also that a canal at Nicaragua was spoken of at the same time, and the rivalry has continued to the present day.

In speaking of the difficulties of its construction, the historian Gomara, writing in 1551, says: "There are mountains, but there are also hands. Give me the resolve, and the task will be accomplished. If determination is not lacking, means will not fail; the Indies, to which the way is to be made, will furnish them. To a king of Spain, seeking the wealth of Indian commerce, that which is possible is also easy." Phillip II, however, decided that it would be contrary to the Divine Will to unite two oceans which the Creator of the world had separated, and he decreed that no canal should be constructed. This action was, however, probably due to the fear of the maritime strength of England. Phillip III of Spain again caused surveys to be made for a canal. In 1701 William Paterson of Scotland, in his book on Central America, speaks of the great benefits to be derived from the building of it.

Alexander von Humboldt, who spent several years in Central America in the beginning of the nineteenth century, spoke of the feasibility and desirability of constructing an artificial waterway between the two oceans. The German poet Goethe, alluding to the canal at Panama, is reported to have said: "So much, however, is certain, that if they succeeded in cutting such a canal that ships of any burden and size can be navigated through it from the Mexican Gulf to the Pacific Ocean, innumerable benefits will result to the whole human race, civilized and uncivilized. But I should wonder if the United States were to let an opportunity escape of getting such a work into their own hands." He was, indeed, a prophet! When the Central and South American republics came into existence, the construction of the canal claimed their immediate attention, and was the cause of considerable diplomatic activity.

In 1850 the much discussed Clayton-Bulwer treaty was ratified. It provided that neither England nor the United States should exercise exclusive control over any inter-ocean canal. The wrangling over the interpretation of its provisions commenced before the ink was dry upon its signatures. Secretary Blaine's comment upon it in 1881 is worthy of repetition. He says: "It was misunderstandingly entered into, imperfectly comprehended, contradictorily interpreted, and mutually vexatious." The treaty was finally abrogated in 1901, but only after strenuous efforts upon the part of the United States, as England was naturally not disposed to give up the advantages her diplomacy had given her.

Meanwhile Ferdinand de Lesseps, inspired by his success at Suez, where he had completed the canal in 1869, turned his attention to the Isthmus of Panama. A French company was formed in 1876, and three years later a congress was called together at Paris to consider all questions concerning the building of the American canal. The Panama route was decided upon and the Universal Interoceanic Canal Company was organized. The following year De Lesseps reported to the company that the plans for a tide-level canal were perfected, that its cost would be $132,000,000, and that it was proposed that its neutrality should be guaranteed by Europe.

On February 1, 1881, the work was inaugurated with due ceremony. It was to be a great work, and was to be handled upon a magnificent scale. It is startling to read of the purchases that were made and how they were made. Everything was done in an extravagant and showy manner and corruption reigned supreme. After seven years, in 1888, hardly half of the work had been done, the company had spent $400,000,000, and was bankrupt. New companies were organized to save what could be saved from the wreck. The scheme of a tide-level canal was abandoned and the construction of locks decided upon. It was announced that the canal could be and would be completed for an additional $180,000,000, and the work was continued.

Meanwhile the government of the United States had been negotiating with the Nicaraguan government in regard to the construction of an inter-ocean canal on her territory.

The spectacular voyage of the *Oregon* at the outbreak of the Spanish-American war called the nation's attention to the necessity for a shorter waterway between our Atlantic and Pacific Coast states, and the canal question again became an active one in Congress. A commission was appointed to report to Congress upon the matter. It looks almost as though the commission acted under instructions to scare the French company at Panama. Their first report favored Nicaragua, after rejecting the offer of the Panama company to sell out its interest for $100,000,000. When, however, the French company, alarmed at the prospect of the Nicaragua Canal, reduced its price to $40,000,000, the commission changed its recommendation, and in June, 1902, Congress accepted the offer of the French company under certain conditions, and a law was passed authorizing the completion of the canal at Panama.

Then came the vexatious negotiations with the United States of Colombia, of which Panama was one of the states. The government of Colombia endeavored to prolong the negotiations until such a time that the concessions to the French company would be forfeited and Colombia would be in a position to possess herself of the purchase price. Treaties were rejected and obstacles put in the way of final adjustment until the State of Panama became alarmed at the action of the central government, fearing that the United States would again turn her attention to Nicaragua. Panama had once been an independent state and, if independent now, could bring the negotiations with the American government to a quick and satisfactory conclusion. It is a matter of surmise to what extent these ideas were inspired and also the source of the inspiration.

At all events, a revolution took place in November, 1903, and Panama became an independent republic without the necessity of bloodshed. Diplomatic relations were established, and the United States having acquired the canal zone by treaty, the construction of the canal was taken up, the first commission being appointed in February, 1904.

The commission appointed by President Roosevelt consisted of Admiral J. G. Walker, Judge Geo. W. Davis, Professor W. H. Burr, Mr. Wm. Barclay Parsons, Colonel F. J. Hecker, Major B. M. Harrod, and Mr. C. E. Grunsky.

Plans had been prepared and the work under American control was commenced on May 4, 1904. The lock plan was decided upon, after two years' study, as the most practical one, raising the canal eighty-five feet from the level of the Atlantic to Gatun Lake, and lowering it again near Panama to the Pacific Ocean.

The canal was practically completed under the direction of Colonel Goethals during the year 1914, at a cost of close to three hundred and seventy-five million dollars. Slides have interfered seriously with the use of the canal, but it is predicted that the year 1915 will find it ready for its formal opening to the ships of the world. At its lowest point the canal has a depth of 42 feet, and its length from deep water to deep water is about 49 miles.

The commercial world is looking forward to interesting trade developments owing to the change of communications by the establishment of new steamship lines with various new routes. Surely the Panama Canal is but another link in the chain binding the nations of the world closer together in their governmental, commercial and social relations.

WEATHER CONDITIONS ON THE PACIFIC COAST

BY ALEXANDER MCADIE
Abbott Lawrence Rotch Professor of Meteorology, Harvard University

IT MAY pay us to begin right by realizing that in discussion of the weather, not only of the Pacific Coast, but of any section, we must first free our minds of the impression that we definitely know the causes of those rather abrupt atmospheric changes which we call weather, as distinguished from the slower and more uniform changes which combine to make the climate of a place.

Scientific men are partly responsible for the confusion that exists regarding cause and effect in weather phenomena; and too much has been advanced regarding the structure of storms, general and planetary circulation, rainfall distribution, and other problems, based on assumptions which modern soundings in the air are disproving. Indeed we have much to unlearn even in so fundamental a matter as the distribution of heat. Many instances could be given of explanations published in text books which are inadequate and out-of-date. Then there are numerous popular misconceptions for which scientific men are in nowise responsible, and which are due to press headlines. One of these which is widespread is that the Kuroshiwo, or black current, more popularly called the Japan current,* warms the northern Pacific Coast. This current, even off the coast of Japan, is only a few degrees warmer than the surrounding water; it fans out into a drift as it moves eastward, and later divides. Except for that return branch known as the California current, the Japan current does

* The principal currents in the North Pacific are the north equatorial, the equatorial counter-current, the Kuroshiwo, the California current, and the Bering Sea current. The north equatorial flows westward in the region of the trade winds and reaching the islands off the Asiatic coast is deflected northward. The equatorial counter-current flows eastward a little north of the equator. The Kuroshiwo is a portion of the north equatorial current, passing north of Formosa and southeast of Japan. Leaving the Japanese coast, the current becomes more a drift, fanning out and flowing eastward past the Aleutian Islands, dividing into north and south drifts on the Alaska coast. The California current is that portion of the Kuroshiwo flowing southeastward some distance from the Oregon-California coast. Between this current and the shore is a narrow counter-current known as the Davidson current, flowing northward. (See fig. 2.) The California current is colder off the California coast than the water of the Pacific farther west.

not come near the coast and could not very well raise the temperature. The California current moves from north to south and, as will be seen

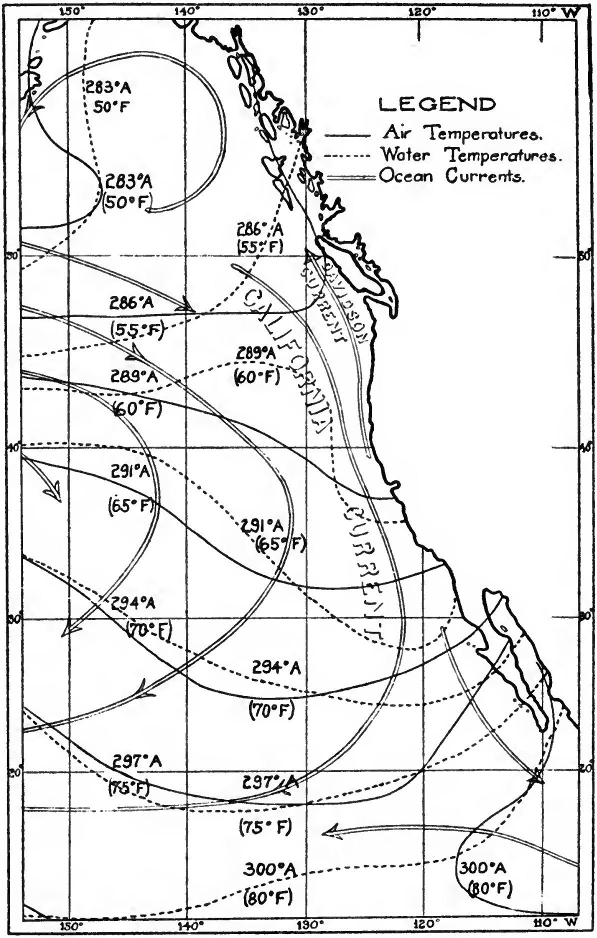


Figure 2

Oceanic temperature chart for the Pacific Coast.

by the chart of ocean and air temperatures (fig. 2), from a colder to a warmer region, and so evidently does not *warm* the coast. The really effective factor in controlling the temperature along the coast is the general and steady drift of the surface air from west to east, that is, from a water surface to a land surface. The specific heat of air at constant pressure is about one-fourth that of water, which means that it requires four times as much heat to raise a given volume of water one degree as for air.

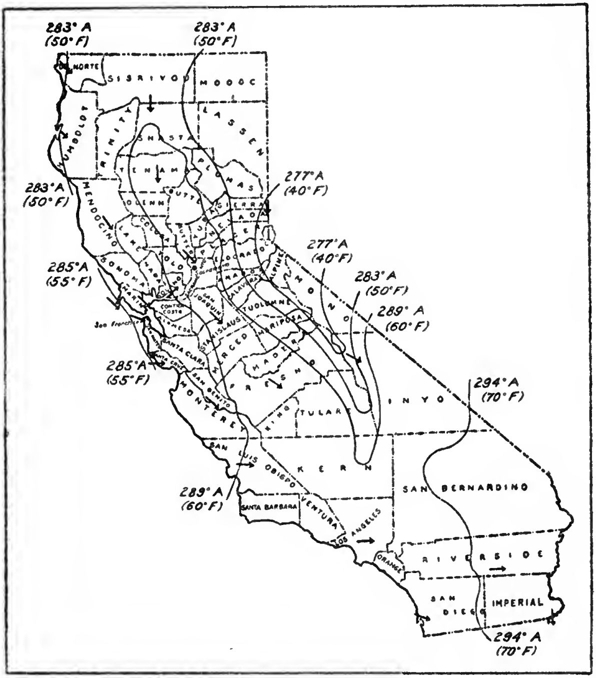


Figure 3

Temperature chart for California, showing mean annual isotherms and direction of prevailing winds.

The specific heat of water vapor, however, is twice that of air, or half that of water. The water vapor is free to move and does move in the form of invisible vapor or in the visible form of condensed vapor which we call fog. This is a matter of much importance, but to it little attention has been given heretofore in explaining temperature control in coast regions. If, as is the case on the Pacific Coast, the prevailing winds are from the water surface to the land, and the circulation is strong and steady, the reason why the temperature is comparatively uniform is plain. There is little doubt but that if our surface circulation were to be reversed and the air moved from land to sea, there would be decided changes in temperature; and the isotherms would run east and west instead of north and south as they now do (fig. 3).

It is the practice of meteorologists to regard the weather of the coast section of California, Oregon and Washington as irregular and to try to account for the irregularity by ocean currents, up-welling waters, etc. A more rational view, it seems to us, is to regard the weather of this section as regular and of a simple type; and consider the weather of other sections, especially our Atlantic Coast, as irregular.

The first control, then, of weather on this coast is the quantity of water vapor brought in by the prevailing west winds. Other factors are, distance from storm tracks of maximum frequency, and the orography of the coast. For detailed information regarding the first of these factors the reader may consult various Weather Bureau publications showing average storm-tracks; and particularly *Climatology of California* (McAdie, 1903). Regarding the other factor, one may refer to the physiographic features of the coast as discussed elsewhere in this volume.

Two conspicuous illustrations of a direct connection between weather and physiographic features may be found in California; first, the forced draft through the Golden Gate and the deflection of the surface air northward through the Sacramento and northern bay valleys, also southward through the Santa Clara and the San Joaquin valleys; and second, the draft through El Cajon Pass. Through the latter, under certain pressure distribution, the dry, sand-laden air pours into the Colton-Riverside-Ontario section. Known locally as Santa Anas, these wind storms constitute the most disagreeable feature of the weather in the great valley of the south. They are trying to man, beast and vegetation, and at times interfere with traffic.

The last weather control of importance is the location of the particular hyperbar or infrabar determining the general surface circulation. These more or less permanent pressure areas have been called "centers of action;" but the newer names are more appropriate. The best known of the infrabars is the Aleutian low, which in a normal winter extends from latitude 40° N to 60° N and from longitude 130°W to 140° E. In the summer this infrabar disappears. The most marked hyperbar is the one over the Pacific extending from latitude 25° N to 40° N and from longitude 125° to 160° W. There is also a marked continental hyperbar. It has been found (McAdie, 1914) that typical wet winters on the coast of California occur when the Aleutian infrabar is displaced eastward, overlying in part the continent west of a line drawn from Alberta to central California. And, as further illustrating the control of weather, it is found that dry winters occur with a displacement north and west of the normal center of the Aleutian infrabar and a westward extension of the continental hyperbar. In summer the Aleutian infrabar practically disappears and the oceanic hyperbar moves north with the result that the winds are northwest and the days and nights rainless, although fogs (day) are prevalent.

Compared with other sections of the United States the Pacific Coast south of Cape Mendocino has few storms. The zone of maximum storm frequency lies north of latitude 45°, and California, therefore, is practically out of the storm belt. In the extreme south there is, however, a storm track, that of storms of the Sonora type, and during July, August, September and occasionally other months storms are not infrequent. Such storms seldom affect the weather north of the Sierra Madre. In the central and northern portions of the State, there are few storms in June, July, and August. In a period of 64 years only 13 disturbances have been recorded. In September the frequency increases and in the 64-year period 14 storms have been noted. The most noteworthy of these early storms was that of September 22-26, 1904, which stands unparalleled in the history of summer and early fall rains. At San Francisco, for example, the rainfall amounted to 129 millimeters (five inches). In October the number of storms reported amounts to 40; November, 60; December, January and February, about 200 each; March much less, and April and May about as in November. Occasionally there will be a winter month without a single storm, as in December, 1876, and February, 1864.*

* In a recent publication of the Weather Bureau (Bowie and Weightman, Storms of the United States), there is given in table 1 the number of lows for various sections for a period of twenty years. Storms of the North Pacific type have occurred as follows: January, 53; February, 48; March, 44; April, 33; May, 27; June, 16; July, 14; August, 12; September, 23; October, 28; November, 48; December, 53. This table, however, is misleading for California, as many of these storms pass far north of the State. The storm frequency is much less for the central and southern portion of the Pacific Coast than indicated in these figures.

Weather Conditions on the Pacific Coast

The reader can obtain detailed information regarding the weather in various parts of the State by referring to the bibliography at the end of this paper: For San Francisco (McAdie, 1912), (McAdie, 1913); for Berkeley (Reed, 1913); for Lick Observatory (Reed, 1914); for San Diego (Carpenter, 1913). The following condensed data for San Francisco may prove of interest:

Pressure.—Mean annual pressure 1017 kilobars (763 mm. or 30.03 in.); highest pressure 1036 kb. (777 mm. or 30.60 in.); lowest pressure 985 kb. (739 mm. or 29.10 in.). The absolute range of pressure 51 kilobars, i. e., in equivalent force units, 51,000 dynes or 5 per cent of an atmosphere.

Temperature.—San Francisco has a comparatively small range of temperature. The annual mean, based upon records covering a period of forty years, 1871 to 1911, and obtained from the mean of the daily maximum and minimum readings, is 286° A. (56° F.). A truer value determined from the 24-hourly readings for a period of twenty years, 1891 to 1910, is 285.6° A. (54.6° F.).

The departures from the mean are comparatively small in all months. The warmest month is September, with a mean of 288° A. (59.1° F.), and the coldest month, January, 282.6° A. (49.2° F.). The warmest month has practically the same departure above the mean as the coldest month has below. The annual amplitude is 5.5° A. (9.9° F.).

The monthly mean temperatures determined from hourly readings are:

Month	Degrees Absolute	Degrees Fahrenheit	Month	Degrees Absolute	Degrees Fahrenheit
January	283	49	July	289	56
February	284	51	August	287	57
March	285	52	September	288	59
April	285	54	October	288	58
May	286	56	November	286	55
June	287	56	December	283	50

The coldest month was January, 1890, when the mean temperature was 281° A. (46° F.), and the warmest month, September, 1889, when the mean was 291° A. (65° F.).

In an average year there are approximately 1311 hours when the temperature is above 289° A. (60° F.); 4111 hours when the temperature is above 286° A. (55° F.); and 7625 hours, or about 87 per cent of the entire year, when the temperature exceeds 283° A. (50° F.).

Differences between day and night temperatures are small. The warmest hour, 2 P.M., has a mean temperature of 288° A. (59.2° F.). The coolest hour, 6 A.M., has a mean temperature of 273° A. (50.9° F.).

The highest temperature ever recorded in San Francisco is 311° A. (101° F.). This occurred September 8, 1904, during a prolonged period of warm weather. For four consecutive days maximum temperatures exceeded 305° A. (90° F.). This was the warmest spell of which there is record in San Francisco.

The lowest temperature recorded since 1871 is 271° A. (29° F.), which occurred January 15, 1888. In the last twenty years the temperature has not fallen below 273° A. (32° F.).

The absolute range of temperature from 1871 to 1911 is 40° A. (72° F.).

Sunshine.—The amount of sunshine received at San Francisco is not as large as might be expected, but nevertheless compares favorably with that of other cities in the United States. The average number of hours in a year, based upon hourly records from 1894 to 1910, is 2807, or 63 per cent of the possible. The average number of hours of sunshine for different months is:

	Hours	Per Cent of Possible		Hours	Per Cent of Possible
January	147	50	July	308	68
February	163	63	August	258	61
March	213	67	September	252	68
April	256	66	October	236	68
May	294	67	November	175	58
June	345	75	December	160	54

It is interesting to compare the number of hours of sunshine at Mount Tamalpais for a year with the number at San Francisco, fourteen miles away. In 1910 the total number of hours of sunshine at Mount Tamalpais was 3258, or 70 per cent of the possible; at San Francisco, 3019 hours, or 66 per cent of the possible. The difference, amounting to 239 hours, equivalent to the total sunshine of an average month, shows how much sunshine is lost at San Francisco through the summer afternoon fog. In some years there is a difference of as much as 500 hours in the annual amounts of sunshine at the two stations. In some seasons the lower station receives more sunshine than the upper, the clouds forming and remaining on the mountain crest. The fogs can be seen to great advantage from the station at Mount Tamalpais. The fogs are caused by the mixing of air streams of different temperatures and different vapor content. Some are caused by cooling due to elevation and some by excessive loss of heat by radiation. It is interesting to note that in summer San Francisco receives but 68 per cent of the possible sunshine, while at Mount Tamalpais more than 90 per cent is recorded.

The Winds.—The prevailing drift of the surface air along the California coast is from west to east. Briefly, the summer winds may be grouped as follows: West to northwest, 75 per cent; north to northeast, 4 per cent; east to southeast, 3 per cent; south to southwest, 3 per cent; and calms, 15 per cent. The winter winds show a greater percentage of motion from the south. Southerly gales are not infrequent, and there is a common belief that southeast is the prevalent direction in winter months. This, however, is not true. West to northwest winds have a frequency of 30 per cent; north to northeast, 18 per cent; east to southeast, 17 per cent; south to southwest, 22 per cent; and calms, 13 per cent.

It is plain from the above figures that northwest is the predominant direction along the coast in the vicinity of San Francisco. Owing to the topography there are certain deflections and changes in the direction of the wind, especially through the Golden Gate from northwest to west or even west by south. These are referred to elsewhere.

During certain portions of the year, especially May and June, the northwest wind attains a remarkably high velocity.

Another type of high wind experienced at San Francisco is the north-northeast wind of November, December, and occasionally January. This wind differs from the northwest wind of summer and is distinctly a mountain wind. The highest wind velocity recorded in San Francisco, 28.6 meters per second (sixty-four miles per hour), from the northeast, occurred on November 30, 1906.*

The most prevalent high wind of winter is from the southwest, closely followed by the southeast. The latter is the well-known wind preceding winter storms in this section. At San Francisco southeast winds will sometimes prevail for several days; but in most storms the wind after blowing for twelve or more hours increases in velocity to 18 meters per second (forty-one miles an hour), more or less, and then shifts suddenly to the southwest,

* The velocities used here are Weather Bureau instrumental records. These are only approximately correct. For conversion into meters per second it may be convenient to remember that one meter per second equals 2.2 miles per hour.

attaining a slightly higher velocity. After a few hours the velocity decreases and, with the change to northwest, the weather clears. At such times the air is remarkably pure and the distant mountains can be seen distinctly.

The average hourly wind velocity in San Francisco is nearly 4.5 meters per second (ten miles per hour), and the prevailing direction west. The wind attains its greatest velocity about 4:30 P.M. and its least about 6 A.M. The average movement during the twelve hours from 7 A.M. to 6 P.M. is approximately 4.9 meters per second (eleven miles per hour), and from 7 P.M. to 6 A.M., 4 meters per second (nine miles per hour).

Fog.—One of the most marked climatic features of San Francisco is the prevalence of fog. In summer afternoons sea fog moves through the Gate, appearing about 1 P.M. and covering the whole sky by 3 P.M. The average depth of the fog layer is 518 meters (1700 feet). Comparing the percentage of possible sunshine at San Francisco and Mount Tamalpais, it is at once apparent that the summer afternoon sea fog shuts out 50 per cent or more of the possible sunshine between 3 and 7 P.M. during June, July, and August. There is also curtailment of sunshine between 7 and 9 A.M. during May, June, July, August, and September.

In the winter, morning fogs, or, as they are commonly called, "tule" fogs, frequently occur. These are low-lying banks of condensed vapor formed by cooling due to radiation and contact. The land surfaces are much cooler than the water surfaces, and hence these fogs have a decided motion from the land to the sea. The average number of foggy days is twenty-four per year.

In addition to the summer afternoon sea fog, moving from west to east, and the land or tule fog of winter mornings, there is a third kind of fog, which may be called smoke fog. Under certain atmospheric conditions the smoke of the city moves seaward during the forenoon and returns about 1 P.M. as a dense black pall. This is the cause of the so-called dark days. The phenomenon is of brief duration, seldom exceeding two hours; but while it lasts causes some apprehension.

Humidity.—Relative humidity is a term frequently used in attempts to describe relative dampness of a locality. The term is misleading and while generally used can not give a proper basis for comparison unless temperatures are also given, inasmuch as relative humidity is only a ratio and does not indicate a fixed amount of water vapor.

Thus at San Francisco relative humidity throughout the year is high; but during the summer months, owing to low temperatures, the absolute weight of water vapor per unit of volume and the vapor tension are much less than at coast stations of the Atlantic. Notwithstanding high relative humidity in summer, the vapor tension and absolute humidity are low at San Francisco.

Rainfall.—Rainfall records have been maintained in San Francisco for a period of sixty-five years. The greatest 24-hour rainfall occurred on

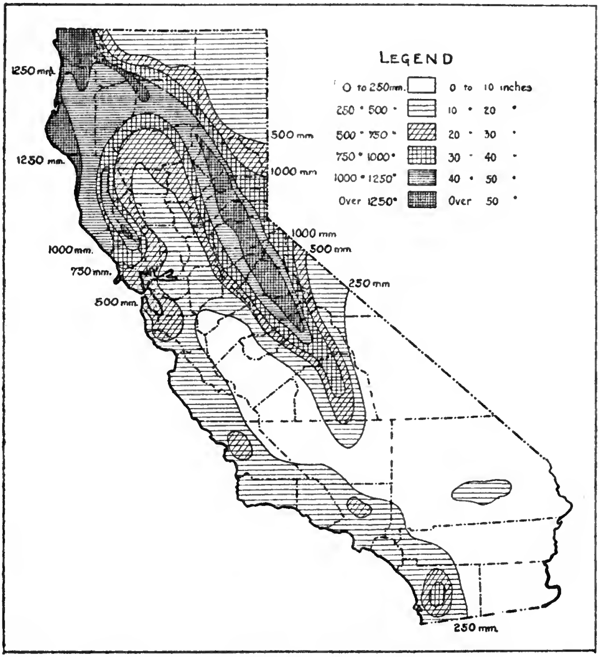


Figure 4
Rainfall chart for California.

January 28, 1881, when 118.6 millimeters (4.67 in.) fell. The next greatest 24-hour rainfall was on September 24, 1904, when 909 millimeters (3.58 in.) fell. The longest rainless period was in 1903, when no rain fell from April 16 until October 9, 175 days. In 1911 there was no rain from June 6 to October 1, 116 days.

In connection with the absence of rain during December, 1876, it may be noted that there was no rain between November 16, 1876, and January 16, 1877. Or, in other words, there was a period of sixty consecutive days without rain in mid-winter.

Some of the months of heaviest rain were January, 1862, when 618.8 millimeters (24.36 in.) of rain fell, and eighteen days of the month were rainy. In January, 1911, 350.3 millimeters (13.79 in.) fell, distributed over eighteen days. In January, 1909, 267.0 millimeters (10.51 in.) fell, but there were twenty-six rainy days, making it in this sense the rainiest month known at San Francisco.

August, like July, is practically a rainless month. The mean rainfall is 0.5 millimeter (0.02 in.). There has never been an August when the total rainfall exceeded 6.4 millimeters (0.25 in.). Only fourteen of the sixty-two months under consideration have had a rainfall exceeding 0.2 millimeter (0.01 in.). The greatest 24-hour rainfall was 3.0 millimeters (0.12 in.) on August 26, 1858.

In the past sixty-two years, 1850 to 1911, there have been 4207 rainy days. The yearly distribution is: January, 11; February, 10; March, 11; April, 6; May, 4; June, 1; July, 0; August, 0; September, 2; October, 4; November, 7; December, 11. For the year, average number 67.

Thunderstorms occur infrequently at San Francisco. In the past twenty years there have been twenty-nine, distributed as follows:

January 2	April 3	July 1	October 3
February 3	May 1	August 2	November 3
March 1	June 1	September 2	December 7

The greatest number recorded in any one year was eight, in 1906. During the past twenty years there have been eight years without record of a thunderstorm. The storms are mild in character, the lightning flashes of moderate intensity, and the thunder usually limited to a few peals. Damage from lightning is rare, although flagpoles have been shattered and trees struck.

There have been fifty-six hailstorms in the past twenty years. January and December are the months of maximum frequency. There is no record of any hailstorm occurring during June, July, August, and September.

During winter storms the tops of the hills in the southwestern portion of the city are occasionally whitened by snowflakes. These melt rapidly and snow of appreciable depth is rare. However, snow can be seen frequently during winter months on Mount Tamalpais, Mount Diablo, and the peaks of the Mount Hamilton Range. The heaviest snowfall in the bay section occurred January 9, 1913, when Mount Tamalpais and Angel Island were covered.

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PLATE IV

Relief Map of Washington and Oregon.
Constructed by S. Shedd, 1896 and 1898.

From the Geological Museum of Stanford University.

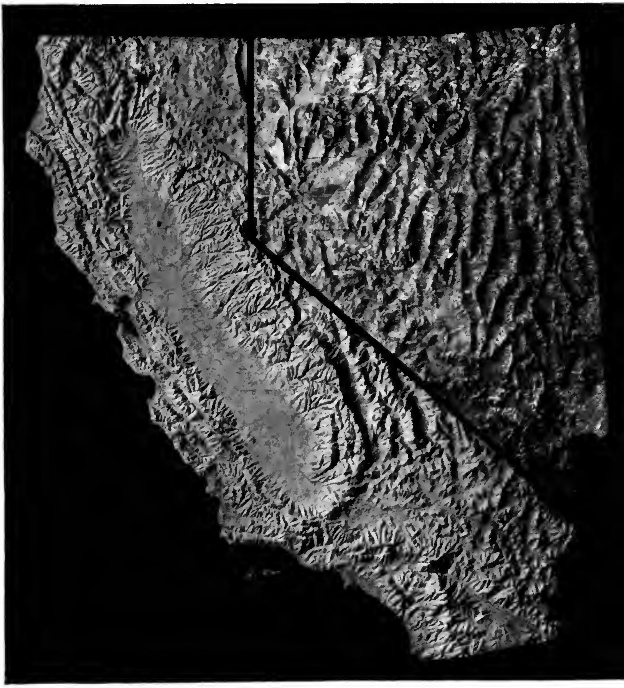

PLATE V

Relief Map of California and Nevada.

California Portion Constructed by N. F. Drake,
Department of Geology, Stanford University.
Nevada Portion Constructed by Lloyd and Simkins,
Reno, Nevada.

PHYSIOGRAPHIC GEOGRAPHY

BY RULIFF S. HOLWAY
Associate Professor of Physical Geography, University of California

THE physiographic geography of the Pacific Coast region is far from being uniform in character; in fact the type areas of the various subdivisions cover almost the entire range of the physiographic scale outside of the torrid zone. Differing thus widely among themselves the subdivisions must also be in strong contrast to the physiographic provinces of the Atlantic Coast from Maine to Florida. Some few suggestions of these contrasts may make this brief outline of the physiography of the Pacific Slope stand out more clearly.

On the north the forests of Washington and of Maine are both growing in regions bearing the scorings of ancient glaciers, but in the western state, although the winters are extremely mild in comparison with those of Maine, the forests rise on the higher peaks until they meet the ice fronts of still living glaciers. In the extreme southern portion of both the Pacific and the Atlantic shores the orange and the lemon flourish under subtropical conditions. On the western coast, however, the thriving citrus groves extend as far northward in the Sacramento Valley as the latitude of the southern boundary of Pennsylvania, yet the growers are subject to no more if as much risk of serious loss from frost as are the growers of southern California and of Florida. The contrasts in temperature between north and south on the Pacific Coast are less than those on the Atlantic, but if the general physiographic conditions are examined on an east and west line in each case, geographic contrasts more vitally controlling man's movements and occupations are found on the western shore. For example, in going directly inland from Norfolk, Virginia, for a distance of three hundred miles the area at first traversed is a low coastal plain which gently rises to an elevation of only five hundred feet above the sea in a hundred and fifty miles. The remaining half of the line extends up the Piedmont slope and over the Blue Mountains among peaks from three to four thousand feet in elevation. Throughout the entire three hundred miles the annual rainfall is uniformly from forty to fifty inches and the difference in the mean temperature of January and July is 35° to 40°F. Turning now to the Pacific Coast, Santa Cruz, on the same parallel of latitude, has within a fraction of a degree the same mean annual temperature as has Norfolk, but the difference between January and July is less than 14°F. instead of 38°F. Inland from the Pacific the same distance as from the Atlantic, we find rapid changes in rainfall and in temperature, with rapid changes in the elevation which varies from over fourteen thousand feet above to nearly three hundred feet below the level of the sea.

Starting at Santa Cruz, where surf bathing is possible in January and where July is pleasantly cool, there is no coastal plain, the mountains rising abruptly from the sea to elevations of over three thousand feet within twenty miles. Close to the coast the redwood groves thrive under from twenty to fifty inches of rainfall; but continuing inland over the alternate mountain ridges and intervening valleys, one descends suddenly within sixty miles from the ocean to the low-lying wide plains of the Great Valley of California with less than ten inches of rain along its western border. In this interior valley the annual range of mean temperature is only slightly less than in Virginia but the winters are ten degrees warmer. On the eastern side of the Great Valley, near Merced and Fresno, the 37th parallel passes through irrigated vineyards and citrus orchards growing on the extensive alluvial slopes at the foot of the mountains. Eastward again the rainfall rapidly increases up the long gentle slope of the Sierra Nevada through the mining district to the great forest belt. Still upward the now lessening precipitation is largely snow and at the crest line of the High Sierra, fourteen thousand feet above the sea, is found the Palisade Glacier.* Standing on the top of the high cliff of the two-mile-wide amphitheater at its head, the observer may look over the yawning crevasses in the green ice, down the steep eastern front of the Sierra Nevada fault scarp, across the narrow green irrigated belt at its foot, to the sage-brush marking the edge of the arid plateaus. Eastward for another seventy-five miles, over high ranges and across arid basins, brings him to Death Valley, in places at least 278 feet below sea level. This valley, with its burning summer heat rising sometimes to 137°F. in the shade, and its dry sandy and salt-incrusted waste slopes fully satisfies one's early conception of a desert.

* Palisade Glacier is fifteen miles from Big Pine on the railroad running northwest from Mohave through Owens Valley.

Physiographic Geography

That physiographers do not agree on definite boundaries to the subdivisions of this great western region, the varied characteristics of which have been barely suggested in the foregoing paragraphs, is not surprising. Sometimes one province almost imperceptibly grades into another. As a usual thing reasonably sharp limitations seem possible, but exact knowledge is lacking as yet in these extensive and thinly settled regions largely because geographical science necessarily views the earth from so many standpoints that criteria for classification are many and varied compared with the relatively simple conditions used as determinants in the more specialized sciences. There is, however, fair approach to unanimity in dividing the Pacific Slope primarily into four major physiographic provinces each roughly parallel to the ocean: the Coast Ranges, the Pacific Valleys, the Sierra Nevada-Cascade ranges, and the Arid Plateaus. This classification is based largely on a consideration of topography, climate and vegetation; but these three factors, each involving many details, have no fixed relative value in determining boundary lines of the various provinces. The resulting subdivisions, however, have a general and easily recognized physiographic unity which justifies the use of varying criteria in classification. The four primary regions, on more detailed study, are themselves subdivided by lines that sometimes roughly depend on climate, sometimes on geologic structure as expressed in topography or soils, or on vegetation which may be taken as the surface expression of both topography and climate.

Two important and absolutely necessary conditions for the appreciation of the different physiographic provinces of the west coast are, first, their position on the east of a great ocean in such latitudes that the winds prevailing from the west bring inland the moderate and nearly constant temperature of the sea; and, secondly, the fact that the two great mountain systems lie squarely athwart these moisture-laden west winds. The result is an alternation of belts of greater or less rainfall. This varying amount of rain helps in determining the limits of the first three provinces and is the chief determinant of the Arid Plateau Province—the "rain-shadow" area of the Cascade-Sierra Nevada ranges. With this parallelism of the major physiographic provinces and their extent practically from Canada to Mexico, it follows that the visitor to the Panama-Pacific International Exposition traveling through the United States must cross all four of the major provinces. Furthermore, it is significant that he sees first of all the Arid Province placed by nature as a definite boundary and barrier marking off this western region with its distinctive individuality. The peculiarities of the west coast, its problems and its needs, would have been better understood in the eastern portion of the United States had communication been more free, and the Panama Canal in a vital, if not in a literal sense, cuts away part of the desert barrier between the two great sections of our country.

The Arid Province, by reason of its very aridity, has great areas of soil exceptionally rich in plant food and wonderfully productive in the localities where water may be obtained for irrigation. To many visitors the arid region is "a desert"—uninteresting and disagreeable, to be at least partially escaped by travel at night. But viewed either as a lost paradise to be regained by irrigation, or viewed as a physiographic barrier to perfectly free intercourse, which the non-irrigable areas must always remain to a large degree, or viewed as a region fortunately either bare or thinly covered with vegetation that man may study the forces and processes by which nature evolves scenery from the raw materials, it is full of interest and of charm. Even the discomfort of the heat and dust found in passing through the extreme types of this province in the hottest or windiest day is a valuable experience. The characteristic distinction in the physiographic processes of the type arid region compared with those of the humid climate of the Mississippi Valley and the East is that owing to scanty rainfall the rivers are unable to maintain their courses to the sea. The streams drop the greater part of their load of sediment at the foot of the mountains, forming great alluvial fans, and only the finer material and the matter in solution are carried to the bottom of the various basins where more or less temporary salt lakes are formed. The general result is that while the mountains are being lowered the lowlands around them are being built up, covering their basal slopes, and the amount of relief becomes less and less. The tendency is finally to approximate a plain from which rise the resistant tops of the yet unburied mountains. In contrast with the humid regions where erosion at first deepens the valleys, thus increasing the relief but constantly lowering the average elevation of the entire region and tending ultimately to form a peneplain close to sea level, the typical arid basin levels *up* as well as *down* and tends to form a peneplain at the average level of the original land surface—less whatever material the winds may export altogether from the region.

The Arid Plateau Province is naturally subdivided into three parts, the Columbia Plateau, the Basin Plateau, and the Lower Colorado Plateau. The central division which most travelers enter at Great Salt Lake is typical in having no drainage to the sea, but is not to be thought of as a single drainage basin, for in reality there are still hundreds of separate depressions notwithstanding the tendency to integration through filling. The Columbia Plateau is least typical of the arid or desert province because of its slightly greater rainfall and its drainage to the sea by the Columbia River, and also because its topography is so largely controlled by the nearly horizontal beds of the great Tertiary lava flow. The southern third of the Arid Belt is also traversed by a large river, the Colorado, but many depressions of considerable size are undrained and the temperature and aridity make it in many ways more representative of arid provinces than is the Columbia Plateau. (See Pls. IV and V, and fig. 5.)

The Great Basin region may possibly be traversed at least one way by more visitors to the Panama-Pacific Exposition than any other section of the Arid Province, and it offers more examples of typical topography already familiar in scientific and popular literature. Great Salt Lake is but the last remnant of its great predecessor, and from the car windows may be seen many fragments of terraces marking the shore-lines of successive levels of Lake Bonneville, the extensive lake of glacial times (Gilbert, 1890). In northwestern Nevada similarly are found fragments of the shore-lines of the contemporaneous Lake Lahontan (Russell, 1885). These shore-lines are visible from either the Southern Pacific or the Western Pacific railroad and both lines pass through or near several of the characteristic playa lakes, sometimes partially filled with thin sheets of water, but nearly always showing portions of the mud flats of their beds incrusted with the salts deposited from the evaporating water.

The traveler by the Sunset Route at the extreme south will find much typical arid province scenery through Arizona. Entering California at the head of the old delta of the Colorado River which makes the rich lands of Imperial County, he will have the experience of descending below sea level in passing Salton Sea. Throughout the arid region the peculiar vegetation, sage-brush, grease-wood, or cactus, constitutes no small part of the characteristic scenery; but this is described in a later chapter.

Adjoining the Arid Plateaus on the west is the Sierra Nevada-Cascade Province. The southern range is a great block sharply uplifted on the east and sloping gently westward to the central plain of California (Le Conte, 1907). Starting from Mohave Station, just within the Basin Province, the automobile road, "El Camino Sierra," skirts the base of the steep fault scarp forming the eastern front of the Sierra Nevada as far as Lake Tahoe, practically tracing thus far the boundary between the two provinces. For the first third of the way the Los Angeles aqueduct follows nearly the same route to the intake on the Owens River. The southern end of Owens Valley contains Owens Lake, the alkaline sink in which the unused waters of the river evaporate. A short distance northward of Owens Lake is Lone Pine, the most convenient outfitting place for the ascent of the highest mountain in the United States outside of Alaska, Mount Whitney, which although but thirteen miles away in an air line, towers nearly 11,000 feet above the little village. Northward the road crosses the aqueduct, and, passing through Big Pine, fifteen miles from the Palisade Glacier, leads to Bishop, the commercial center of Owens Valley. The middle third of the road from Bishop to Mono Lake rises in places to an elevation of over 7000 feet, the magnificent snow-capped wall of the Sierra Fault Scarp always on the left with the moraines of its ancient glaciers frequently found at the very road-side. (See Pl. VII.) Mono Lake, the "Dead Sea of America," is 6412 feet above the sea, but having no outlet is intensely alkaline. Here the great glacial moraines, the old shore lines of the lake, and several volcanic craters form an interesting field for physiographic study (Russell, 1897). The last third of El Camino Sierra ends at the famous Lake Tahoe, 6225 feet above the sea, but, unlike Mono Lake, it has an outlet and its waters are fresh and pure. Near Tahoe the Sierra has no longer a single fault scarp and the lake lies between two of the separate fault blocks. The main rivers of the uptilted Sierra block are on its long western slope where the rejuvenated streams have carved cañons, since modified by ice. Wonderful as are Yosemite and Kings River cañons, it is believed that the trip along "El Camino Sierra," with the ascent of Mount Whitney and the climb to Palisade Glacier, is no less enjoyable either for mountain scenery or for general physiographic interest.*

* This scant reference to the well-known scenery of the Sierra Nevada is supplemented by Professor Le Conte's descriptions of mountaineering in another chapter.

The Sierra Nevada Range terminates at the North Fork of Feather River not far from the line of the Western Pacific railroad. Its correlative, the Cascade Range, has some common features in past physiographic history, but in a hasty view it may be sufficient to call attention to the greatest contrast, namely, that in the northern range upbuilding by volcanic flows has played a vastly more important part than in the Sierra Nevada. At the extreme southern end of the Cascade Range stands Lassen Peak (Diller, 1895), an old volcanic cone which suddenly became active on May 30, 1914, and which has now been in intermittent action of the explosive type for nearly eight months (Holway, 1914). (See Pl. VI.) As this page was written, January 23, 1915, the newspapers announced that at nine o'clock in the morning the 74th eruption took place from a new crater on the east side of the mountain.* Northward the well known extinct (?) volcanic cones of Mount Shasta, Crater Lake, Hood, and Rainier serve to emphasize further the contrast between the Cascades and the Sierra Nevada.

The next of the four parallel physiographic belts of the west coast region is the Pacific Valley Province—a depression, not continuous however, between the Cascade-Sierra Nevada Range and the Coast Ranges. The valley of Puget Sound in the State of Washington is continued southward through the greater part of Oregon as the Willamette Valley, and although the Cascade and Coast ranges for a short distance practically meet in southern Oregon, the same type of depression reappears beyond and is known as the Great Valley of California. As commonly described, the Pacific Valley Province ends where the Sierra Nevada turns westward to meet the Coast Ranges. The different portions of the Pacific Valley are the lowland plains of the west coast in which must always center the most important agricultural interests.

In the Pacific Valleys possibly the side trip available to the greatest number of visitors on the line of approach to San Francisco may be made by changing from the railroad at Sacramento, the capitol of California, and continuing to San Francisco by steamboat on the Sacramento River and through Suisun Bay and the northern half of San Francisco Bay. The Sacramento River throughout most of its course in the Great Valley has by floods built up natural levees and these, strengthened by

* The best railroad points from which to visit the peak are Redding or Red Bluff on the west, or Susanville on the east. An auto ride of fifty to sixty miles is necessary to reach the base of the mountain.

artificial levees, hold the river channel in the center of the low alluvial ridge built by the river itself. The fine silt of the alluvial land on either side is extremely rich, and from Sacramento down stream is subject to flood unless leveed. As Suisun Bay is approached, many of the most valuable farm lands, some of them largely peat, are five to ten feet below sea level. This region, the Netherlands of California, may all be seen by daylight if a morning steamer from Sacramento is secured.

The Coast Ranges, as has already been stated, usually rise abruptly from the sea. In Washington they are known as the Olympic Mountains, and in southwestern Oregon and northwestern California the structure and topography have caused another subdivision to be set off as the Klamath Province. The other sections are commonly spoken of as the Coast Ranges of Oregon or of California. The Coast Ranges, as a whole, somewhat exceed the Appalachian Mountains in elevation. The peaks of the Olympic and the Klamath ranges rise to 9000 feet and over, and south of Monterey Bay, Santa Lucia Peak of the California Coast Ranges is about six thousand feet above the sea. In southern California the Sierra Madre is commonly accepted as part of the Coast Ranges, notwithstanding a change in trend and their distance from the sea. In the ranges of the Sierra Madre the highest peak is over eleven thousand feet in elevation.

Space for physiography in this guide book has been pages where volumes are needed. The Coast Range Province, like the others, must be passed with brief reference to features of special interest. Possibly the most striking fact is that the Coast Ranges have been so recently uplifted from the ocean that the seaward front still shows at intervals from San Diego to Portland the successive shorelines deeply scored by the waves during the standstill of the land between successive uplifts. Yet if Mount Tamalpais, just north of Golden Gate, be climbed, the magnificent panoramic view from the top shows San Francisco Bay most plainly as a drowned valley made by recent subsidence which has admitted the sea through the gorge that was formerly the old mouth of the Sacramento (Lawson, 1914). In contrast with this view of local subsidence, if the railroad be taken to Santa Cruz (three hours away), the coast for ten or fifteen miles to the westward shows four broad old ocean strands with their former sea cliffs at the rear, the whole rising like steps of a giant stair-case to some seven hundred feet from the present ocean level (Lawson, 1913). Fragments of older and much eroded terraces are found up to two thousand feet above the sea at other places. The excellent preservation of the major terraces near Santa Cruz is due to a shale formation which, though easily eroded by wave action, is yet quite resistant to ordinary weathering. Series of marine terraces may be seen also at San Pedro Hill, Los Angeles, and at Soledad Hill near San Diego.

Another peculiarity of the Coast Ranges affects largely the life of the people. The successive mountain ridges from the Pacific to the interior valleys are roughly parallel to the coast line and to each other, but frequently they coalesce. Transverse valleys are very rare. Lines of travel are up and down the valleys rather than over the intervening ridges. Few main wagon roads run from east to west and they have heavy grades. Between Los Angeles and Puget Sound only two passes through the Coast Ranges from the ocean to the interior lowlands are so available for traffic that they have become great trade routes—the Columbia River and the drowned valley of the lower Sacramento River forming the Golden Gate and San Francisco Bay. Through railroad communication from north to south on the Pacific Slope is as yet confined to the Pacific valleys. Not only is there no extensive coastal plain on the Pacific Coast of the United States, but it is literally true that for many miles at a stretch, and for possibly hundreds of miles in the aggregate, there is no flat land at the coast of sufficient width for a right of way.

The modern geographer is trying to describe the regions of the world in their various physical aspects as they affect the surface of the earth as the home of man. It is to be hoped that the reader will find in the rather impressionistic picture of the physiographic aspect of the Pacific Coast region, here sketched, a framework into which will fit the more detailed information he may gather in planning and in making a visit to this coast.

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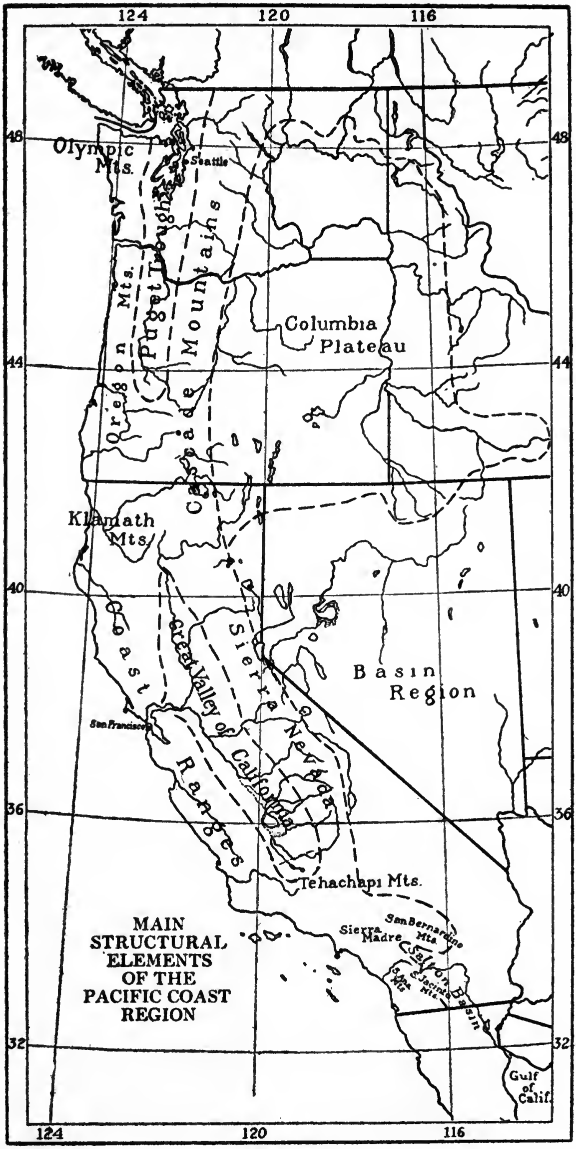
GEOLOGY OF THE WEST COAST REGION OF THE UNITED STATES

BY C. F. TOLMAN, JR.
Associate Professor of Economic Geology, Stanford University

NATURE has left voluminous records of the geological history of the west coast of the United States in the numerous and thick sedimentary formations of the region. The records are fragmentary and incomplete for the pre-Cambrian eras, those antedating the appearance of life on the earth or at least containing no evidence of the teeming population that existed in the oceans from the Cambrian period on. Beginning with the Cambrian and extending down to the present time, each period is represented by marine deposits which register the geography, climate, and something of the denizens, of the times in which they were formed. The story of vulcanism and earth movements is read not only in the character and distribution of the igneous rocks of this region, but also in the metamorphism and deformation of the sedimentary rocks. This second record, imprinted by metamorphism, often erases, partially or completely, the earlier records of the sea. The history of the relatively recent periods, of the geologic yesterday, is written in more detail than elsewhere in the world. It treats of marine, terrestrial, and glacial conditions, of the base leveling of mountain ranges followed by vulcanism, earth movements and the re-birth of mountain systems.

In the attempt to select and describe a few of the salient features of this long and complicated history, it has been difficult to make the treatment accurate, or to give alternate interpretations which may be as worthy of consideration as those presented here. The limited space allotted to this article has rendered it inadvisable to cite the contributions of each of the geologists who have added to our knowledge of west coast geology. The brief bibliography includes a few important papers bearing on the subjects emphasized in this summary. In the accompanying geological map the formations have been grouped according to the divisions adopted in the text of this article. (See Pls. XXXIX and XL.)


124
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Olympic Mts.
Seattle
Puget Trough
Cascade Mountains
Oregon Mts.
Columbia Plateau
Klamath Mts.
Coast Ranges
Great Valley of California
Sierra Nevada
Basin Region
San Francisco
Tehachapi Mts.
San Bernardino Mts.
Sierra Madre
Salton Basin
S. Jacinto Mts.
S. Ana Mts.
Gulf of Calif.
MAIN STRUCTURAL ELEMENTS OF THE PACIFIC COAST REGION

Figure 5

THE PRE-CAMBRIAN OF THE WEST COAST.—Formations of pre-Cambrian age doubtless exist in numerous localities in this region, but in most cases the proof of the suspected antiquity of these strata is lacking. East of the region under consideration, intense and widespread metamorphism is generally considered a proof of great geological age. In the Pacific region such metamorphism merely indicates an age antedating the intrusion of the Sierra Nevada batholith.

Patches of known pre-Cambrian occur northwest of Owens Lake, where a metamorphosed series appears underneath strata carrying an Olenellus (lower Cambrian) fauna. Numerous areas of probable pre-Cambrian occur in the desert mountain ranges of the region adjoining Arizona, as proved pre-Cambrian is found in the Grand Cañon of the Colorado, and neighboring areas. All other components of these ranges are of later age, including Palaeozoic formations, chiefly quartzites and limestones, granitic intrusions of post-Palaeozoic age, contemporaneous with, or possibly somewhat later than, the batholiths to the north and west, and also still younger deformed but unmetamorphosed strata.

The granitic core of the Sierra Nevada forms the largest of the batholiths mentioned above. The granite masses of the Sierra Madre, San Jacinto and San Bernardino ranges of southern California, are now generally considered as outlying members of the main batholith. Most batholithic masses, when studied in detail, have been found to be complex, consisting of rocks of varying ages, the older members of which have been caught up and fused into the later intrusives. It is not improbable, therefore, that the older gneisses and schists appearing within the less metamorphosed granites, are of pre-Cambrian age, but until these are studied in detail, the entire complex is best classified as late Jurassic in age.

Certain apparently ancient schists of Siskiyou County, California, have been provisionally assigned to the pre-Cambrian, and the somewhat similar Colebrook schists of Oregon may belong here. The basin in which the late pre-Cambrian formations of the Belt series were deposited, lies just east of the boundary line between Washington and Idaho. Certain still older gneisses and schists which form the basement upon which the Belt sediments were laid down occur in northeastern Washington.

These scattered fragments of the ancient rock formations furnish few data from which we may reconstruct the geography of the west coast region, immediately preceding the great invasion of the sea during the succeeding Palaeozoic era. We know in general that the American continent was elevated above the sea, probably far beyond its present boundaries, and was gradually reduced in level. Towards the close of the pre-Cambrian a great trough, east of Washington, was filled with sediments. Early Cambrian times witnessed an extension of the Great Basin Sea of Nevada and adjoining states into eastern California. There existed at this time, perhaps, an archipelago of small islands in southeastern California, and low land masses in the region now occupied by the Sierra Nevada Mountains. The Pacific Ocean lay to the west of the present coast line, a condition which probably existed on through Palaeozoic, Triassic, and Jurassic times.

THE PRE-CRETACEOUS METAMORPHICS.—During Palaeozoic times the western strands of the Great Basin Sea occupied the eastern portion of California, now advancing, now retreating, and finally, towards the close of the era, reaching well into western California, possibly as far west as the present coast line in the vicinity of Monterey, where the extensive Santa Lucia limestone of Palaeozoic age is well developed. The northern Palaeozoic Ocean occupied a considerable portion of Oregon, but its full extent is not known, as much of both Oregon and Washington are covered by the Columbian lavas.

The Palaeozoic strata are largely the metamorphosed equivalents of shales and sandstones, but in Devonian and Carboniferous times extensive strata of limestone were deposited. The late Palaeozoic sediments are interstratified with large amounts of volcanic material, lavas and tuffs. The total thickness of this series of coastal deposits is at least 10,000 feet in California.

The Triassic and Jurassic sediments were laid down in a relatively small inland sea or sound, extending over only the western portion of the region occupied by the former Great Basin Sea. These early Mesozoic seas were undoubtedly connected with the Pacific Ocean, but a great island, including the western portion of California and Oregon, and probably extending west of the present coast line, separated the inland sea from the Pacific Ocean. The maximum thickness of the marine Triassic and Jurassic of northeastern California is not less than 8000 feet. This suggests that there was a nearby land mass, although no mountain ranges were formed as yet.

Geology of West Coast Region of United States

Along the west coast there is a thick and widespread series of rocks known as the Franciscan series, which, with the exception of certain granites and limestones that occur in the southern ranges, is the oldest of the formations exposed in the Coast Ranges. This series is of interest to visitors of the Panama-Pacific Exposition, as it forms the rock foundation of the city of San Francisco, as well as much of the higher and scenic portions of the Coast Ranges. In spite of wide distribution and easy access, many difficulties have been encountered in the study of these rocks. Few fossils have been found except tests of radiolaria and foraminifera, which furnish little data suitable for geologic correlations. Close folding and the general prevalence of a double cover of soil and brush have hindered structural studies. One of the best sections is found in Corral Hollow, southwest of the old coal mining camp of Tesla, and can be reached by automobile from San Francisco. Here a measured section includes 15,000 feet of sedimentary rock without exposing either the top or the bottom of the series. The lowest formation exposed is a dense blue sandstone cut by innumerable intersecting quartz veinlets. Above are the Corral Hollow shales which contain massive beds of crumpled and folded cherts, and, especially in the vicinity of serpentine intrusions, of lawsonite, chlorite, and glaucophane bearing schists, which seem to be peculiar to the Franciscan series and similar metamorphics in Greece, Asia Minor, and Japan. The upper member is the slightly metamorphosed Oakridge sandstone.

The geologists who have studied the Franciscan formation are not in agreement as to its age. It has been assigned in part to the Cretaceous; but its position under the Knoxville series (Early Cretaceous) suggests a pre-Cretaceous age. A portion of the series lies unconformably on granite, and if this granite is contemporaneous with the last of the granites of the Sierra Nevada, a post-Jurassic age is indicated; but the history of the batholith is as yet undeciphered in detail, and possibly may have occupied several geological periods in the forming.

We conclude, therefore, that an important trough, in which deposition was active, was located west of the Sierra Nevada Mountains. On the east side of this trough the Mariposa formation (Jurassic slates) was deposited, and the Franciscan series to the west. This trough was probably post-Palaeozoic and pre-Cretaceous in age. To the west the more important types of marine life were rare, but large amounts of organic siliceous ooze were deposited. The land mass from which the terrigenous sediments were derived may have existed to the west of the present coast line.

THE CORDILLERAN REVOLUTION AND THE SIERRA NEVADA BATHOLITH.—The intrusion of the Sierra Nevada batholith and most of the outlying members took place in late Jurassic times. The main batholith occupies the eastern portion of California, extending northward in a direction a little west of north. It disappears under the lava cover of northern California and Oregon. In the northern part of California and southern Oregon, small granitic masses may be outlying members of the same great intrusion. Towards the south the batholith ends in a hook which curves around the southern rim of the great valley of California. The irregular masses of the Sierra Madre, San Jacinto and San Bernardino ranges of the southern part of California, as well as the smaller granite areas of the Coast Ranges south of San Francisco, may be closely related to the main batholith. The intrusion was accompanied by metamorphism so intense and widespread that it resembles regional rather than contact action. As a result much of the pre-Cretaceous rocks appear as schists, slates and recrystallized limestones. The small granitic masses of the desert region of southeastern California belong to the Great Basin province, and a close relationship to the Sierra Nevada batholith has not as yet been proved. In northeastern Washington, the granitic intrusives are related to the Idaho batholith rather than that of the Sierra Nevada, while in central Washington a batholith of proved Miocene age is reported.

Sills and dikes of serpentine were intruded along the axes of the present Coast Ranges. These may have been contemporaneous in part with the later phases of the batholithic intrusions of the Sierra Nevada, which also include basic derivatives. The intrusion of the Coast Range serpentines continued, however, into early Cretaceous times.

Prior to the intrusion of the last of the Sierra Nevada granites, the earth movements which brought about the Cordilleran revolution were well under way. The pre-Cretaceous sediments west of the batholith were closely appressed into isoclinal folds. The axes of the folds are nearly vertical, occasionally overturned, and trend northwestward well into Oregon, where they swing to the northeast as if to round the point of the main batholith, and disappear under the cover of Tertiary lavas.

PLATE VI

Lassen Peak in Eruption on June 14, 1914. The Point From Which This Photograph Was Taken Is About Six Miles Northwest of Lassen Peak. The Foreground Is Nearly 5000 Feet Above Sea Level. The Elevation of Lassen Peak Is 10,437 Feet Above Sea Level.

Photograph by B. F. Loomis.

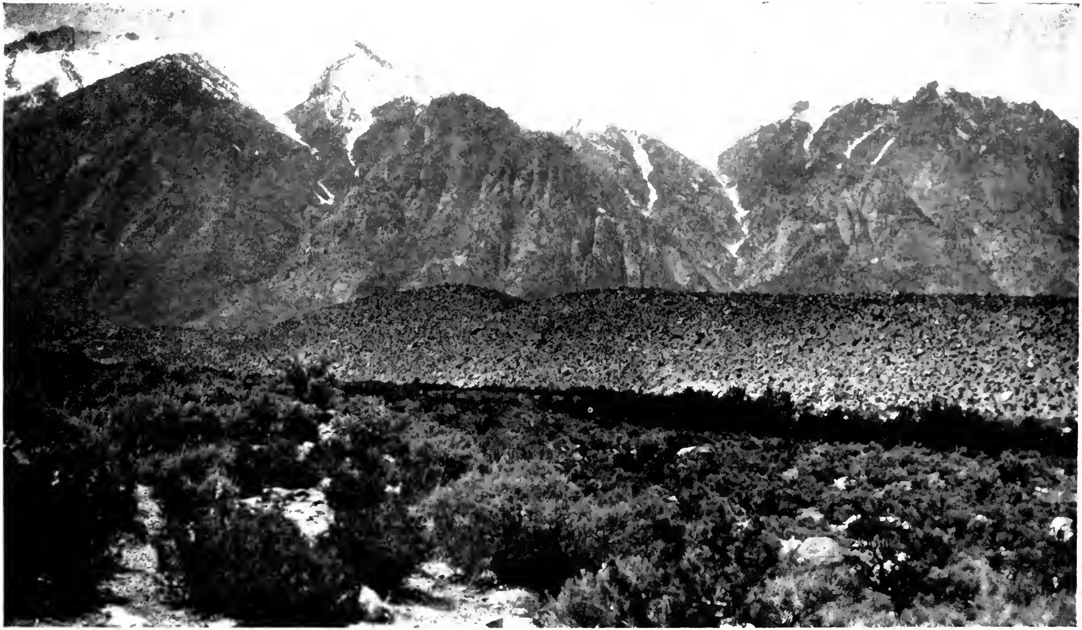

PLATE VII
The Fault Scarp of the Sierra Nevada Near Bishop, California. The Glacial Moraine of Pine Creek in the Center Is Nearly 300 Feet High, and Two Miles Long. The Peaks of the Skyline Rise Over 8000 Feet Above the Foreground.
Photograph by Ruliff S. Holway.

The Coast Ranges of California received their first and greatest folding at this time. The Franciscan series is pressed into a regular system of folds which often consist of open synclines and broken, compressed anticlines, but locally of isoclinal structures. Throughout the region affected the trend of the folding is northwestward. The folds of the Coast Ranges of California are cut diagonally by the present coast line, the system disappearing under the ocean in the neighborhood of the boundary line between California and Oregon. The Klamath Mountains, which may be considered as a mountain knot connecting the Coast Ranges with the Sierra Nevada-Cascade system, belong structurally with the folded complex of the latter range. The Oregon and Olympic mountains west of the Puget Sound trough have been considered as the continuation of the Coast Ranges. They are, however, gently folded, and possibly were affected only by the middle Miocene revolution, which was much less violent than the one under consideration.

In the southern Cascades, the folded structures produced by the Cordilleran revolution are buried under the thick Tertiary lavas, but in a few places a closely folded complex of the older rocks has been uncovered by erosion of the lavas, indicating that the folded zone persists under the later cover. In the northern Cascades, the rocks are even more closely crushed and folded than in the Sierra Nevadas. Here we have the super-imposition of the movements and metamorphism accompanying the intrusion of batholiths of Cretaceous and later age, upon the effects of the Cordilleran revolution.

The Cordilleran revolution impressed upon the west coast region its present structural pattern, and outlined the positive (rising) and negative (sinking) elements which persist today (fig. 5). The main negative element is the great central trough extending from Puget Sound to the Gulf of Mexico, via the Willamette Valley, the Valley of California, and the Salton Sink. This trough is separated into three main basins by the mountains north and south of the Valley of California. The positive elements are the highlands and mountain ranges on either side of the trough.

In California, especially, the folded zones initiated during late Jurassic times have governed subsequent deformation. The great faults, for the most part of subsequent origin, show a general parallelism to the trend of the folds.

The Cordilleran revolution also resulted in a complete re-arrangement of the distribution of the land and water. The Great Basin Sea was drained, the Pacific Ocean advanced eastward, and from now on we have to do with the advances and retreats of the epicontinental stages of the Pacific Ocean, the records of which form the final volume of the geological history of the west coast.

The Geological History of the West Coast Since the Cordilleran Revolution.—The early Cretaceous (the Shastan of the west coast) was marked by the rapid advance of the Pacific Ocean over the western portion of the Pacific States. The recently folded Coast Range stood but a brief interval above the ocean, which also crossed the site of the present Cascade range in southern Oregon. The enormous thickness of the combined Knoxville and Horsetown of the Shastan system (maximum thickness 25,000 feet) suggests that the highlands east of the Shastan trough were eroded rapidly. There was considerable shifting of areas of sedimentation between the Knoxville and the Horsetown, and also between the latter and the Chico (upper Cretaceous). The Chico sediments register a second great advance of the Pacific Ocean which occupied the western portion of the Pacific States, and covered the bevelled Klamath Mountains, bathed the western foothills of the Sierra Nevada, and reached the Blue Mountains of eastern Oregon.

No revolution comparable with that which affected the Rocky Mountain region to the east, separated the Cretaceous from the Tertiary. In numerous localities, especially in southern California, no pronounced break can be recognized between the Chico and the Tejon (Eocene).

The Eocene strata reach their greatest thickness in the Puget Sound embayment, where at least 10,000 feet of sediments were deposited, including the thickest and best coal strata of the Pacific Coast region. Elsewhere along the coast local Eocene basins were converted into swamps for brief intervals, the organic accumulations of which are preserved as lignite, or a poor grade of bituminous coal. Oligocene strata have been recognized, especially in Washington and Oregon.

The Miocene is supposed to represent a brief period of geologic time compared with earlier geologic divisions. In California it was marked by the deposition of great thicknesses of sediments, and embraces a mountain-making epoch of no mean dimensions. The thick lower Miocene sediments include many thousand feet of diatomaceous material—one of the principal sources of California oil. The second folding of the Coast Ranges of

California is generally dated as middle Miocene and was accompanied by a partial elevation of the region affected. However, local but pronounced folding occurred in the late Miocene or early Pliocene east of San Francisco Bay. Important disturbances of probable Miocene age also took place in northern Washington, accompanied by the intrusion of a granite batholith. Thick upper Miocene marine strata occur in central and southern California. In the vicinity of San Francisco Bay thick lacustrine deposits of upper Miocene and lower Pliocene age appear.

In the Pliocene and Pleistocene periods lacustrine and terrestrial deposition has been active, resulting in the filling of the larger valleys to a depth of several thousand feet. During this time marine deposition was confined to a narrow coastal strip. From Miocene times on, northeastern California, eastern Oregon and Washington have been affected by enormous volcanic eruptions, which have resulted in the construction of a great plateau composed of from 3000 to 5000 feet of lava flows, and covering an area exceeding 200,000 square miles. This plateau slopes towards the northwest from an elevation of about 5000 feet in southeastern Oregon to 1500 feet in central Washington. It is sentineled on the west by lofty volcanoes, such as Mount Shasta, Mount Hood, Lassen Peak, etc. The last mentioned is now in a state of mild activity, which, according to Mr. Diller, may prove to be preliminary to more violent eruptions.

In southeastern California deposition was terrestrial and lacustrine throughout all the Tertiary and Quaternary. In the Quarternary period the continental ice sheet covered the northern portion of Washington, an important lobe invading the Puget Sound region. Mountain glaciers occupied the higher portion of the Sierra Nevada and Cascade ranges, remnants of which are preserved as the small mountain glaciers of today. The complete study of the glaciation of the Sierra Nevada-Cascade ranges has not as yet been undertaken. It is an important and much needed work.

The dynamic history of this great region since Jurassic times is varied and complicated, and does not lend itself to simple summary statement. During the Cretaceous, the Sierra Nevada-Cascade ranges underwent erosion, and at the close of the period, portions at least were reduced to an approximate base level as in the Klamath Mountains. In the Sierra Nevada, base leveling was delayed by a number of elevations of the mountain region, which may be considered broadly as a great fault block, with an important zone of faulting on the east side. The movements consisted in a tilting of the block towards the west, the eastern portion being elevated above the desert basin region of Nevada. In early Tertiary times erosion gained the upper hand and the Sierras were reduced in part to a peneplain. In late Tertiary and Quaternary times uplifts culminating in great elevations during the Quaternary period gave birth to the present Sierra Nevada, and subsequent erosion is as yet in its youthful stage. Except for this tilting, this great mountain block has acted as a resistant buttress and has not suffered the intense deformation that affected the weaker regions to the east and west in Tertiary and Quaternary times.

The early Tertiary history of the Cascade ranges is largely hidden under the great lava mantle. The southern Cascades owe their present height in part to constructional processes, majestic volcanic cones dominating the range. Since Miocene times these ranges seem to have suffered a gentle upwarping but no important folding. The history of the northern Cascades and adjacent regions is much more complicated, folding probably occurring in the Cretaceous, at the close of the Eocene and in Miocene times. The present elevation, as in the other ranges, is largly the result of relatively recent uplift.

The Klamath Mountains received the full force of the later compressive movements, intensified possibly by the resistance offered by the unyielding Sierra Nevada block. The boundary between the Coast Ranges and the Klamath Mountains is marked by a great thrust, along which crystalline schists have overridden the Jurassic and Cretaceous rocks to the west, and similar thrust faults have been described in Oregon.

Along the Coast Ranges compressive stresses accumulated throughout the Tertiary. Locally the relief and crumpling took place at various times, the most pronounced folding occurring in the middle Miocene. In this same region great faults developed in general parallel to the trend of major folds. Some of the faults are old and date back to early Tertiary or possibly Cretaceous times. The fault movements seem to have reached a maximum during the elevation of the entire west coast region in Quaternary and Recent times, and are continuing with perhaps undiminished intensity at present.

The elevated beach lines show that recent elevations of the coast have been important. Local

PACIFIC RECORD

COAST RANGES						SIERRA NEVADA		
Cenozoic	Quaternary		Terrace					Terrace gravels
			San Pedro sandstone					
			Cañon-cutting epoch					Glacial beds
	Tertiary	Pliocene	Santa Barbara beds		Santa Clara lake beds	Auriferous Gravels		
			San Diego and Merced sandstone		Tulare lake beds			
			Etchegoin sandstone		Orinda formation			
		Miocene	Santa Margarita and San Pablo sandstone		Lake beds of Tesla, with Upper Miocene leaves			Post-volcanic gravels, with Upper Miocene leaves
			Coast Range revolution					Chief volcanic period
			Monterey shales and Temblor sandstone					Ocoya Creek sandstones, with marine fossils
			Vaqueros sandstone					
		Oligocene	Astoria sandstones and shales					
		Eocene	Tejon sandstone		Lake beds of Corral Hollow, with Eocene plants		Ione Formation	Mohawk lake beds, and coal beds of Ione. Marine sandstone of Merced Falls
			Martinez sandstone					Wanting
Mesozoic	Cretaceous	Chico	Chico sandstone	Chico flora	Plant beds in northern California associated with Chico marine species	Chico		Chico sandstone of Butte County, with marine fossils
		Horsetown	Horsetown sandstones and shales of Shasta and Tehama counties	Shasta flora	Plant beds of northern California and southern Oregon, associated with Knoxville and Horsetown marine species			Erosion period. Record wanting
		Knoxville	Knoxville shales and conglomerates					
	Jurassic		Cordilleran revolution	Oregon flora	Plant beds of northern California and southern Oregon, supposed to be of Jurassic age			Cordilleran revolution
		Franciscan	Cherts, limestones, shales, and schists without definite fossils and with great intrusions of basic igneous rocks, all pre-Cretaceous, and in part possibly even Triassic in age			Colfax		Colfax shales and altered tuffs, and igneous rocks. Marine record almost destroyed
						Mariposa		Mariposa shales, with marine fossils of Upper Jurassic age
							Oroville flora	Oroville flora, with cycads of Middle Jurassic age
	Triassic		Wanting?			Triassic of the Gold Belt		Sailor Cañon shales Genessee Valley limestone and shales
Palaeozoic	Palaeozoic	Santa Lucia	Santa Lucia limestone without definite fossils			Carboniferous	Calaveras formation	Limestones and quartzites of the Sierra Nevada, with Carboniferous fossils
						Devonian		Talorsville formation — quartzite and shale
						Silurian	Grizzly	Montgomery limestone of Plumas County, with Niagara fauna
Pre-Cambrian			Pre-Cambrian schists of the Siskiyou Mts.			Pre-Cambrian	Older gneisses and schists of Sierra Nevada and Mohave Desert	

downwarpings, however, have occurred, which have let the ocean into Puget Sound, drowned the mouth of the Sacramento River, forming the beautiful San Francisco Bay, and isolated Santa Catalina and other islands from the main land.

Professor J. P. Smith has kindly revised his table* summarizing the Pacific geologic record, which appears on page 51.

ECONOMIC GEOLOGY.—In the following paragraphs I shall attempt merely to call attention to those episodes of the geologic history that have developed valuable characteristics in certain of the rocks, or resulted in the introduction of metallic substances, and note some of the more important mineral belts, with a list of their economic products. These belts do not lie at hap-hazard, but appear as units of the giant earth pattern which is reproduced in the geological map.

ECONOMIC PRODUCTS OF THE PRE-CAMBRIAN ROCKS.—The scattered pre-Cambrian rocks have furnished only a small portion of the mineral production of the west coast. We might expect to find such products as slate, graphite, marble, etc., in the metamorphosed rocks of this age, but, as a matter of fact, all the production of this class of substances has come from Palaeozoic and early Mesozoic rocks, metamorphosed by the Jurassic batholiths. A few unimportant copper and gold deposits, which bear certain characteristics of great age, are believed by Lindgren to be of pre-Cambrian age. These include gold prospects near Hedges, Imperial County, and of Whipple Mountain, San Bernardino County, California.

THE MINERAL DEPOSITS OF PRE-CRETACEOUS AGE.—The sediments deposited in the vanished ocean of the Great Basin region contain an impressive array of economic products. The sedimentary rocks consist chiefly of argillaceous and sandy material, but contain great belts of limestone of late Palaeozoic age and strata of basic tuffs. The limestone belts west of the Sierra Nevada furnish excellent marble, which is quarried in Amador, Calaveras, Mariposa and Tuolumne counties. These outcrops broaden towards the north, where they reappear from underneath the lava cover of northeastern California, and while Shasta and Siskiyou are registered with the producing counties, untouched mountains of white marble, inaccessible at present, are reported in the northern part of the State and continue into Oregon. In southern California the small broken desert ranges often expose upturned strata of limestone

* Published in the Jour. Geol., vol. XVIII (1910), p. 225.

and marble, and even in the extreme west, south of Monterey, limestone of probably Palaeozoic age appears in massive strata, and the Pico Blanco of this region is reported to be formed of massive limestone strata which can not as yet be utilized on account of isolation in the heart of a rugged country. This wide distribution of limestone gives California her practically inexhaustible resources for the manufacture of Portland cement, an industry which is rapidly assuming importance.

The heat and pressure that accompanied the intrusion of the Sierra Nevada and related batholiths developed various rock products of economic value, the most important of which are the marble deposits mentioned above. In addition to these is the excellent slate found in the Mariposa slate formation, especially in Mariposa and El Dorado counties of California. The demand for this article, however, has diminished greatly in the last few years. Small amounts of graphite, also formed by contact action, are produced in Calaveras County.

The rocks of the batholith are of considerable value. Granite is used as a building stone, as rubble, etc., in cement work, and in the construction of roads. The value at the quarries of the granite produced in 1913 exceeded half a million dollars. The gem mines at Pala, San Diego County, distinguished for their beautiful two-colored tourmalines, and beryl, hyacinth, kunzite, etc., are found in pegmatite dikes in the granite. Lithium-bearing mica has been mined at this locality, and sent to Germany for reduction and preparation of salts of lithium.

The chief contribution of the batholith to the wealth of the west coast, however, was the result of the chemical activity which accompanied and followed the intrusion, and which resulted in the concentration of the major portion of the metallic wealth for which California is famous. The batholith is flanked on the west by compressed belts of rocks with a northwestward trend in California, swinging around to the northeast in Oregon. The metallic zones are oriented according to these belts. The groups of gold deposits, as well as the individual veins, lie, in general, parallel to these directions, as do the copper belts mentioned below. During both late Jurassic and early Cretaceous times the Coast Ranges were intruded by extensive belts of serpentine rocks, which are characterized by mineral deposits of varied character.

The gold belt of California is the most famous of the mineral zones of the west coast. This consists of a well-defined zone of gold-bearing quartz veins, including the important group to which the name "Mother Lode" has been applied. It starts in Tulare and Kern counties, broadening to a width of sixty miles in Plumas and Butte counties. In Tehama, Lassen and Plumas counties the belt disappears under the lava, reappearing near Redding and extending into Oregon. The veins in general are in the metamorphic rocks, especially the Mariposa slates, west of the batholith. In the southern part of the State gold veins appear in or near schists included in the granites of Los Angeles, Riverside and San Diego counties. The Grass Valley, Nevada City and Mother Lode districts have been the most productive of this great zone of gold veins. Placer deposits skirt the western margin of the entire belt, the economic value of which, especially in the northern portion, is often confined to these secondary deposits. The total gold product of California, which is derived very largely from this belt, from 1848 to 1913, is estimated at $1,588,087,904. The maximum production was reached in 1852, when the pioneer placer miners produced over eighty-one million dollars, a figure which compares well with the total gold production of the United States at the present time.

An extensive copper belt lies west of the gold deposits, the most productive portion of which is known as the "Foothill Copper Belt," and includes such mines of note as the Copperopolis and the Campo Seco in Calaveras County, and the Dairy Farm mine in Placer County.

Separated from the main copper belt by the lava tongue mentioned above, are the copper deposits of Shasta County, which include the largest copper producers of the west coast, such as the Mammoth, Iron Mountain, Bully Hill, Balaklala, etc. These occur in the margins of an acid intrusive rock, which is perhaps an outlying member of the main batholith.

The second belt containing copper occurs in the northern Coast Ranges and Siskiyou Mountains of California, and reaches well into Oregon. The ores are found chiefly in serpentine and related rocks. Although the belt is extensive, it has not as yet produced important mines. It furnishes to geologists, interesting, puzzling, and as yet unanswered questions as to the origin of these high-grade lenses of copper ore in serpentine. Nickel ores in Baker and Josephine counties, Oregon, are also found in the serpentine.

Southeast of the main Sierra Nevada batholith lies the desert region of California, which presents scores of irregular ranges, half buried in the surrounding mantles of desert debris. Many of these ranges contain small granitic masses which intrude the upturned Palaeozoic strata. Each of these small intrusives has its "metallic aureole," or boundary zone, in which deposits of gold, copper, silver, and iron, with subordinate lead and zinc, are developed. Near Randsburg, Kern County, tungsten and gold-bearing veins of importance occur in genetic relation to one of these small granitic masses. This complex group belongs to the general type of Arizona contact deposits. While no deposit of magnitude has been developed in California, this type is destined to produce a larger proportion of the mineral wealth of the State than it has up to the present.

In Oregon the mineral regions are confined to two small areas, one already mentioned lying immediately north of California and containing the continuation of the California gold belt. The second area appears in the Blue Mountains in the northeastern portion of the State. Here a number of intrusive masses occur, similar in age and type to those mentioned for southeastern California, and are bordered by groups of gold veins best known in the Cracker Creek district and the adjacent mining districts of Baker County. The rest of the State is either covered by the great Tertiary lava flows already mentioned, or near the coast by the later Tertiary sedimentary rocks, which contain few metallic deposits in this State. Similarly the southern half of Washington and the Olympic peninsula are either covered by lavas or contain Cretaceous and Tertiary sedimentary rocks without important deposits of metals. The Cascade Ranges and the strip of country adjacent to the Canadian boundary line in the eastern part of the State, however, contain many ore deposits of various types, especially in Ferry, Stevens and Okanogan counties. All these deposits lie in or near granitic intrusives (granodiorite), which are probably related to the great Idaho batholith.

In addition to copper and nickel mentioned above, the mineral products of the older metamorphosed rocks of the Coast Ranges and of the intrusive serpentines include manganese, occurring in small amounts in bedded cherts; chromite occurring as lenses in the serpentine; magnesite, found in large amounts, but as yet only slightly developed; talc and soapstone. We also must include here the gem mineral benitoite, which not only has great beauty of color and crystal form, but also is the only mineral representative of a particular class of crystal symmetry, and further is known to occur in no other locality in the world. As this locality is largely worked out, it seems probable that the mineral will assume additional value as a mineralogical curiosity.

Mercury is one of the most important products of the Coast Range. Becker and Lindgren believe it to have been formed at a later date than the mineral deposits discussed above, and it is, therefore, included among the products formed during the Cretaceous and later periods.

MINERAL DEPOSITS IN CRETACEOUS AND POST-CRETACEOUS ROCKS.—These include products of great value, such as oil, coal, borax, silver and gold. Of these oil is the most important. It is treated at length elsewhere in this volume. Geologists have long puzzled over the fact that enormous quantities of oil are concentrated in the Tertiary strata of southern California, while northern California, Oregon, and Washington contain only relatively small amounts of oil. A suggestion of Dr. Branner possibly gives a clue in regard to this concentration. He has pointed out that an archipelago existed in Tertiary times in the Pacific epicontinental sea along the axis of the present Coast ranges terminating in a cul-de-sac in southern California with the opening towards the north. The cold arctic currents which favored the development of the diatoms, etc., were caught, and the diatomaceous material accumulated to the landward of the islands and in this bay.

In the southeastern portion of California, east of the Sierra Nevada Range and its continuations, the sedimentation of the period occurred in lakes rather than in the ocean. The character of the deposits suggests that conditions of marked aridity occurred throughout the Tertiary. The deposits formed by evaporation include borax, nitrate, sodium carbonate, salt, etc. The world's greatest accumulation of borax occurs in ancient lake beds of probable Miocene age. These beds are now turned up on end, so that the miner considers them as ledges rather than bedded deposits. The mining law is applied according to this interpretation. Secondary deposits have been leached from these strata, and deposited by evaporation in present day lakes and playas.

Other economic products, concentrated under the conditions of aridity, include not only sodium and magnesium salts, but also those of potassium, notably in the case of Searles Lake, San Bernardino County, California.

Coal is an important product of the Tertiary strata. In California the coal is of poor quality and erratic in distribution. Better deposits occur in Coos Bay, Oregon; and in Washington and the adjoining portions of Canada, the great deposits of the Puget Sound region occur. Washington coal, to some extent, has been replaced by California fuel oil, but at some future date the former will assume increased importance when the necessity of conserving the vast California oil deposits becomes more evident.

Other non-metallic products of Cretaceous and Tertiary age include asphalt, bituminous rock, onyx, and travertine, bauxite, clay, fullers earth, diatomite, and pumice, road metal and construction material.

MINERAL PRODUCTS OF CALIFORNIA, OREGON, AND WASHINGTON, FOR THE YEAR 1913, FROM "MINERAL RESOURCES OF THE UNITED STATES" (1914), PUBLISHED BY THE U. S. GEOLOGICAL SURVEY.

Product	Values California	Oregon	Washington
Asphalt	$ 1,680,179	$	$ ....
Borax	1,491,530	....	....
Cement	8,896,734	....	2,853,260
Chromite	2,854	....	....
Clay products	5,344,958	771,795	2,390,226
Coal	84,073	116,724	9,243,137
Coke	....	....	432,770
Copper	5,359,126	6,716	147,883
Gems and precious stones	26,507	2,975	500
Gold	20,406,958	1,627,710	696,275
Gypsum	230,936	....	....
Lead	154,631	3,837	8,909
Lime	569,874	30,704	178,945
Magnesite	77,056	....	....
Mineral paints	3,174	....	....
Mineral waters	531,925	19,409	18,834
Natural gas	1,883,450	....	....
Petroleum	45,709,400	....	....
Platinum	17,802	675	....
Pyrite	218,525	....	....
Quicksilver	627,228	....	....
Salt	745,708	....	....
Sand and gravel	439,009	432,938	385,886
Sand-lime brick	38,839	....	....
Silver	832,553	108,139	200,068
Stone	4,118,935	357,498	1,399,475
Talc	6,000	....	....
Tungsten ore	226,260	....	....
Zinc	59,219	....	....
Miscellaneous*	1,213,377	181,200	92,345
Total value eliminating duplications	$100,791,369	$3,563,919	$17,579,743

*For California: Other products, briquets, feldspar, fullers earth, infusorial earth, iron ore and pig, manganese ore, pumice, quartz, sulphuric acid, and tungsten ore, are included in miscellaneous.

*For Washington: Briquets, mineral paints, sand-lime brick, are included in miscellaneous.

Metallic products of Tertiary age also are of impressive value. The great belt of mercury deposits of the Coast Ranges of middle California were formed along a zone of fracturing which was probably initiated at the close of the extensive basaltic eruptions of middle Miocene times. Antimony is found in connection with some of the mercury deposits. Valuable deposits of gold and silver are found at certain favorable localities in the Tertiary volcanic rocks of the three Pacific Coast states. These were deposited by heated mineral-bearing currents formed subsequently to the enclosing lavas. The more notable examples occur at Bodie and Calico in southern California, in the Bohemia district, Douglas County, Oregon, and in the Republic district, Ferry County, the Monte Cristo district, Snohomish County, and the Pierre Lake district, Stevens County, in Washington.

Mineral springs, of value for medicinal and less often for potable properties, are distributed along the major structural lines of the west coast.

Finally, we may mention the underground water resources of the west coast. The amount, direction of flow, and availability of many of the underground currents have been studied by numerous geologists. It is to be hoped that the men engaged in the development of the agricultural resources of the vast Pacific Coast empire may become more familiar with the data already available.

How to Reach the Important Mines of California.—Mr. H. M. Wolflin, mining engineer for the Industrial Accident Commission of the State of California, has recently visited most of the mines of the State. At my request he kindly furnished the following information as to how the most interesting mines may be reached.

I. *Copper and Iron Mines of the Northern Part of the State:*

These can be reached from Redding on the main line of the Southern Pacific Railway from San Francisco to Portland.

1. The largest mine at present in operation is the Mammoth. The smelter and main office of the company are located at Kennett and can be reached by rail from Redding.
2. Other important mines in this district are: Balaklala near Coram, which can be reached by rail from Redding.
3. Mountain Copper Company at Keswick.
4. Heroult Iron Mines, situated near the town of Heroult, which is reached by Sacramento Valley Railroad, which connects with the Southern Pacific at the town of Pit.
5. Bully Hill Mine, reached by Sacramento Valley and Eastern Railroad from Pit.

II. *Principal Gold Mines of Trinity and Neighboring Counties:*

1. Gladstone Mine, situated near French Gulch, reached by stage from Redding.
2. La Grange Hydraulic Mine, near Weaverville, reached by stage from Redding.
3. Globe Consolidated, near Dederick, reached by automobile from Weaverville.

III. *Grass Valley District:*

Grass Valley is reached by Narrow Gauge Railway from Colfax, which is located on the main line of the Southern Pacific between Sacramento and Reno.

1. The principal mines at Grass Valley are the Empire, North Star, Pennsylvania, Brunswick, and Golden Center. These are all within walking distance of the Grass Valley hotels.
2. The Champion Mine is located near Nevada City and may be reached by interurban from Grass Valley.
3. The Plumbago and Tightner mines are located at Alleghany, which may be reached by stage from Grass Valley, except during the winter months.

IV. *Mother Lode District:*

It would probably be best for the visitor to the Mother Lode District to go to Jackson, California, and make this temporary headquarters from which he could visit the mines lying between Plymouth and Angels Camp, for there are plenty of stage lines and numerous opportunities for livery and automobile hire.

1. The following mines are within driving distance, say twelve miles of Jackson: Plymouth (at Plymouth), Fremont, Treasure, Bunker Hill, Original Amador, Keystone (Amador), Central Eureka, South Eureka (Sutter Creek, four miles from Jackson), Kennedy and Argonaut, within one mile of Jackson.
2. Angels Camp, reached by railway from Stockton via Jamestown: Utica and Gold Cliff mines, located near the town.
3. Jamestown: Harvard Mine is within walking distance of the town.

   The Dutch Mine is about six miles out and will have to be reached by livery team or automobile.

   The Eagle Shawmut is some six miles south of Jamestown and can be reached by livery team or automobile.
4. The Campo Seco Copper Mines can be reached by automobile or livery team from Valley Springs, California.
5. Melones Mine, located at Melones, California, reached by railway from Angels Camp or Jamestown.

V. *Quicksilver Mines:*

1. New Idria, reached by stage from Tres Pinos, near Hollister, or from Mendota, on the valley line of the Southern Pacific, or preferably by automobile from Hollister, except in the winter months. This is the largest operating quicksilver mine in California at present.
2. New Almaden and Guadalupe, near Los Gatos, can be reached by livery team or automobile from Los Gatos or San Jose.
3. Oceanic Quicksilver Mine, near Cambria, can be reached by automobile stage from San Luis Obispo. A daily auto stage meets the south bound Southern Pacific train which arrives at San Luis Obispo about 6:30 a. m.

4. There are a number of quicksilver mines in Lake and Napa counties, which can be reached by livery team from Calistoga or Middletown.

VI. *Randsburg-Johannesburg Mines and Searles Lake:*

Headquarters at St. Charles Hotel, Johannesburg. From this point the following may be reached by stage or automobile:

1. Yellow Aster Gold Mine at Randsburg.
2. Tungsten Mines at Atolia.
3. Searles Lake, Trona, where the American Trona Company is operating. Trona may also be reached by a new railroad from Searles.
4. Skiddoo Mine, reached by stage or automobile from Trona.

There are a number of other isolated mines which probably would not be of particular interest to the average visitor; for instance, the American Girl Mine near Ogilby, California, twelve miles west of Yuma; the mines of the Julian district, about sixty miles east of San Diego, reached most conveniently by automobile; the Dairy Farm Mine, reached by automobile or livery team from Lincoln, California; the mines near the line of the Western Pacific through Plumas County; etc.

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EARTHQUAKES

BY J. C. BRANNER
President, Stanford University

All parts of the earth are subject to earthquakes, but they are notably more common in some regions than in others. Some earthquakes are felt all over the entire globe, others are confined to areas of only a few square miles. It is a matter of common knowledge that the Pacific Coast is a region in which earthquakes are more frequent than they are in other parts of North America.

It is not uncommon for those who have had no experience of earthquakes or whose imaginations have been impressed by stories about them to suppose that earthquakes are, one and all, mysterious and disastrous cataclysms, while exaggerations of the most extravagant kinds often add to their fancied terrors. To suppose that earthquakes are necessarily disastrous, however, is as far from the truth as it would be to suppose that all rains produced disastrous floods or that all winds were destructive tornadoes.

As a matter of fact, earthquakes are natural phenomena, and there is no more reason for being alarmed by them than there is for being alarmed by wind or rain or snow.

Earthquakes are directly related to the geology of the regions in which they are felt. The shocks are simply vibrations, jars, or elastic waves, propagated through the rocks of the earth's surface. The vibrations are caused directly by the breaking of the rocks or by the slipping of them against each other. This breaking is due to uneven strain or pressure within the rocks themselves, and of sufficient energy to cause the displacement or slipping.

FAULTS.—When a fracture is produced and the beds or rock masses are dislocated these breaks are known technically as faults. The dislocations of the rocks along faults may be small or great, and the faults may be long or short, shallow or deep, and the movements may be vertical or horizontal or at any angle or in any direction whatever.

The depth of faults is probably limited to the outer ten or eleven miles of the crust of the earth for the reason that below that depth the rocks yield to the pressure of the overlying rocks and act somewhat like plastic bodies. Faults are not to be thought of as open gaping cracks, however, for, as a rule, the two sides of a fault are pressed closely against each other, and the stories of yawning chasms, and the swallowing up of people and buildings are the veriest fabrications. Indeed, faults do not necessarily appear at the surface of the ground at all, or, if they are visible, they are not necessarily conspicuous. The dislocation along the main fault on which the movement took place at the time of the 1906 earthquake in California was about eight feet, but in many places this movement was taken up in the crushing of the surface soil, while at others it appeared as a mere furrow. Nor is it to be supposed that all faults are liable to slip and to cause earthquakes. Some faults have long been inactive, and the rock faces have been recemented, and the rocks are now practically solid. Others, however, may be regarded as active faults and it is along them that the strains in the earth and in the immediate vicinity are relieved.

EPICENTER.—Earthquake shocks must necessarily originate well below the surface of the ground, and spread as elastic waves from the centers or planes of disturbance in all directions. From the points where they reach the surface (called the epicenters) they spread out on all sides, gradually dying out or becoming less severe as they get farther and farther from the epicenters.

Once the rocks are broken or faulted the strains within the earth and within a limited adjacent area, are relieved along the same faults, for the reason that on account of their being broken, movements are easiest and strains are most readily relieved and adjusted along those fractures. Within a given region the earthquakes, therefore, tend to repeat themselves in the same places.

INTENSITY.—The intensity or destructiveness of earthquakes is determined to some extent also by the nature of the ground. Loose materials containing water are more violently disturbed than are the solid rocks. This violence or high intensity is due to the fact that loose wet materials do not move as promptly as the solid rocks, but are tossed about like loose objects upon a table when the latter is jerked beneath them.

The earthquakes of California are almost invariably felt over limited areas only, and they are rarely severe enough to cause damage. And when damage is done it is quite as often due to faulty construction as to the violence of the shocks.

DISPLACEMENT.—The amount of actual movement of a point on the surface of the earth at the time of an earthquake is not as great as is generally supposed. The displacement is rarely more than five millimeters or two-tenths of an inch. A movement of three-hundredths of an inch is quite perceptible. The destruction caused by such slight movements is due not so much to the amount of displacement as to the time occupied in the displacement. These statements regarding movement do not relate to swinging or loose objects, however, or to the displacements along faults or to the slipping of unsupported banks of loose earth.

"EARTHQUAKE WEATHER."—One sometimes hears the expression "earthquake weather," implying that either the weather causes the earthquakes, or that an approaching earthquake modifies and determines the weather. But inasmuch as the weather is due to atmospheric conditions, and as earthquakes are produced by disturbances in the rocks of the earth's crust, evidently the relations between them must be very remote and certainly no such relations have been apparent from personal observations.

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MINES AND MINING

BY H. FOSTER BAIN
Editor, Mining and Scientific Press,
San Francisco

Gold was the magnet that drew population to the Pacific Coast of North America and set in operation the forces which transformed a region of forests and half-tenanted ranches into one of varied and important industries. But time is bringing changes in mining along the Pacific Coast. Only in Alaska and Oregon do the gold mines now make the largest contribution to the annual output. In California, petroleum now outranks it; while in Washington coal takes first place, and even in British Columbia, that province of marvelously varied mineral wealth, coal outranks not only gold, but copper, which there takes second place.

Using for convenience the more complete figures for 1913, and following the statistics compiled by the United States Geological Survey, it appears that the mineral output of the three Pacific Coast States is now as follows:

California	$100,791,369
Washington	17,579,743
Oregon	3,563,919
	$121,935,031

To this may be added the production of Alaska and British Columbia, $19,636,213 and $32,440,800 respectively, making a total of $184,012,044. The present production is at an even larger rate. The total is impressive even in these days of large sums. What is still more significant, however, is the large portion of the total which represents fuels and structural materials; the former accounts for $64,478,524, and the latter for $21,904,369. Of these the expenditure on structural materials—including clay products, stone, cement, and lime—represents money spent at home largely in building up permanent structures. In a sense, it stands for savings of the present for the future. The fuel, too, is largely consumed at home. Each barrel of oil or ton of coal represents work done by unseen hands; labor that does not eat and does not consume. The waterfalls, oil wells, and coal mines make up in part for the small population in the large area.

Mines and Mining

Ninety per cent of the mineral output of the Pacific Coast is represented by four items:

Fuel	$64,478,524
Gold	44,407,282
Structural materials	21,904,369
Copper	16,288,741

The remainder of the production is in widely varied form. California is the most important North American producer of quicksilver, and Alaska has the only important tin mine. Silver and lead are not mined in any large quantities on the Pacific Coast, though in eastern British Columbia there is a thriving industry and in the Coeur d'Alene, barely outside the state of Washington, is one of the world's great lead-silver districts, and at Tonopah, in western Nevada, there is a large silver production. The Comstock lode, nearby and easily accessible en route to or from California, produced so much silver as to disturb seriously the world's financial balance. On the Coast itself, however, silver is not common, though almost all the metals and non-metallic minerals of economic importance occur in the region and many of them are produced. It is not likely that in any period of present character the dominance of fuels, gold, copper and building materials will be challenged.

While the days of gold easily won from shallow placers have gone, gold mining is still a great industry and it is now based upon deposits that assure it a long life. The dredging fields, it is true, will be exhausted in a few years by the great 16-cubic-foot buckets used on modern boats, but the quartz mines grow in importance rather than the reverse. The reason is that each new device, each increase in scale of operations, so lowers the cost of production as automatically to convert into ore much that was previously too lean to rank as more than waste. When mining began at Juneau, small veins of quartz containing gold to the value of $20 per ton or more were worked, just as even richer veins have been, within a few years, opened near Sitka. Such veins are quickly exhausted, but the Alaska Juneau is now preparing to mine ore worth but $1.35 per ton net, and is counting on treating 12,000 tons per day. On this basis the supply is considered adequate for 300 years. Two neighboring mines, the Alaska Gastineau and the Ebners, are likewise arranging for wholesale production.*

* Juneau is easily accessible by comfortable steamers through the famous inland passage from Seattle and Vancouver. Connections from San Francisco by boat and train are excellent.

Approaching the Pacific Coast through Canada, the traveler has the choice of two routes of the Canadian Pacific. Both traverse regions of much scenic beauty and scientific interest. The more southerly one carries the traveler more directly into and through the mining regions. Leaving the great plains and crossing the mountains, the route tra-

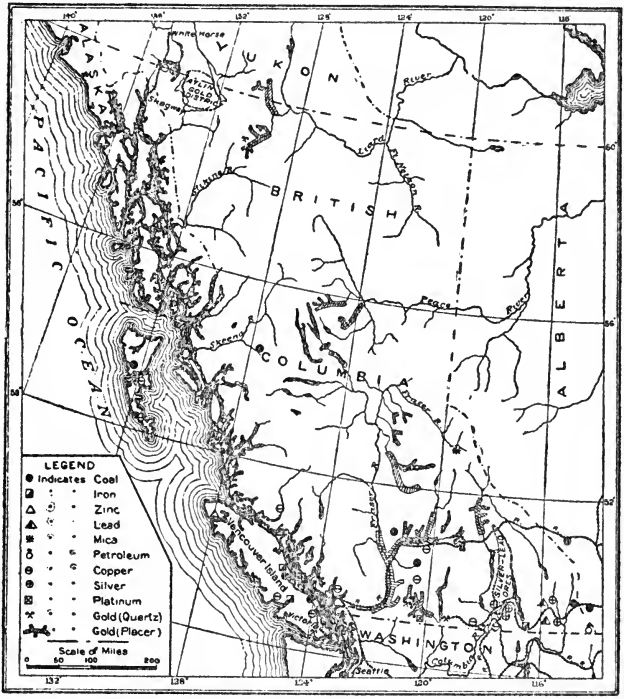

Figure 6

Mineral map of British Columbia.

verses the Crows Nest Pass coalfield, one of the most important in the West, and the source of the coking coal used in nearby smelters. West of the coalfield, in the Kootenay and Slocan region are important lead-silver mines such as characterize the Rocky Mountain province. Still farther west, at Greenwood, Phoenix, and Grand Forks, is a copper mining and smelting region of much interest. Southwest from Grand Forks an easy excursion may be made to Republic, the only, as yet, large gold mining district in the state of Washington. From Grand Forks, also, one may travel north and west to Vancouver and Victoria, from which latter place the Nanaimo coalfields are easily accessible. At present these fields are the most important sources of coal for the coast cities.

Turning south from Grand Forks to Spokane, Washington, or reaching the same city over the Great Northern or Northern Pacific, the traveler finds himself within an easy side journey distance of the Coeur d'Alene mining district in Idaho. This may also be reached direct from the East by taking the St. Regis Pass route of the Northern Pacific. However it may be approached, it will be found a district of much technical interest, aside from having the second largest output of lead in the United States. The lead, with silver and in places zinc, occurs in a pre-Cambrian quartzite and is prepared for smelting elsewhere in immense concentrating mills belonging to the Federal, Bunker Hill & Sullivan, and other famous companies.

From Spokane the route may lie direct west to Puget Sound, where coal mining may be seen in the vicinity of Tacoma, or southwest to Portland where the interests are agricultural, commercial, and lumbering, rather than mining. Indeed in Oregon mining is as yet but little developed though a traveler by way of the Oregon Short Line has opportunity by stopping over at Baker City to make a side trip to Sumpter, where gold-silver ores are mined. South from Portland on the main route to San Francisco there is little of especial mining interest to see until Shasta County, California, is reached, though near Grants Pass, Oregon, and in Siskiyou County, California, both placer and lode mining may be seen if one has time to pause.

Shasta County is California's most important copper mining district. It has produced about 450,000,000 pounds of copper and ranks tenth in the United States. According to L. C. Graton the ore bodies are in intrusive alaskite porphyries of Mesozoic age. The ore minerals replace this along shearing zones. The ore is mainly pyrite with chalcopyrite admixed and, in the eastern mines, the Bully Hill and Afterthought, important amounts of zincblende. Mining in the district has been depressed owing to trouble over smelter fume. The Bully Hill smelter, at Winthrop on a branch line from Pit, is closed; as is also the Balaklala at Coram. The Mammoth smelter, using a bag-house, may be seen to the west near Kennett, as may also the idle works at Coram. At Keswick another branch road leads off to the mines of the Mountain Copper Company, Ltd., which smelts its ore at Martinez, on San Francisco Bay, making sulphuric acid and fertilizer as by-products. At Heroult, on the branch line leading to Winthrop, are the furnaces of the Noble Electric Steel Company, where electric smelting of iron and manganese ores is undertaken. In passing through the Shasta River cañon also the traveler may glimpse an ill-fated gold dredge struggling not any too successfully against the stiff current and hard rock bottom. Below the cañon at Redding is

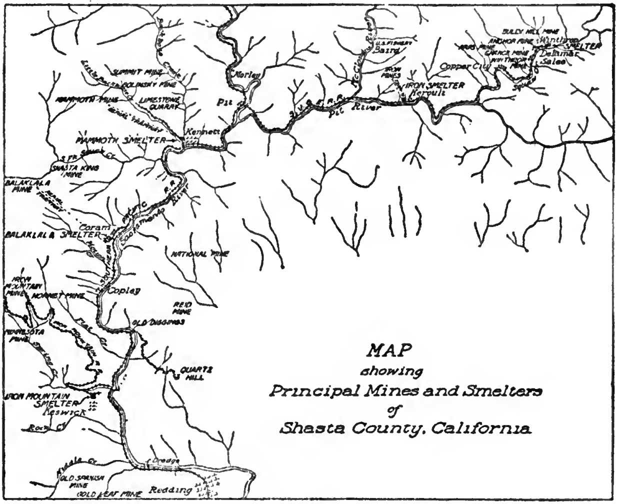

Figure 7
The Shasta mining region.

the point of departure for the gold fields of Trinity County, to be reached by stage. Both placer and quartz mining are conducted, but Weaverville is principally famous as being the centre of operations of the La Grange Mining Company, operating the largest hydraulic gold mine in the world. The property is now controlled by the Consolidated Gold Fields of South Africa, but is managed, as for years back, by Pierre Bouery, the genial Frenchman who marched with Marchand and has explored many of the far places of the earth. The La Grange is of the type of mines which made California famous and affords the best opportunity to see large-scale hydraulic mining. The water usually permits mining to continue into or through June.

From Redding south, if the route be by the east side of the valley, or if the traveler come from the east by way of the Western Pacific, he will see at Oroville one of the famous gold-dredging fields. Of the total gold production, of about $20,000,000 per annum that California now yields, 37½% is won by the dredges. These are huge machines mounted on boats floating in ponds, and digging as much as 65 feet below water level by means of a continuous

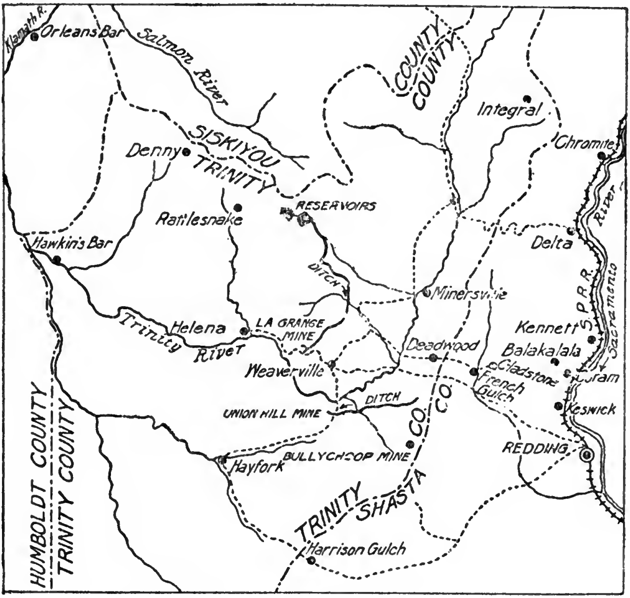

Figure 8

The gold dredging region of the Sacramento Valley.

chain of heavy steel buckets which scrape up or break off the gold-bearing gravel. It is delivered by the buckets to a big revolving trommel screen from which the fine material passes over riffles while the coarse rock is delivered, by means of a belt conveyor, to the rock pile in the rear. Most of the boats are held against the bank by steel masts or "spuds" dropped into the loose ground at the rear of the boat. The dredges are swung backward and forward across the face of the cut by wire ropes manipulated by winches. The whole machine is driven by electricity. Other important dredging fields occur east of Marysville, and at Auburn and

Folsom near Sacramento. There are a few dredges in other counties.

About half the gold now won in California comes from quartz mines. The minor part comes from hydraulic mines in Trinity, Sierra, Plumas, and other mountain counties. The great hydraulic mines of the Sierra Nevada were closed by debris troubles, but the old workings may be seen from the train near Dutch Flat on the main Southern Pacific line. Colfax, nearby, is the point of departure for the Nevada County Narrow-gage, a line leading to Grass Valley and Nevada City. Here are numerous famous mines. Perhaps the most notable are the Empire and the North Star where a 30-inch (approximately) quartz vein containing $11 to $18 per ton in gold has been worked to unusual depths. In the North Star, mining extends to 5390 feet in the plane of the vein, corresponding to a vertical depth of 2000 feet. To the close of 1912 the mine had yielded 1,064,782 tons, of a gross value of $15,515,515. The Empire mines have not yet extended to as great depth, but have been so profitable that a surplus equal to the full value of the capital stock has been accumulated. Both mines are notable for beauty of situation. At the Empire the grounds have been improved by most unusual landscape gardening and by building so that the visitor must revise any previously held notion of ugly mining camps. The ore is treated by stamp-milling, amalgamation, and cyanidation.

The California mining region made famous by Bret Harte and some of the Mark Twain stories (for example, The Jumping Frog of Calaveras) is now known as the Mother Lode region. Interest here centers in quartz mining. The five Mother Lode counties, Amador, Calaveras, El Dorado, Mariposa, and Tuolumne, yield $4,500,000 to $5,000,000 per annum. In general, mining is now in the zone extending from 1500 feet to nearly 4000 feet (vertical), in the Kennedy mine at Jackson. The Kennedy is the deepest gold mine in North America and one of the deepest in the world. The vein is wide, the walls are hard to hold, and square-setting and other methods of timbering require much attention. The ore is crushed by stamps and amalgamated, and the practice is simple. At the Plymouth mine on the north, however, and the Black Oak at Soulsbyville on the south, most modern fine grinding plants may be seen. At the Kennedy and at the Eagle-Shawmut, chlorination works are operated, and at the Kennedy there is a notable equipment of tailing wheels and a multiple arch dam to protect the mine from claims for damage by agriculturists below. The

Mother Lode region is easily accessible from Jackson, Angels, or Jamestown. West of it, and in the foothills, is the older copper region the importance of which has been dimmed by the development of Shasta County.

Quicksilver is one of the important minerals mined in California which still yields 20,000 to

Figure 9
The Mother Lode region of California.

25,000 flasks of 70 pounds each per annum. Quicksilver is found in the coastal range in connection with young rocks. One of the most famous of the mines, still an important producer, is at New Almaden, near San Jose, and easily accessible from San Francisco, as is also the St. Johns mine, near

Vallejo, and other properties near Napa. Among minerals of minor interest it may be noted that there is an active pyrite mine at Leona Heights on the edge of Oakland, while magnesite is mined in Alameda and Santa Clara counties, also near San Francisco. The most important magnesite mines are near Porterville and Fresno, in the big valley. Portland cement is made by the Standard Portland Cement Company at Napa Junction, and the Pacific Portland Cement Company at Cement, both works being near tidewater on San Francisco bay. The Pacific works are in sight from the main transcontinental trains near Suisun. The Standard Company also has works near Santa Cruz, and at Colton and Riverside in southern California there are large works. At Monolith, north of Mohave, are the works built to furnish cement for the Los Angeles aqueduct. The methods of cement manufacture on this Coast do not differ especially from those elsewhere, though oil is used as fuel at all California plants. The three in Washington burn with coal.

Visitors to San Diego will be near several famous gem regions, and those traveling across southern California will see typical desert mining. North of Mohave, accessible through Searles on the Southern Pacific, or Randsburg on the Santa Fe Railway, is Borax Flat, where the potassium works of the American Trona Corporation are situated. The famous borax mines are in Death Valley, reached by way of the Tonopah & Tidewater Railroad, while Bodie and other old mines of Owens Valley are accessible by rail from either Mohave, California, or Reno, Nevada. Limitations of space forbid more detailed mention of many interesting mineral industries on the Coast. In the Ferry building at San Francisco will be found the large collections of the State Mining Bureau. Maps and descriptive reports are available there, and detailed information will be given. At Los Angeles the Chamber of Mines and Oil maintains a similar service in the Germain building. In Oregon the State Geologist, H. M. Parks, State Bureau of Mines, Corvallis, will gladly answer inquiries. At Seattle the headquarters of the State Geological Survey, similarly equipped for service, is at the University. At Victoria, William Fleet Robertson, the Provincial Mineralogist, has unusually complete information regarding mining in British Columbia, and may be addressed.

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PETROLEUM RESOURCES AND INDUSTRIES OF THE PACIFIC COAST

BY RALPH ARNOLD
Consulting Geologist and Petroleum Engineer, Los Angeles

GENERAL STATEMENT: In 1914 the United States produced 292,000,000 barrels of oil, or about two-thirds of the world's production. California ranks first of all the states in the Union in the production and value of petroleum, the total output in 1914 being approximately 103,000,000 barrels, or a little more than 38 per cent of the total produced in the United States. Oil stands first in value in the State's mineral products, the output in 1914 being valued at about $50,000,000, as against $20,406,958 for gold, its nearest competitor.

The proved area of oil-producing territory in California aggregates from 100,000 to 125,000 acres, depending on the conservatism of the estimate. This last figure practically represents the possible acreage, as it does not seem probable that any more large districts will be discovered. For that reason, further development doubtless will be carried on within the limits of the proved fields or along the line of minor extensions of the same. Assuming the possible productive area confined to the present districts, California is still destined, according to the most conservative estimates, to hold premier place among the oil-producing states of the Union for many years.

With the exception of a negligible quantity of oil carrying some paraffine, all of the oil from the California fields has an asphalt base. This is in direct contrast to the oils of Pennsylvania and most of the eastern states, which are practically all of paraffine base. The gravity of the commercial crude oil ranges from 10° to 36° Beaumé (1.000 to 0.8433 specific gravity).

The wells vary in depth from 200 to over 5700 feet, the average probably being about 1500 to 1800 feet. There are now 5826 producing wells within the State, yielding a total daily average of 263,503 barrels in November, 1914, or a daily average per well of 45.2 barrels. This average is very high as compared with the daily average of the eastern wells, especially those in the older fields. The length of life of the wells varies from 10 to 25 or 30 years; the average probably will be 20 years or more. The California fields as a whole probably will have a life of from 50 to 75 years more, depending on the rate of development and the effect of the water troubles.

Historical.—The oil industry in California owes its origin to asphaltum mining, the first definite effort at development being in the Ojai Valley, Ventura County, in 1867, when a shallow well was drilled near one of the numerous brea or asphaltum deposits of that region, which had been worked for some time previously. Owing to the lack of proper tools for operation and insufficient knowledge concerning the handling of the heavy oil obtained, this well was not a success. Several years later, more determined development work was carried on in the region of Pico Cañon, in western Los Angeles County, where light oil suitable for refining was obtained, and a little later, development work south of Santa Paula, in Ventura County, and in the Puente Hills, southeast of Los Angeles, was rewarded by the finding of refining oils.

The discovery of the Los Angeles and Summerland districts in 1894 marked the beginning of the fuel-oil production in California. The Coalinga field was the first commercially productive district in the San Joaquin Valley, producing about 14,000 barrels in 1896. The Kern River district was discovered in 1900, this discovery marking the beginning of important development and the initiation of California as a factor in the world's oil production.

There are at present nearly 300 oil-producing companies operating in the State, with a combined production of about 103,000,000 barrels yearly. Nearly 90 per cent of this production is now controlled by the first three groups of companies to be mentioned below. The first group comprises the Southern Pacific Company and its subsidiaries, the Kern Trading & Oil Company and the Associated Oil Company, and controls the greater portion of the undeveloped land in proved territory which contains the bulk of the fuel-oil supply of the State. It also controls from 30 to 35 per cent of the present production of the State. The Standard Oil Company early entered into the transporting, marketing, and refining of oil in California and has pipe lines in every important district in the State, with refineries near San Francisco and Los Angeles. It controls over 30 per cent of the production of the State and the greater part of the refining industry. A group of companies, including the Union Oil Company, the General Petroleum Company, and the

Independent Oil Producers Agency, which are more or less closely affiliated, controls about 25 per cent of the State's yield. The Agency includes approximately 170 companies. The Royal Dutch-Shell interests have one large producing property and are actively entering into the refining and marketing end of the industry.

Figure 10

TRANSPORTATION.—One of the most important items in connection with the oil industry is that of transportation. Most of the oil in California is transported through pipe lines varying in size from four inches to ten inches in diameter, with pump stations situated from six to twenty-four miles apart. The daily capacities of the lines range from 2,500 to 30,000 barrels, depending on the size of the pipe, profile of the pipe line, and the viscosity of the oil handled. Tank cars carrying from 150 to 300 barrels are also used extensively, especially by the railroads. When the oil reaches tide-water it is carried by steamers or barges with capacities up to 65,000 barrels. (See fig. 10.)

The San Joaquin Valley districts are connected with tide-water at San Francisco Bay through lines 275 miles long; with Port Harford and Monterey by lines 80 to 110 miles long; and with Los Angeles Harbor by a line 158 miles long. The coast districts are all adequately supplied with lines up to 50 miles in length, connecting them with such ports as Port Harford, Ventura, and Los Angeles Harbor. The total carrying capacity of all the pipe lines in the State is about 350,000 barrels daily, their total length between 2,100 and 2,500 miles.

STORAGE.—Under normal conditions oil must at times be stored in fairly large quantities, and when there is an overproduction, as has been the case in California for the past several years, large quantities of the oil must be put by for future consumption. The storage facilities in use include open earthen reservoirs with capacities up to 1,000,000 barrels; covered, cement-lined reservoirs, and covered, reinforced-concrete reservoirs up to 750,000 barrels' capacity; and steel tanks of 37,500 and 55,000 barrels' capacity. The total storage capacity in the State is approximately 60,000,000 barrels, practically all of which is now filled.

REFINERIES.—During the earlier stages of the intensive development in the valley districts, little high-grade refining oil was secured, and even up to a year or so ago, gasoline was imported here from the East Indies. In the last three or four years fairly good refining oils of 21° to 30° Beaumé gravity (0.9271 to 0.8750 specific gravity) have been discovered in large quantities within the State, these, with the "tops" or lighter constituents from the heavier oils and the gasoline from casing-head gas, furnishing an adequate supply for the refineries.

The largest refinery on the Coast is that of the Standard Oil Company at Point Richmond, on San Francisco Bay. This has an estimated daily capacity of 60,000 barrels. The same company also has a 30,000-barrel refinery at El Segundo, near Los Angeles.

The Associated Oil Company has a refinery at Avon, on San Francisco Bay, daily capacity 20,000 barrels; another at Gaviota, Santa Barbara County, capacity 8,000 barrels daily; and a 5,000-barrel plant operated by its subsidiary, the Amalgamated Oil Company, near Los Angeles.

The Union Oil Company has a complete refinery, daily capacity 18,000 barrels, at Oleum, on San Francisco Bay; a 12,000-barrel topping plant at Port

Harford, and an asphalt refinery at Bakersfield. The General Petroleum Company has a very complete topping plant near Los Angeles, and the Royal Dutch-Shell interests are now building a large refinery near Martinez, on San Francisco Bay. There are about twenty-five small independent refineries throughout the State, most of them being located either near Los Angeles or San Francisco.

UTILIZATION OF THE OIL.—About 70 per cent of the oil produced in California is either refined or topped, the balance being used in the crude state as fuel or road dressing. The great bulk of the heavy oil is burned as fuel, the railroads using a very considerable part. Large quantities of heavy oil are also used for road surfacing, producing resistant dustless surfaces ideal for motor and other traffic. Crude oil is also used for sprays to combat insect pests, and in minor quantities for various other purposes.

The products of the refineries consist of gasoline, engine distillates, kerosene, lubricating oils, fuel and road oil, and a residuum of asphalt or coke. Gasoline is also condensed from casing-head gas in large quantities in those fields in the State furnishing "wet" gas. The gasoline is used largely in motor vehicles and for stationary gas engines; the engine distillate in gas engines for generating power for pumping water, and other purposes; the kerosene is largely exported to Asia and South America; the lubricating oils are used locally and exported. Asphaltum from the refineries has entirely replaced that formerly obtained by mining natural deposits, none of the latter at present being operated on the Pacific Coast. Asphaltum is used in paving and for roofing.

Most of the oil is utilized in the Pacific and adjacent States and western Canada, but some is exported to Hawaii, Japan, Alaska, Panama, and South America. Practically none reaches the Atlantic Ocean, nor is it likely that much will in the future, owing to the adequate supply of Mexico and Trinidad for the Atlantic seaboard markets.

GEOLOGIC FORMATIONS OF THE OIL DISTRICTS.—Oil is found in commercial quantities at one place or another in California in every important geologic horizon from the Chico or upper Cretaceous to the Fernando or Pliocene. These formations are all much younger than those from which the oil of the eastern United States comes, and there is little connection between the two provinces either in origin, character of oil, or mode of occurrence.

The principal formations involved in the California oil districts, in order of age, beginning with the oldest, are:

Jurassic or pre-Jurassic crystalline rocks; occurrence of oil rare.

Franciscan formation, probably of Jurassic age, of metamorphosed sediments with associated serpentine dikes; very minor quantities of oil in northern California.

Knoxville-Chico Cretaceous conglomerate, sandstones, and shales; commercial quantities of paraffine-asphalt base oil at Coalinga.

Tejon or Eocene sandstone and shale; minor quantities of paraffine oil at Coalinga.

Sespe or Oligocene red conglomerate, sandstone and shale; commercially petroliferous in Ventura County.

Vaqueros, lower Miocene, and Monterey, middle Miocene, sandstones and shales; the reservoir for much of the oil in the Coalinga, Santa Maria, Santa Clara Valley and Puente Hills districts.

Fernando and equivalent formations, upper Miocene-lower Pilocene, conglomerates, sandstones and shales; carrying commercial quantities of oil in nearly every district in the State.

The great bulk of the oil comes from the Miocene formations.

ORIGIN OF THE OIL.—The oils of the California fields are believed to have been derived largely from the organic shales which are associated with the oil-bearing beds in all of the fields of the State. It is believed that the oil originated from the organic matter, both vegetable and animal, once contained in these beds. Probably the principal source of the oil has been the diatomaceous deposits, which make up a large percentage of the Tejon or Eocene formation in the Coalinga district, and the Monterey or lower Miocene formation throughout the balance of the districts. Other organisms that may also be the source of some of the oil are plants, foraminifera, bryozoa, and possibly molluscs and fish. A great deal of evidence can be advanced favoring the organic origin of the oil in California, and enough demonstrating the impossibility of its inorganic origin locally to practically prove the former theory by the process of elimination.

RELATION OF GEOLOGIC STRUCTURE TO OIL DEPOSITS.—Commercial quantities of petroleum occur at one place or another in the California oil fields in practically every form of geologic structure known to the Coast Ranges. When it is remembered that the Coast Ranges of this State afford some very involved folds and faults, complicated by igneous intrusions, the significance of this statement is apparent. In the San Joaquin Valley fields the occurrences are usually associated with moderately low-dipping monoclines, local areas of maximum concentration being determined by cross anticlines, which are developed on the monocline or plunge obliquely off it into the adjacent valley. In some instances the synclines associated with these anticlines are also productive. In one case a dome is developed on the flank of a monocline. The Coalinga anticline, the largest of the subsidiary structures, is 65 miles in length. The areas of concentration in the coastal fields are usually determined by well-defined anticlines, or nodes or domes on long and sometimes sinuous folds.

Practically all of the wells secure their oil from porous marine sedimentary sandstone. In rare instances, notably in the Santa Maria district, a portion of the oil comes from cracks and interstices in fractured, hard, flinty shales. The oil reservoirs are usually capped by hard blue or brown shale or clay. Occasionally, as in the McKittrick and Los Angeles fields, impervious beds, brought into position by horizontal or oblique faulting, have acted as an efficient barrier to the escape of the oil, while in others the oil sands are sealed by the asphaltic contents near the outcrop.

The oil sands in the California fields are usually associated with water sands, known as "top" or "bottom" in accordance with their occurrence above or below the oil sands. "Edge" water also occurs in most of the fields and its entry into a well marks the termination of the productivity of the well, as it occurs in the same bed with the oil and follows it up as the oil is removed from the stratum. The problem of casing out the water from the oil sands is one of the most serious confronting the operators of the State, and great damage has been done, and is now being done, by water which, through carelessness or ignorance, has been permitted to flow into the productive sands, thus lowering the quality of the oil and retarding or completely stopping their production. Voluntary remedial measures are being practiced throughout all of the fields and, with care, much damage can be averted in the future.

TECHNOLOGIC METHODS.—The standard churn drill or cable method and the rotary method of drilling are both utilized in the California fields. The former is by far the more common and is in use in those fields in which the wells are shallow or the formation hard. The standard method is also more desirable for drilling test or "wild-cat" holes, as the logs obtained by this method are more reliable than those obtained by the rotary. The rotary is used in the moderately deep wells, 2000 to 3500 feet, when the formation is largely soft. A combination of the two methods is often advantageous, the depth being obtained by the rotary and the hole finished by the standard. The "circulation method," a combination of the standard drilling tools and the rotary method of removing the debris from the bottom of the hole by circulating water, is sometimes used.

Cementing is now nearly always resorted to in shutting off the water. The pumping method, dumping the cement from a bailer, and forcing down the cement between discs which fit snugly inside the casing, are among the ways in which the wells are cemented. Two to twenty-five tons of cement are used in the process, seven to ten tons being the usual amount in the deep holes.

Many of the wells flow of their own gas pressure, especially when first brought in, but sooner or later pumping has to be resorted to. The plunger pump, air lift, and various modifications of these standard methods are in use. Steam, gas, and oil engines, and electricity, are utilized for power generation in connection with the pumping operations, while steam is still used almost entirely in drilling and in the large pumping plants along the trunk pipe lines.

THE OIL DISTRICTS: Eleven principal districts furnish the oil in California, these, in their order from north to south, being as follows:

San Joaquin Valley Districts	Estimated Production for 1914	
Coalinga	15,925,887	bbls.
Lost Hills	4,830,921	"
McKittrick	3,820,857	"
Midway and Sunset	50,025,843	"
Kern River	7,030,545	"
	81,634,053	"
Coast Districts		
Santa Maria	4,303,080	bbls.
Summerland and miscellaneous	83,118	"
Santa Clara Valley	968,421	"
Los Angeles	2,504,475	"
Puente Hills	14,130,548	"
	21,989,642	"
Total	103,623,695	"

The relative location of the districts is shown on the accompanying map.

Coalinga District.—This district is the northernmost of the important ones of California and is situated on the southwestern edge of the San Joaquin Valley, in Fresno County, 170 miles southeast of San Francisco. The proved oil-bearing area embraces about 25,154 acres, or forty square miles. It is connected with Monterey, Port Harford and San Francisco Bay by adequate pipe lines. The wells in this district, of which there are now 807 producing, vary in depth from 300 to 4700 feet; the daily production per well ranges between 4 and 3000 barrels, with a present daily average of 51.2 barrels. The product varies in gravity from 12.4° to 34.5° Beaumé (0.9833 to 0.8519 specific gravity), some of the oil carrying as high as 4 per cent of paraffine, the highest of any in the State. The oil comes from the Chico (Cretaceous), Tejon (Eocene), and Vaqueros and Jacalitos (Miocene) formations on the flanks of a great monocline, across which a fold known as the Coalinga anticline is developed. The upper end of the plunging syncline between this anticline and the outcrop of the oil sands of the monocline is also oil-bearing.

Lost Hills District.—This district, in which is included the recently-discovered Belridge field, lies in the northwest corner of Kern County, about forty miles south of Coalinga. The proved area of the Lost Hills field proper consists of a strip six miles long and 1000 to 2000 feet wide, along the crest of the Coalinga anticline, embracing about 1300 acres. The Belridge field occupies a locally-saturated area of 1100 acres or so on the Temblor monocline, eleven miles south of Lost Hills.

Adequate pipe-line connections are had with Port Harford and San Francisco Bay. The wells, of which there are now 251 producing, range in depth from 500 to over 2000 feet; the daily production varies from 10 to 500 barrels, with a present daily average of 49.3 barrels. The oil from the north end of the field comes from the Jacalitos (middle Fernando) upper Miocene formation and is of 18° Beaumé gravity (0.9459 sp. gr.), while that from the south end of the district comes from the Santa Margarita (lower Fernando) and ranges from 30° to 40° Beaumé (0.8750 to 0.8235 sp. gr.).

McKittrick District.—The McKittrick district occupies a narrow strip along the foothills in Kern County, near the southwestern corner of the San Joaquin Valley. The McKittrick field proper is separated from the north end of the Midway field by only two or three miles of unproductive territory, but the structure of the two districts is very distinct. The proven territory in the field includes about 1096 acres. The wells, of which there are 247 now producing, range in depth from about 600 to 1800 feet; the oil is dark-colored and varies from 12° to 20° Beaumé (0.9859 to 0.9333 sp. gr.). The production of the individual wells varies from 2 to 1000 barrels per day, the present average being 43.2 barrels. The structure of the field is very complex, three distinct and, in some instances, overturned and overthrust folds being involved. On this account relatively more dry holes have been drilled in this district than in any other in the State. The oil comes from sands in the basal McKittrick (middle Fernando), upper Miocene formation. The cap rock over a part of the field is middle Miocene (Monterey) shale thrust horizontally over a nearly flat-lying upper Miocene oil-sand zone.

Midway-Sunset District.—The Midway and Sunset districts are continuous and lie in the southwestern corner of the San Joaquin Valley, in western Kern County. They include about 90 square miles, or 57,117 acres, of proved oil-bearing ground, probably the largest continuous area in the world. There are 1274 producing wells in the two districts, varying in depth from 500 to over 5000 feet. The oil ranges from 11° to 29° Beaumé (0.9929 to 0.8805 sp. gr.), and oil of 36° Beaumé (0.8433 sp. gr.) has been found in the Elk Hills field. The production of individual wells varies from 10 to 2500 barrels daily, and a flush production of 58,000 barrels daily was recorded for the famous Lake View No. 1, which produced over 8,000,000 barrels in eighteen months. The present average daily production is 94.4 barrels. The oil comes from sands, largely of upper Miocene age, in the Temblor Range monocline and subsidiary anticlines developed on its flank, the principal secondary folds being the Elk Hills, Buena Vista Hills and Thirty-five anticlines.

Kern River District.—The Kern River district lies on the low rolling hills at the foot of the Sierra Nevada, in the southeastern corner of the San Joaquin Valley. The proved territory has an area of about 6400 acres, or ten square miles, having an irregular elliptical form, with its longest axis extending in a northwest-southeast direction. The productivity of the wells within this area varies with the distance from the center in a more or less uniform ratio, the more productive wells being located near the central portion. The depth to the productive oil horizons varies from 400 feet on the northeast rim of the fold to 1100 or 1200 feet on the south and west borders. The average depth of all the wells in the district will approximate 900 feet, and the gravity of the oil produced averages about 14° Beaumé (0.9722 sp. gr.). It is used mainly for fuel and the manufacture of asphalt. There are 1228 producing wells, their average daily production per well being 15.4 barrels. The oil comes from the sands of the Fernando horizon (upper Miocene), which are here slightly domed on the flank of a great monocline. From 200 to 400 feet of productive sands are encountered in the wells.

Santa Maria District.—The Santa Maria district lies in northern Santa Barbara County, in the region of rolling hills and sinuous anticlines between the Santa Ynez and San Rafael mountains. The district comprises the Santa Maria or Orcutt field, Lompoc field, and Cat Cañon field, which include, respectively, 6000, 4390 and 7505 acres of proven ground, a total of 17,895 acres. The wells, of which there are now 220 producing, range from 1000 to 5200 feet in depth, the great bulk of the production coming from wells over 2500 feet deep. The individual wells yield from 60 to 2500 barrels daily; the gravity of the oil being from 18° to 31° Beaumé (0.9459 to 0.8695 sp. gr.) in the Orcutt field; 16° to 37° Beaumé (0.9589 to 0.8383 sp. gr.) in the Lompoc field; and 11° to 19° Beaumé (0.9929 to 0.9395 sp. gr.) in the Cat Cañon field. The oil from the first two fields is largely used for refining; that from the last for the manufacture of asphalt and for fuel. The oil from the Orcutt and Lompoc fields comes from the Vaqueros and basal Monterey (lower and middle Miocene) formations; that from the Cat Cañon field from the Fernando or upper Miocene. The fields are all situated on well-defined anticlines, the maximum production coming from nodes or domes on the main folds.

Summerland District.—The Summerland district owes its importance largely to the fact that its oil is obtained from wells which penetrate sands lying below the Pacific Ocean, and one of the most novel and interesting sights along the coast of California is that of the wharves carrying the derricks which mark the location of these unique wells. The field lies in southern Santa Barbara County and the productive area covers about 125 acres. The wells, of which there are now 125 producing, range in depth from 100 to over 600 feet and originally produced as high as 100 barrels daily; the average daily production is now 1.3 barrels per well. The oil varies from 10° to 18° Beaumé (1.000 to 0.9459 sp. gr.), and because of its high asphalt content, is used largely for asphalt manufacture and road dressing. The oil comes from sands of Fernando age, lying as a seaward-dipping monocline, complicated by a transverse anticline. (See Pl. VIII.)

Santa Clara Valley District.—The Santa Clara Valley district includes several isolated fields or pools situated in the mountains of southern Ventura and northwestern Los Angeles counties, 30 to 90 miles northwest of Los Angeles. The principal fields are the Ojai Valley, Sulphur Mountain, Sespe, Hopper Cañon, Modelo, Bardsdale, Montebello, Torrey Cañon, Pico Cañon, Newhall and Simi. The total proven territory is about 6895 acres. The wells vary in depth from 250 to 3700 feet, and in productive capacity up to initial flows of 500 barrels daily. There are at present 430 producing wells in the district, with an average daily production per well of 5.9 barrels. The oil ranges from 11° Beaumé (0.9929 sp. gr.) in the Ojai field to 38° Beaumé (0.8333 sp. gr.) in the Simi and Montebello fields; most of the oil now produced is of the higher grades. The oil is obtained from sands ranging in age from the Tejon (Eocene) to the Fernando (Miocene-Pliocene); the productive areas are small and are usually associated with anticlines or nodes on anticlines, which in some cases are very steep-sided.

Los Angeles District.—The sight of oil derricks distributed thickly among the residences of a great city is the unique feature of the Los Angeles oil field. The producing territory extends from a point in the northern part of the city near the Los Angeles River, westward for about five and a half miles to what is known as the Salt Lake field. The area includes about 1722 acres. In the City field proper the wells vary in depth from 500 to 1200 feet, and the oil from 12° to 19° Beaumé (0.9859 to 0.9396 sp. gr.). The initial production of the wells varies from 10 to 200 barrels; the average now is about 2.4 barrels per day. The wells in the Salt Lake field vary from 1200 to over 4000 feet in depth, the average gravity of the oil being between 16° and 18° Beaumé (0.9589 and 0.9459 sp. gr.). The initial production of individual wells in this field has run as high as 5000 to 10,000 barrels per day. There is a total of 700 wells now producing in the entire district, the average daily yield being 8.9 barrels. The oil comes from the lower Fernando formation and upper Monterey (upper Miocene), the productive sands lying normally as a monocline, in some cases faulted near the outcrop and in others complicated by minor anticlinal cross folds.

Puente Hills District.—The Puente Hills district has come forward recently as one of the richest

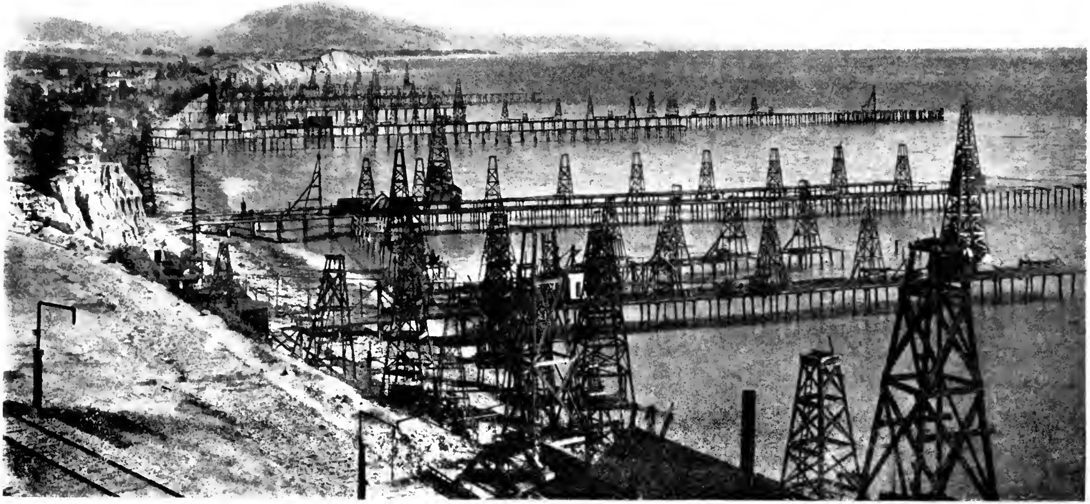

PLATE VIII
Oil Wells at Summerland, Santa Barbara County, California, Showing the Ocean Bluffs in Front of Sumerland, the Wharves and Derricks Over the Wells.

Photograph by G. H. Eldridge.

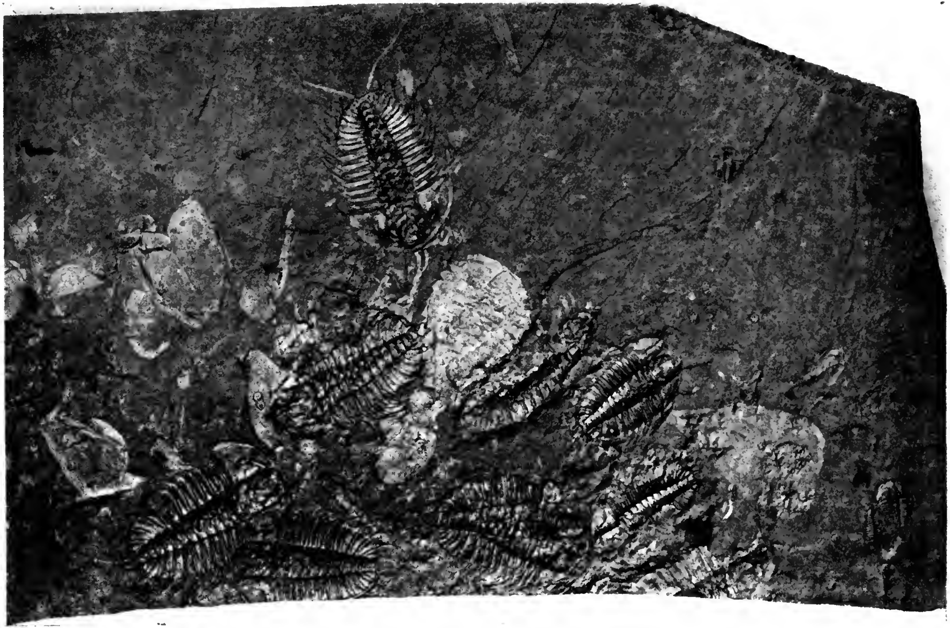

PLATE IX

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.

in the State, due to the development of some deep flowing wells at the west end of the Coyote Hills anticline, north of Fullerton. The district comprises the Whittier, Coyote Hills, Puente and Olinda (Fullerton) fields, and includes 8150 acres of proven ground. The wells range in depth from 600 to 5725 feet; the gravity of the oil varies from 15° to 33° Beaumé (0.9655 to 0.8589 sp. gr.). The initial production of the wells, of which there are now 544 producing, has ranged as high as 10,000 barrels in the Coyote Hills field; the average for the entire district in November, 1914, was 73.9 barrels per well. The oil occurs in sands of the Vaqueros, Monterey, and lower Fernando formations, all of Miocene age. The structure ranges from typical anticlines to overturned anticlines, fault zones and faulted monoclines.

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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

INTRODUCTION.—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

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 91. 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 Samwel Cave Fossil Lake	San Pedro Merced	Rancho La Brea
	Pliocene	Thousand Creek Ricardo	Merced Purisima	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 Limestones West Humboldt Range	Shasta Limestones West Humboldt Range Aspen Ridge	
Palaeozoic	Permian		Shasta County	
	Carboniferous		Shasta County	
	Devonian		Kennett	
	Silurian		Plumas County	
	Ordovician			
	Cambrian		Field, B. C. Inyo	

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

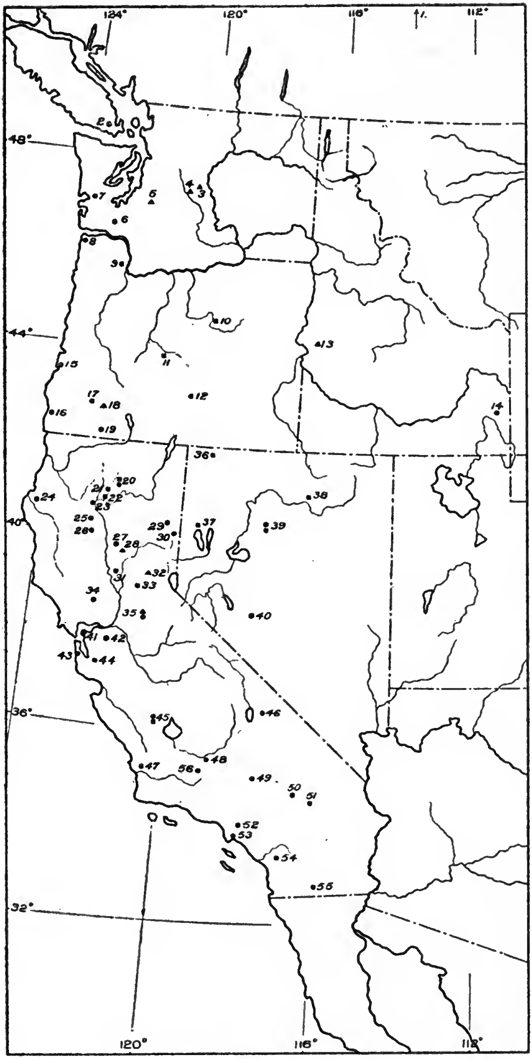


Figure 11
Geographic situation of important localities at which fossil remains are found in the West Coast region. Legend for locality numbers on opposite page.

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.

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 preservation. 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 California. 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 development 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 material 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 exceptionally 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.

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 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.

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 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.

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 Reptile 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, Skulls of the Extinct Horse and Bison, and Limb Bones of the Camel and Mastodon.

Photographed by John C. Merriam.

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.

THE VERTEBRATE FAUNA OF THE PACIFIC COAST

BY JOSEPH GRINNELL
Director, Museum of Vertebrate Zoology, University of California

THE observant traveler has in one respect a distinct advantage over the resident naturalist: the traveler is enabled to secure first impressions in rapid succession of the conspicuous peculiarities of the various regions through which he passes; in other words, even though his survey may be extremely superficial, many facts having to do with variation in faunal complexion from place to place are borne in upon his senses as they certainly never can be upon those of the sedentary naturalist.

The vertebrate fauna of the Pacific Coast region of North America shows wonderful variation often within limited space. The tourist reaching the Pacific Coast for the first time across any one of the transcontinental routes from the East will be astonished at the great and abrupt changes in evidence in the flora as he emerges from the interior desert tracts toward the seacoast. No less striking are the abrupt transformations in faunal complexion.

Roughly speaking, there are two main intersecting division lines in faunal demarkation: the one shows a general east and west trend, though tortuously diverted along mountain ranges, and divides the Pacific Coast area into a northern or Boreal region and a southern or Austral region, evidently having to do with temperature; then there is a north and south dividing line which separates the region into a Pacific Coast strip, of obviously humid climatic conditions, and an interior, much more extensive area, conspicuously arid. Correlated with the quadrants thus roughly designated are four major sets of animals, each one of which possesses a greater or less proportion of peculiar specific, generic, or even family types.

The student of faunistics in the West is, however, soon impressed with the fact that there is really no such simple situation as above indicated. The broken topography, with lofty elevations, and the long coast line extending from the latitude of Sitka, far up in the belt of the prevailingly westerly winds, to the horse latitudes of Lower California, constitute some of the important factors which lead to great diversification locally in temperature and humidity. Within the single state of California the effects of this climatic diversity on the animal life are abundantly illustrated. Terrestrial vertebrate animals at home within the boundaries of the state are representative of the life of the far North and of that of portions of Mexico. Marine life, of both cold and warm waters, is also abundantly represented. The result is a very large number of species and higher groups in proportion to the size of the area. Within the state of California alone there have been detected up to the date of writing this chapter a total of 361 species of mammals, 539 of birds, 76 of reptiles, and 24 species of amphibians. It may be stated with confidence that no other state in the Union, or even contiguous pair of states, possesses so many species as California, unless Texas proves more prolific than present knowledge indicates.

It is true that visitors to California have complained of the apparent lack of bird life as compared with their home localities on the Atlantic Coast or in the Middle West. There is doubtless some basis for this impression locally in California, to be accounted for on the grounds of sparse vegetation, lack of water, or cultivation by such methods as leave little waste ground where birds can forage. Some one has suggested, too, that many native birds on the Pacific Coast are still adjusting themselves, though slowly, to the conditions of cultivation and settlement, and that before many more years have elapsed our races of wrens, martins, and bluebirds will be as familiar about our California homes as are their counterparts in the East. Our mammal population certainly includes an abundance of individuals as well as of species. Even the most arid parts of the great deserts, of forbidding aspect, possess a phenomenal population. In order to appreciate this numerical feature the enquirer must resort to systematic trapping; for the great majority of our mammals are strictly nocturnal in their habits.

It will probably prove most profitable to the reader who is privileged to journey in the West if we present an outline, though of necessity severely brief, of the more conspicuous elements in some of the faunal subdivisions of the country likely to be traversed.

In considering the distributional areas of western North America, it may be explained that the term life zone is applied to the unit of largest area. Six of these life zones are recognized north of the Mexican line. These are, enumerated from south to north, Lower Sonoran, Upper Sonoran, Transition, Canadian, Hudsonian, Alpine-Arctic. The three zones above Transition are often grouped together and spoken of as Boreal, while the two Sonoran are together designated as Austral. The Transition zone, as its name implies, is an area of overlapping and blending of the two main divisions. In a general way all these zones or belts of animal and plant life exhibit a general east and west trend; but in California, because of the effect of the adjacent ocean, and the great altitude and north and south trend of the mountain ranges, the zones apparently bear little relation to latitude (see life zone map of California, Pl. LXIII).

The extremes of climate are so great within the limits even of California that all six of the zones named are represented within its confines. The traveler who will seize the opportunity, and devote a week or so to a side excursion, may best appreciate the fact of the existence of these life zones by journeying up over the crest of the high central or southern Sierra Nevada. In much smaller limits and briefer time the ascent of one of the high mountains of southern California such as San Jacinto Peak or San Gorgonio Peak will serve to demonstrate the same situation.

A section across the central Sierra Nevada in the latitude of San Francisco will pass through the Yosemite Park. In following the Yosemite Valley Railroad out of Merced the sightseer for the first hour traverses the floor of the San Joaquin Valley toward the foothills. From the train along that section of the route traversing the Merced River bottom he will note Fremont cottonwoods, valley oaks, and planted orchards of fig, olive and orange trees, all indicative of the Lower Sonoran zone. A day put in appropriately at a representative point in this valley area will show the presence of mockingbirds about the ranches, a peculiarly Californian species of beaver along the river, and many other exclusively warm-belt types of animal and plant life.

A little above Merced Falls the railroad enters the first foothills of the Sierra Nevada, and concurrently appear with remarkable abruptness an entirely new set of trees and lesser plants accompanied by as distinct a set of birds and mammals. The Upper Sonoran zone has been entered and may be recognized in distant view by the presence of the digger pine, the blue oak, and by a host of bushy plants which constitute the chaparral. Some birds which may be seen throughout this zone are: California jay, brown towhee, wren-tit, California thrasher, Anna hummingbird, and California bush-tit. Industrious trapping would disclose characteristic species of gophers, wood-rats, chipmunks, and mice of various genera. The Upper Sonoran zone continues for fifty miles until El Portal is reached where, on certain warm sun-facing slopes, it extends up to an elevation of over 4000 feet.

At the same point, El Portal, 2000 feet altitude, on cool, north-facing slopes, the visitor for the first time encounters the Transition zone, characterized conspicuously by yellow pine, incense cedar, black oak, and certain kinds of deer-brush *(Ceanothus)*. Proceeding by stage into Yosemite Valley the naturalist finds this zone represented continuously throughout the floor of the Valley and up to about 6000 feet altitude around its walls. Very few typically Upper Sonoran animals extend their ranges so far as the floor of the Valley. Instead, one encounters the blue-fronted jay, robin, western bluebird, junco or snowbird, and woodpeckers of several species, notably one with a white head.

If the tourist be of hardy frame and ambitious nature he will want to push on east by trail to the top of the great Sierran crest. In so doing he will traverse the remaining three life zones. Upon emerging by way of, say, the Tenaya trail upon the rim of the Valley he will enter forests of silver and red fir and lodgepole pine, these trees in company characterizing the Canadian zone. Here he will find bird life more plentiful than in the Yosemite Valley below, and many new kinds will make themselves known by sight or sound. Restless droves of golden-crowned kinglets and mountain chickadees enliven the tree tops far overhead; nuthatches of three species call incessantly; the curious Clarke nutcracker shows obvious interest in the wayfarer, for he expects to find forage about the camping places; and sapsuckers of two species add to the census of woodpeckers. These are only a few among the many birds of the Canadian zone, while mammals are likewise plentiful and include characteristic species of chipmunks, gophers, red squirrels or chickarees, porcupines, bushy-tailed wood-rats, and many kinds of mice and shrews.

The Hudsonian zone is the belt of forest just below timberline, and in it are encountered such trees as the Alpine hemlock and white-bark pine, together with several mammals and birds more or less restricted to it. Above timberline, at about 10,000 feet altitude and for some one or two thousand feet farther, plant life of dwarfed types continues, and here the rosy finch and the rabbit-like cony find their permanent abode. They, with other similarly restricted species, characterize the Alpine-Arctic zone.

In so brief a portrayal it is practically impossible to carry to the reader a satisfactory idea of the facts of zonation as they really are. The traveler who goes out to see and learn will quickly secure vivid realization of this order of distributional behavior.

Now, if one extends his acquaintance to other areas of California he will rarely be at a loss to diagnose any locality as to zone; but minor differences will present themselves, and these will come to link themselves in his mind with differences in humidity, just as the life zones do with temperature. Thus, while wren-tits and brown towhees and wrens and thrashers are to be found in the Upper Sonoran zone of both the Yosemite section and the San Francisco Bay region, the subspecies represented in the two areas are in these cases more or less distinct. Some very different species, too, are severally characteristic of the humid divisions of the different zones. These subdivisions of life zones are called, in a restricted sense, faunal areas, some, of weaker peculiarities, subfaunas.

Then there are still other divisions—associations. In each zone and in each fauna one finds certain types of vegetation and surroundings repeated; for example, stream side, marsh, meadow, brush belt, and forest, with minor variations. In each of these is likely to be found a peculiar set of birds and mammals, adapted to the narrow range of conditions imposed. Thus, as will be readily understood, is it possible to designate the range of a bird or a squirrel or even a reptile or amphibian with fair accuracy. For example, the black-footed gray squirrel belongs to the forest association, to the Santa Cruz subfaunal division of the humid coast belt, to the Transition life zone.

The fascination attending this study of the geography of animals lies not alone in the exhilaration of exploring and search for rare specimens through interesting regions, but in the infinite bearing such findings have upon the problems of the origin and behavior of species through both space and time.

Of the many minor subdivisions of the western United States the most distinctive is that to which the term Californian Fauna may be closely restricted. There is apparently no counterpart or analogue on the Atlantic side of the continent. It is an aggregation of animals occupying the vast extent of lower mountain and foothill country of southern and west-central California sometimes known as the chaparral belt. This belt lies wholly within the Upper Sonoran zone, and shows associational variations locally, but on the whole is remarkably uniform. (See Pls. XX and XXVI.)

Botanists tell us that the plants of this belt are of relatively ancient origin and that they are quite certainly indigenous. The same may be said of most of the birds and some of the mammals which we find restricted to the chaparral belt. Among these are to be counted the huge grizzly bear of California, now exterminated, and the nearly extinct condor. Of the smaller mammals peculiar to the same belt we may mention the diminutive brush rabbit, the parasitic white-footed mouse, like the grizzly the largest member of its numerous tribe found in North America, and certain species of five-toed kangaroo rats. Of the birds, we must call particular attention to the California thrasher, of marvelous song exceeding in clearness of tone and general execution that of the mockingbird, the California brown towhee, the California bush-tit, the rufous-crowned sparrow, the Bell sparrow, the California jay, and the wren-tit, the latter so different from any other bird of America that it is placed in a genus and family all of its own. (See Pl. XII.)

If the visitor wishes to see for himself this peculiarly Californian fauna and flora, let him penetrate the chaparral slopes at some typical and accessible point. It will, however, require more than a few minutes; one should spend days in order to adequately understand the environmental characteristics as well as the inhabitants. The Mount Lowe railroad north of Pasadena, passing through a chaparral belt 2000 feet or more in vertical width, the railroad to Yosemite winding for fifty miles or more through the foothills of the western slope of the Sierras, and the trail or railroad up Mount Tamalpais, afford paths along which are many points sure to serve well as bases of observation.

The humid coast strip of British Columbia, Washington, Oregon and northern California is quite uniform in faunal character. The luxuriant vegetation is of a northern or Boreal type, consisting chiefly of coniferous forests and undergrowth of various northern plant types. With the animals, too, we find a preponderance of northern types, though at the south, from the vicinity of Humboldt Bay to the extreme southern part of the coast belt proper, in Monterey County, California, one finds an admixture with southern elements. Birds and mammals in the northern coast belt are, relatively to adjacent districts, more plentiful in individuals than they are in species. Of the more interesting kinds may be mentioned the Columbian black-tailed deer, famed in sportsmen's annals; the Roosevelt elk, now reduced to small remnants existing in extreme northwestern California, western Oregon and the Olympic region of Washington; the strange rodent called *Aplodontia* or mountain beaver, which lives in burrows in wet hillsides overgrown with rank clumps of sword fern; the peculiar shrewmole, as its name implies combining the external features of the shrews and of the moles, but probably descended from some Asiatic stock not closely similar to either; the varied thrush, or Oregon robin, whose weird yet sweet notes may be heard throughout the summer south even to the Humboldt redwoods and in winter generally over west-central and southern California; and the diminutive western winter wren whose creaking song greets one from dense tangles in ravine bottoms or from mossy logs in the deepest shade of the redwoods. There are, in addition, a number of other mammals and birds, of more or less wide general range elsewhere, though presenting local species or subspecies in different parts of the humid coast belt. (See Pl. XIV.)

While reptiles are very few in species and individuals in the coast belt, amphibians are correspondingly numerous in both respects, and include some species of exclusively Pacific distribution. The big, slug-eating salamander, *Chondrotus,* is one of these.

The fascination ascribed to the desert and portrayed so vividly by many literary writers does not limit itself to such features as the clearness of the atmosphere and the ruggedness of the scenery. The naturalist who visits the Lower Sonoran desert for the first time finds a world of wonderful things so new to his experience in many respects as to make comparison with the previously known impossible.

The widespread idea that the desert is inhabited only by the horned-toad and side-winder is a true reflection of the fact that reptiles are there the most conspicuous of the vertebrate classes. This is partly due to the fact that the mammals are nearly all strictly nocturnal, while the reptiles are in large part actively abroad by daylight, though not as a rule exposing themselves to the intense sunshine of midday.

The midwinter season on our western deserts finds but few reptiles actively abroad at any time of day; for the nights and sometimes the days are cold. But by April the heat of the sun makes itself

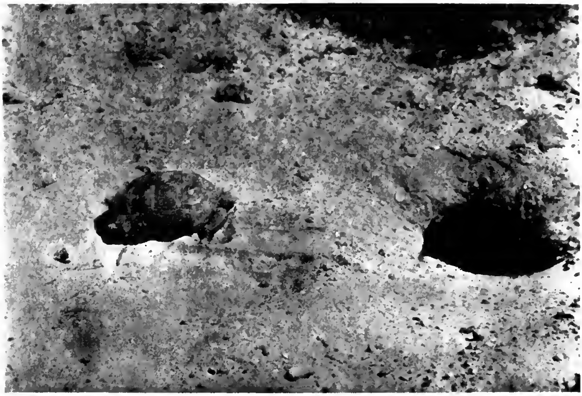
Wren-tits *(Chamaea fasciata)*, in Two Poses. This Is a Characteristic Bird of the Chaparral Belt, in the Californian Fauna and in the Upper Sonoran Zone. It Is the Sole Representative of a Genus and a Family of Birds Which Is Restricted to the Pacific Coast Strip West of the Sierra-Cascade Divide.

Photographed by T. I. Storer in Berkeley.

California Condor *(Gymnogyps californianus)*, the Largest Bird of the Pacific Coast Region, Restricted to the Californian Fauna of the Upper Sonoran Zone, and Now Approaching Extinction. The White Patch on the Under Side of the Wing Distinguishes the California Condor From the Common, and much Smaller, Turkey Vulture.

Photographed by J. Grinnell in Foothills Near Pasadena.

PLATE XII



Desert Tortoise *(Testudo agassizii)* Near Its Burrow in the Yielding Desert Sand. This Reptile Feeds on Plants, and Never Visits Water.

Photographed by C. L. Camp on Mohave Desert Near Barstow.

Chuckwalla *(Sauromalus ater)*, a Characteristic Reptile of the Lower Sonoran Desert Region of the Southwest, West of the Colorado River. It Is Harmless, and Has Been Used for Food by Indians and on Occasion Even by White Men.

Photographed by C. L. Camp on Mohave Desert Near Barstow.

PLATE XIII

felt beneath the surface of the ground and the various lizards and snakes come out in force.

The poisonous reptiles of the Southwest include only the rattlesnakes, of several species, the Gila monster, a huge lizard found only east of the Colorado River, in southern Arizona and Mexico, and the small red-banded snake, *Elaps*, also found in southern Arizona and Mexico, but not west of the Colorado River. The largest lizard next to the Gila monster is the chuckwalla, a black-and-orange colored reptile reaching a length of fifteen inches, and stout-bodied in proportion, which lives on rocky hills and may be seen in profile for considerable distances as it rests at the summit of some boulder. The fleet-footed leopard lizards and whip-tails are among the first to attract the attention of a rider across the desert. Finally there is the desert tortoise which lives in burrows which it excavates for itself in sandy places and which wanders indifferently over the vast stretches of the Mohave. (See Pl. XIII.)

One wonders how such a prolific reptile population secures a livelihood where vegetation is so scarce; but it is only to be remembered that practically all parts of the southwestern deserts are subject to heavy rains at irregular intervals and that these rains are followed by brief-lived but luxuriant growths of herbs abundantly productive of seeds. These seeds lasting over the periods of drouth form the food of great numbers of insects, particularly of ants and beetles, and also of rodents, and these in turn are levied upon by the lizards and snakes.

The reader is not meant to infer that the reptilian life of the desert is its most numerous vertebrate element. Experience on many parts of the Mohave and Colorado deserts leads me to believe that individually mammals outnumber reptiles and birds combined. The seed-gathering types of rodents, *Dipodomys*, *Perodipus* and *Perognathus*, popularly called pocket rats and pocket mice, are the chief representatives. Other nocturnal rodents include white-footed mice, the carnivorous grasshopper mice, and desert wood-rats. Daylight-roaming rodents are not wholly wanting and include the striped antelope chipmunk which holds its short, flat, white-lined tail closely appressed to its back, the round-tailed ground squirrel, and the desert jack rabbit. As with the reptiles, however, none of these are abroad in the scorching midday sunshine, but disport themselves actively only in the morning and evening. There are also a few carnivorous mammals, such as the big-eared kit fox, and a small, pale-colored species of coyote, and also bats of a surprisingly large variety, again an evidence of the abundance of insect life in proportion to the scant vegetation.

Birds of the Lower Sonoran deserts are few in individuals save on the bottomlands along such streams as the Gila, Colorado and Mohave. Here, where the deciduous mesquite, cottonwood and willow furnish directly or indirectly abundance of food and shelter, birds are plentiful and strikingly different as a rule from those familiar to the visitor coming from either the Atlantic Coast or the Pacific. The titmouse-like verdin, Abert towhee and crissal thrasher are resident the year through, while the Lucy warbler, plumbeous gnatcatcher, Cooper tanager, white-winged dove, Sonora yellow warbler, and a score of other species are but summer visitants. Out on the desert proper, far from water, one may find here and there a pair of Say phoebes nesting in some rocky ravine or mine tunnel; rock wrens associate with the chuckawallas in the bare broken rock masses; cactus wrens build their conspicuous covered nests in clumps of the most prickly cactus without apparent inconvenience to themselves but safe from ordinary predators; and, finally, we must mention that elusive songster of the desert wastes, the LeConte thrasher. A veritable will-o-the-wisp by reason of its sand-toned color and extreme wariness, it was for many years considered the rarest of southwestern birds. Its clear whistled notes are to be heard in the cool of the mornings ringing out over the desert; but days may pass before the most alert collector has gained even a glimpse of the bird itself. From the transcontinental trains are frequently seen a pair of ravens, scavengers that have learned to follow back and forth along the railroad tracks gleaning food from the garbage thrown from the trains. Strange as it may seem, the desert avifauna includes also several species of woodpeckers, most of which excavate their homes in the trunks of the giant cactuses. One little ladder-backed woodpecker, however, ranges far over the desert, foraging among bushes and digging out its nesting cavity in the stem of some yucca or palo verde, not infrequently in the hard wood of a telegraph pole.

Perhaps the most instructive bits of any one of the routes to the Pacific, as far as the zoogeographer is concerned, lie at those points of mingling or separation, where desert and Pacific faunas meet. Such points are the San Gorgonio, Soledad and Tehachapi passes on the Southern Pacific, and El Cajon Pass on the Santa Fe. It is to be hoped that in his travels the reader will find opportunity of sensing for himself the conditions in one of these critical localities, where invisible climatic barriers limit the ranges of many species in one direction or the other.

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FISHES OF THE PACIFIC COAST

BY DAVID STARR JORDAN
Chancellor, Stanford University

THE total number of species of fishes known to exist in the waters of California is 465. These may be grouped as follows in regard to their distribution:

About 170 species may be referred to the cold water fauna. These are species that live near the shore, and whose proper home is found north of Point Concepcion, or in the cold current which sweeps along our coast and which renders its waters less warm than in corresponding regions on the Atlantic side. About 120 species belong to the semi-tropical fauna. This occurs to the south of Point Concepcion and beyond the reach of the cold currents of the north. Of course, these two categories are not sharply divided by Point Concepcion, many of the northern species being found south of this point in deeper water, or among the rocks, some, even of the northern species, going far down into Mexico. On the other hand, many southern species find their way northward as far as San Francisco. Others of them come northward in the summer, moving southward as winter approaches. Thus many species properly southern are found regularly in the bay of Monterey.

Of the 170 species that belong to the north of Point Concepcion, we have two very distinct categories; the one comprises the Arctic and sub-Arctic fishes like the halibut, the sturgeon, and the herring, and several varieties of the flounders. With these are a great body of peculiarly California types, which are scarcely or not at all represented in other regions, and which evidently had their origin upon our own coast. Among these, and most conspicuous, are the twenty or more species of surf fishes, which are commonly and wrongly known as perch. All of these bring forth their young alive, well-developed at birth. Scarcely less abundant are the various species of rock fishes, red, green and black in color, which go by the general name of rock cod. These also bring forth their young alive, although quite small. The presence of these two types, together with the peculiar coast type of salmon, five species in all, may be held as the most remarkable feature of the fish fauna of California.

The species which belong south of Point Concepcion are in most cases closely allied to tropical species, and have evidently had their origin in migrations from the south. These are, as a rule, not distinctly Californian, but belong to types which are widely diffused through the warm waters of the tropics. Their relations are with the West Indian forms rather than with the other fishes of California.

About 120 species of deep-sea fishes have been obtained by the *Albatross* in the depths of the ocean off the continental slope of California. These creatures are as a rule very soft in body, red or purplish-black in color, and many of them are covered with phosphorescent spots by which they can see their way in the darkness of the ocean depths. They live in the open seas at a depth of from two to five miles, and their soft bodies at this depth are rendered firm by the tremendous pressure of the surrounding waters. The light and heat of the sun never penetrate their native haunts, the darkness is absolute, and the temperature of the water is almost at the freezing point. The creatures living at these great depths are not, generally speaking, descended from the shore species of the same region; they constitute groups by themselves, and forms very similar are found in all parts of the ocean from the poles to the equator.

About 45 species of fishes inhabit the fresh waters of California, including the great basin of the Sacramento and San Joaquin, the basin of the Colorado, and the Lahontan basin, represented by Lake Tahoe and the Truckee River. Beside the species of trout, most of the fresh-water fishes come under the head of suckers and chubs. One surf-fish and one bass are native to the rivers of California.

Of the whole number of fishes found, 133 of the marine species are properly to be called food fishes, occurring more or less frequently in the markets, and being more or less desirable for table use. The others, either on account of small size, ill flavor, or tastelessness of flesh, are not used as food. or else are used only when salted and dried, by the Chinese, for whose soups and chowders nothing seems to come amiss. About twenty of the fresh-water fishes are also food fishes, but only seven or eight of these have much value as such.

The distribution of fishes, that is, the question of the extent of the area inhabited by any particular kind, depends on a number of different conditions, the most important of these being the temperature of the water. Most fishes are extremely sensitive to any change of heat or cold. When, as is sometimes the case, the temperature of the water changes abruptly at a given point, the character of the fishes will be found to change with equal abruptness. A very little cold is often sufficient to benumb and paralyze a fish of the tropics. I have seen, in the Florida Keys, where the water suffers a slight chill which brings it down perhaps to 80 degrees, the cutlass fish, ordinarily very active, lying stupid and inert on the surface of the water. On the other hand, the fishes of cold regions can not endure any degree of heat to which they are not accustomed; and doubtless the fishes in the depths would be suffocated by the temperature of the surface water, even if their lives were not destroyed by the reduction of pressure.

Another element almost equal in importance is that of depth. The great majority of the marine fishes that we know well, or that we recognize as food fishes, are shore species, inhabiting depths of from one to fifteen fathoms. The great variety of oceanic life is found within this range through which the light and heat of the sun readily penetrate. As we go lower we find that the shore fauna disappears. The greenish-colored shore fishes give place at fifty to one hundred fathoms to other species, the prevailing color of which is red. The green or gray colors match the colors of the sand and kelp; the red ones harmonize with the red sea mosses, among which the red fishes live. In still greater depths, where light and heat have disappeared, the prevailing hues are violet or black, the color of darkness.

Of less importance, but still a determining quality for very many fishes, is the character of the food to be obtained. Each species thrives best where those creatures on which it naturally feeds are most abundant. The herbivorous fishes live among the tide pools where they can feed upon the small sea weeds, the crab-eating fishes live among the rocks, and those which feed upon herrings and silversides flourish best in the open sea.

The character of the bottom is also of importance. Most of the flounders, for instance, live on a bottom of sand. The so-called rock-cod abound about sunken rocks and banks; while other species are found only where the bottom is soft and muddy. The differences between the fishes commonly found at Monterey and at Santa Cruz indicate clearly the differences in the nature of the bottom at these two points on the same bay.

The character of the water is also an important matter. About the rocks of La Jolla and Santa Catalina the waters are as clear as about a coral reef in the tropics. In these clear waters are found the same types of fishes that would be found about a coral bank. The species are not the same as those which occur very far to the south, but the general character of the fishes is that of a coral region. On the other hand, in the more or less muddy waters of the Bay of San Francisco, only those species are found to which the cloudy or muddy condition of the water is not objectionable; and the brilliant coloration of the clear-water fishes is totally wanting among them.

As regards their preference in the matter of surroundings, the fishes of the Pacific Coast may again be divided as follows: Of the pelagic species, about 30 visit the coast of California. These are fishes which swim freely in the open sea, living mostly near the surface, often moving for hundreds of miles, and belonging to no one oceanic area more than to another. Of species living about the rocks and feeding upon the small animals which abound in the sea weeds, there are fifty species, of which thirty belong to the group known as rock-cod, the genera *Sebastichthys* and *Sebastodes*. All of these are food fishes, though not of the best quality. One feature concerning them which is not generally known is that all of them are viviparous. Their eggs are produced in immense numbers, but they are hatched in the body of the female, the young being then born when at a length of one-sixth to one-fourth of an inch, and each commonly rolled up in a coil. Only by the closest observation is one able to see that the eggs are hatched before the resulting fry are freed to shift for themselves in the sea.

Of the kelp fishes there are twenty-five species. These are chiefly confined to the beds of kelp, which are a special feature of the California coast, nothing like it existing on the Atlantic side of North America. Some of these fishes feed upon the seaweeds themselves, more upon the molluscs and crabs which find their home among the marine plants. Like the rock fishes, the kelp fishes are usually taken by the baited hook from the deck of a boat.

Fishes to the number of 145 species frequent by preference waters with a smooth or sandy bottom. Some of these swim near the surface in the open water, often entering the bays in large shoals; others, as the flounders, lie on the bottom and in

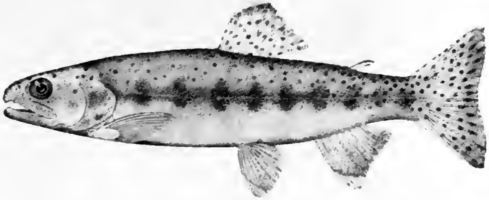
Aplodontia phaea, a Species of So-called Mountain Beaver. One of the Surviving Members of An Ancient Rodent Family Which Is Now Restricted to the Pacific Coast Region of the United States.

Photographed from Animal Captured Near Olema, Marin County, California, and Brought to the California Museum of Vertebrate Zoology.

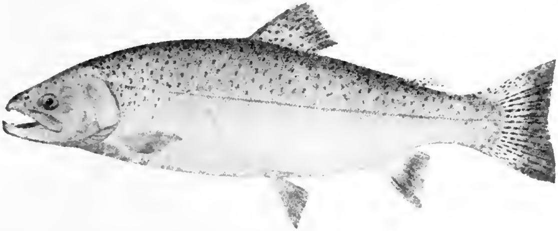
The Oregon Ground Squirrel ***(Citellus oregonus)*, One of Very Many Species of Ground Squirrels Inhabiting the Western United States, All of Which Do More or Less Injury to Grain or Other Crops.**

Photographed by H. C. Bryant Near Link River, Klamath County, Oregon.

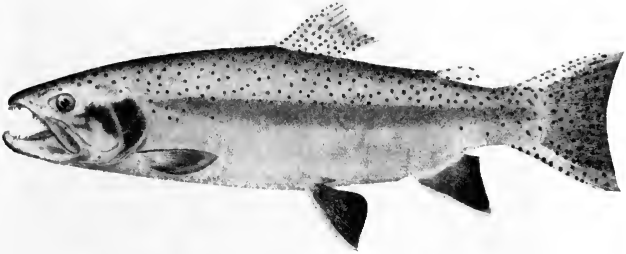
PLATE XIV



Golden Trout *(Salmo aguabonita).* In a Small Stream, Golden Trout Creek, Above Volcano Falls, in the High Southern Sierra Nevada, in the Vicinity of Mt. Whitney.



Steelhead Trout *(Salmo irideus)*, Formerly Considered a Distinct Species, *S. gairdneri;* female. Where Individuals of the Rainbow Trout Gain Access to the Sea, They Are Now Believed to Return to Their Native Stream as the Steelhead.



Rainbow Trout *(Salmo irideus);* Male. The Common Brook Trout of the Pacific States and West Slope of the Sierra Nevada.

PLATE XV

By Permission of the United States Bureau of Fisheries.

color are scarcely distinguishable from the sand.

There are fourteen anadromous species, that is, species which ascend the rivers in the spring or fall for the purpose of spawning in fresh water, but which pass the greater part of their lives in the sea. Of the anadromous fishes the most important are the species of salmon; the largest in size are the sturgeons. But besides these species several little fishes, such as the lampreys, have similar habits.

Four species are confined chiefly to the brackish mouths of streams, a very small proportion, because California has very little of estuary water. Finally, as above stated, about forty-five species are confined exclusively to the rivers.

The fisheries of the coast as a whole are relatively little developed. The bay of San Francisco, the bay of Monterey, the bay of San Diego and a region about Avalon are fully fished, overfished at times, but along the great length of the coast the fisheries remain almost untouched. Captain Collins estimated that on the seven thousand miles of the coast of California, Oregon and Washington, the fisheries are about equal to those of 500 miles on the coast of New England. The value of the product is about the same in the two districts, and may be roughly set down at $40,000,000 per year. Of this amount, the salmon fisheries of the Columbia represent between a third and a fourth, those of Puget Sound nearly a third, and California about $8,000,000. This represents from 50,000,000 to 80,000,000 pounds of fishes caught each year.

The salmon fisheries of the Sacramento are situated chiefly in the counties of Solano and Contra Costa. For a number of years these fisheries steadily declined. This was due to overfishing, and to the destruction of the spawning beds through lumbering and placer mining. Millions of the young fry enter the bayous of the lower Sacramento and are left to die when the water goes down. Practically the only spawning beds left in the Sacramento Basin were in the river itself about Red Bluff. The United States Fish Commission came to the rescue and, through the hatchery stations at Baird and Battle Creek, it has repopulated the river. At present it is said that more salmon run in the Sacramento than when the stream flowed through primeval wilderness, but this statement may be questioned.

The salmon of the Sacramento is the quinnat or king salmon *(Oncorhynchus tschawytscha)*, the largest and finest of all the salmon tribe. It reaches in four years an average weight of sixteen pounds. When mature, usually at the age of four years, it runs up the streams to spawn. It leaves the sea in early summer and spawns in the fall in the upper reaches of the rivers. After spawning all die, male or female. This is true of each of the six species of salmon in the north Pacific Ocean. After leaving the sea, the king salmon never feed, although they readily take the trolling hook in Monterey Bay. The salmon lays 4000 to 5000 eggs. As naturally spawned, one in a hundred or more hatches and escapes its enemies. The fish hatchery undertakes to hatch ninety-five out of every hundred and to put them in the river to drift downward to the sea "tail foremost in the old salmon fashion," to return again as mature fishes. The salmon are best in flavor when taken in or near the sea. From August to October the old ones are practically unfit for food, being lean and poor. Great numbers of quinnat salmon are taken by hook and line in Monterey Bay at the age of two or three years. The other salmon found in California are the silver salmon *(Oncorhynchus kisutch)* and the dog salmon *(Oncorhynchus keta)*.

Artificial propagation may increase still further the run of salmon, as also the stock of trout. Almost every stream in California was originally a trout stream, and almost everywhere these fish ought still to be taken in abundance. Unfortunately, the great enemy of the angler, the trout hog, is naturalized in California, and in many of the best streams the trout scarcely get a chance to lay their eggs. Native to California are the following species of trout:

The rainbow trout *(Salmo irideus)*, also called steelhead when it runs into the sea where it grows to a much larger size than in the streams. (See Pl. XV.) The rainbow trout is found in almost all the streams, running into eight local forms or varieties, as follows:

The true rainbow in the coast streams, becoming a steelhead when it can enter the sea.

The Shasta rainbow *(Salmo irideus shasta)*, in the upper Sacramento river, etc.

The noshi or Stone trout *(Salmo irideus stonei)*, in the Klamath river.

The Gilbert rainbow *(Salmo irideus gilberti)*, in the Kings and Kern rivers.

The golden trout *(Salmo aguabonita)*, of the vicinity of Mount Whitney, the Roosevelt trout *(Salmo roosevelti)*, and the White trout *(Salmo whitei)*, all three small and brilliantly colored forms found in the upper Kern river in different small streams where they are land-locked by waterfalls and prevented from mixing with the parent stock, the Gilbert trout.

The San Bernardino trout *(Salmo evermanni)*, a dwarf trout of certain high mountains of southern California.

The Tahoe trout *(Salmo henshawi)*, a splendid large trout of the Nevada Basin, introduced into the Feather River, the Blue Lakes and other nearby bodies of water. Of this species, a huge deep-water variety is developed, spawning in the lake, the great silver trout of Lake Tahoe *(Salmo henshawi tahoensis)*. There is another trout still in the deep waters of Lake Tahoe, the royal silver trout *(Salmo regalis)*.

The cut-throat trout *(Salmo clarkii)*, the common trout of the Columbia region, is found in the Klamath, and along the Oregon border.

The Dolly Varden trout *(Salvelinus malma)* is found from the upper Sacramento north to Siberia. In Alaska it far outnumbers all other trout, furnishing good sport for the angler in every brook. It is everywhere very destructive to the eggs of salmon.

The eastern brook trout *(Salvelinus fontinalis)* has been introduced into many California streams, as also the European brown trout *(Salmo fario)*.

Besides the trout and salmon, California has many other game fishes. First of these is the great tunny or leaping tuna, which ranges from 150 pounds to half a ton, and finds its greatest abundance about Avalon. This wonderful bay of Avalon has many other roving fishes, taken with the trolling spoon, such as the yellow-tail *(Seriola dorsalis)*, the albacore *(Thunnus alalunga)*, the yellow-fin, or Japanese albacore *(Thunnus macropterus)*, and the huge bass called Jew-fish *(Stereolepis gigas)*, with a head as large as a bushel basket—apparently nearly all head. The sword-fish *(Xiphias gladius)* and the Japanese spear-fish *(Tetrapturus mitsukurii)* are also sometimes taken off the Santa Barbara Islands.

These noble fishes deserve protection from the amateur angler who catches a dozen or a hundred, has them hung up and photographed, himself beside them, then hires the guide to bury them while he goes away to have fun in his own fashion somewhere else.

The barracuda *(Sphyraena argentea)* and the great flying-fish *(Exocoetus californicus)* are among the game fishes about the Santa Barbara Islands.

The bonito *(Sarda chilensis)* and the oceanic bonito *(Euthynnus pelamis)* are also big game fishes. Along the wharves, the chub-mackerel *(Scomber japonicus)*, the small horse-mackerel *(Trachurus symmetricus)*, king-fish *(Genyonemus lineatus)*, queen-fish *(Seriphus politus)*, and a variety of surf-fishes, are also taken.

Of introduced fishes, two, the striped bass, and the shad, both planted about 1878 from the Potomac and the Schuylkill rivers, have been of the greatest value to California. The striped bass can be found in the markets at all times, and in flavor it is as good as in its native waters.

I may note in passing that the markets of San Francisco fall far short of what they ought to be, and many fish are served in a stale condition. Even our best hotels are none too particular, for which reason our eastern visitor often wrongly infers that our fish are not as good as those he is accustomed to. The fish really are just as good. In our glorious climate, they keep longer without decaying. But in doing this they grow very stale and lose their fine flavor. The difference is not in the fish, but in the care the dealers take of them, and as to this San Francisco will sometime grow more exacting. Other fish which have been introduced are the carp *(Cyprinus carpio)*, which has proved an unmitigated nuisance; the two species of cat-fish *(Ameiurus nebulosus* and *A. catus)*, which are excellent food, highly appreciated by the Chinamen; the black bass *(Micropterus dolomieu)*, which thrives well in the ponds; and the green-blue sunfish *(Apomotis cyanellus)*, introduced into Clear Lake as food for the bass.

The fisheries of Alaska are also largely tributary to California, being developed by California capital, and the product to a great extent brought to San Francisco.

The red salmon or blue-black salmon, also called sockeye *(Oncorhynchus nerka)*, in Alaska outranks in value every other species of fish in the world. Its annual product in Alaska is worth a million dollars, more or less, more than the original cost of Alaska to the United States. It now exceeds the entire mineral output of Alaska per year by $2,000,000 or more. The great red salmon fisheries are about Bristol Bay and Kadiak Island, but the species runs in some thirty different streams.

The cod-fish *(Gadus macrocephalus)* is as abundant in the North Pacific as is its twin species *(Gadus morrhua)* in the North Atlantic, but the limitations of the market have prevented the development of the industry except about the Shumagin Islands and in the Sea of Okhotsk. The herring *(Clupea pallasii)* and halibut *(Hippoglossus hippoglossus)* have also a large and growing importance in Alaska and British Columbia.

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MARINE BIOLOGY ON THE PACIFIC COAST

BY CHARLES ATWOOD KOFOID
Professor of Zoology, University of California

PHYSICAL CONDITIONS.—The Pacific Coast of the United States presents in the main a bold line of cliffs mostly of the later geological formations, with relatively few protected waters south of Puget Sound. This results in a paucity of the stable granitic substrata and of collecting ground sheltered from the turmoil of the breakers. These conditions give a barrenness more apparent than real to the littoral area, and considerably increase the inaccessibility of the littoral fauna.

The relatively small Arctic contribution to the California Current which sweeps southward along the coast permits, for the northern latitude, relatively high surface temperatures ranging from 8° in March to 14° in August at the Canadian boundary, and from 15° in January to 18° in August at San Diego. The earth's rotation and the local configuration of the ocean bottom in sunken valleys favor the local upwelling of colder and richer water from the depths at certain points along the coast, notably at Monterey, Cape Mendocino, and San Diego. This moderates surface temperatures in the south and adds greatly to the enrichment of the local faunas both pelagic and littoral. These temperature conditions affect profoundly the nature and abundance of the fauna, giving to the north an exceedingly rich fauna with many individuals, and to the south an exceedingly varied fauna rich in species. Many species of the faunas of Alaska and Puget Sound extend southwards along the coast into progressively deeper water, as, for example, in the case of the rat-fish *(Chimaera collei)* which is caught at the wharves in Alaska but only in 50-100 fathoms off San Diego.

The relatively narrow continental shelf, the infrequency of coastal indentations, and the absence of large rivers in the south, make the marine fauna of the Pacific Coast pre-eminently an oceanic one and bring the pelagic fauna of the high seas within easy reach of the biologist, pre-eminently so at Pacific Grove and San Diego.

Aquaria and Marine Biological Stations of the Pacific Coast.—Six marine biological stations for instruction or research are located on the Pacific Coast.

Marine Biology on the Pacific Coast

Our northernmost is the Pacific Coast Biological Station of Canada, Dr. C. McLean Fraser, Nanaimo, B. C., Director; located on the north shore of Departure Bay, three miles from Nanaimo, B. C., and reached in two hours by boat from Vancouver, or in three hours by train from Victoria. The station is open throughout the year and is centrally located for ichthyological investigations.

The State University of Washington maintains the Puget Sound Marine Station (Pl. XVI), Professor T. C. Frye, Seattle, Director; at Friday Harbor. It can be reached by the Steamer Rosalie thrice weekly from Seattle, or by the launch City of Anacortes daily from Anacortes and Bellingham. It is open during the summer for instruction and research.

The aquarium of the Bureau of Fisheries at the Exposition has an exhibit of food fishes, and the aquarium in the Hawaiian building is remarkable for the beauty of the coloring of fishes of the coral reefs brought here from the world-famous aquarium maintained in Honolulu. The flashing colors of red, blue, yellow and black, the marvelous blending, spotting, barring and striping of the color patterns, the strange and grotesque forms, and the ease and grace of the incessant movements of these fish are revelations in a world new to most lovers of nature.

The Marine Laboratory of Stanford University, Professor C. H. Gilbert, Stanford University, Director, is located at Pacific Grove, an attractive seaside resort reached by street car from Monterey. The building is equipped with rooms for research, running water for aquaria, and is also opened in summer for class instruction.

The Herzstein Research Laboratory of the University of California, at New Monterey, Professor S. S. Maxwell, Berkeley, Director, has been made famous by Professor Jacques Loeb's researches in physiology. It is located near the waterfront on the car line between Monterey and Pacific Beach and offers facilities for a limited number of investigators in certain lines of biological research.

The Laguna Marine Laboratory, of which Professor W. A. Hilton of Pomona College, Claremont, is director, is located at Laguna Beach, about 50 miles southwest of Los Angeles, and is reached by stage (20 miles) from Santa Ana.

The Venice Aquarium is reached by electric cars from Los Angeles. The University of Southern California maintains a laboratory, Professor A. B. Ulrey, Los Angeles, Director, in rooms adjacent to the aquarium and museum, for seaside instruction of university classes and for research. A power boat, equipment for dredging and pelagic collecting, and aquaria for observation or experiment are maintained.

A commercial aquarium at Avalon on Santa Catalina Island, reached by steamer from Los Angeles, often, by reason of its oceanic surroundings, contains pelagic rarities and maintains an exceptionally fine exhibit of fish and crustaceans.

The angling for the pelagic big game fishes off Avalon is of interest both to the sportsman and the biologist. The marvelously transparent water in the harbor at Avalon makes possible the use of glass-bottomed boats for the observation of the rich and varied pelagic and bottom fauna and the submarine forests of kelp.

The Marine Biological Station (Pl. XVII) of the Scripps Institution for Biological Research of the University of California, Professor W. E. Ritter, Director, is located at La Jolla and is reached by suburban train and motor service from San Diego. La Jolla is a beautiful seaside village with good hotel and cottages and the Station has a few cottages on its premises for visiting biologists. The station has a sea-going boat, the Alexander Agassiz, equipped for oceanographic investigations, for pelagic collecting, with tow nets, closing nets, etc., and with dredging engine and cable for work to the depth of 1000 fathoms. An excellent biological library and research rooms are provided in the building, and a wharf, pumping plant and viviers are in process of construction. The Station is open throughout the year and climatic conditions are exceedingly favorable for biological investigations at all seasons.

Collecting Grounds.—The productive salmon, halibut and herring fisheries of Alaska and the Northwest, and the pelagic fisheries of the albacore (tuna) and other pelagic fishes off southern California are commercial indices of the fertility of the sea on the Pacific Coast. The biological stations at Nanaimo and Friday Harbor are convenient centers for the collection of marine life in the sheltered waters of the Northwest, which are famous for the quantity of life they produce. The plankton is especially rich in larval stages and often in *Noctiluca,* and locally abounds in brackish water forms such as rotifers and *Evadne.* The littoral and tide-pool fauna is rich in hydroids, bryozoans, echinoderms, molluscs, and annelids often of extraordinary size, submarine fields of eel-grass and

PLATE XVI
Puget Sound
Marine Biological
Station,
Friday Harbor,
Washington.
By Courtesy of
T. C. Frye.

PLATE XVII
Scripps Institution for Biological Research.
The Town of La Jolla, California, in the Distance.

By Courtesy of W. E. Ritter.

Ulva teem with animal life, and the bottom fauna is rich in echinoderms, pennatulids, anemones, Solenogastres, Amphineura, lamellibranchs, and gastropods. Fine collecting grounds are to be found near Willapa and Coos bays on the Oregon Coast.

The California coast offers attractive local collecting grounds, often with less abundant but more varied life. Cape Mendocino, Humboldt Bay, Shelter Cove, and Point Arena share to some extent the abundance of the north. Dillon's Beach above Point Reyes, and Duxberry Reef at Bolinas, both picturesque and interesting localities easily reached from San Francisco, are noted for the sponges, hydroids, and molluscs which the wrack of winter storms brings ashore. Tomales Bay has rich mud flats and near its outlet great beds of the rare and curious worm *Phoronis*.

San Francisco Bay itself by reason of its brackish water, sewage, and industrial wastes, its receeding mud-flats and commercial development, offers few attractive collecting grounds, and even its planted oyster beds are rapidly declining. The plankton of the bay is rich, and abounds in shrimps, three species of *Crangon*, and the relatively large Hydromedusa *Polyorchis*, whose pearly globes, 1-1½ inches in diameter, may be seen in great swarms along the wharves at the surface of the water on quiet afternoons. There are some sheltered nooks at the foot of the cliffs along the Golden Gate accessible at low tide on occasional quiet days in which there is a very rich and varied assemblage of stalked barnacles *(Pollicipes)*, Bryozoa, hydroids, sponges, anemones, and occasional echinoderms and devil-fish. The dredging on the rocky and shelly bottoms of the Bay is locally rich in Crustacea and molluscs, and the mud-bottoms, which are widespread, are rich in annelids, nemerteans, ophiurans, pennatulids, lamellibranchs, and mud-loving gastropods. The fish markets of the Italian and Chinese quarters in San Francisco have many gastronomic treasures of the *frutti di mare* which will interest both the biologist and epicure. South of the Golden Gate the rocks and shelving reefs at Mussel Rock and Moss Beach on the Ocean Shore Railroad are easily accessible and rich in a great variety of attached forms.

The collecting grounds at Monterey, Pacific Beach and Carmel are famous for their richness and for the great variety of marine forms which may be obtained. The tide pools accessible at low tide at Point Lobos, near Pacific Beach and elsewhere to Carmel and below, are rich in sponges, sea urchins, starfishes, keyhole limpets *(Lottia)*, sea cradles, and abalones *(Haliotis)*, as well as the smaller sea mosses (hydroids and bryozoans), while burrowing worms and crustaceans find hiding places in the nooks and crevices, and small tide-pool fishes lurk in the crannies of the rocks.

The best known collecting grounds near Los Angeles are those at White's Point and Portuguese Bend, extending northward from San Pedro to Redondo. Tide flats of wide extent are to be found at Anaheim, Alamitos Bay, Wilmington, and Newport Bay, and sandy beaches at Venice, Long Beach and Huntington Beach. The dredging along the rocky shores of Santa Catalina Island yields wonderfully rich collections of sponges, brachiopods, the large sea urchin *Strongylocentrotus franciscanus* and a great variety of invertebrates which require oceanic conditions for their growth.

The collecting grounds at San Diego are rich and varied. Dredging on the bar and in shelly deposits in the channel yields *Amphioxus californiensis*, the mud bottoms abound in *Pectinaria*, the little annelid living in brown conical tubes, sting rays *(Urolophus halleri)* and some interesting sponges. On the mud and sand flats exposed at low tides are found *Balanoglossus*, sand dollars, sea pansies *(Renilla)*, *Corymorpha*, *Harenactis*, *Virgularia*, and burrowing white alpheid crustaceans which are called pistol crabs from their habit of snapping their claws, and occasionally brilliantly colored nudibranchs and opisthobranch sea slugs. The reefs at Point Loma are rich in chitons and other molluscs, compound ascidians, and huge colonies of the sand tubes of colonial annelid *Sabellaria*. Here the San Diego blind fish or goby *(Typhlogobius californiensis)* may be found under rocks. The hold-fasts of the giant kelp cast up on the beaches are veritable menageries of the smaller marine invertebrates, ophiurans, annelids, nemerteans, crustaceans, and attached hydroids and bryozoans. The rocky shores are in places riddled by burrowing molluscs *(Pholadidea penita)*. The harbor fauna, as elsewhere on the coast, has been contaminated by the cosmopolitan forms brought by shipping such as barnacles, tubularian and companularian hydroids, mussels *(Mytilus)*, clams *(Mya)*, and anemones *(Metridium)*. The big blue domes of the beautiful jelly fish *Stomolophus* are sometimes seen in great swarms in the quiet waters of San Diego harbor in autumn months. The fauna of the beaches includes many sand-hoppers and burrowing amphipod and isopod crustaceans, and at times great numbers of the unique crustaceans *Hippa analoga* with barrel-shaped body and long antennae. In some years great windrows of the small lamillibranch *Donax* with a commensal hydroid *(Clytia bakeri)* attached to its hinge line, are cast up on the beaches by the breakers.

The dredging off-shore in southern waters is very rich indeed and varies greatly with the depth and nature of the bottom. Compound ascidians resembling large brown pancakes, purple crabs *(Randallia)* and myriads of small sea urchins *(Strongylocentrotus)*, the large flabby brownish mottled sea hare *(Aplysia californica)* and the yellowish warty sea-cucumber *(Stichopus californicus)* are found inside of the kelp belt. On the banks or rocky bottoms where fish are more abundant, the attached and burrowing forms are detached by the dredge, such as the gorgonian *Muricea*, siliceous sponges often of considerable size, and rare echiurid and sipunculid worms from burrows in the soft black shale. Pectens, brachiopods, and crinoids are locally abundant, and the deeper mud bottoms yield abundant spatangoid sea urchins, sea cucumbers in variety, ophiurans, and occasional stalked sponges, and fan shells *(Pinna)*. In the great Los Coronados sunken valley the United States steamer *Albatross* brought to light an extraordinarily rich fauna of deep-sea pennatulids, sponges, crustaceans, and echinoderms.

Pelagic Life.—The pelagic life, best seen off Catalina Island on a quiet afternoon, includes the large purple-striped medusa *Pelagia* which sometimes forms great windrows in the tide rips off the kelp and harbors commensal minnows under its bell and parasitic amphipods in its radial canals, siphonophores in considerable variety, pink ctenophores, the brilliant yellow Venus's girdle *(Cestus veneris)*, heteropod and pteropod molluscs, *Sagitta*, *Salpa* in chains and circles, and, in hauls from deeper water, pelagic cephalopods and stalk-eyed fish, and an occasional phantom *Leptocephalus* or larval eel, or an equally transparent *Phyllosoma* or larval stage of the spiny lobster *(Panulirus interruptus)* of the Pacific Coast.

The microplankton in the California current is generally very abundant and varied. In the spring and early summer the vernal wave of diatoms is so marked as to form a coastal belt known to mariners as "black water." In mid-summer and early fall the southern coasts are often visited by extraordinary displays of phosphorescence, due to microscopic organisms, principally dinoflagellates of one species, *Gonyaulax polyedra* (text figs. 12, 13), which becomes so abundant as to discolor the sea for several miles off-shore and thus causes great belts of "red water" which extend for considerable distances up the coast. At night they give a remarkable display of yellowish-green light in the breakers, on the sands of the beach, and in the wake of ships. Each passing fish leaves behind it a trail of light to mark its path. This outbreak is accompanied by the death of many of the invertebrates of the littoral and bottom fauna in the region of the phosphoresence and by the development of a penetrating and disagreeable odor at the beaches, due to the decay of the myriads of *Gonyaulax*.

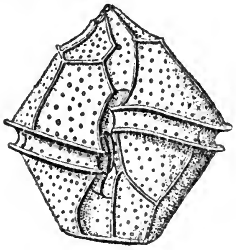

Figure 12

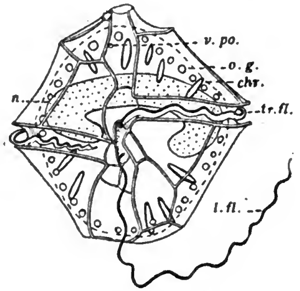

Figure 13

Figure 12. Protozoan (Gonyaulax polyedra) causing red water and phosphorescence along the coasts of southern California. Surface view showing cellulose exoskeleton. Magnified 667 diameters.

Figure 13. The same, showing internal structure, nucleus (n), chromatophores (ch.) yellowish in life, oil globules (o. g.), and flagella for locomotion, transverse (tr. fl.) in the girdle and rotating, and the trailing one (l. fl.) for propulsion and steering, and the ventral pore (v. po.).

The abundance of pelagic life on this coast in the past is recorded in fossil deposits of infusorial earths rich in the skeletons of diatoms, silicoflagellates and radiolarians, found at Santa Barbara, San Luis Obispo, and San Pedro, and now extensively used in the dynamite industry. The pelagic life in the past has also contributed to the deposits from which the petroleum of the California oil-fields is derived.

The Abalone.—One of the most characteristic molluscs of the Pacific Coast is the abalone or *Haliotis* which lives on rocky shores from low-tide levels to depths of fifty feet or more. Its huge stout muscle, by means of which it holds firmly to its position on the rocks is the occasion for its extensive use as food. The body is dried entire and shipped to the Orient by the ton, and canned as a table delicacy. The shell of the abalone is noted for its brilliancy of coloring, more varied and more highly colored than the mother-of-pearl, running through a marvelous range of tones of green, blue, red, purple, and violet. Its thickness and colors make possible its utilization in industry, for curios and jewelry, and for many of the various articles into which mother-of-pearl is manufactured. The abalones also produce fine, baroque and blister pearls of exceptional beauty in form and color. The blister pearls are usually formed over the internal scar caused by the penetration of a small burrowing lamellibranch *(Pholadidea parva* or *sigitata* or rarely *Martesia intercallata* and *Adula stylina,* Pl. XVIII, figs. 4-7), through the lining nacre. Six species are known on this coast. The green abalone *(Haliotis fulgens,* Pl. XVIII, fig. 3) has been extensively used for drying and canning. Overfishing and the red water of 1904 have locally all but exterminated it. The black abalone *(H. cracherodii,* Pl. XVIII, fig. 1) because of its uniform color and hardness is extensively used in the button industry. The red abalone *(H. rufescens,* Pl. XVIII, fig. 2) because of its hardness and brilliant colors is much employed in the manufacture of curios and jewelry.

Marine Mammals.—The marine mammals of the Coast have been greatly reduced in numbers by the whale fisheries formerly centered at Monterey and by the fur trade. The sea otter *(Latax lutris).* great bands of which formerly basked in the kelp, is all but extinct. The pelagic sealing of the north is depleting the fur-seal *(Callotaria alascana)* herd found off northern California in the winter, and only a remnant of the once abundant northern elephant seal *(Macrorhinus angustirostris)* now persists at Guadalupe Island. Travelers by steamer may still see the California gray *(Rhachianectes glaucus)* and the Pacific sulphur-bottom whales spouting in the Santa Barbara Channel or a squadron of whale killers *(Orcinus rectipinna)* cruising along the coast. Porpoises *(Phocaena phocaena)* and harbor seals *(Phoca richardi)* still enter San Diego and San Francisco bays occasionally. Sealions *(Eumetopias stelleri)* of the Seal Rocks off the Cliff House at San Francisco and of more southern waters *(Zalophus californianus)* are gradually disappearing as the result of destruction by fishermen whose nets and catch they destroy.

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OCEANIC CIRCULATION AND TEMPERATURE OFF THE PACIFIC COAST

BY GEORGE F. MCEWEN
Scripps Institution for Biological Research, La Jolla, California

DEPTH OF THE PACIFIC.—The Pacific Ocean occupies a basin extending over an area of 69,000,000 square miles, and has a depth averaging from 2000 to 3000 fathoms. While the Antarctic Ocean is an integral part of the Pacific Ocean, communication with the Arctic Ocean is limited to the relatively small channel of Bering Straits. The eastern portion of the Pacific is characterized by great uniformity of depth, mostly exceeding 2000 fathoms, with a few volcanic islands and a number of deep submarine valleys extending nearly to the shore line. The western portion, with its irregular depth-contours and numerous high volcanic ridges and islands, is in complete contrast with the eastern portion.

OCEAN CURRENTS OF THE NORTH PACIFIC AND THEIR CLIMATIC INFLUENCE.—The warm Kuro Siwo, or Japan Current, which is similar in many respects to the Gulf Stream of the Atlantic, flows north from the equator along the Asiatic coast. From there it turns east and strikes the North American coast at Sitka, Alaska, with a considerably diminished velocity and volume. From this point it broadens out and drifts slowly toward the equator, curving away from the coast. While this current has long been popularly supposed to exert a powerful influence on the California climate, authorities now agree that this is erroneous.

The southward drift of surface water bordering the Pacific Coast between latitudes 40° and 20° is known as the California Current. This current, which is distinguished by its low temperature from what would naturally be called the eastern portion of the Japan Stream, flows southward as a cold current, increasing in volume and breadth until at latitude 25° it extends more than 1000 miles off-shore. Indeed it really is the part of the Japan Stream bordering the Pacific Coast, and doubtless would not have been given a different name were it not for its low temperature and relatively greater velocity. While the existence of this current, the low temperature of which appears to result from a cooling of that part of the Japan Stream bordering the coast, has long been admitted, attempts to account for the reduction in temperature have given rise to many different hypotheses.

This cold coastal water is of interest from a meteorological point of view, since there are good reasons for believing it to be the cause of the relatively cool summers of the California coast.

Average Temperatures of the Pacific.—Except for the comparatively narrow margins bordering the continents and islands, where the depth is less than a thousand fathoms, the bottom water is characterized by a remarkably uniform temperature, varying from 34° to 36° Fahrenheit. From latitude 40°, near Cape Mendocino, to latitude 30°, 150 miles south of San Diego, the water below a depth of 500 fathoms rarely exceeds 39°; and at a depth of 200 fathoms, the average temperature of the eastern half of the Pacific is 46°, while that of the western half, though higher, rarely exceeds 50°. The annual variation of temperature is scarcely perceptible below 150 fathoms, while the surface temperature of most of the Pacific has an annual range varying from a minimum of 4° at the equator, to a maximum of 18° at latitude 40°.

A Comparison of In-shore and Off-shore Temperatures.—Between latitudes 45° at Puget Sound and 25° at the southernmost point of Lower California the mean annual surface temperature is progressively lower as the coast is approached. This fall in the mean annual temperature is clearly indicated at every depth from 250 fathoms up to the surface, where there is an in-shore temperature averaging 5° less than that found 1000 miles offshore. Also, in general, the western shores of the islands off southern California are bordered by colder water than their eastern shores.

Some of the most interesting facts relative to the average monthly surface temperatures in-shore as compared with those off-shore are shown in the tables on the following page.

The tables show that the off-shore surface temperatures at latitude 30° are much below the normal (the temperatures given in the first column), while those at latitude 40° are somewhat greater, at least in winter. Also it appears that the annual range of the off-shore temperatures agrees with the normal range for the same latitude. But the in-shore temperatures are notably less than the others for the same latitude, especially during the warmest part of the year, and consequently have less than the

PLATE XVIII

Abalone Shells and Pearls. 1. Black Abalone *(Haliotis cracherodii)*. 2. Red Abalone *(H. rufescens)*. 3. Green Abalone *(H. fulgens)*. 4. The Common Boring Mollusc *(Pholadidea parva)* Which Causes the Formation of Blister Pearls. 5. Another Mollusc *(Adula stylina)* Which Bores Into the Heavy Rim of the Abalone Shell. 6. Exterior of the Abalone Shell Showing the Aperture of the Bore of the Parasitic Mollusc. 7. An Abalone Pearl.

PLATE XIX
A Mountain Meadow,
or Cienaga,
in the Boreal Zone.
The Low, Clumpy Plant Is
the False Hellebore
(Veratrum),
Beneath the Rank Growths
of Which
Juncos, Lincoln Sparrows,
and Certain Shrews
and Meadow-mice
Find Shelter.
The Trees Include
Jeffrey and Lodgepole Pines,
and Silver Firs,
and Harbor a
Summer Population of
Such Birds as Kinglets,
Wright Flycatchers,
and Sapsuckers.

Photographed on Slopes of San Jacinto Peak, Southern California, by J. Grinnell.

annual normal range. Again, the maximum and minimum temperatures occur in-shore some months after the corresponding normal times; and the variation of the in-shore temperatures with respect to the latitude is scarcely half the normal amount.

SURFACE TEMPERATURES AT LATITUDE 30°, 150 MILES SOUTH OF SAN DIEGO

	Average ocean temperatures for the whole circle having the given latitude		Temperature of the Pacific at the boundary of the California and Japan currents		Temperature of the in-shore water along the Pacific Coast	
	Temp.	Time of occurrence	Temp.	Time of occurrence	Temp.	Time of occurrence
Maximum	77°	August	72°	Aug., Sept.	65°	September
Minimum	64°	February	61°	April	59°	May
Annual range	13°		11°		6°	

SURFACE TEMPERATURES AT LATITUDE 40°, OFF CAPE MENDOCINO

Maximum	66°	August	66°	September	57°	October
Minimum	48°	February	51°	April	52°	March
Annual range	18°		15°		5°	

SUMMARY OF HYPOTHESES PROPOSED TO ACCOUNT FOR THE BELT OF COLD IN-SHORE WATER ALONG THE WEST COAST OF NORTH AMERICA.—In the earlier explanations of the temperature anomalies then known, the assumption of a southerly surface drift from the Arctic was prominent. As later observations indicated belts of alternately warm and cold water lying at right angles to the coast, and revealed the presence in the summer time of the coldest in-shore water at latitude 40°, this hypothesis was abandoned in favor of the view that off-shore winds caused an upwelling of bottom water all along the coast, as had been demonstrated by Murray in the case of certain shallow lakes. But more careful attention showed that this would require an extension of the trade wind belt greatly beyond its observed limit, the prevailing winds being mostly in-shore where the cooling effect is greatest. By assuming that an eastward drift, extending from the bottom to the surface, prevailed over a wide belt of the northern portion of the Pacific, Holway in 1905 accounted for several of the facts without incurring the objection that applied to the former hypothesis. However, the new and more detailed facts revealed by later observations made it plain that the above explanations were inadequate.

RECENT RESEARCHES ON THE OCEANIC CIRCULATION AND TEMPERATURE DISTRIBUTION OFF THE PACIFIC COAST.—By attempting to explain and interpret hydrographic observations we can obtain a more thorough and extensive knowledge of the hydrographic conditions of a region than is given directly by a tabulation of the data. Because of this fact it was thought advisable to include a study of purely hydrographic problems with the biological problems of marine ecology, in the program of the Scripps Institution for Biological Research. Accordingly in 1910 the writer commenced a study of the problems suggested by the results of hydrographic observations off the Pacific Coast.

As the conclusions reached in this investigation are based not only on hydrographic observations,

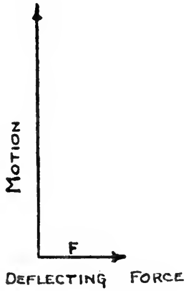

Figure 14
Constrained motion on the surface of a spheroid.

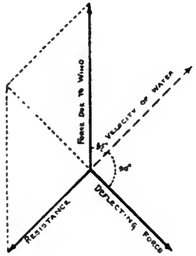

Figure 15
Three forces that determine the velocity of the surface water.

but also on recent theoretical results brought out by Nansen and Ekman, I shall begin with a brief sketch of Ekman's theory of oceanic circulation. Suppose a wind is blowing horizontally over the surface of a large body of water. Then the water will move under the action of three forces, that of the wind acting in the direction toward which the wind blows, that of the deflecting force due to the earth's rotation,* and that of the resistance due to the friction of the water underneath.

Hence, in order that the three forces (figure 15) may be in equilibrium, the resultant surface velocity must be directed to the right of the wind. This upper layer of water will act upon the one underneath just as the wind acts upon its upper surface, and so on downward. The mathematical theory shows that if differences in density are neglected,

* Whenever a body moves along the earth's surface, it becomes acted upon by a force directed to the right of the motion in the northern hemisphere, as shown by figure 14, but to the left in the southern hemisphere.

the motion will be as follows: Imagine a spiral stairway so situated that the edge of the top step is directed at an angle of 45° to the right of the wind velocity, thus coinciding with the arrow (Vo) of figure 16. Now if, as we descend, the steps are shortened so as to have in succession the lengths of the arrows in the diagram, the length of each will represent, in magnitude and direction, the velocity of the water at that depth. And at a depth corresponding to a half turn the velocity of the water is only 4 per cent of its initial value, and decreases rapidly from there downward. So, for practical purposes, we may neglect the motion below that depth. This depth increases with the wind velocity, but decreases with the latitude. At latitude 35°, if the wind velocity were ten miles per hour, the depth would be about twenty-five fathoms.

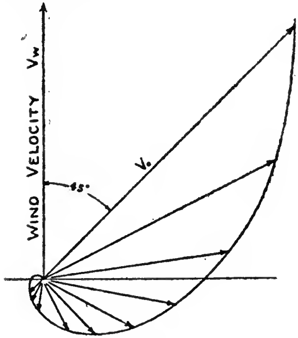

Figure 16
The direction and velocity of the water at increasing depths.

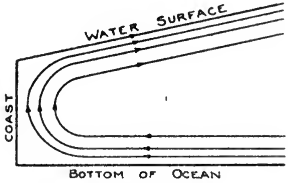

Figure 17
Upwelling of ocean water.

Suppose the wind has a component parallel to the coast line, and the water lies to the right when looking in the direction of that component (in the northern hemisphere). Suppose, further, that the depth of the water exceeds about twice that of the "wind current"*. Then, according to Ekman's theory, surface water will be carried to the right of and along the coast, thus causing a depression of the water level. The corresponding reduction in pressure on the bottom will cause a flow of the deepest water toward the coast and up-

* Wind-current is a technical term used to denote the current in the upper part of the water produced by wind over the open ocean.

ward to the surface, thus continually replacing the surface water that is forced away from the coast by the wind (figure 17). In addition, owing to the fall in pressure as the coast is approached, and because of the deflecting force due to the earth's rotation, there must be a flow parallel to the coast at all depths in the general direction of the wind.

Now if, instead of being vertical, the coast is inclined, the velocity of upwelling, and consequently the cooling effect on the in-shore water, will be less marked. Also, as the average depth of the water decreases below that of twice the depth of the "wind current," the effect of the wind will be less modified by the deflecting force, and the motion will take place more in accordance with the commonly accepted laws.

WINDS OF THE NORTH PACIFIC.—Numerous observations have shown that the winds over a wide belt of the Pacific along the west coast of North America are usually directed to the southeast. Moreover, these winds which form a part of a vast anti-cyclonic or clockwise circulation of air over the North Pacific are subject to an annual variation corresponding to the annual fluctuation of the difference between the air pressure over the continents and over the oceans. This difference is caused by the familiar fact that bodies of land acquire different temperatures from bodies of water under similar conditions. Thus in summer, when the land is relatively warmer than the ocean surface, there is a relatively high air pressure over the latter which results in a correspondingly greater wind velocity along the coast. On the other hand, in winter the pressure difference and consequently the wind velocity decreases owing to the relatively low temperature of the land. Hence an upwelling of bottom water would be expected along the Pacific Coast, and the rate of this upward flow would vary from a maximum in August to a minimum in February. This accounts qualitively for the peculiar temperature distribution previously described. Also the observed surface drift along the coast agrees well with what would be expected from the theory.

As an additional test of the theory I obtained a mathematical relation between the wind velocity, the surface temperature of the in-shore water, and the normal value for the latitude. A very satisfactory agreement was found between the temperatures computed from the above relation and the observed monthly in-shore temperatures, which at times are as much as 14° below the normal.

An examination of other coastal regions indicates the presence of a similar type of circulation off the west coasts of South America and Africa.

AERATION OF OCEAN WATER DUE TO OVERTURNING.—As recently pointed out by Juday, some agent other than diffusion is responsible for the aeration of large bodies of water. In lakes the aeration is accomplished by the spring and summer overturning and the resulting circulation which continues for some time afterward. The type of circulation just described for the Pacific amounts to a continual overturning of the water. There are good reasons for believing that the bottom water in the North Pacific is derived largely from the Antarctic Ocean, and that the return of the surface water to the Antarctic is accomplished in part by a slow southward surface drift due to differences in density of the upper layers of water, and in part by the motion of the upper air which carries moisture to the poles where it is precipitated. Thus it follows that aerated water is continually carried down to the depths of the ocean, especially in the south polar region, and is forced upward in upwelling coastal regions. It is manifest that the downward current would supply oxygen to all depths, and the upward current by transporting nitrogen and carbon dioxide from the sea bottom would enrich the upper layers, especially of the coastal water, thus giving rise to an increased production of plants. Numerous observations on the general fertility of coastal areas where upwelling is indicated by other evidence corroborate this conclusion.

DETERMINATION OF OCEANIC CIRCULATION FROM BIOLOGICAL FACTS.—Dr. A. H. Clark recently formulated a hypothesis of oceanic circulation to account for the distribution of the Crinoids, one of the widely distributed bottom animals. While he inferred that the cold in-shore water was of Antarctic origin, his hypothesis of the character of the circulation is quite contrary to the conclusions just reviewed, which were based on hydrographic evidence.

Though biological evidence may be of value in supplementing and checking our knowledge of the broader aspects of oceanic circulation, it is evident that the most reliable results must be obtained from direct observations on the water itself.

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INSECTS OF THE PACIFIC COAST

BY VERNON L. KELLOGG
Professor of Entomology, Stanford University

WHEN one speaks of the insects of the Pacific, they are the insects of Pacific shores and Pacific Islands that one refers to. For with all the amazing adaptiveness of insects to variety of habitat and habit, and with all the pressure of enormous numbers of species and individuals to drive them far and farther and into all the available places of earth, the insects have, curiously, so far not invaded the oceans. Although they constitute of known living animal kinds a full two-thirds, perhaps three-fourths, they are restricted in habit to but one-third part of the earth's surface, to-wit, its dry land and fresh and brackish waters. The real salt sea is tenantless of insects. A few long-legged surface-treading kinds are found on ocean waters far from land, but these are really inhabitants of surface sea-weed patches, which, like their fresh-water cousins, the familiar water-striders or skaters of ponds and quiet stream-pools, can run or glide quickly over the water's surface, denting but not breaking the supporting surface film.

There are also a few small kinds which haunt the beaches and rocks between tide lines for sake of the rich harvest of food thrown up by the waves. Such a kind is a little long-legged fly with atrophied wings, which lives on the headlands of the California shore in the Monterey Bay region. When the tide is out it runs actively about, looking like a small slender-bodied spider, over the rough damp rocks, seeking bits of organic matter thrown up by the waves that dash over the rocks at high tide. When the waters come back these odd little flies seek refuge under small silken nets they have spun across shallow depressions in the rocks. They cling desperately to the under side of the protecting silken mesh, while the great waves dash and break over them. Of course they are much of the time actually submerged in salt water. But they stand it.

Recently a similar and closely-allied fly has been found on the shores of bleak South Georgia Island in the South Atlantic about 500 miles east of Patagonia. And another tide rock fly of like habits is known from the cold and tempestuous Kerguelen Island of the South Indian Ocean.

The insects of the Pacific are, however, more conspicuous by the kinds familiarly known all over our continent than by the sorts peculiar to the region. In fact, what with the same old houseflies and blue-bottles, mosquitoes and fleas, cockroaches and bedbugs, and other familiar close companions of men, the insect fauna of a Pacific island or of the Pacific Coast of America is likely to be disappointingly familiar and familiarly troublesome.

But this familiar character of the first seen and most often seen insects of the Pacific points an important moral to the student of insect distribution and of insect troubles. It is the moral of man's personal aid in the wide dissemination of insect pests. Wherever he goes by wagon, train or ship, he carries his pests with him, colonizes them wherever he settles, and supports them in their new homes by his own presence and the presence of his domesticated animals, and his quickly planted grains and vegetables, fruits and flowers.

So the casually inquisitive visitor to Pacific lands will find himself irritated by the same kind of fleas, mosquitoes, buzzy flies and biting flies, nocturnal bed-fellows, same old Croton bugs and black beetles and the rest that he knows in the East and Middle West.

They have all come to California and Oregon and Washington, and gone on to the Hawaiian and Samoan and Philippine islands, just as many of them came from Asia to Europe and Europe to the Atlantic and went on to the Mississippi Valley in earlier years. And this emigration and immigration by the side and with the aid of man accounts for a considerable, and from the economic point of view, a very important part of the Pacific insect fauna. For most of the worst insect pests of California and the rest of the Pacific Coast are imported and comparatively recently imported species.

The most important single group of insects to the citrus and deciduous fruit growers of California are the scale insects *(Coccidae)*, small degenerate, specialized, wax-covered and protected sap-sucking creatures, of hardly the seeming of an insect at all. The San Jose scale, the cottony-cushion scale, the black scale, the soft brown scale, the red orange scale, and all the rest of the scaly crew are ever threatening clouds on the fruit grower's horizon. And he spends annually much time, energy and money in fighting back the swiftly multiplying hordes of these pests.

Now practically all of them are natives of other lands; they are man-aided immigrants into California. The San Jose scale, that once threatened the whole deciduous fruit interest of California, came from China, probably by way of Japan, about 1875. The cottony-cushion scale that similarly once threatened all the citrus orchards came from Australia about 1868. And the story of the coming and settling and finding the country good, of several of the other kinds is as well known.

But fortunately the economic entomologists have learned something to their advantage from this kind of insect emigration. They have learned deliberately to hunt for and import good bugs to fight the bad ones. For example it was discovered that the Australian cottony-cushion scale, so dangerous a pest in this country, was not so dangerous in Australia, and this because of the active efforts made there by a certain kind of little black and red ladybird beetle known as the Vedalia. The scale pest had got carried to America without its Vedalia enemy and accordingly found California in truth the promised land. Now what more commonsensible than deliberately to import and colonize Vedalia in the California orange and lemon orchards?—which was accordingly done, and done easily and successfully, so that here as in Australia, Vedalia keeps the cottony-cushion scale insect within practically harmless bounds.

Naturally such a success has led to many other attempts in many other similar cases. Perhaps no other success has been so marked as the now classic first one, but much other success there has been, both on the Pacific Coast and on Pacific Islands, notably Hawaii, and also in the Eastern states. The great fight against the imported foliage and forest tree pests of New England, the dire gipsy and brown-tail moths, is resolving itself more and more into a search for and colonizing of their natural parasites in Europe and Japan. More than thirty kinds of parasitic and predacious insect enemies of these moth pests have been brought to this country and offered a hospitable welcome. Some of them, notably a voracious Calosoma beetle, seem to be already more than earning their living.

Another type of good bug brought to the Pacific Coast by deliberate importation and carefully nursed to an effective colonization is the curious little fig-wasp, *Blastophaga,* by whose means the "caprification," i. e. pollination, of figs depends, on which depends in turn, the full size, sweetness and the nutty flavor of the best commercial figs. The fig is a hollow but fleshy receptacle with many minute flowers inside. The Blastophaga eggs are laid in ovules of these flowers and there the tiny grub (larva) lives and feeds and changes finally into a little chrysalid and then adult. The adult male Blastophaga is a curious deformed wingless creature, and remains in the fig of its birth until it dies. But the female is a winged active insect that leaves its natal and cradle fig and flies to others to lay its eggs. Curiously it can find suitable egg-laying places only in the wild or so-called capri figs and so does not leave eggs in the cultivated figs, but in walking about over their flowers it dusts them with pollen brought from the fig last visited, and thus produces the necessary cross-pollination. As the Blastophaga lays no eggs in the domestic figs it is necessary to keep a few wild fig trees growing in or near the orchard.

But not all the Pacific Coast insects are excessively bad bugs or excessively good ones. Some call for attention because they are just beautiful, or singular, or of unusual habit or habitat. And these are likely to seize the interest of most of us, more certainly than the pests. For, after all, our interest in Nature is not primarily one of dollars and cents. It is one of curiosity and of "wanting to know."

A matter that lends California's fauna and flora a special interest to naturalists, and even to just nature-lovers, is the peculiar biogeographic situation of the state. Biologically, California is essentially a large island, shut off by barriers of actual water on one side and by hot deserts and high cold mountain ranges on the other, with the ends also similarly barred by desert and mountain. This results in her showing the characteristics of an island fauna and flora, possessing monotypic plants and animals, unique, solitary kinds, developed in isolation and under special local conditions. California's insect fauna, therefore, includes many unique species and genera, and even a few families, not found elsewhere on this continent, not even in other neighboring states. This makes it an exceptionally happy hunting ground for the insect collector and systematist.

But not only does its biological isolation give an exceptional interest to its insect kinds, but its extraordinary topographic and climatic diversity introduce unusual and highly contrasted conditions in insect living and, through environmental influence, produce strange kinds of specialization of structure and habit. For example, the brave little butterflies *(Chionobas)* that live on the summits of the Sierra Nevada are bound to attract our attention, for their nearest cousins (other species of the same genus) are similar butterflies confined to the summits of the Rocky Mountains, 1000 miles away, and Mt. Washington in New Hampshire and Mt. Katahdin in Maine, 2000 miles farther. These lonely mountain-top butterflies are good illustrations of the fact that the conditions of great altitude can replace those of high latitude in the distribution of many animals. And they undoubtedly owe their marooning on widely separated peaks, through their neglect to follow the retreating glaciers of the close of the Great Ice time northward, but remained instead in these isolated regions where conditions have remained practically glacial.

The California mountains, especially the Coast Ranges, have another especially interesting group of insect inhabitants in a curious small family of delicate, long-legged, stream-haunting flies called net-winged midges (Blepharoceridae). Although scattered widely over the world in mountain regions hardly more than a score of species are known, of which almost one-half are peculiar to the Pacific Coast. Their immature life is passed, as larva and pupa, in the swiftest and clearest of mountain streams, clinging by strong little sucking pads to the smooth rock bottom on the verge of a fall. The larvae die if they happen to get into slow or stagnant water, and many of the delicate flies are torn away by the current and lost as they emerge from the pupae. But nevertheless with all this restriction of life to certain narrow and dangerous conditions, the net-winged midges, like the water ouzels, near whom they domicile, maintain a successful existence to add to our interest in the mountain streams.

Another interesting group of insects, well represented in California and very sparingly elsewhere in this country or anywhere out of the tropics, is the family of termites, or white ants (Termitidae). Indeed, out of the eight species known to occur in the United States, but two are found in the East, the other six being limited to the Southwest and Pacific Coast. Three species occur in California, of which two are common and constantly met with. One *(Termopsis angusticollis)* is unusually large, and makes its communal nests in fallen pine trees, telegraph and telephone poles and other dry wood. I have found colonies containing thousands of individuals in fallen trunks of the great trees of the Sierran forest.

Another group of interesting insects unusually well represented in California are the gall flies (Cynipidae) which form the galls, or, better, stimulate the trees to form the galls, on oaks. Seventy species of these odd little flies have been listed for the state, and there are others in Oregon and Washington. As each species has its own special kind of gall, the oak trees of the Pacific Coast often bear a curiously variable load of "fruit" besides the acorns.

I should like to speak of some of the West Coast insects of unusual appearance or pattern, the kind that catch the eye of the most casual traveler, such as the giant tarantula-killing, bronze-winged, blue-black Pepsis wasp, that indulges in battles royal with the big hairy tarantulas and trap-door spiders, which themselves, though not insects, are near enough related to them to warrant mention in any account of our insect fauna. But I may not. I may not speak further at all except to say that the Pacific Coast will match its insects against the equivalent fauna of any other region for interest and opportunity for fascinating observation and profitable study.

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FLORA OF THE PACIFIC COAST

BY HARVEY MONROE HALL
Assistant Professor of Botany,
University of California

THE flora of the Pacific Coast offers many attractions to the botanical traveler. No matter what phase of botany may interest him most, whether it be the aesthetic, the systematic, the genetic, or the ecologic, he will find ample material for his studies and a never-ending succession of problems to tax his skill as an investigator. The flowers are more highly colored than are those of most other regions, and the number of species is larger, while fluctuating variations in vegetative characters are exceedingly abundant and often give rise to very dissimilar forms within the species.

The diverse and variable character of the western flora is undoubtedly due in large measure to a wide variety of climatic, soil, and other environmental factors. At the lower altitudes are desert areas where the vegetation is strongly xerophytic and the flora evidently related to that of Mexico, the high mountain summits are likewise arid but the vegetation here is Alpine in character and the flora undoubtedly of boreal origin. Between these extremes are areas of highly diversified topography. Rugged mountains alternate with fertile valleys; deep cañons furnish walls of varying slope and all exposures; there are lakes, swamps, alkaline depressions, and in addition such variety of soils that nearly every class of plants somewhere finds conditions suitable to its needs. The Sonoran, or Mexican, element of the flora occupies most of southern California and extends north through the interior valleys even into Washington. The boreal element is naturally best represented in Washington, Oregon, and Idaho although the boreal zones extend down the whole length of the Sierra Nevada and into southern California. Where the two meet there occurs a mingling of the northern and southern elements and in many places one also encounters a peculiar flora, especially of shrubby species, not closely related to that of any other region and believed by many to be endemic.

In the following account we shall be able to mention the flora of only a few of the more prominent and accessible plant formations. The desert area is entirely omitted since its flora is described in a succeeding chapter.

Coastal Formations (chiefly of the Upper Sonoran zone).—Except for those places where the bluffs or mountains extend to the water's edge, the shore line exhibits a series of sandy beaches often backed by a belt of dunes of varying width. Here is found a characteristic xerophytic vegetation composed chiefly of perennial herbs and shrubs. Since the floral composition is fairly uniform from north to south one may study these plants equally well near almost any of the beach resorts.

Very characteristic of the dunes are the Abronias, or sand verbenas, of which *A. umbellata* (rose-pink) and *A. latifolia* (yellow) are the most common. The roots of these plants are often much enlarged, thus serving for storage, while the broad opposite leaves are thick and succulent. The most marked examples of succulent herbage, however, are the Mesembryanthemums, or sea figs, the enlarged often trigonous leaves of which serve admirably as water reservoirs. The pale scurfy-leaved saltbushes *(Atriplex)* and the hairy-coated Franserias *(F. bipinnatifida* and *F. chamissonis)*, bear unmistakable evidence of their xerophytic nature. More beautiful than the humble herbs just mentioned are the bush lupines of the dunes with their attractive racemes of yellow, bluish, or purplish flowers and silvery-pubescent compound leaves. Similarly pleasing are the Oenotheras, the most common of which is *OE. cheiranthifolia,* whose tough woody stems either trail over the dunes or arise reluctantly from them and bear, in addition to their hairy-protected leaves, an almost continuous succession of yellow blossoms. On the southern beaches occur *Calandrinia maritima,* a succulent glabrous annual with red flowers, and *Amblyopappus pusillus,* an erect fleshy Composite herb found also on the coasts of Chile. The sand strawberry *(Fragaria chilensis)*, another species which occurs also in Chile, will be found from San Luis Obispo to Vancouver. The dune tansy *(Tanacetum camphoratum)* is restricted to the beaches and dunes from Monterey to Humboldt, but is replaced on the coast of Oregon and Washington by *T. huronense.* From Monterey northward will be found the beach pea *(Lathyrus littoralis)* which although botanically a sweet pea, looks much more like a Hosackia or a lupine because of its silky-villous herbage.

Flora of the Plains and Lower Foothill Slopes (Lower Sonoran and Upper Sonoran zones).—In early springtime, when the sun's warm rays heat up the soil still moist from winter's rain, innumerable annuals cover the plains, first with green, then with a gorgeous array of floral colors and extend up the slopes until lost amid the shrubs of the foothill belt. This is the scene over which poets thrill and botanists despair. For this is the home of the California poppy (of which some claim that there are more than a hundred species), and of the cream-cups, and Phacelias, and Godetias, and Baerias, and tidy-tips, and a thousand other beautiful but, to the botanist, perplexing groups of closely related species.

Suburban railways from almost any city, from San Diego to Seattle, will carry one into these flowery gardens, but it is in southern California and along the borders of the Great Central Valley that the greatest profusion of flowers is to be seen. One reason for this is the absence of sod-forming grasses, the annuals thus being permitted to occupy the whole area whenever moisture and temperature conditions are favorable.

If the visiting botanist selects the plains or foothill slopes of southern California for his excursion he will be impressed with the preponderance of Composites, indicating perhaps, the close relation with the Mexican flora. *Baeria chrysostoma* grows in such abundance that it is known as gold-fields. *B. coronaria* is equally plentiful in some parts of San Diego County and both species furnish excellent material for the study of variation as related to environment. *Layia, Coreopsis, Chaenactis*, and (at San Diego) *Pentachaeta* are other abundant Composite genera. Because of the large and showy cup-shaped flowers, the various species of *Calochortus* (mariposa lily), a characteristic western genus, are easily found, especially along the foothills. Another liliaceous group, the Brodiaeas, which grow from edible corms and bear umbels of usually bluish flowers, inhabit clay soils. The rare Matilija poppy, well known for its magnificent white flowers, is best seen in the Ojai Valley, Ventura County, and in Santiago Cañon, Orange County, but it also occurs in masses in Temescal Wash, southeast of Corona, and in San Diego County.

Many of the genera just mentioned may also be found on the coastal slope of middle California, but here there is a larger proportion of grasses and of perennials, consequently the foliage is more luxuriant, and the flowers are less conspicuous. During the spring and summer months, Baerias, Layias and other Composites still dominate certain slopes, such as those around Lake Merced, just south of San Francisco. On down the San Francisco Peninsula are to be seen extensive fields of *Eschscholtzia* and *Platystemon.* Those who journey still farther southward will find all of the foothill slopes around the Santa Clara Valley teeming with attractive and interesting species. To the east and north of San Francisco Bay the hill districts form the chief attraction. Here will be found *Brodiaea, Chlorogalum, Sidalcea, Orthocarpus, Castilleia, Wyethia, Nemophila, Lathyrus,* and many other genera of showy or otherwise interesting seed plants. Passing northward into Oregon and Washington these formations become of less and less importance. There the coniferous forests predominate.

The Chaparral Flora (Upper Sonoran zone).—*Chaparral* is a term applied in the West to any low and shrubby growth regardless of the species of which it may be composed. Its individuals are literally the "little chaps" as contrasted with the forest trees. It corresponds to the *maqui* of the Mediterranean region, and to the *scrub* of Australia. Although it occurs also in other life zones, chaparral is with us preeminently characteristic of the Upper Sonoran, or, as it is often called, the foothill or chaparral belt.

Our Upper Sonoran chaparral is strongly xerophytic in character. The root system is well developed and in many cases harbors bacteria the presence of which is presumably beneficial; the branching is profuse and intricate; the usually narrow evergreen leaves are heavily cutinized, often covered with tomentum *(e. g., Artemisia californica, Eriodictyon tomentosum, Malvastrum* of several species), or they may assume a vertical position *(Arctostaphylos, Dendromecon).* Often the herbage is strongly resinous *(Ericameria, Baccharis)* or coated with a gummy or wax-like layer *(Eriodictyon californicum).*

In order to observe the many peculiarities of our shrubby vegetation it is necessary to travel only a short distance from the cities and towns usually visited, for chaparral abounds in almost every district except along the northwest coast. In the immediate vicinity of San Diego it is restricted chiefly to northerly slopes of the arroyos, but here are found Mexican species of the Lower Sonoran zone which do not occur much farther north. Such are *Viguiera laciniata* and *Encelia farinosa,* both yellow-flowered Composites, the latter ranging north to San Bernardino. Along the foothills from this last-named city to Los Angeles is found a broad chaparral belt in which the chamisal *(Adenostoma californica)* is very prominent. This narrow-leaved Rosaceous shrub is one of the most abundant in the whole

PLATE XX

Spanish Bayonet, *Yucca (Hesperoyucca) whipplei*, a Conspicuous Member of the Chaparral Belt of Southern California. The Panicle of Heavily Fragrant, White Flowers Rises Eight or Ten Feet Above the Dense Cluster of Stiff, Sword-like Leaves at the Base. The Method of Fertilization by the Pronuba Moth Which Lays Its Eggs in the Flower Is a Striking Example of Interdependence of Plant and Animal.

Photograph by Harley P. Chandler.

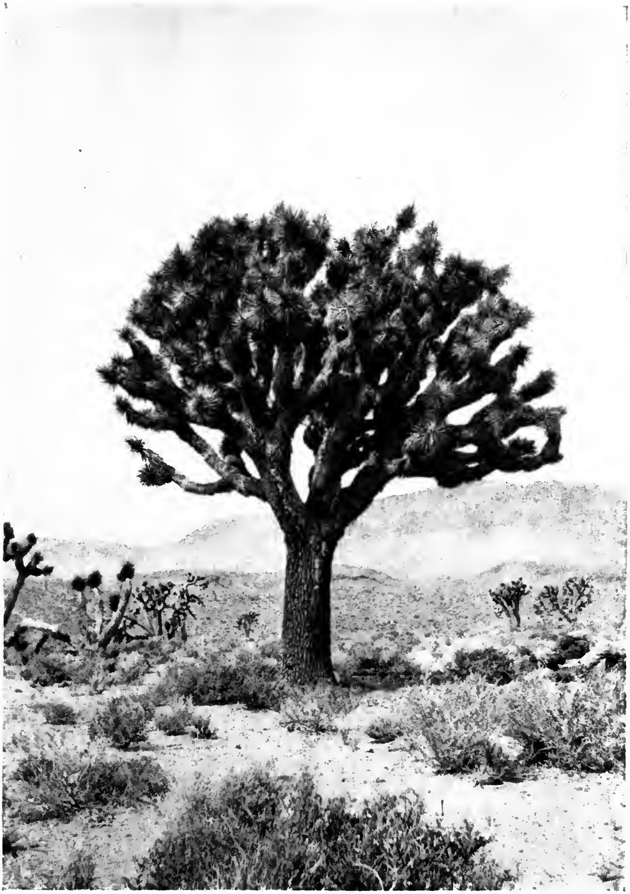

PLATE XXI

Tree Yucca, *Yucca (Cleistoyucca) arborescens,* Characteristic of Certain Levels on the Mohave Desert. Often Referred to as a Palm or even as a Cactus-Palm, It is Somewhat Surprising to Find That This Tree, Reaching a Height of Twenty-five Feet, Is Botanically a Member of the Lily Family. The Desert Wood-rat *(Neotoma desertorum)* Feeds on the Young Leaves and the Fruit. In Early Times the Indians of the Mohave Desert Pounded the Small, Dry, Black Seeds Into a Meal for Food.

Photograph by Harley P. Chandler.

state and is especially beautiful in summer and autumn when thousands of miles of foothill slope are suffused with the warm reddish-brown tints of its fading bloom. This southern chaparral also includes the scrub oak *(Quercus dumosa)*, many species of *Ceanothus*, *Arctostaphylos*, and *Artemisia*, as well as other elements. Of economic as well as biologic interest are two shrubby species of *Salvia*, *S. apiana*, the white sage, and *S. mellifera*, known as black sage. Both of these are important bee plants as is also an abundant shrubby *Eriogonum (E. fasciculatum)*. The yellow-flowered tree poppy may be seen at its best on the Santa Ynez Mountains back of Santa Barbara. The Spanish bayonet *(Yucca whipplei)* is of more general distribution, for it grows on nearly all the lower mountains where its creamy white panicles far overtop the surrounding vegetation, giving to the landscape a unique and pleasing aspect. (See Pl. XX.)

The general appearance as well as the floral composition changes but slightly as we pass northward, except that northerly slopes are given over to broad-leaved shrubs and trees of the Transition zone. On the south-facing slopes of Mount Tamalpais, in the vicinity of San Francisco, the dominant shrubs are the same as in the chaparral of southern California. In addition to these one will encounter some species and even a few genera not represented in the south. An example of the remarkable ability of chaparral to re-cover a burned area by means of stump-sprouting may be studied on the south slopes of Mount Tamalpais. In July, 1913, these were swept by a fire which killed to the ground all shrubs over a large area. The present condition is therefore the result of growth since that time.

In the more northerly Coast Ranges the chaparral is confined to the poor soil of dry ridges which occur here and there in the redwood belt and to the arid districts beyond the immediate influence of coast fogs. The San Joaquin and Sacramento valleys are completely encircled by a chaparral belt which extends up to the forests of the Coast Ranges and of the Sierra Nevada. Therefore any excursion into the inner North Coast Ranges, or from the Great Central Valley to any of the mountain resorts will necessarily lead one through districts where chaparral may be studied to advantage.

In northeastern California, Oregon, and Washington is encountered a more open formation, characteristic of the Columbia and Great basins. Here the shrubs are low and often pale or gray in color. The most abundant species are the sagebrush

(Artemisia tridentata), rabbit-brush *(Chrysothamnus* of several species), hop sage *(Grayia spinosa)*, antelope brush *(Purshia tridentata)*, and in alkaline soil black greasewood *(Sarcobatus vermiculatus)*.

The Mountain Flora (Transition, Canadian, Hudsonian, and Arctic-Alpine zones).—In the mountainous districts the most important life zone is the Transition, so-named because here the boreal and the southern elements of the flora meet. Except along the coastal strip it coincides in general with the yellow pine belt. Here the botanical traveler will find a delightful and exhilarating climate during the summer months. If he comes from the eastern states most of the genera and some of the species will be already familiar to him, if from the north or from northern Europe he will feel more at home, botanically, in the higher zones. Vast areas of yellow pine forest are easily accessible by wagon road or trail from all the mountain settlements and resorts, while those who desire more strenuous mountaineering will find ample test for their skill.

In the open forests will be found a scattering growth of flowering herbs. These increase in abundance as the trees become better spaced, thus admitting more light. Pentstemons are plentiful, especially in the south. Monardellas, Gilias, several species each of *Pedicularis, Lathyrus, Hosackia,* and many other genera are not uncommon. Thick-stemmed saprophytes like *Pterospora, Pleuricospora, Corallorhiza,* and *Pyrola aphylla* force their way through the carpet of pine needles. The most popular of these saprophytes is the snow plant *(Sarcodes sanguinea)* the thick red stalks of which appear soon after the snow has melted and remain as conspicuous elements until autumn. Although not abundant it may be expected anywhere in this zone from southern California to Oregon.

But it is only in the forest openings that one finds flowering plants in profusion. Gravelly slopes along rocky outcroppings and exposed ridges are the most productive. Such localities may be yellow with *Eriogonum* and *Eriophyllum,* both of which western genera are represented by many species, or blue with Erigerons or Asters, or brilliant with several sorts of *Pentstemon,* but always with an admixture of many species belonging to other genera.

Here and there the forest opens up to make room for a mountain meadow the composition of which will vary with the moisture content of the soil as well as with geographical position. A small meadow in Butte County, California, may be described as typical of those to be found in the Sierra Nevada.

Here the most prominent species is *Castilleia miniata* the numerous red spikes of which impart a rich warm color to the vegetation. Next in importance are the white heads of *Selinum,* which overtop all else save where the clumps of lupine *(Lupinus polyphyllus)* carry their blue racemes still higher. On one gentle southerly slope the elephant heads *(Pedicularis attollens)* are very conspicuous and the whole meadow is punctuated with the white spikes of the Sierra rein-orchis *(Habenaria leucostachys).* More than twenty other species in addition to the grasses and rushes also inhabit this meadow.

Comparatively dry meadows and grass-land are also frequent, affording excellent opportunity for researches upon the relation of environment to distribution and structure.

The riparian and bog formations have each their characteristic species, but mention can be made only of the California pitcher plant *(Darlingtonia californica).* This noted insectivorous species grows in boggy meadows of northern California and southern Oregon. It may be most conveniently examined at the "18th crossing," a few miles south of Sisson on the San Francisco and Portland line of the Southern Pacific Railroad, or in Butterfly Valley, just south of Keddie on the line of the Western Pacific Railroad. The plants are much finer and more abundant at this latter locality.

Passing over the Canadian and Hudsonian zones we may now take a brief survey of the flora above timber-line. The Arctic-Alpine zone, the lower limit of which is marked by timber-line, scarcely occurs in southern California. On southerly slopes it begins at an average altitude of 11,000 feet in the southern Sierra Nevada, at 9500 feet on Mount Shasta, and at about 6500 feet in Washington. Throughout its whole extent the vegetation and the flora are fairly uniform. In this zone all plants have deep perennial roots and low tough stems. The leaves, closely huddled near the base or along the short stems, are heavily cutinized. Among the characteristic species, all of boreal origin, may be mentioned the Arctic willow *(Salix arctica* var. *petraea)* with stems only two or three inches high; *Cassiope mertensiana* with thick overlapping leaves and dainty pendant flowers; the Alpine sorrel *(Oxyria digyna),* well known in Arctic and Alpine districts around the world; *Polemonium eximium,* with showy blue flowers (replaced in Washington by *P. elegans),* and a number of Composites, mostly with yellow flowers. This is only the beginning of a long series of species which might be enumerated.

The large number of forms, the remarkable adaptations to so rigorous a habitat, and the brilliancy of the colors displayed all conspire to make a study of the Alpine flora an exceedingly attractive occupation. The highest summits are beyond the reach of seed plants, but the rocks support a meager lichen flora.

Flora of the Northwest Coast (mainly of the Humid Transition area).—The term Northwest Coast is here used to designate the coastal slope of Washington and Oregon, west of the Cascade Mountains, and northern California west of the Coast Ranges. Because of its moist climate and equable temperature this coastal strip sustains the densest forests in North America. Save on the open prairies, which occur in limited number, the herbaceous flora is composed almost entirely of broad-leaved mesophytes. These, however, are exceedingly luxuriant. In the densest shade the ground is covered with mosses and ferns, of which a sword fern *(Polystichum munitum)* is the most abundant. Here also are found the huckleberries *(Vaccinium parvifolium* and *V. ovatum)*. Where the forest is more open the sword fern is replaced by the common brake *(Pteris aquilina)*, and two sub-shrubs become common, namely, the Oregon grape *(Berberis nervosa)* and the salal *(Gaultheria shallon)*. The salal is especially prominent, often covering the forest floor for miles with almost impenetrable thickets. Along stream-borders from Santa Cruz northward to near the Oregon line will be found the delightfully fragrant western azalea *(Rhododendron occidentale)*, while the California rose bay *(R. californicum)* is partial to rugged mountain sides and grows as far north as British Columbia.

In favorable situations, particularly in the more southerly redwood belt, we find a good representation of herbaceous shade-plants. Several species of *Heuchera* and *Tellima* throw out their rounded leaves in broad rosettes, and twin-flowers *(Linnaea borealis)* overhang the moss-covered logs. *Vancouveria*, with fern-like foliage but flowers so odd that they are termed inside-out flowers, grow in small clumps on the better-drained slopes. Here also trail the wood-loving Whipplea *(W. modesta)* and the yerba buena *(Micromeria chamissonis)*, the trailing mint which gave to San Francisco its earliest name. On wet bottom-lands and along streams one will find the salmon berry *(Rubus spectabilis)*, the red-berried elder *(Sambucus callicarpa)*, and several species of *Ribes*. The devil's club *(Echinopanax horridum)*, a foetid prickly red-fruited shrub with large palmately lobed leaves, also belongs to this association but does not occur south of Oregon.

LOCALITIES OF SPECIAL BOTANICAL INTEREST

TUCSON, ARIZONA. Here are located the Desert Botanical Laboratory of the Carnegie Institution and the University of Arizona. The surrounding territory affords splendid opportunities for the study of desert flora.

SAN DIEGO, CALIFORNIA. The mesa flora is here of particular interest and is abundant to the north and east of the exposition grounds. Visitors to Tia Juana should take private conveyance in order to drive to the westernmost boundary monument, where *Agave shawii* may be seen, and to return by way of the Silver Strand in order to study the beach flora. Back of San Diego will be found a highly interesting mountain region, dominated by Cuyamaca Peak, considerable areas of which extend well into the yellow pine belt. El Campo, forty miles east from San Diego, is in the midst of a chaparral flora of exceptional interest since desert and Mexican elements are much in evidence. Annual flowering plants are abundant in springtime, filling in all spaces left vacant by the shrubs which are themselves often brilliant with the blood-red flowers of a climbing Lathyrus. El Campo is on the San Diego-El Centro stage line. Those traveling by private conveyance should return via Pine Valley and the Viejas Grade. The desert flora may be observed by continuing easterly to Mountain Springs

RIVERSIDE, CALIFORNIA. The mesa and foothill flora may be examined to best advantage by taking the electric cars to the Bloomington plains or the daily San Jacinto auto-bus to "the fill" on Box Springs Grade and walking back cross-country to Eighth and Ottawa streets where return transportation may be had.

REDLANDS, CALIFORNIA. San Timoteo Cañon, back of Smiley Heights, should be explored for its profusion of annuals intermixed with chaparral. Mill Creek Cañon is very interesting botanically.

SAN BERNARDINO, CALIFORNIA. The electric line to Arrowhead Hot Springs will carry one to the heart of the chaparral belt. Annuals grow in abundance around the mouth of Waterman Cañon, crossed by the same line.

LOS ANGELES AND PASADENA. Numerous electric lines lead to Hollywood, Altadena, Sierra Madre, and other foothill stations as far east as San Bernardino. The Mount Lowe Railway takes one into the edge of the yellow pine belt in a few hours. More will be seen, however, if one has time to make the ascent by train or to drive (by auto or team) up the Santa Anita grade. Redondo, Playa del Rey, and other beach resorts afford opportunity for the study of the beach and dune flora.

SANTA BARBARA. From the mission one may explore Mission Valley or, better, follow the Mountain Drive. Here will be found the rare and showy *Venegasia,* a sub-shrub much more handsome than the sunflowers, to which it is related. The Tunnel Trail to the summit of the Santa Ynez Mountains affords a delightful day's trip for the observation of chaparral and annual flowering plants.

SAN FRANCISCO AND ENVIRONS. Dune and beach plants are abundant south of Golden Gate Park and at Land's End. Electric lines running south to San Mateo, etc., lead through many fields of showy annuals. These are especially luxuriant on the slopes a short distance west of Millbrae. The foothills back of Stanford University are very attractive botanically and easily reached from Palo Alto.

Mount Tamalpais dominates the peninsula north of the Golden Gate and should be visited by all botanists. Salt-marsh plants abound between the bay shore and the foot of the mountain. From Mill Valley the railroad winds through a sea of chaparral which extends to the very summit. Both the peak and Muir Woods, a redwood reservation with a characteristic vegetation, may be visited in one day but this is not advisable. The enthusiast will much prefer the trails from Mill Valley, or he may take the train to the summit or to Muir Woods and walk back.

On the easterly shore of San Francisco bay numerous electric lines lead to the hills and cañons where good collecting abounds. The Oakland and Antioch Railway pierces the Oakland Hills and so transports one in less than an hour's time to localities where the vegetation is still in its original condition. Pinehurst Station, in Redwood Cañon, is especially recommended. From here a two-mile walk brings one to Moraga, where return trains may be taken.

UKIAH, CALIFORNIA. This is in the heart of the inner Coast Ranges. The Terraces, where many native plants are grown under cultivation, lie some seven miles to the east up an interesting cañon. Lake County resorts are reached by stage from either Ukiah or Calistoga.

YOSEMITE VALLEY. The best botanizing is on the slopes around the valley borders and away from the popular trails. The Tenaya trail *above* Mirror Lake is recommended. Bog and shade plants abound near Happy Isles and Iron Spring. The wise enthusiast will use the trails early in the day and avoid the parties "under guidance" as far as possible. The most productive fields are around the valley's rim. One should make headquarters for a portion of his time at Glacier Point, whence the rich flora of Sentinel Dome as well as that of numerous meadows and bogs may be easily explored. In order to reach the Alpine zone of the High Sierra from Yosemite it is necessary to make a packing trip of several days' duration.

LAKE TAHOE. The Sierra Nevadan flora may be conveniently investigated from any of the numerous resorts around the Lake. Deer Park Springs and the resorts from Emerald Bay to Fallen Leaf Lake are well situated for plants of the forests. Glen Alpine affords more ready access to the higher zones and especially to the Alpine flora of Pyramid, Ralston and other high peaks.

MOUNT SHASTA. This mountain is usually ascended from Sisson. The flora of the middle zones is very rich but the Alpine flora is disappointing.

SUMMIT, PLACER COUNTY, CALIFORNIA. Passengers on the Central Pacific Railway may stop over here and examine the sub-alpine flora. Peaks above timber-line are within a day's walk and Donner Lake lies two miles to the east.

EUREKA, CALIFORNIA. The flora of the redwood belt is conveniently observed about Eureka and Arcata. Samoa Peninsula with a rich beach and dune flora is also within easy reach.

PORTLAND, OREGON. A trip should be taken up the Columbia River, one way by boat, the other by train. Abundant plant material may be obtained by stopping at Cascade Locks. The coast may be visited at Seaside which may be reached by boat or rail from Portland. This is a day's trip each way. The beach may also be reached from Albany by rail to Newport, and from Eugene by rail and boat to Florence. The available plant life of dune and down and bog is abundant.

CRATER LAKE, OREGON. This national park may be reached from Medford by auto stage. The trip is of great botanical interest and there is an especially good display of flowering plants at the summit. Those who have sufficient time should by all means make the trip by private conveyance.

TACOMA. A visit to American Lake and vicinity by any of the several lines is recommended. The running time is less than an hour and both prairie and forest plants will be found in abundance along the route. At Tacoma one will find excellent opportunity to study the vegetation of the salt marshes. Mount Rainier, which extends above the limit of flowering plants is reached by stage. Those who take the Rainier trip will find an abundance of alpine species in and around Paradise Park.

SEATTLE. The flora of the coniferous forest formation may be reached by any line that extends beyond the cleared districts. The Lake Washington district is recommended.

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FORESTS OF THE PACIFIC COAST

BY WILLIS LINN JEPSON
Associate Professor of Dendrology, University of California

THE forests of the Rocky Mountains do not usually make a strong impression upon the railway traveler. Journeying westward over the old "Overland Route," one may cross the great backbone of the continent by a slope so gradual and treeless that he may scarcely be aware of his transition from the barren Great Plains to the hot sage-brush of the Great Basin. Extensive forests, to be sure, occur in the Rocky Mountains, but in their southerly part they are mostly limited to the higher ranges.

One species in these coniferous forests is more widespread and abundant than any other. It is characterized by two needles and small bur-like cones, and is everywhere known in this region as the lodgepole pine *(Pinus contorta* var. *murrayana)*. Its slender, bamboo-like trunks form admirable poles for the tent dwellings of the plains Indians. Unlike most other western conifers it has a very thin bark and suffers severely under fire, but its abundant cones, often remaining closed for several years, provide a safeguard against excessive mortality by forest conflagrations.

The western yellow pine *(Pinus ponderosa)*, Engelmann spruce *(Picea engelmannii)*, white fir *(Abies concolor)* and, in Idaho, the western larch *(Larix occidentalis)* are other species which inhabit this area. The first named species is remarkable in that it is accommodated to a greater variety of soil, exposure and climate than any other North American coniferous tree.

By whatever route the traveler sets his face westward to the Pacific from the Rocky Mountains, hundreds of miles of monotonous sage-brush weary his eyes ere he breast the Sierras or Cascades and views with expectant gaze forests which are among the botanical wonders of the world. These forests of the Pacific Coast of the United States really form only a narrow, coastal strip on the western edge of the continent, clothing the Coast Range and the slopes of the next succeeding inner range. It is in Oregon and Washington that this forest attains its most extensive development, a few species or even a single one being dominant over extensive areas.

In California the height of the mountain ranges and their distance from the sea determine the degree of rainfall, and influence the temperature. The main forests are thus limited to definite bands on the main mountain ranges, between which intervene valleys and foothills destitute of forests or woodlands, or characterized only by scattered oak or fringes of trees along the streams.

The alluvial plains of the Sacramento and San Joaquin valleys, while in the main treeless, may take on, in places, the aspect of park-land by reason of the presence of the valley oak *(Quercus lobata)*. This is a fine tree 50 to 80 feet high, its broad crown giving rise to pendulous cord-like branchlets which may sometimes be so long as to sweep the ground. Near the coast this species gives place to the coast live oak *(Quercus agrifolia)*, an evergreen tree with low broad crown and holly-like leaves, or on the floors of the Coast Range valleys these two species may frequently be associated.

The main forest on the western slope of the Sierra Nevada is about five hundred miles long and twenty-five miles in breadth. The densest median part of the strip is principally composed of five species: Western yellow pine, sugar pine *(Pinus lambertiana)*, white fir, red fir *(Abies magnifica)*, incense cedar *(Libocedrus decurrens)*, and big tree *(Sequoia gigantea)*, while silver, or little sugar pine *(Pinus monticola)*, lodgepole pine, here a less slender tree than in the Rocky Mountains and now known as tamrac pine, and black oak *(Quercus kelloggii)*, are secondary species on the upper or lower borders of the main forest. All the principal components of this forest have their greatest development in the Sierra Nevada, and with two exceptions range little beyond its borders. In the foothills scattered trees of the digger pine *(Pinus sabiniana)* with thin crowns and branched axes, and of blue oak *(Quercus douglasii)* with white trunks and bluish foliage, give character to the landscape.

Of greatest historical interest is the Big Tree. North of Kings River it is found at middle altitudes in eight "groves" of very restricted areas buried for the most part at widely separated intervals in the remote depths of the main forest. South of Kings River it occurs in twenty-three larger areas (or "forests") which are less widely separated or are nearly contiguous.

The historical grove, the one visited by early travelers and the first discovered, is the Calaveras Grove. The tide of travel in this day, however, turns to the Mariposa Grove in the Yosemite Park, which is on the whole a more interesting assemblage of trees. On beholding a Big Tree the observer is at once impressed with the enormous bulk of the trunk, which holds its diameter well upward with a diminution often inappreciable to the eye, and with the somewhat fluted red-fibrous bark, which is one-half to two feet in thickness. The trunk more truly simulates a Grecian column than does that of any other tree, all the more in that the crown in the adult is small, rounded, and with branches remarkable for their shortness and thickness. (See Pl. XXII.)

In diameter the trunks average ten to twenty feet, and in height one hundred and twenty-five to two hundred and fifty feet.* While the average age of adult trees is from 500 to 1400 years, many individuals live to be 2000 to 2100 years. The two highest ages known to the writer, which have been definitely determined, are 2177 and 3148 years. The maximum of possible error in the determination in the case of either would not range beyond five or six years. Figures for greater ages thus far published are not, so far as known to the writer, the results of accurate studies, but are based on calculations resting on diameter measurements, or on partial counts, or on a frank admiration of the imposing bulk and stature of these forest giants.

By well-nigh universal consent *Sequoia gigantea* is regarded as the most remarkable member of the earth's silva. Its great age, its enormous bulk, its restricted habitat, its somewhat precarious biological foothold in the northerly part of its range, and its plain relationship with the dominant types of the Miocene flora, combine to give this species a unique interest among all the trees of the earth.

While the Big Tree is found, as described above, in "groves" or "forests," and is not scattered singly through the Sierran forest belt, it is always associated in its restricted areas with typical Sierran conifers, such as yellow pine, sugar pine, incense cedar and white fir. These trees are so tall and at the same time so ponderous that the eye of the traveler, becoming accustomed to trees of vast proportions, is likely, after his journey through the forest, to be disappointed on arrival at the groves of the Big Tree. For this effect of dwarfing, the

* A tree in the Calaveras Grove is 325 feet high. No taller individuals, so far as known to the writer, have been accurately measured. The General Sherman tree in the Giant Forest is 279.9 feet high and 27.4 feet in diameter at six feet above the ground. The McKinley tree in the Giant Forest is 291 feet high.

dominant species of the Sierran forest belt are responsible. The tallest of all pines is the five-needled sugar pine. The finely checked bark of its great trunk, its cones, twelve to twenty inches long, and pendulous from the tips of the unequal, horizontally spreading arms in the top of the crown, make the tree a never-failing object of interest.

Conifers in general are characterized by cone-like crowns, and divergence from this type of architecture attracts attention. The crowns of the Big Tree are always rounded and the tops of nearly all old trees have been struck by lightning. Again, no two sugar pine crowns are exactly alike. These two species, then, scattered among the uniform coniferous tops of the other species break their monotony, and give to every place in the Sierran forest where they grow an air of individual interest and local habitation.

The most common forest species in the Sierras is the western yellow pine, which everywhere shows its heavy three-needled foliage and its splendid yellow trunks checked into huge plates. These smooth plates, often three to six feet long and one to two feet wide, and the ovoid cones of this tree, four to six inches long, readily characterize the species. At higher altitudes the closely related variety, or, as most foresters would have it, species, *Pinus jeffreyi,* shows beautiful wine-colored trunks and cones nearly twice as large. In common association with the yellow pine is the incense cedar, characterized by its arborvitae-like foliage, and the white fir with its very much elongated narrow crown and horizontally stratified sprays of foliage. The trunk of the former is suggestive of a Big Tree trunk, but the color is a duller, browner red. The trunk bark of the latter is whitish, as it is inside when checked with a knife or axe; in this way it may be distinguished from that splendid fir of higher altitudes, the red fir, which shows a reddish trunk bark, almost blood red when chipped. The bark is very thick in all these typical Sierran species and this structure in connection with the open stand, shows marked adaptations to long-continued fire conditions through primitive times.

All the characteristic Sierran species (including the high altitude *Pinus albicaulis* and *Juniperus occidentalis)* may be seen by travelers entering the State over the Central Pacific route, excepting only the Big Tree. Over the Shasta route the more characteristic species may also be seen. By far the most extensive and in many ways the finest examples of *Sequoia gigantea* are to be looked for in the Sequoia National Park, where trees of every age, from seedlings to weathered ancients, occur in great abundance and in markedly different habitats. This park holds the Giant Forest, which may well be considered in many respects the most remarkable forest on the earth's surface.

The Coast Ranges present fundamentally different conditions from the Sierra Nevada. They are of far less altitude and broken into shorter ranges with narrow intervening valleys. The inner ranges are nearly barren or merely chaparral-covered, while a true forest is found only on the ranges in the immediate neighborhood of the ocean, or sometimes on mountain summits, where these reach a sufficient altitude. Two outstanding features make an appeal to the traveler: One is the Redwood Belt, mainly north of the Golden Gate; the other the peculiar and very small "tree islands" scattered at intervals along the very edge of the continental bench, mainly south of the Golden Gate. These two leading features, in common with many others, which are associated with a more varied topography as well as with an oceanic climate, combine to give the woodlands of the Coast Ranges a unique and in some respects a more varied interest than the forests of the Sierras.

The Redwood Belt is 450 miles long and one to twenty, rarely more, miles wide. The coast redwood *(Sequoia sempervirens)* is a scarcely less remarkable tree than the Big Tree. It is the tallest tree on earth, even exceeding in height the Big Tree,* and attains an extreme height of 350 feet and with trunk diameters averaging ten to sixteen feet. In the areas of best development, on the lower Eel, Van Duzen, Mad and Smith rivers of the north coast, it has established nearly or quite pure forests. No other tree is able to compete with the coast redwood in its chosen home, partly because of biological peculiarities of the redwood and partly because of climatic conditions. The first named factor, the biological peculiarities, will be considered first.

When an adult redwood tree is overthrown, or is felled by the axe, it produces about its base large numbers of stump sprouts, which eventually, by competition among the survivors, form a circle of trees, which is called a "redwood circle." Beautiful examples of nearly perfect circles may be studied to advantage in Mill Valley, within an hour's ride of San Francisco by suburban train. No Big Tree

* Mr. J. H. Maiden, Government botanist of New South Wales, makes the statement that no authentic measurements of eucalyptus trees exceed those of Sequoia gigantea.

reproduces vegetatively, nor have conifers in general this power, their propagation depending on the production of abundant seed. In the redwood, on the contrary, while stump sprouts are abundant and vigorous, seedlings in the forest are a rarity by reason of the unfavorable character of the seed-bed, the heavy layer of undecayed twigs and leaves, and the dense shade. Perhaps 80 per cent of the present redwood stand has arisen from stump sprouts, and not from seed. Aside from its power of regeneration the redwood is well safeguarded against forest fires by its very thick fibrous bark and non-resinous trunk, features of protection which recall the structural characteristics of the Big Tree.

In the second instance the redwood owes its dominance to favoring climatic conditions. The daily range of temperature varies little, on the whole, from the seasonal range. The climate is moist or rainy during the rainy season, foggy and moist during the rainless summers. Proximity to the ocean brings the redwood within the influence of the summer fog belt, and, indeed, there is no other influence so potent as the summer fogs in determining the presence and limits of the Redwood Belt. In a favorable spot such as Sherwood Valley, where the redwood forest ends on the inside like an abrupt wall, the writer has watched of afternoons the fog bank drift inland and then seaward, swinging in and out like a pendulum, and finally coming to rest just over the edge of the Redwood Belt—a wall of foliage reaching into the air 150 to 175 feet with a sharply defined fog bank resting directly over it. One is seldom privileged to view so impressive a spectacle of this kind, or one so freighted with ecological significance.

Everywhere associated with the redwood one finds the tan oak *(Quercus densiflora)*, highly valuable for its bark, and the madroña *(Arbutus menziesii)*, a tree of singular beauty. Both these species attain almost gigantic size in the forests of Humboldt County.

The "tree islands" of the south coast ("islands," in the biological sense), are vestiges or fragments of at one time extensive forests of the southern Coast Ranges; their history is associated with the geological history of the region and the succession of uplifts and subsidences which have taken place in the land mass on the edge of the continental shelf since Miocene time.

The "tree island" at Monterey is at once the most accessible, the most interesting, and the most typical. One of the species, the Monterey cypress *(Cupressus macrocarpa)* survives by clinging to the very edge of the continental land margin. It has assumed highly picturesque shapes on the edges of the cliffs and is nowhere found more than 350 yards from the ocean shore. (See Pl. XXIII.) While this species has not the power to extend itself along the coast, or inland over the Coast Range hills away from its present home, it yet lends itself to horticultural extension and is grown not only in various parts of the United States, but also in Europe, New Zealand and elsewhere. Indeed it has the most extensive horticultural distribution of any Californian species. The seeds are sufficiently viable, and if favored artificially during the critical or seedling stage the young plant will develop into an adult.

The Monterey pine *(Pinus radiata)* has a similar interest. It forms the local forest at Monterey and also occurs in a number of other "islands" along the coast. It grows rapidly on thin soils under a favorable rainfall, and has a wide horticultural distribution. A small colony of the Gowen cypress *(Cupressus goveniana)* and another of the Bishop pine *(Pinus muricata)* occur in the heart of the Monterey pine forest, a little west of old Monterey town. Both of these species are also confined to a limited number of rather small "islands" along or near the coast.

The Bishop pine is an excellent example of a fire-type pine. Its behavior under fire conditions may be seen to great advantage near Point Reyes at Inverness, a three-hours' journey by local train from San Francisco. The small cones are borne on the tree in great numbers. They persist for periods of fifteen to twenty-five years or more, never, or rarely, opening except under the influence of the fire which destroys the forest. Under this heat the cones gradually open and the area of the Bishop pine is thus promptly resown with its own seed. Most pines produce one or only two or three cones on a season's shoot. This species is biologically one of the most interesting of our pines since it produces as many as five cones in a circle, and commonly two or three circles. More significant still, the cones are produced at a very early age, when the tree is only seven or eight years old, thus guarding further against extinction by fire. Near Inverness are small areas consumed by fire at different times, so that pure stands, each of a given age, are found in close proximity, as well as many old isolated trees, interesting architecturally, which grow in the wind-gaps in the hills.

Near San Diego, about Delmar, occurs an island of the peculiar Torrey pine *(Pinus torreyana)*. It is found elsewhere only on Santa Rosa Island, one of the Santa Barbara group.

On the high mountain summits of southern California, such as those of the San Gabriel, San Bernardino and San Jacinto ranges, the four leading species of the Sierras, white fir, yellow and sugar pine, and incense cedar recur and are likewise the prevailing species. The forest stand is much more open than that in the north. (See Pl. XIX.)

In Oregon and Washington a practically continuous forest extends from the ocean over both slopes of the Coast Ranges to the eastern base of the Cascades. The most abundant conifer is the Douglas fir *(Pseudotsuga taxifolia)*. It forms vast and very dense stands in the rain forest between the coast and the Cascades. On account of the lightness, strength and straight grain of the wood, the timber of this species (sold as Oregon pine) is very valuable. Sticks of unexampled length, one hundred feet long and two feet square are carried in stock by the mills and twice that length can be furnished. Along the Oregon and Washington coasts the lowland fir *(Abies grandis)*, the Sitka spruce *(Picea sitchensis)*, and coast hemlock *(Tsuga heterophylla)* grow to very great size, usually in company with the magnificent canoe cedar *(Thuya plicata)*. From the wood of the latter the northern Indians made their great war canoes; and from the bark of the same tree they manufactured mats, clothing, rope and various other articles. In its human relations this is the most interesting tree of the northwest coast.

The fine forest on Mount Rainier offers the most convenient means of studying several characteristic northern mountain species of unusual interest, such as the lovely fir *(Abies amabilis)* and noble fir *(Abies nobilis)*. The alpine hemlock *(Tsuga mertensiana)*, with its slender steeple-like top resting on a broad base, is one of the delightful trees of the subalpine zone, an area which includes the subalpine fir *(Abies lasiocarpa)* and the white-bark pine *(Pinus albicaulis)*, two of the most widespread and characteristic trees. Another prevailing subalpine species of the timber-line slope of Mount Rainier is the Nootka cedar *(Chamaecyparis nootkatensis)*.

The forests of the Pacific Coast are remarkable in that they have at once great biological and distributional interest, and are of very great economic value. From the standpoint of water protection and

PLATE XXII

The Grizzly Giant, One of the Big Trees *(Sequoia gigantea)* of the Mariposa Grove, Near the Yosemite Valley, California. This Tree Measures in Circumference 84 Feet, 4 Inches, Four Feet Above the Ground (Jepson), and 64 Feet, 3 Inches, Eleven Feet Above the Ground (Whitney). The Trees in the Background Are White Fir and Sugar Pine.

PLATE XXIII
The Monterey Cypress *(Cupressus macrocarpa)*. This Tree Occurs Only in Two Narrow Belts Near Monterey, One at Cypress Point (Two Miles Long), and the Other at Point Lobos (One-half Mile Long). The Position of These Wind-Racked Trees at the Edge of the Sea Cliff is Typical.

water development as well as of timber resource, our forests have come to hold a peculiar place in the minds of the people of the West. Save for the Redwood Belt, the greater portion of still unexploited forest, that is, virgin timber of high commercial value, lies within the boundaries of national forests and is being administered with reference to yielding a perpetual annual income.

It is not, however, primarily the extent of the forest or size of the individual tree, but the number and variety of the species which makes the Pacific Coast the headquarters for conifers, and gives to the area in the matter of distribution of plants on the earth's surface a general as well as a special interest. On account of the sharply defined life zones, some of these forest species have an importance as zone indicators, while the number of local species adds to the geographical distinctness of the region. While the forests of the eastern United States are largely deciduous, those of the Pacific Coast are coniferous. It is significant that these areas have only two species in common, namely, the aspen *(Populus tremuloides)* and the black willow *(Salix nigra)*. The former grows at high altitudes in the mountains; the latter in the Great Valley of California and southward. Both these species belong to the same family and both are furnished with light hairy seeds, which secure wide dispersal.

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THE DESERTS AND DESERT FLORA OF THE WEST

BY LEROY ABRAMS
Associate Professor of Botany, Stanford University

THE American deserts, like the mirages that hover over their surfaces, are ever receding as man advances. Our grandfathers were taught in their youth that the territory between the Rocky Mountains and the Missouri River was a desert waste,—the Great American Desert, void of vegetation and uninhabitable. To-day we speak of the Colorado Desert, unmindful that what was at one time its bleakest and most forbidding part, where travelers by the score have perished from heat and thirst, has been transformed into a productive valley, the second largest in California, with a dozen or more flourishing towns surrounded by alfalfa, grain and cotton fields, orange groves, vineyards and dairies. Skillful engineers are penetrating the deserts with railroads and irrigation systems. Pioneers are converting their barren wastes into fertile fields. But finally, when man's resources are exhausted, large areas too rough and inaccessible for profitable cultivation, will remain undisturbed, harboring the native desert life. In outlining the deserts of North America, therefore, we may include all of the naturally arid region within which may be found many valleys made rich and productive by irrigation.

DESERT REGIONS OF NORTH AMERICA.—The arid areas of western North America fall into two natural divisions, the Great American and Mexican plateau regions lying east of the Continental Divide, and the Great Basin and Sonoran regions lying between the Continental Divide and the Pacific mountain systems. Roughly speaking, the plateau regions east of the Continental Divide include the Bad Lands of Dakota and Montana, the Red Desert of Wyoming, the Staked Plains of Texas, and the Mexican tablelands east of the Sierra Madre from San Luis Potosi to southwestern Texas and New Mexico. The western division, or Great Basin and Sonoran regions, is the territory with which we are at present concerned. Of this, the Great Basin region embraces the sage-brush plains of eastern Washington, eastern Oregon and southern Idaho, the closed basins of Utah and Nevada, and the Mohave Desert of southern California, while the

Sonoran region comprises southern Arizona, the Colorado Desert of southern California, and the Mexican states, Sonora, Sinaloa and Baja (Lower) California.

Scanty rainfall, low humidity, high temperatures, and excessive evaporation are the principal causes of desert conditions throughout all these regions.

CHARACTER OF THE DESERT VEGETATION.—The severe arid conditions of the deserts are fatal to plants not furnished with special drought-resisting devices. Following favorable rains when the temperatures are moderate, annuals lacking these special devices spring up; but like arctic plants they vegetate, flower and fruit in a remarkably short time. The desert is transformed at such times into a riot of color, more varied and brilliant than an alpine meadow,—an ephemeral carpet that vanishes with the return to normal arid conditions.

The dearth of forest trees and the prevalence of low straggly sparsely scattered shrubs are predominant features of the desert. These shrubs are usually of a light gray tone due to thickened cuticle or other protective covering. Their short stubby or spiny branches are thinly clad with small leaves or are entirely destitute of foliage. As a rule they present a monotonous landscape, such as the sagebrush plains of Utah and Nevada. But in the deserts of southern Arizona and southern California the dull monotony of the northern deserts gives way to a weird and fantastic vegetation. The great columnar trunks of the giant cactus, and the tree yuccas bristling at every point with tufts of bayonet-like leaves, offer an unfamiliar flora, more foreign than Europe or Asia.

ORIGIN OF THE DESERT FLORA.—Arid conditions have prevailed in the Mexican plateau region since Cretaceous time, even during the time when the United States was covered with rich deciduous forests from the Atlantic to the Pacific. While the common genera familiar to us all were evolving in the moist temperate climates to the north, and spreading over northern North America, Europe and Asia by means of land connections that have disappeared, drought-resisting plants were taking form on this great arid plateau. Here originated the cacti, yuccas, dasylirions and most of the other genera peculiar to the American deserts. At the end of the Glacial Period this Mexican flora pushed northward into the western United States following increased aridity. It is this ancient Mexican element that gives the unique character to our desert vegetation.

In origin and development it is wholly distinct from the north temperate and boreal floras that are common to Europe, Asia and North America. It belongs to another floral realm.

Sage-brush Plains of the Great Basin.—The principal physical features of the Great Basin region are the beds of ancient lakes and the surviving Great Salt Lake, which are bordered by short isolated mountain ranges. Many of these mountains rise to an altitude of 10,000 feet, and are covered with coniferous forests, while at the top they support typical arctic-alpine plants. These ranges present interesting problems of distribution. Biologically each range is an island of boreal life, completely shut off from the main northern body and that of the other ranges by the intervening desiccated plains.

The ancient lake beds, or sinks, are "smooth hard plains composed of bluish clay incrusted in wavy lines with white saline incrustations,"—great barren stretches with scarcely a plant as far as the eye can see. The plants that do endure are such as the salt grass, *Distichlis spicata,* and the two chenopodaceous plants, *Allenrolfia (Spirostachys) occidentalis* and *Salicornia herbacea.*

At higher elevations on the drainage slopes, where excessive saline accumulations have been prevented, the predominating plants are compositaceous shrubs or half-shrubs, of which the common sage-brush, *Artemisia tridentata,* is by far the most abundant. This silvery gray shrub, easily identified by its pungent sagey odor and small wedge-shaped leaves, three-toothed at the apex, spreads over the plateaus of the Great Basin like an enormous sheet. *Chrysothamnus* is also common. This is a peculiar west American genus of tufted half-shrubs, with sparse foliage of small narrow leaves and rayless heads of yellow flowers.

Grand Cañon of the Colorado.—The Grand Cañon of the Colorado River lies in the arid plateau region of northern Arizona. This magnificent gorge, a mile in depth and over 200 miles in length, is one of the sublime wonders of the world. Horizontal beds of solid rock are cut to a depth of 5000 to 6000 feet, exposing a splendid series of lower and upper Carboniferous marine deposits. At the bottom of the gorge are 800 feet of crystalline rock, an Archaean mountain range that began to sink slowly in early Carboniferous time. Upon these ancient granites rest the horizontal beds of sedimentary rocks; first about 800 feet of quartzite, followed by 500 feet of greenish sandstone. Resting upon these are 700 feet of bedded sandstone and limestone which are often weathered into terraces and alcoves. Then comes the great red wall, 1600 feet of limestone, "stained a brilliant red by the ironoxide washed from the overlying beds." At the top are 1000 feet of limestone with gypsum and chirt, sculptured into terraces and turrets, pinnacles and spires, the whole an endless city of magnificent cathedrals and citadels built by the genii of nature.

FLORA OF THE GRAND CAÑON.—The rim of the cañon in the vicinity of El Tovar is on the Cocinino plateau at an elevation of 6866 feet. This plateau is covered with a yellow pine forest *(Pinus ponderosa scopulorum),* which is an extension of the magnificent pine forests of the San Francisco Mountains. But a narrow belt of the piñon-juniper forest extends along the edge of the rim, and is encountered at the head of Bright Angel Trail.

Descending Bright Angel Trail, trees continue for the first 2600 feet. On account of the cool shaded slopes species are found here that are not met with on the rim, but which belong to the higher altitudes of the San Francisco Mountains; such a species is the Douglas fir *(Pseudotsuga taxifolia).* A thousand feet farther down and the desert shrub *Coleogyne ramosissima* becomes abundant, forming thickets over the terraces of limestone. From this point to the bottom of the gorge desert plants occupy all the terraces and sun-scorched slopes. Agaves, cacti, parkinsonias, ephedras, and, along the river, *Baccharis glutinosus,* indicate a desert flora essentially like that of the lowlands many miles to the west, whence they have worked their way up the cañon along the hot slopes of the gorge.

OTHER WONDERS OF THE GRAND CAÑON REGION.—*The Painted Desert.*—The Painted Desert, lying north of the San Francisco Mountains, and traversed by the Colorado River, is another wonderland of color, as gorgeous and spectral as the land of the Arabian Nights. In this region the great bed of limestone, known as the "red wall," has been changed to a beautiful marble.

The Petrified Forests.—The Petrified Forests of Arizona are the finest fossil woods known. Giant trees five to seven feet in diameter and 200 feet long remain intact. One spans a chasm sixty feet across, forming a bridge of solid jasper and agate. There are three principal forests situated about 100 miles east of Flagstaff and easily accessible from Adamana, a station on the Santa Fe route. The first grove is six miles from the station, the second two miles farther south, and the third thirteen miles to the southwest. This third grove is the largest and finest. It is locally known as Crystal or Rainbow Forest. Huge clear crystals in the fragments strewn everywhere over the ground reflect the brilliant desert light in a myriad dazzling suns and beautiful rainbow effects.

MOHAVE DESERT.—The Mohave Desert extends from the eastern base of the Sierra Nevada eastward through the Death Valley region to the Virgin River Valley in the extreme southwestern part of Utah and the northwest corner of Arizona. To the southward it spreads out over the great barren wastes to the desert slopes of the San Bernardino Mountains and their eastern spur, the Chuckawalla Mountains. In southern California the Mohave is mainly an arid plateau 1000 to 3000 feet high, a broad level expanse broken by isolated peaks or short mountain ranges that rise abruptly from the floor-like plain. Here and there are low drainage basins similar in character to those of the sage-brush plains of Utah and Nevada.

Death Valley is a notable desert sink lying between the Panamint and Funeral mountains. This extremely arid valley is sunk like a great bowl deep into the bowels of the earth and is walled by rugged mountains 6000 to 9000 feet high. It is 350 feet below the level of the sea. Seventy miles to the west is Mount Whitney rising nearly 15,000 feet above the sea, giving in close juxtaposition the highest and the lowest points in the United States.

Flora of the Mohave Desert.—With the exception of the upper altitudes of the higher mountains the entire Mohave region belongs to the Lower Sonoran life zone. Throughout this typical desert region the vegetation is sparse, weak in individuals, but surprisingly rich in species, especially in woody or shrubby forms. The principal floral belts are the salt-bush, the creosote, and the yucca.

The dry lakes or sinks are covered with incrustations of soluble salts, forming a soft fluffy powder which the prospectors with characteristic aptness call "self-rising soil." They usually support no vegetation except on the margin, where such saline species as *Atriplex polycarpa, Atriplex confertifolia,* and *Dondia (Suaeda) suffrutescens* are the most conspicuous.

The creosote, *Covillea (Larrea) tridentata,* is the most common and widely distributed species in the desert region. It is as universally spread over the Lower Sonoran zone as is the sage-brush over the

Transition and Upper Sonoran zones of the Great Basin. The shrub is readily recognized by its small, bright green, wax-coated leaves and heavy medicinal odor. In rocky or gravelly situations, wherever the soil is slightly alkaline, the desert holly *(Atriplex hymenelytra)* may be found. This is an attractive shrub with the leaves toothed as the true holly but silvery white in color.

The yuccas occupy a belt between the creosote and the junipers of the mountains. The tree yucca, *Yucca (Cleistoyucca) arborescens,* locally known as the Joshua tree, is the most striking feature of the desert. These weird and fantastic trees grow in open forests that suggest great orchards as one looks down upon them from the mountain slopes. Young trees have tall erect simple trunks, densely clothed with stiff sword-like leaves. (See Pl. XXI.) Older trees are branched into rounded heads, and are often thirty feet in height. A comprehensive account of the distribution of the yuccas of the Mohave Desert was given by Dr. C. H. Merriam as one of the results of that important biological survey known as the "Death Valley Expedition."

About twenty-five to thirty species of cacti are found in the Mohave Desert. Most of these belong to the genus *Opuntia,* but there are also species of *Cereus, Echinocactus* and *Mamillaria. Opuntia echinocarpa* is the common arborescent cactus and is widely distributed. Its branches are cylindrical and densely clothed with light-colored spines, and its flowers are greenish yellow. *Opuntia basilaris* is another common species. This is a platopuntia type, and is easily distinguished by the scantiness or absence of spines. Its flowers are a deep purple red.

Flora of the Desert Mountains.—Certain desert ranges lying between the southern Sierra Nevada and the Colorado River push up into cold Boreal climates humid enough to support coniferous forests. The Charleston Mountains of southern Nevada, for example, rise to nearly 12,000 feet. On their slopes are found all the extra-tropical life zones of North America, from the Lower Sonoran at the base to the Arctic-Alpine above timberline on the highest peaks. Ascending one of these ranges, the floral belts above the typical desert are encountered in the following succession:

The juniper-piñon belt, or Upper Sonoran life zone, extends from about 6000 to 7500 feet. The juniper *(Juniperus utahensis)* is principally confined to the lower half of the belt, appearing 200 to 300 feet lower down than the piñon *(Pinus mono-*

phylla). Above the piñon are forests of yellow pine *(Pinus ponderosa scopulorum).* This tree is characteristic of the Transition zone. Associated with it is the white fir *(Abies concolor).* In the Boreal zone between the yellow pine and timber-line, are forests of the bristle-cone pine *(Pinus aristata)* and the limber pine *(Pinus flexilis).* Above timber-line are typical Arctic-Alpine species.

On the desert slopes of the San Bernardino Mountains in southern California similar conditions exist. The piñon forms an interrupted belt below the typical Sierran forests, ranging in altitude from 3500 to 6000 feet. The juniper, here another species *(Juniperus californicus),* is abundant and ranges from 2700 to 3800 feet. Excellent groves of this arborescent shrub may be seen along the Santa Fe route at the desert base of El Cajon Pass.

DESERTS OF SOUTHWESTERN ARIZONA.—Botanically the deserts of southwestern Arizona are the most interesting of all the arid West. They belong phytogeographically to the Sonoran region, which embraces the Mexican states, Sonora, Sinaloa and Baja (Lower) California. The Mexican floral element is more in evidence here than it is in the Great Basin or the Mohave Desert; its yuccas, dasylirions, nolinas, parkinsonias and fouquierias are common and conspicuous components of the flora. The giant cactus, or saguaro *(Cereus giganteus),* is unique,—the most striking feature of the landscape. Its columnar trunks, ribbed and spined, stand thirty to forty or even fifty feet high, giving off a few erect lateral branches of almost equal diameter.

The Desert Laboratory.—When the Carnegie Institution of Washington was organized, Mr. Frederick V. Coville presented plans for a desert laboratory, where the complex biological problems of the deserts might be studied under natural conditions. His own excellent work in connection with the Death Valley Expedition had pointed out the possibilities of intensive investigations, and the governing board promptly approved his plans. The result was the establishment, some twelve years ago, of the Desert Laboratory at Tucson. Already this unique laboratory, under the able directorship of Dr. D. T. MacDougal, has brought forth valuable contributions to the knowledge of the deserts, their soils, climates and vegetation. It has become a mecca for scientific investigators, and one of the principal centers of botanical research in America.

THE COLORADO DESERT OF SOUTHERN CALIFORNIA.—The Colorado Desert is a low depression lying south of the Chuckawalla Mountains between the

PLATE XXIV

Desert Palms
(Washingtonia filifera),
Growing in Their
Native State
in Palm
Cañon, Colorado
Desert.
Widely Cultivated
in Gardens
Under the Name
of "California
Fan Palm."
One of the Most
Northern
Members of
the Palm
Family.
Photograph by
L. R. Abrams.

PLATE XXV

Lake Spaulding Dam, Built by the Pacific Gas and Electric Company in 1913, on the South Fork of the Yuba River, Nevada County, California, Near Emigrant Gap. At Present 225 Feet in Height.

By Courtesy of the Pacific Gas and Electric Company.

Colorado River on the east and the mountain divide of southern California on the west. It is principally the bed of an ancient inland sea or lake, with pebble-covered beaches that are still discernible along the base of the surrounding mountains. At one time this depression was part of the Gulf of California. Along its eastern shores the Colorado River deposited the materials ground from the Grand Cañon. Finally a great delta was formed across the gulf to the Cocopa Mountains, and that part of the gulf so cut off became a desiccated sink. But time and again the flood waters of the Colorado have cut channels through the delta and partially refilled the basin. Definite proof of these vagaries of the river are found in the two channels, known as the Alamo and New River, that lead from the delta into the basin. And the presence of the lakes is shown by the numerous shells of fresh water mollusks scattered through the soil of the basin.

One of the most surprising characteristics of the flora of the Salton sink is the absence of cacti, yuccas and other succulents.

The most striking botanical feature of the Colorado Desert, and the most picturesque tree in California, is the desert palm, *Washingtonia filifera.* This unique tree is limited in its native state to a few isolated groves fringing the base of the mountains at the northwestern end of the Colorado Desert. Groves may be seen from the station at Indio, about eight miles to the north, at the base of the Chuckawalla Mountains. But the most interesting grove is in Palm Cañon at the eastern base of San Jacinto Mountain. These are splendid trees, with straight, unbranched trunks, 80 to 100 feet high, crowned by great tufts of spreading fan-shaped leaves and clothed well down the trunk with withered leaves that lie pendant along the sides in great thatch-like masses. (See Pl. XXIV.)

In visiting this grove one will encounter many plants not seen in the Salton sink. Two cylindrical opuntias, *Opuntia echinocarpa* and *Opuntia bigelovii,* are found in this region. They may be distinguished even from the car window by the stout erect habit and more or less evident central trunk of *bigelovii.* The curious little gymnosperm, *Ephedra nevadensis,* with slender equisetum-like branches, is a common shrub, as is *Gaertneria (Franseria) dumosa* and *Encelia farinosa,* a compositaceous shrub with silvery gray leaves and bright yellow flowers of the sunflower type. Around Palm Springs and between the Springs and the Cañon one will encounter the mesquite, screwbean, palo verde, smoke tree, and flowering willow, and on the rocky mountain slopes the curious bisnagas *(Echinocactus cylindraceus)*, known as the vegetable water-barrel of the desert.

In season one may see the sands carpeted with massed colonies of brilliant abronias and gilias, or dotted with numerous rounded mats of the beautiful little desert aster *(Eremiastrum bellioides)*. A diminutive poppy *(Eschscholtzia minutiflora)*, with flowers about one-tenth the size of the common coastal species, is scattered among the bushes. Late afternoon the evening primrose opens its delicate pink and white flowers which are often two inches across.

The traveler who knows these western deserts only from the car window and associated only with alkali dust and desert heat will find it difficult to come upon any understanding of the strange fascination of this land of little rain. To feel their charm, one must move out into their open spaces; become a part of their boundless silence; face their trackless sands and bare mountain reaches in the wonderful opalescent light of sunsets and sunrises; gain an insight into the significance of the curious adaptations of plant and animal life, and of the page of earth's physical history laid bare in their reft gorges.

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THE MARINE FLORA OF THE PACIFIC COAST

BY WILLIAM ALBERT SETCHELL
Professor of Botany, University of California

The marine flora of the Pacific Coast of North America is a rather large topic to be considered in four or five pages; consequently only salient features can here be spoken of, and but general directions for obtaining acquaintanceship may be given. The general heading of marine flora may be taken to include the vegetation of the submerged shore areas and of those maritime rocks or other areas within the direct influence of the ocean.

Along this extensive line of shore may be found, so far as the marine flora is concerned, three or four distinct temperature zones, namely, the Upper Boreal Zone, including Bering Sea; the Lower Boreal Zone, extending from Bering Sea south to the Straits of Fuca or below, perhaps even to the mouth of the Columbia River; the North Temperate Zone, from Cape Flattery or the mouth of the Columbia River south to Point Conception; the North Subtropical extending from Point Conception south to Magdalena Bay or Cape San Lucas, south of which is the Tropical Zone. Each zone has a flora the general aspect, or facies, of which is distinct and characteristic. Each temperature zone includes on the west coast of North American one region. Each region may be divided into districts, and the districts according to varying physical characteristics, into formations, such as reef, cliff, tide-pool, beach, salt marsh, and others. For each formation there are bathymetric or tidal zones, in which characteristic plant associations may be found.

The spermaphyte, or phaenogamous element of the marine flora, is limited to a very few species. The genus *Phyllospadix* represents this element on our exposed coasts and the genus *Zostera* in quiet waters. Another genus of the Naiadaceae, namely, *Zannichellia* is found in brackish waters, together with *Ruppia* and one or two species of *Potamogeton.*

Phyllospadix is characteristic of the west coast of North America and contains two species, *P. scouleri* and *P. torreyi.* They form the eel-grass associations of rocky exposed formations, conspicuous as patches of small extent where the surge or currents are strong. *P. scouleri* withstands more violence than does *P. torreyi,* has rather broader leaves and seldom has more than one spadix, while

P. torreyi has narrower leaves and two to five spadices. The fruits of *Phyllospadix* have a device whereby they cling to jointed Corallines, germinate, and by catching sand build up small aggregations of sand which may grow into beaches. *Zostera,* or eel grass, inhabits shoal quiet water of bays and is represented by two species (or varieties), the wide spread *Z. marina* with narrow leaves and *Z. pacifica* (or *Z. latifolia)* with broad leaves. All four species of eel grasses are distributed along the coast from Alaska or Puget Sound to Mexico.

The lichens, peculiar to maritime rocks, are well represented, at least on the Californian coast, by comparatively conspicuous and peculiar species. *Rocella decipiens* and *R. leucophaea* occur about San Diego, the former on rocks, the latter on bushes. The rare and curious *Schizopelte californica* occurs on earth on Catalina Island. On maritime rocks of central California (Lands End, San Francisco, and about Monterey) occur *Ramalina ceruchis, R. combeoides, R. homalea, Placodium coralloides, Lecanora bolanderi* and *L. phryganitis.* These are all fruticulose species. Foliaceous or conspicuous crustaceous species peculiar to maritime rocks of the same region are *Endocarpiscum guepini, Placodium murorum,* and *Lecanora pinguis.* A few crustaceous lichen species are found on smooth rocks even within the upper tide limits.

Of fungi, two interesting marine species are found on the coast of California. About Lands End and near Fort Point of the San Francisco shores, a small Ulva, occurring at the upper tide limit, is usually infested with *Guignardia ulvae,* and around San Pedro, *Cystoseira osmundacea* and *Halidrys dioica* often show considerable bur-like distortions caused by *Guignardia irritans.*

The conspicuous portion of the marine flora belongs to the group of the algae, or Phycophyta. All the main groups are well represented on the west coast of North America and some, particularly the reds and the browns, by conspicuous and distinctive forms.

The Myxophyceae, or blue-green algae, while common, are inconspicuous, mostly microscopic species and present few cases of prominence. A species of *Dermocarpa (D. fucicola)* is common on many of the coarser red algae. *Brachytrichia quoyi,* one of the larger and more interesting species of this group, occurs in some abundance at Laguna in southern California. *Rivularia biasolettiana* is common in localities just above high water mark on dripping rocks. In general, however, the display of *Rivularia* and *Calothrix* species does not appear to equal that of the New England coast.

The marine Chlorophyceae, or grass-green algae, of the western coast of North America present few conspicuous species of special interest. The Ulvas and Enteromorphas are abundant, and *Ulva fasciata* is represented by a number of curiously unlike forms. There are comparatively few species of *Cladophora,* but *C. trichotoma* is common, forming green spongy masses on exposed rocks from Vancouver Island to Mexico. *Spongomorpha arcta, Sp. saxatilis* and *Sp. spinescens* occur in the northern portion of our range, while *Sp. coalita* is common along the whole coast and is easily to be recognized by its dark-green rope-like masses. *Codium mucronatum* and *C. adhaerans* occur along the whole coast and are easily to be recognized by their firm structure, the former being repeatedly dichotomous, the latter forming a shapeless expansion. The curious little *Halicystis ovalis,* with its green pear-shaped fronds, one-half to one centimeter high, occurs on crustaceous corallines on rocks near Monterey and on Vancouver Island.

The Phaeophyceae, or brown algae, of the western coast of North America are numerous and many of them conspicuous and world-famed. The smaller forms while abundant, and many of them peculiar to the coast, present few species of very special interest. The bladder-like *Colpomenia sinuosa* presents some curious forms. *Soranthera ulvoidea,* another bladder-like form spotted with coarse "fruiting-dots," the fir-like *Chordaria abietina,* the brain-like *Leathesia difformis,* and the prostrate *Cylindrocarpus berkeleyi* may be mentioned for the middle Californian coast, the last occurring also in southern California. On the southern Californian coast occur *Endarachne binghamiae,* a *Phyllitis*-like plant, and *Hapterophycus canaliculatus,* a member of the Ralfsiaceae with a branched thallus. Several species of *Coilodesme,* a genus of elongated tubular or bladdery species occur on *Cystoseira* or *Cystophyllum,* or even *(C. bulligera)* on rocks.

The chief glory of the west coast marine flora and of the Phaeophyceae, as well, are the kelps or Laminariaceae. No coast in the world has such a variety or can show so many conspicuous forms. The kelp flora is largely different for the different temperature regions of the coast; but one species, the long bladder kelp, *Macrocystis pyrifera,* extends its entire length, or at least, from Sitka, Alaska, to Magdalena Bay in Lower California. This kelp is very long, 100 feet or more in length, with a number of stems arising from a massive root-like holdfast, branching at the base, but simple through the greater portion of their length and bearing small leaves with bases enlarged into spherical or pear-shaped bladders. Along the coast of southern California, in particular, the long bladder kelp forms submarine groves for miles, in water down to twelve or more fathoms in depth. Along with *Macrocystis* are found two big bladder kelps, the one to the south of Point Concepcion being called the elk kelp, or *Pelagophycus porra,* the one to the north, and extending up to the Shumagin Islands, being called the bull kelp, or *Nereocystis luetkeana.* Each possesses a branching conical holdfast about the size of a man's fist, from which arises a stout single stem, solid to above the middle where it broadens and becomes hollow for some distance. At the top, the hollow portion, or apophysis constricts and then expands into a large hollow bulb, beyond which are the leaves. The elk kelp has long broad leaves arranged on one side of each of two long arms, while the bull kelp has a considerable bunch of long narrow leaves springing almost immediately from the top of the bulb.

Besides these three long and conspicuous kelps of deeper water are many others, smaller, but no less interesting and curious. In southern California are *Laminaria farlowii, Egregia laevigata,* or "sea boa," and *Eisenia arborea;* also *Pterygophora californica* which extends up to Vancouver Island. In central California are *Laminaria farlowii, L. sinclairii, L. ephemera, Costaria turneri, Dictyoneuron californicum, Postelsia palmaeformis, Lessoniopsis littoralis, Pterygophora californica* and *Alaria marginata,* while in the Puget Sound region and northward, are found most of these, as well as *Laminaria saccharina, L. bullata, L. platymeris, L. complanata, Cymathaere triplicata, Agarum fimbriatum, A. cribrosum, Pleurophycus gardneri, Hedophyllum sessile, H. subsessile, Thalassiophyllum clathrus,* the large *Alaria fistulosa* and several other species of *Alaria.* For details the papers in *Fertilizer Resources of the United States* (62d Congr. Sen. Doc. no. 190) should be consulted, as well as for the reasons for looking to the kelps for a supply of potash for fertilizing purposes.

The rockweeds and gulfweeds of the West Coast are also of great interest. Along the whole coast are to be found species of *Fucus, Hesperophycus, Pelvetia* and *Pelvetiopsis.* On the coast of California is to be found *Cystoseira osmundacea* and in the south, also, *C. setchellii* and *Halidrys dioica,* while in Puget Sound and on the coast of southeastern Alaska *Cystophyllum geminatum* is abundant. Of the gulfweeds (Sargassaceae) two species are found, namely, *Sargassum agardhianum* (common in southern California) and *S. piluliferum* (San Diego, rare; Catalina Island, abundant).

Finally among the brown algae, there are to be found to the south of Point Concepcion several members of the warm-water group of the Dictyotaceae, namely, *Dictyota binghamiae, Dilophus flabellatus, Dictyopteris zonarioides* and *Taonia lennebackerae.* A species of *Padina* is occasionally found at San Diego, but is more abundant on the coast of Mexico to the south.

The Rhodophyceae, or red algae, of the west coast of North America are numerous in both species and individuals. In character they are, on the whole, much coarser and more conspicuous than those of the eastern coast or those of Europe. Many persons have collected and mounted specimens for sale; but unfortunately, specimens collected at Monterey, on the coast of central California, a north temperate locality, have been sold as having been collected in southern California, a subtropical region, and even as having grown in Florida, a tropical region. This sort of mixture causes much confusion in the study of distribution.

There are several hundred species of red algae on our coast so that it is impossible to mention many. The higher rocks in the tidal zones are usually decorated and even festooned with purple laver *(Porphyra perforata)*. Large rocks in the same general situation, in central California, are covered with extended red, purple or blackish, tightly adhering crusts of *Petrocelis middendorfii.* Caves in the upper tidal zone have their walls covered with velvety red patches of *Rhodochorton rothii* and of several other dwarf species of reds. In surge formations are many coarse membranous reds as well as in tide-pool formations. Some of these are beautifully iridescent under water, especially the species and varieties of *Iridaea.* Coarse Gigartinas, delicate membranous but branched Nitophyllums, the "red moss," or *Plocamium coccineum,* favorite of collectors, the large coarsely veined *Erythrophyllum delesserioides,* the smaller, more delicately veined *Delesseria quercifolia,* and many other membranous species might be mentioned and described. Delicate species of *Polysiphonia, Callithamnion,* and *Ceramium* are in abundance, but are less conspicuous than on other coasts because of the preponderance of coarser forms. California possesses many relatively gigantic forms of red algae. *Porphyra nereocystis,* for example, grows to be ten or twelve feet long, and membranous reds of two to four feet in length and several inches to a foot in width are frequently found. The West Coast shares with northeasternmost Asia the exclusive possession of sea roses, the most complex of all the red algae. They belong to the genus *Constantinea* and are represented by three species. The simplest, *Constantinea simplex,* is not uncommon on the coast of central California, *C. subulifera,* a branched ample form is found in the Puget Sound region, while *Constantinea rosamarina* occurs in Alaska and the Sea of Ochotsk.

Parasitic red algae are relatively abundant on the west coast. The species of *Janczewskia* on species of *Laurencia* and *Chondria* are frequent and have been described and illustrated. Many others are met with particularly on the coasts of southern California.

The Corallines, or calcareous red algae, are abundant on the west coast and in a variety of species and associations. The jointed forms or true Corallines occur everywhere on rocky coasts, both on exposed rocks and in tide pools, while the crustaceous forms, or "Nullipores," line tide-pools, cover exposed rocks, and the interior of caves at upper tide limits with their red, pink, and salmon colored, smooth or variously tuberculate crusts.

In the matter of collecting, it must be borne in mind that the algae are largely attached to rocks or to other rock-inhabiting algae. Consequently rocky coasts are to be sought for in collecting. Also, it is to be remembered that low tides are practically the only favorable times for collecting. The times of low tides may be learned from the Pacific Coast Tide Tables issued by the United States Coast and Geodetic Survey. In the tables low water is given both as to date and hour, together with a statement of degree of lowness relative to mean low water. As a rule, only those tides designated as below mean low water, that is, with a minus sign, are profitable. Drift and wash, representing plants torn from their attachment, may be found along beaches but are not always present. Some beaches have little or none at any time, while other beaches are usually fairly well supplied, especially after blows or storms. As to localities for collecting, space permits only a few to be mentioned. About Seattle, Channel Rocks, Friday Harbor and vicinity, Mats Mats Bay, near Port Ludlow, and the region south of Port Townsend; about

San Francisco, Lands End, Fort Point, and Moss Beach in San Mateo County; the region from Monterey and Pacific Grove around to Carmel Bay (one of the best); Santa Monica to San Pedro, near Los Angeles; Laguna, to be reached from Santa Ana; and La Jolla, near San Diego.

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BURBANK'S GARDENS

BY VERNON L. KELLOGG
Professor of Entomology, Stanford University

THE most interesting specimen in Burbank's gardens is Luther Burbank himself. He is a specimen—to look at him impersonally, analytically, scientifically—of that inexplicable but fortunately real and though rare, at least occasional, human type called genius. For Burbank truly has that vision, and that impulse to work out his vision into concrete terms, that characterizes genius. He is possessed of the creative spirit. "Burbank's New Creations in Flowers and Fruits," as the title-page of his old-time fascinating, thin annual catalogue runs, are the poems, paintings and songs of a naturalist-genius.

But one does not usually look at Burbank impersonally; he is not a specimen to those who know him, but a most lovable, sensitive, sweet-voiced, shy, twinkling-eyed human soul and body, whose simplicity both reveals and conceals the dreaming and capacity of the man.

Sixty-six years old on March seventh of this Exposition year (1915) he is still (and may he be long!) an active worker in his gardens, keen-eyed, deft-handed, and clear-witted as ever. Just forty years he has worked in these same California gardens. Before that he had a few years in a Massachusetts garden. So for nearly half a century he has been a gardener and, in all that time, a creative one. For he had developed the Burbank potato from a few seeds found in a seed boll of the Early Rose before he came to California. This was in 1873, only twenty-four years after his birth in Lancaster, Worcester County, Massachusetts. He came to California in 1875, settling at Santa Rosa, Sonoma County. Here he has since resided and carried on his work. To his Santa Rosa garden he added, in later years, another one at Sebastopol, a few miles west. In these two he has done all his wonder work. It is a work familiar, in general terms, at least, to all the world. He is certainly the best known plant-breeder living.

The gardens themselves are not show gardens. Indeed they are, as they ought to be, and even must be, if the master gardener is to continue to do work in them, difficult places to see at all. Would-be visitors should inform themselves of the strict rules guarding entrance to them before skipping blithely to Santa Rosa "to see Burbank and his gardens."

They are not formal gardens, not landscape gardens. Just gardens to work in, laid out for convenience and efficiency of work, changing their aspect from week to week as this or that experiment is begun, is fully under way, or is completed. The few saved seedlings or grafts or fully grown plants or trees, the "new creations," make no very great show. The huge bonfires of the rejected make a bigger sight. Burbank's catalogue for 1894 reproduces a photograph of a "sample pile of brush, ready to burn, 12 ft. wide, 14 ft. high, and 22 ft. long, containing 65,000 two- and three-year-old seedling berry bushes (40,000 blackberry-raspberry hybrids and 25,000 Shaffer-Gregg hybrids), all dug up with their crop of ripening berries. Of the 40,000 blackberry and raspberry hybrids of this kind 'Phenomenal' is the only one now in existence. From the other 25,000 hybrids, two dozen bushes were reserved for further trial."

But as little showy as these gardens are, compared with others, the more intensely fascinating are their contents. Here a strongly growing plum tree bearing 600 varying seedling grafts! There a small close patch of Shirley poppies, each flower showing more or less blue in its color tone. They are the results of an earlier growing of 200,000 seedlings of the common crimson field poppy of Europe. Among them Burbank found one showing faintest trace of sky blue—and these are the descendants, after several generations, each one re-selected for blue, of this solitary ancestral variant. Here is a great walnut tree, child of the crossing of a black walnut and a California walnut, and growing at the rate of twice that of the combined growth of both parents. Here is a calla lily with a fragrance suggesting that of violets or water lilies. It is an established "creation" now, but traces its pedigree back but a few years to the common odorless Little Gem Calla. A curiosity, although not a stable creation yet and perhaps never to become one, is the odd fruit called plum-cot, produced on trees that have a plum on one side and an apricot on the other for parents. Burbank's work with plums has been especially extensive—even more extensive than his twenty-five years constant experimenting with berries—and he has produced a long list of new varieties, among them most of the standard shipping varieties now grown in California. Much of his results have come from a few grains of pollen from the Chinese Simoni plum, a plum that produces almost no pollen. But the few grains that Burbank has been able to obtain enabled him to revolutionize the whole plum shipping industry. An odd result of using the bitter Simoni in a crossing with Delaware, itself a Simoni hybrid, is the Bartlett plum, with almost the exact fragrance and flavor of a Bartlett pear.

Of all of Burbank's recent work—his Burbank potato, his Shasta daisy, his red California poppy, his famous score of new plums and berries have long been established—the most interesting, perhaps, is his work with "spineless cactus." And much—much too much, indeed, taking into account the paucity of information on which a considerable part of this writing was based—has been written about it, some of this writing not being very complimentary. For adopting the postulate that Burbank claims to be the creator of spineless cactus it has not been difficult, on the basis of the common knowledge of most botanists and horticulturalists that several kinds of cactus plants are quite thornless, and that the German, French, and Italians have known for a long time, various kinds of spineless or "near-spineless" cactus of much the same kind as Burbank's, to make Burbank out an imposter in all things and an unredeemed charlatan by habit and principle.

But although Burbank's spineless and spiculeless Opuntia cactus is really of his own origination, through repeated crossings and selections, it is less the "dehorning" than the notable improvement in kind and amount of the *food content* of the cactus that Burbank makes his special claim in connection with cactus improvement. He has produced a kind of spineless and spiculeless Opuntia that grows like Jack's beanstalk as regards rapidity. "By actual weight," writes Burbank, "my new Opuntias produced the first year, six months from single rooted leaves, an average of 47½ lbs. per plant, on one-fourth acre, yielding at the distance planted (2½x 5 ft.) at the rate of ninety tons of forage per acre. This forage can be fed to stock at any season throughout the whole year when most needed, and will be just as available in the most drouthy as in the rainiest season. For arid regions it is a forage that should be invaluable." These are Burbank's own claims for his "spineless cactus," and the claims of others for him may be disregarded.

This brief account of the Burbank gardens can, of course, enter on no cataloguing of the things that are in them. They are many and they are amazing. But this must be said: They are things guarding entrance to them before skipping blithely to Santa Rosa "to see Burbank and his gardens."

They are not formal gardens, not landscape gardens. Just gardens to work in, laid out for convenience and efficiency of work, changing their aspect from week to week as this or that experiment is begun, is fully under way, or is completed. The few saved seedlings or grafts or fully grown plants or trees, the "new creations," make no very great show. The huge bonfires of the rejected make a bigger sight. Burbank's catalogue for 1894 reproduces a photograph of a "sample pile of brush, ready to burn, 12 ft. wide, 14 ft. high, and 22 ft. long, containing 65,000 two- and three-year-old seedling berry bushes (40,000 blackberry-raspberry hybrids and 25,000 Shaffer-Gregg hybrids), all dug up with their crop of ripening berries. Of the 40,000 blackberry and raspberry hybrids of this kind 'Phenomenal' is the only one now in existence. From the other 25,000 hybrids, two dozen bushes were reserved for further trial."

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This brief account of the Burbank gardens can, of course, enter on no cataloguing of the things that are in them. They are many and they are amazing. But this must be said: They are things produced by no wizard; that is, by no black art, nor any other art save that of a gifted, self-educated, utterly devoted and patient and industrious man. Any credit for these beautiful and beneficent things that is not Burbank's is Nature's. For "Burbank's ways are Nature's ways." His whole life has been given to the study of how Nature does things, and his greatest service is, after all, that he has shown what can be achieved by man through a deeper knowledge of Nature.

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ETHNOLOGY OF THE PACIFIC COAST

BY T. T. WATERMAN
*Assistant Professor of Anthropology,
University of California*

A LARGE proportion of the people who visit the Pacific Coast pass through the great Southwest. It may prove of interest to travelers, therefore, to mention, first, some of the Indian tribes which one encounters in this area. Today there are two quite different modes of life in this region. We see on the one hand sedentary Indians living in terraced villages and carrying on elaborate farming operations. The same region is the abode, also, of restless, roving hunter tribes such as the Navaho and the Apache.

The Navaho have recently acquired large flocks of sheep without, however, essentially changing their ways. The so-called "pueblo" peoples have changed even less. The agricultural Indians of today are, it is quite certain, the lineal descendants of the people who left the famous ruined structures or cliff dwellings which abound in the cañons and cliffs all over the Southwest. In physical peculiarities, in the arts of life, in architecture and religious observances, the two peoples, one ancient and the other modern, seem to be practically identical. The pueblo or terraced village of today is in architecture, arrangement, and even in size, merely a cliff-dwelling located in the open.

The pueblo peoples have for centuries cultivated a variety of plants, corn, squashes, tobacco, cotton and sunflowers. In many places they have in the past used remarkable systems of irrigation. Remains of engineering works capable of watering two hundred and fifty thousand acres are, for example, still to be seen in the valley of the Rio Salado (Salt River), a tributary of the Rio Gila in southwestern Arizona. These ruined irrigation systems are among the most interesting antiquities in America. It is a picturesque fact that agriculture in the Southwest is found only in desert regions. It is only when the traveler abandons well-watered lands and enters the country of cactus and horned toads that signs of native agriculture begin to appear.

Another primitive industry which is still to be observed in the Southwest is the making of pottery. This is a typical feature of Southwestern Indian life. Some of the Southwestern tribes, such as the

Navaho, Apache, and Havasupai, have never become proficient in it. The last named inhabit an extremely romantic gorge opening off of the Grand Cañon, one of the most extraordinary dwelling places in the world. The textiles, also, of the Southwest have become very widely known. For centuries all of the sedentary tribes have made highly ornamental blankets, first of native cotton, and more recently of woolen yarn. These blankets have become very common in civilized homes as hangings, couch-covers and even as rugs. They are, among the Indians, purely articles of attire. The manufacture of the finest blankets has become associated with the name of one of the wandering tribes, the Navaho. It is nevertheless an art borrowed by this tribe from the sedentary peoples.

The one thing, however, which most attracts the attention of travelers among the villages of the Southwest is the religious life of the Indians. The native people of the different pueblos still hold a great many striking ceremonies. The wandering tribes have even more elaborate observances, but they are less widely known, because the tribes themselves are less accessible. Perhaps the most frequently mentioned performance is the Snake Dance of the Hopi pueblos, in which members of a certain secret society dance with living and venomous rattlesnakes in their mouths. Conspicuous in the religious life of all pueblo peoples is the *kiva,* or sacred underground chamber. These chambers, called "estufas," or ovens, by the Spaniards, are quite as characteristic of the ancient cliff ruins as they are of the modern pueblos. Among all the Southwestern tribes, nomad and sedentary, we find the custom of making on the ground curious drawings in connection with ceremonies. These earth drawings, or "sand paintings," or "sand Mosaics," as they are sometimes called, are often surprisingly elaborate. On the whole there are few places where the workings of primitive religion can be as satisfactorily observed as among these Southwestern pueblos.

The Southwest is now in large part fairly accessible. To visit some of the hunter tribes, for example some of the Apache groups, a long journey on horseback is necessary. Several of the pueblos, however, such as Isleta and Laguna, can be seen from the car windows on the Santa Fe railway. Some of the cliff-dwellings, even, which were located originally in remote and inaccessible places, can now be visited with comparatively little trouble. The extremely interesting Mesa Verde region, which contains some of the most famous cliff ruins, is easily reached from the branch of the Denver & Rio Grande railroad passing through Durango and

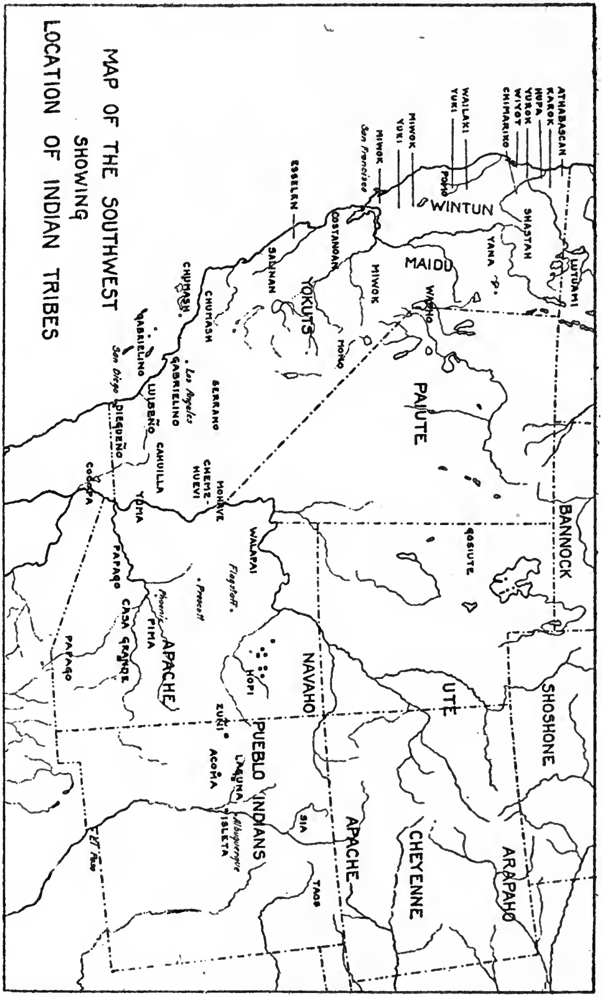

Figure 18

Mancos, in southwestern Colorado. The largest of these ruins, the Cliff Palace and Spruce Tree House, have been cleared of debris and most painstakingly repaired by the National Government for the sake of tourists and visitors. Dr. Dorsey's remarkable little book, *Indians of the Southwest,* gives complete instructions for reaching every place of interest, Indian tribes, pueblos, and ancient ruins. (See fig. 18.)

The Indians of California, while on the whole in a much ruder state than the Southwestern peoples, nevertheless have some very interesting institutions. The art of pottery, for example, somehow or other passed over the waterless Mohave desert west of the pueblo Indians, and is common in that part of California south of Tehachapi Pass. This art, though it is very ancient in the Southwest, seems to have been derived ultimately from Old Mexico. It is rather curious that certain elements of the highest Pueblo culture, such as pottery, should have spread to California before they affected the remoter tribes in the Southwest. We find in southern California other things which have been borrowed from the pueblo region. Among them might be mentioned sand paintings and the custom of using an infusion of the common jimson weed as a religious intoxicant. In other words, the Indians of southern California have been considerably influenced, in spite of the distance and intervening barriers, by the more highly civilized peoples of the Southwest.

The most interesting ancient remains in California are the numerous shell-heaps, or kitchen middens, which mark the sites of old Indian villages, and which consist for the most part of the accumulated ashes from ancient fires and the remains of the shell-fish on which the people very largely subsisted. Some of them are very large, and represent a history of thousands of years. A few in the vicinity of San Francisco extend for fifteen feet below the level of the bay, showing that the Coast has subsided to that extent since the sites were first inhabited. The shell-heaps from top to bottom offer few if any evidences of change or progress. In many cases objects have been recovered from the lower levels of the mounds which are identical with those used by living Indians. Careful study of the materials of these kitchen middens gives us a good deal of information not only about the mode of life of the people, but about changes in the fauna and flora of the region since early times. Some of these mounds are situated amid rather attractive surroundings within an hour's ride of San Francisco. Mixed in with the ashes and shells of which these mounds for the most part consist are large numbers of lost and broken artifacts, and even human remains.

The living Indians of California are very much scattered. There are villages here and there, usually spoken of as "rancherias," but most of the aborigines are now widely distributed among a white farming population. There is one small group of Indians living within thirty miles north of San Francisco on Tomales Bay (via Northwestern Pacific) who still speak their old language and make a few baskets. Another and somewhat larger group is to be found to the south, at Pleasanton. The only large reservation in California is Hupa, in Humboldt County, in the northern part of the State. This is a beautiful valley, in the midst of a fine, forested country, and is now, with the completion of the Northwestern Pacific, fairly accessible. Within easy access of this same railroad are the Round Valley reservation at Covelo, Mendocino County, and the rancheria at Hopland. The Hupa reservation lies on the Trinity River, just above its junction with the Klamath. Along this latter stream a great deal of Indian life is still to be seen, such as fishing, the manufacture of baskets, and religious performances. The trip down the Klamath in an Indian canoe, through rapids and among the giant redwoods is exciting and interesting. This is, I think, the only locality in California where the Indians may still be seen living more or less in their original type of house.

In the southern part of the State considerable groups of Indians may still be seen near the railroad at San Jacinto and at Indio and Banning. There are numerous other groups somewhat more difficult of access, such as those at Pala, Mesa Grande, and, close to the Mexican border, around Campo, on the State road from San Diego to Imperial.

From northern California to Alaska there is a remarkable stretch of coast where the native life is very picturesque and peculiar. (See fig. 19.) The coast from Vancouver Island to the Copper River seems to be the region where the most characteristic institutions developed. Among the things of interest I might mention the social organization of the natives, their art, and their remarkable customs connected with property.

All of the Coast tribes of southern Alaska and British Columbia have a way of dividing up into groups, each group tracing its descent from one ancestor, often alleged to have been an animal or a supernatural being. Some of these groups are recognized as very aristocratic. On the other hand absolute slavery was, until just recently, a well recognized institution. Capture in war and inability to

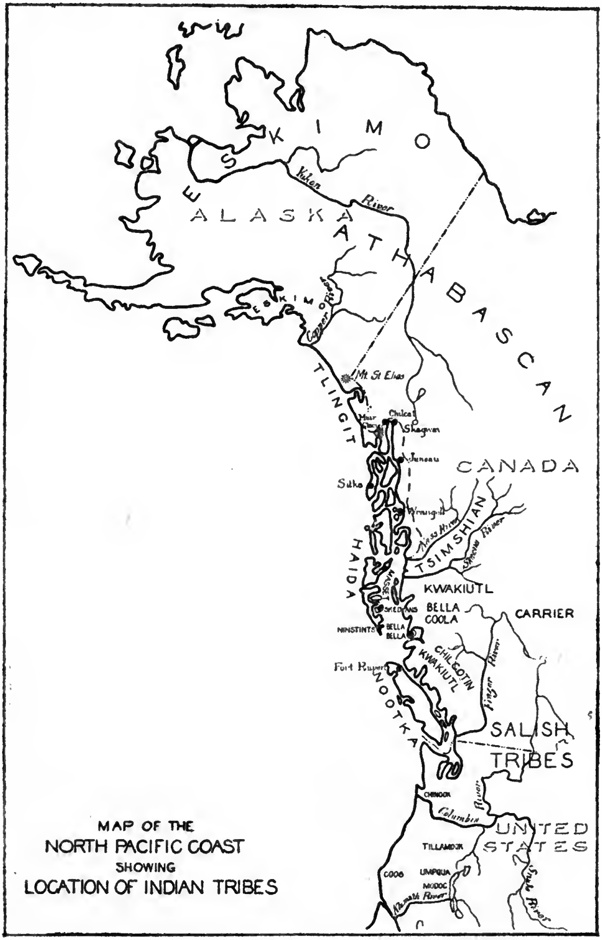

Figure 19

settle debts rendered a man a mere chattel. The lot of very poor people, even if free, was scarcely better. Aside from the accident of birth, an individual's standing and rank was and is, even now, determined by his wealth. Property is reckoned in terms of blankets, a fifty-cent cotton article obtained in the old days from the Hudson's Bay Company being the unit of value. Wealthy Indians possess enormous numbers of these blankets.

The north Coast people still celebrate elaborate feasts, or potlatches, at which they distribute blankets broadcast among the guests. Potlatching has been bitterly opposed by missionaries and officials in charge of Indian affairs, who object to the practice as a sinful waste. As a matter of fact the Indian financier at feasts is not really giving away anything. He parcels out blankets not among his friends but rather among his enemies. Every such "gift" has to be repaid after a given term with an exorbitant rate of interest, sometimes as high as two hundred and fifty per cent. Such a gift was really a *dare,* since it carried with it very serious responsibility. The victim was not considered at liberty to refuse it. The whole institution was a game in which the loser sacrificed his property, his rank, his liberty, and even the standing of his posterity.

An individual of noble rank possesses a great many crests and symbols, which are carved on his utensils, painted on his canoes, and represented on enormous totem poles which are placed in front of his dwelling or set up over his grave. These totem poles are among the most picturesque objects of primitive American life. A person who wins great wealth assumes or purchases similar crests, which he in turn hands down to his descendants. All the objects obtained among these North Pacific Indians are elaborately ornamented with crest designs, often of grotesque and striking appearance. The art on the whole is of a most unusual but highly specialized sort. The meaning of the designs and the methods of working them out form a most interesting study.

This art receives perhaps its highest expression in the weaving of certain blankets or robes composed of cedar-bark string and the wool of the mountain goat. These fabrics are usually called Chilkat blankets, from the name of one of the tribes in southern Alaska. The weaving of these blankets was formerly common along the whole Coast. They are among the most beautiful objects of native American art. Single blankets often have a value at the present time of several thousand dollars. Within recent years only the Indians in the neighborhood of Chilkat keep up the practice.

Ethnology of the Pacific Coast

The trip by steamship among the islands and fiords of the coast of British Columbia and Alaska is one of the wonders of America. The Indian villages are sometimes difficult to reach, but when once seen are picturesque enough to repay the trouble. Totem poles in front of Indian houses are to be seen at Ketchikan, Wrangel and other places which are regular ports of call for the steamers. The quaint old town of Sitka is perhaps most worthy of a visit, both on account of its Indians, and because of the reminders it contains of the old Russian occupation. The region offers a variety of quite unusual scenery, which is in places romantic beyond description.

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ASTRONOMICAL OBSERVATORIES

BY R. G. AITKEN
Astronomer, Lick Observatory, Mount Hamilton

THE first research observatory established within the Pacific area was the Lick Observatory of the University of California. It stands on the summit of Mount Hamilton, the highest peak in a spur of the Coast Range Mountains forming the eastern boundary of the Santa Clara Valley, at an altitude of 4209 feet. An excellent mountain road connects the summit with the city of San Jose, thirteen miles distant in an air line. The road was built and is kept in repair by the county of Santa Clara and is very popular with automobilists, for it is wide enough for two machines to pass safely, the grade is easy, and the scenery beautiful. The road is a very winding one and lengthens the air line distance of 13 miles to 26. (See Pl. XXVII.)

Provision for the observatory was made in James Lick's famous deed of trust, dated July 16, 1874. The sum of $700,000 was set aside for the erection of a telescope "superior to and more powerful than any telescope ever yet made * * * and also a suitable observatory connected therewith." Actual construction at Mount Hamilton was begun in 1879, and the completed observatory was transferred to the Regents of the University of California on June 1, 1888.

The principal telescope provided by the Lick trustees is an equatorial refractor with an object glass 36 inches in diameter figured by Alvan Clark & Sons. The mounting was constructed by Warner & Swasey. A 12-inch Clark equatorial refractor and a 6½-inch Repsold meridian circle, besides smaller telescopes, fine clocks and chronometers and other pieces of auxiliary apparatus were also provided.

A 36¼-inch reflecting telescope was presented in 1895 by Edward Crossley, Esq., of Halifax, England, the cost of transportation and erection at Mount Hamilton being met by subscriptions by prominent citizens of California. A 37¼-inch Cassegrain reflecting telescope, with spectrographs and a modern dome, the gift of the late Mr. D. O. Mills, is at present located on the summit of Cerro San Cristo-

NOTE.—This chapter is, by permission of Dr. W. W. Campbell, based largely upon his "Brief History of Astronomy in California," which is inclued in Eldredge's History of California. Some sentences have been copied verbatim.

bal, Santiago, Chile. It is used to secure spectrographic observations of stars not visible from stations in the northern hemisphere. The D. O. Mills Observatory is administered by the director of the Lick Observatory.

It was Mr. Lick's intention that the observatory should be made "useful in promoting science." A brief review of the work accomplished there since 1888 shows that the scientific staff has been faithful to the trust reposed in it. To make new discoveries, in the ordinary sense of the phrase, is not the chief function of an astronomical observatory. On the contrary, all great observatories devote their energies principally to carrying out large programs of work, often requiring many years for their completion, which have been carefully planned to aid in solving definite problems relating to the structure and the evolution of the solar system and of the sidereal universe. Discoveries in the usual sense are, however, the inevitable by-products of such researches and the Lick Observatory has many of these to its credit. Thus, its astronomers have discovered 4 new satellites to Jupiter; 19 unexpected comets, and 10 periodic comets whose return had been predicted; 4400 double stars; 250 spectroscopic binary stars, and many hundred new nebulae.

The first great successes in photographing comets and the Milky Way were made there, and the unequaled Lick series of comet photographs has taught us more about the structure and formation of comets' tails than had been learned in all previous time. The photographs of the minor planet Eros led to a new and accurate determination of the earth's distance from the sun. The photographs of nebulae and star clusters made with the Crossley reflector established for the first time the tremendous advantage of this form of telescope in photographing such objects, with the result that many reflecting telescopes of equal or of greater power are now in use, or in process of construction, at other observatories. The photographs materially changed our ideas of the nebulae. Some 10,000 nebulae had previously been discovered, of which a few dozen, supposed to be exceptional, were known to be spiral in form. The Crossley reflector photographs showed that many other known nebulae were spiral, revealed hundreds of new nebulae, and proved that the majority of them have the spiral form—undoubted evidence of their rotation.

A systematic survey of the northern sky has been carried out with the 36-inch and 12-inch refractors to collect data for a statistical study of double stars, stars which appear to the eye to be single, but which are shown by the telescope to consist in each case of two suns in mutual revolution about their center of mass. This survey has not only revealed over 4000 such systems, before unknown, but has proved that at least one star in eighteen of those as bright as the ninth magnitude is a double star visible in the 36-inch refractor. Many thousands of exceedingly accurate positions of the stars have been secured with the meridian circle which form important contributions to studies of the apparent motions of the stars on the surface of the celestial sphere. With the aid of the spectrographs attached to the equatorial telescopes, extensive additions have been made to our knowledge of the spectra of nebulae, comets, new stars, and stars of special interest.

The observatory's most comprehensive investigation has been the measurement of the radial velocities—the motions toward us or away from us in the line of sight—of the stars. With spectrographs attached to the 36-inch refractor at Mount Hamilton and to the D. O. Mills reflector at Santiago, the radial velocities of about 1500 naked-eye stars, distributed over the entire sky, have been measured. These data have been utilized in the solution of many important problems concerning the stellar system. Among the results thus obtained we may note the following: The motion of the solar system through space is about 12 miles per second toward the boundary line between the constellations Hercules and Lyra; certainly one bright star in every four, though appearing single in the most powerful telescopes, is in reality a double star; the velocities with which the stars travel through space are functions of their effective ages, the speeds increasing as the stars grow older. These observations have shown, further, that the scale of the universe is about 50 per cent larger than former estimates had made it; that is, the brighter stars are, on the average, about 50 per cent more distant from us than we had thought.

Space limitations forbid reference to many other important researches, and only permit us to mention the extensive and unique series of photographs of the sun in total eclipse obtained by expeditions sent out from the Lick Observatory at the expense of generous friends.

James Lick's gift of a great telescope and observatory aroused wide-spread interest and called attention to the peculiar advantages for astronomical research afforded by the atmospheric conditions in the Pacific area, with the result that many observatories, public and private, have been established here.

The most important of these is the great Solar Observatory of the Carnegie Institution of Washington. This is located on Mount Wilson (altitude 5885 feet), near Pasadena, California. (See Pl. XXVI.) As its name implies this observatory was established primarily for investigations of the sun, considered not only as the central body of our own system, but as a typical star, the only one near enough to us to be studied in detail. The equipment was planned with direct reference to the proposed investigations. The principal instruments on Mount Wilson are:

A 60-inch reflecting telescope, equatorially mounted and equipped with secondary mirrors to convert it into the Newtonian and Cassegrain forms, and with a variety of spectrographs and other auxiliary apparatus.

A horizontal reflecting telescope, aperture 24 inches, whose focal length can be varied from 60 feet to 145 feet. It is fed by means of coelostat mirrors and supplied with spectro-heliographs, etc.

Two "tower" telescopes, in which the coelostat mirrors on the top of a tower receive light from the sun and send it vertically downward through a lens to form an image near the ground at the top of a "well." The well contains spectrographs mounted vertically in such positions that their slits, at the top of the well, are in the focal plane of the lens on the tower. The first tower telescope had a lens with a focal length of 60 feet, and a well 30 feet deep. It proved so successful that, in 1910, a similar telescope 150 feet high, supplied with a well 75 feet deep was constructed. The lens on the tower supplies an image of the sun about 17 inches in diameter, and the large scale spectrographs in the well enable exceedingly minute details of the solar image to be subjected to powerful analysis.

A reflecting telescope with a mirror 100 inches in diameter and an equatorial mounting is approaching completion.

A unique feature of the Solar Observatory consists in the maintenance of a physical laboratory, equipped with the most refined and powerful instruments of their class, whose principal function is to assist in the interpretation of phenomena observed in the sun and the stars.

The mountain station is used to secure the astronomical observations, nearly all of which are photographic. The results are studied and prepared for publication in Pasadena, where the administrative offices, measuring and computing bureaus, the physical laboratory, and the extensive shops for the manufacture of instruments are located.

A second departure from existing practice consists in the manufacture of essentially all of the instrumental equipment, except highly specialized optical parts, and the more massive parts of mountings, by the observatory itself. In this connection we refer especially to the construction of the great number of silver-on-glass mirrors with diameters ranging from 100 inches down.

A third departure from previous practice is the provision made for the temporary employment of specialists from other institutions.

The general plan of work at the Solar Observatory is to carry on simultaneously observations of solar phenomena, observations of the stars, and investigations in the laboratory, and to co-ordinate the results thus gained. By photographs taken directly and with the spectro-heliograph and spectrograph, it has been found possible to study not only the surface features of the sun but also to penetrate its atmosphere and to investigate its chemical composition and its physical condition at various depths.

It has been shown that a sun-spot is the center of a local magnetic field and that it is probably an electric vortex caused by the revolution of negatively charged particles. There is a connection between the variations of terrestrial magnetism and changes in the solar activity as indicated by the flocculi. The intensities of the sun-spot fields are too weak, however, to account for the magnetic storms observed upon the earth.

It has been proved that the sun itself is a magnet whose poles are near the sun's poles of rotation, and whose polarity—with reference to north and south—agrees with the earth's polarity.

The effective relative levels in the sun's atmosphere of at least 27 chemical elements have been determined, the element which occupies the highest level, so far as observed, being calcium, the next hydrogen. In general the heavy elements occur in the lower strata. The large scale of the solar image has permitted 1200 bright lines in the chromospheric spectrum to be photographed without an eclipse, and it is found that their wave-lengths agree well with those of corresponding dark lines in the general solar spectrum. Great attention has also been devoted to determining the law of the solar rotation.

While the sun has formed the chief object of study at Mount Wilson, the great 60-inch reflector has been used to photograph the more prominent spiral and irregular nebulae, and the principal star clusters, to obtain spectra of special classes of stars and of the Milky Way, to determine the radial velocities of stars, and to establish a scale of photographic magnitudes.

The photographs of nebulae and of clusters are of the highest excellence. They show that nebulous stars in great numbers are associated with many of the spiral nebulae and in the clusters reveal unexpectedly great numbers of stars fainter than those photographed with smaller reflecting telescopes.

Some evidence has been obtained to show that light from the stars is absorbed appreciably in its passage through interstellar space. Many investigations are in progress to determine the arrangement of stars in space and the relations to each other of great groups of stars. The great reflector has also proved to be an admirable instrument for visual observations of planetary surface features.

The extensive researches in the physical laboratory at Pasadena relate chiefly to the effects of varying temperatures, pressures, magnetic fields and other factors on the spectra of the principal chemical elements. In many cases the results have been applied to the interpretation of solar and stellar spectra.

The observatory of the Smithsonian Institution has maintained a branch station on Mount Wilson, within the grounds controlled by the Solar Observatory, since 1905. It is occupied in the summer months for the purpose of making measures of the sun's radiation, the radiation from the sky, clouds, etc., to compare with similar researches made in Washington, in Algiers (for two years), and on Mount Whitney. These researches have determined the average intensity of the solar radiation as a function of the spottedness of the sun and have made it very probable that the radiation varies as much as 8 or 9 per cent in irregular periods of from 7 to 10 days.

In 1909, a three-room shelter of stone, steel and glass was built by the Smithsonian Institution upon the summit of Mount Whitney (altitude 14,500 feet). It is intended that this shall be available to scientific parties who wish to occupy the summit of the mountain for research purposes. Detailed infomation regarding the conditions may be obtained from the Smithsonian Institution. For information about local conditions, and means of ascending the mountain, application should be made to Mr. G. F. Marsh, Lone Pine, Inyo County, California. This shelter was utilized in August-September, 1909, by an expedition from the Lick Observatory which made spectrographic observations to determine the extent of the atmosphere of Mars and of its water-vapor. Expeditions from the Astrophysical Observatory of the Smithsonian Institution carried out measures of the sun's radiation at this station in the summers of 1909, 1910 and 1913.

The chief function of the Students' Observatory, founded in 1885, on the campus of the University of California, Berkeley, as its name implies, is instruction. In addition to this, extensive researches have been carried out in the theory of orbit determinations, qualified students have been encouraged to participate in these investigations and their practical applications, and the result has been the building up of a great school of astronomy. The instrumental equipment includes five equatorial telescopes with apertures ranging from 8 to 5 inches, transit instruments, clocks, chronometers and auxiliary apparatus.

The International Latitude Observatory at Ukiah, Mendocino County, California, is one of four stations, widely distributed in longitude, but on the same parallel of latitude (39° 08′ north) which were established in 1898 by the International Geodetic Association to make systematic observations of the same series of selected stars as a basis for the study of the problem of latitude variation. The equipment consists of a zenith-telescope of 4¼-inches aperture. This station has been in continuous existence to the present time, but its future is uncertain because of conditions arising from the European war.

The Chabot Observatory, located in Lafayette Park, Oakland, is under the control of the Oakland School Department and has been used liberally for the instruction of students and the public. The principal telescope is an 8-inch refractor. To increase the observatory's efficiency, the Board of Education has authorized the purchase of a 20-inch refracting telescope, which is now in process of construction. It is to be mounted on a site selected in the eastern suburbs of the city, and will be used for research work as well as for instruction.

Another observatory whose principal function is instruction is the Frank P. Brackett Observatory of Pomona College, Claremont, California, which was constructed in 1908. The principal instruments are a 6-inch refractor and a 6-inch photographic telescope of forty feet focus, mounted horizontally and fed by a coelostat mirror. The department of astronomy maintains a local astronomical society and issues a journal.

There are several other college observatories that deserve mention: the observatory of the College of the Pacific, established in San Jose in 1885, which has a 6-inch Clark equatorial; the observatory of Mills College, Oakland, erected in 1887, and provided with a 5-inch refractor and an 8-inch reflector; and the observatory of the University of Santa Clara, Santa Clara, California, whose principal instruments are a 7-inch refractor and a 6-inch photoheliograph. This observatory possessed a 4-inch telescope, with altazimuth mounting, as early as 1860. In addition to its use for instruction, the equipment is employed in solar observation.

While excellent instruction in the elements of astronomy has been given at Stanford University from its beginning, no provision was made for an observatory. A 6-inch reflecting telescope is now in process of construction in the shops of the engineering department, and a suitable dome has been built.

There is a small observatory at the Mare Island Navy Yard, whose work is confined to time determinations, upon which the Western Union Telegraph Company depends for the accurate time signals which it distributes. The Lowe Observatory, erected in 1894 on Echo Mountain, a shoulder of Mount Lowe, north of Pasadena, California, contains a 16-inch Clark refractor, made famous by the comets and nebulae discovered with it by Dr. Lewis Swift. It is now used entirely for the entertainment of visitors.

All of the institutions so far described are located within the state of California, but there are other observatories, outside of the State, within the Pacific area. Chief of these is the Lowell Observatory, located at Flagstaff, Arizona (altitude 7250 feet), on the line of the Santa Fe railroad. The institution is the personal property of its director, Mr. Percival Lowell, and was established in 1894, primarily for the purpose of studying the details of planetary surfaces—particularly those of Mars. The principal telescopes are a 24-inch Clark refractor, and a 40-inch reflector, also provided by the Alvan Clark Sons.

The work of Mr. Lowell and his assistants has added greatly to our knowledge of the planets of our system, particularly of Mars and of Jupiter. The 24-inch refractor was also used for a year or two in the observation of double stars, the result being the discovery of about 500 new systems. Extensive photographic studies of comets and nebulae as well as of the planets have been made, and a program of spectrographic work on stars and nebulae is in progress. The most striking result so far obtained relates to the enormous radial velocities of certain of the nebulae, which exceed many-fold, the average velocities of even the most rapidly moving stars.

The Society of Jesus established a small observatory in the suburbs of Manila, Philippine Islands, more than half a century ago. More recently the observatory has acquired a Mertz refractor with aperture of 19 inches and focal length of 23 feet and a number of smaller instruments, and is in a position to undertake serious research work. The observatory also possesses a full equipment of meteorological and seismological instruments and its director is the head of the Weather Bureau for the Philippine Islands.

The Canadian government has purchased land in the suburbs of Victoria, British Columbia, as the site for a branch station of the Dominion Observatory, which is located at Ottawa. The principal instrument of this new observatory is to be a 72-inch silver-on-glass reflecting telescope, which, in conjunction with spectrographs, is to be used chiefly in measuring radial velocities. The telescope mirror, as well as mounting, is nearly completed, and, it is hoped, may be in position within a year.

The National Observatory of Mexico is situated at Tacubaya, near the City of Mexico at an altitude of 7480 feet. Its equipment includes refracting telescopes of 15-inches and 6-inches aperture, a 13-inch astrographic equatorial, a 5-inch photoheliograph, supplied with siderostat, and the usual auxiliary apparatus, besides complete sets of magnetic, seismologic and meteorologic apparatus. The principal work of the observatory at present is the determination, by photography, of the star places in the zone —10° to —16° declination, in furtherance of the great photographic map of the sky known as the Carte du Ciel.

No account of astronomy on the Pacific Coast would be complete without some reference to the popular astronomical societies. The one at Pomona College has already been mentioned. The Sociedad Astronomica de Mexico, is another, which is stimulating interest in astronomy in Mexico. It is now in its 14th year. The chief society, and the oldest, is the Astronomical Society of the Pacific, founded in 1889, as a consequence of the interest in astronomy excited by the total solar eclipse on January 1st of that year. This society has its headquarters in the Phelan building, San Francisco, where it maintains an astronomical library. Four regular meetings annually, to which the public are welcomed, are held in or near San Francisco; a journal (Publications of the Astronomical Society of the Pacific), favorably known to astronomers the world over, is issued every two months; and the Bruce Gold Medal is awarded annually for "distinguished services to astronomy." This medal is justly regarded, by virtue of the method of award, as one of the highest honors that can be conferred upon an astronomer.

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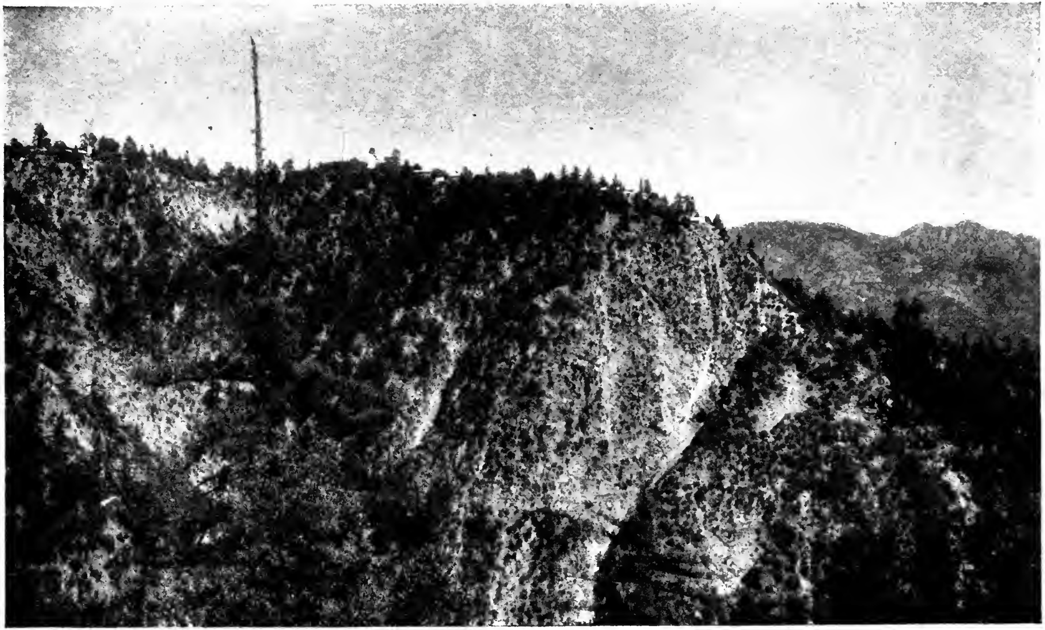

PLATE XXVI

Mount Wilson Solar Observatory. The Buildings Shown are the 150-Foot Tower Telescope, the Snow Horizontal Telescope, the Sixty-foot Tower Telescope, the Laboratory and Power House, Behind Which Rises the Dome of the Sixty-inch Reflector. To the Right is the "Monastery," the Living Quarters of the Astronomers While on the Mountain. At the Extreme Edge of the Peak Is the Solar Laboratory of the Smithsonian Institution

PLATE XXVII
Lick Oservatory, Mount Hamilton. View Toward the West. The Great Dome of the Thirty-six-inch Refracting Telescope Rises Just Above the Skyline. The Dome for the Crossley Reflector Is Lower on the Mountain at the Extreme Left of the Picture.

Photograph by C. A. Bergmann.

MUSEUMS OF THE PACIFIC COAST

BY BARTON W. EVERMANN
Director of the Museum, California Academy of Sciences, San Francisco

THE Pacific Coast has its fair share of museums. There are general museums of history, science, and art, and there are special museums, chiefly in connection with the different departments of the universities and colleges of the coast. There are museums of natural history, of anthropology, of history, and of geology, some of which rank with similar institutions in the eastern states. A brief statement giving the more important facts regarding each of the museums of the Pacific Coast for which data are available is here given.

IN SAN FRANCISCO.—*Museum of Anthropology, Affiliated Colleges.* An integral part of the University of California. Principal departments: Ancient Egypt, Greece and Rome, Peru, California Indians, Indians of Alaska and the Southwest. The largest museum of its kind west of Chicago, and one of the most complete collections of anthropology in the world; contains 75,000 specimens illustrating the history and development of civilization from the earliest times. The Egyptian collections go back to the dawn of civilization and are extraordinarily varied. This museum possesses also a remarkable collection from the site of the oldest American civilizations, namely, Peru, the country of the Incas. There are also very large collections from the savage tribes in the South Seas, the Philippines, Africa, and North and South America. There is, among other exhibits, one of the finest collections of Indian baskets in the world. The collections of baskets, implements and specimens of all kinds from every Indian tribe in California is of special interest and value. And the collection of actual Greek and Roman antiquities is unusually complete and instructive.

Reached by Market and Hayes street car (line No. 6).

A. L. Kroeber, curator.

Memorial Museum. Contains large and valuable collections of paintings (including the famous Keith collection), tapestries, antique furniture, arms and armor, art metals, the Bardwell collection of 700 Japanese wood and ivory carvings, and in ethnology, mineralogy, forestry and produce, and a collection pertaining to early California history. It also maintains a reference library. In Golden Gate Park. Reached by various Park cars.

George Haviland Barron, curator.

California Academy of Sciences. Founded in 1853. Maintains a general museum of natural history, including all departments. Although all the collections and the library of the Academy were lost in the great fire of 1906, large and valuable collections have been assembled since that time.

The collection of birds embraces about 20,000 specimens, among which is included what is perhaps the most complete and valuable collection of sea birds in the world.

The Academy's collection of reptiles and amphibians contains more than 31,500 specimens and, excepting that of the National Museum and that of the Museum of Comparative Zoology, is the largest and most valuable in America. It is particularly rich in Pacific Coast species and those of the islands off the Pacific Coast of the Americas. It includes 266 specimens of the gigantic land tortoises of the Galapagos Archipelago, a more complete representation of that interesting fauna than is found in any other museum in the world.

The collections in mammalogy, entomology, conchology, and invertebrate paleontology, are also large and important. The museum has recently received by gift from Mrs. Charlotte Hemphill Hosmer the conchological collection made by the late Henry Hemphill, which embraces 60,000 to 70,000 specimens, representing between 12,000 and 15,000 species of marine, fresh-water and land mollusks. It has, through the generosity of Wm. M. Fitzhugh, Esq., also acquired the Lowe collection of Indian baskets, pottery and Indian implements, perhaps the most complete collection of West Coast Indian baskets in existence outside the National Museum.

The Academy's herbarium contains more than 18,000 sheets and is very rich in West Coast species and in exotics growing in California.

The collections are now in temporary quarters at 343 Sansome street, but will soon be installed in the Academy's new museum building, now under construction in Golden Gate Park.

Barton Warren Evermann, director.

San Francisco Institute of Art. This organization maintains a museum illustrative of the fine arts, principally examples of paintings and drawings, in all mediums, and of sculpture. The paintings and drawings are by artists of repute of all nationalities, chiefly of the last century.

Location, Mason and California streets; reached by California street car line.

Robert Howe Fletcher, director.

California State Mining Bureau. Located on the third floor of the Ferry Building. Is under the direction of the State Mineralogist and endeavors to promote the interests of the mineral industry in California. This is done through its bureau of information, its publications, library and reading room, laboratory, statistical department, and museum. The museum contains some 20,000 mineral specimens attractively arranged and representing fully the varied mineralogical resources of the State. The museum is open to the public.

R. P. McLaughlin, curator.

IN OAKLAND AND BERKELEY.—*University of California, Berkeley.* Several departments maintain extensive collections of specimens pertaining to their fields. These have been gathered with reference to their value in research and class work. The more notable of these department collections are: The paleontological, consisting of more than 150,000 invertebrate fossils, with several hundred types, 15,000 vertebrate fossils, with more than 100 types, and 3000 plant fossils, with about fifty types; the botanical, containing an herbarium of more than 135,000 sheets; a geological, of rocks, minerals, and slides, many of them of rare value; zoological, consisting of specimens of invertebrate animals, plankton, etc.; and a large archaeological collection where may be found casts of famous statuary.

California Museum of Vertebrate Zoology. Located in a corrugated iron building immediately north of football field, campus of the University of California, Berkeley. An institution devoted to the study of problems in natural history, geographic distribution, and speciation of the higher vertebrates of the western coast of North America, with special reference to California.

There are three notable exhibition groups—one of the Steller sea lion, one of the California sea lion and one of the Kenai mountain sheep. The major part of the collection is solely of a research character. There are catalogued to date 53,186 specimens, distributed as follows: Birds' nests and eggs, 1384; reptiles and amphibians, 5558; mammals, 21,304; birds, 24,940. Adding to the value of these, are series of photographs, maps, and field note-books.

Joseph Grinnell, director.

Oakland Public Museum. Maintained by the city of Oakland. Contains exhibits of natural history, ethnology, American history and antiquities.

In natural history there are over 26,000 specimens, including nearly 1000 mounted birds, 1700 selected minerals, 350 fossils, 16,000 shells, 500 insects chosen because of special interest or attractiveness; also a special exhibit of blossoming native flowers, that is maintained throughout the year, the number varying from thirty to forty in winter to 200 or more in other seasons.

In ethnology, about 5500 articles, chiefly Indian, embracing excellent exhibits illustrating the primitive life of several California tribes; also a valuable collection of Pacific island material.

In history, nearly 4000 specimens, including a colonial exhibit that illustrates the home life of the pre-revolutionary era in the Eastern United States, undoubtedly the best colonial exhibit west of Chicago; there is also valuable material illustrative of California history and American history in general. There are also more than 2500 specimens of money and medals.

Location, 1426 Oak street; reached by East Twelfth or Thirteenth street cars, or Key Route East Oakland train.

C. P. Wilcomb, curator.

Piedmont Art Gallery. A private art gallery in Piedmont Park and owned by Mr. Frank C. Havens. Contains some 350 pictures, principally modern, representing various European and American schools.

Reached by Piedmont car line from Oakland.

Richard L. Partington, curator, in charge.

AT STANFORD UNIVERSITY, VIA PALO ALTO, CALIFORNIA.—*Leland Stanford Junior University.* Maintains no separate public museum but has very large and complete research collections of fishes, mammals, birds, reptiles and amphibians, insects, minerals, fossils and plants. The collection of fishes is one of the largest and most valuable in the world and is the largest in America outside that of the United States National Museum. These are located in various buildings according to the department concerned.

Leland Stanford Junior Museum. Founded in 1891 as a memorial to Leland Stanford, Junior, the only son of Senator and Mrs. Stanford. The museum is now part of the university.

Special features: Chinese, Japanese and Korean collections, Danish stone and bronze implements, Cyprian material, porcelains, paintings and Californiana.

The earthquake of 1906 destroyed the newly-erected additions, entailing a very heavy loss of material, particularly Egyptian and fine arts. The latter is still rich in certain lines and contains some fine examples of Keith and Hill, Benjamin West, Gustave Richter, Meissonier, Bonnat, Brozik and others. The present installation is but temporary.

H. C. Peterson, director.

At Pacific Grove, Monterey County, California.—*Pacific Grove Museum Association.* Maintains a museum containing collections as follows: Botany, an herbarium of about 1000 cryptogams, 2500 phanerogams, and a forestry collection of fifty species of cones and a large number of seeds; geology and paleontology, more than 200 minerals and invertebrate fossils; zoology, about 2900 shells; and collections of birds, reptiles, fishes, etc.

Mrs. Mary E. Hesser, curator.

In Los Angeles, California.—*Museum of History, Science and Art.* One building, 270 feet front by 50 feet, with one wing to rear 100 feet, in Exposition Park. Funds furnished by the Board of Supervisors of Los Angeles County.

Has important collections as follows: About 12,000 bird skins, mostly western; 2000 birds' eggs; small but constantly growing collections of mammals, reptiles and shells; the Daggett collection of about 3000 species of Coleoptera, mostly western, and a good exhibition of exotic Coleoptera; the Davidson collection of about 2000 species of plants; a large collection of great value of fossil skeletons, and remains from Rancho La Brea; the Johnson collection of Chinese porcelain, second only to the Morgan collection, installed in a gallery 50 by 100 feet, beautifully lighted and said to be the best equipped in the west; large historical collections, covering the history of California, also the Cherry African collection, and a large collection of weapons from the English cross-bow to modern guns. There is also a library of about 2000 volumes and 4000 pamphlets.

Frank S. Daggett, director.

The Southwest Museum. Incorporated in 1907, supported largely by the Southwest Society, which has 400 members. Was presented by the Southwest Society with a $50,000 site of twenty acres on Museum Hill, a bequest of $50,000 for the first building, and collections valued at about $300,000. Has since largely increased its collections, has completed the first building, costing $115,000, which has been in use since July 1, 1914. Open every day in the year from 12 to 5 p. m.

Has large collections of California and Southwest archaeological specimens (over 100,000); the

J. A. Munk Library of Arizoniana, 15,000 items; the flag, medals, paintings and other relics of John C. Fremont; the Caballeria collection of paintings from the old Missions, thirty-four canvases; oil studies of the Missions in 1882 by Wm. Keith, seven pieces; Wm. H. Golisch collection of conchology, about 75,000 specimens, etc.

Charles F. Lummis, in charge.

University of Southern California. Has collections embracing about 3000 fossils, 3700 minerals, 1000 geological specimens, 5000 plants, 730 ethnological, 22,500 zoological specimens, 19,500 mollusks, 525 birds, 125 birds' eggs, 350 other vertebrates.

Southern California Academy of Sciences. Maintains a museum containing a collection of local pleistocene fossils and other material.

Board of Education of the City of Los Angeles. Maintains a Science and Art Museum, containing collections chiefly in anthropology.

J. Z. Gilbert, in charge.

AT PASADENA, CALIFORNIA.—*Throop College of Technology.* Has no museum building, but owns some excellent collections of minerals, etc.

Charles F. Holder, honorary curator.

AT CLAREMONT, CALIFORNIA.—*Pomona College.* Maintains a museum consisting chiefly of teaching collections, comprising about 200,000 phanerogams, 10,000 cryptogams, synoptic collections in geology and paleontology, and extensive collections in zoology, including about 5000 shells, 250,000 insects (many types), 10,000 other invertebrates, and 5000 vertebrates.

Wm. A. Hilton, in charge.

ON SANTA CATALINA ISLAND, CALIFORNIA.—*Tuna Club, at Avalon.* Has a museum of mounted game fishes of southern California and Texas, and a library on angling.

A. L. Beebe, honorary curator.

Zoological Station, at Avalon. Maintains an aquarium, and an alcoholic collection of rare fishes; also a collection representing the archaeology of the Channel Islands, a part of which is on exhibition in the Chamber of Commerce at Los Angeles.

SACRAMENTO, CALIFORNIA.—*E. B. Crocker Art Gallery.* Contains a notable collection of paintings, also collections of minerals, coins and Indian relics. Situated on O street, between Second and Third streets; reached by Third street car line.

W. F. Jackson, custodian.

IN OREGON.—*Oregon Agricultural College.* Located at Corvallis. Maintains exhibition and research collections in connection with the science departments. The herbarium contains 10,000 phanerogams and vascular cryptogams and 1500 fungi. In zoology there are collections of birds, mammals, fossils, and miscellaneous specimens.

Geo. F. Sykes, in charge of zoological museum.

University of Oregon. Located at Eugene. Has the Condon collection of vertebrate fossils from the John Day beds, a mineralogical collection of about 4000 specimens, and considerable collections in botany and ethnology.

Portland City Free Museum. In City Hall, between Fourth, Fifth, Madison and Jefferson streets, Portland. Started in 1903; general in character, containing much valuable material not catalogued.

C. F. Wiegand, curator.

State Fish and Game Commission. Is accumulating collections of the vertebrate animals of Oregon. Located at Reed College, Portland.

William L. Finley, in charge.

IN WASHINGTON.—*State College of Washington, Pullman.* The general museum contains collections of mounted birds, mammals, fishes, etc. Other scientific collections are maintained by the departments of entomology (200,000 specimens), botany (about 85,000 herbarium sheets), geology and agriculture.

The State University. Located at Seattle. Contains the State Museum, in which are valuable collections as follows: Anthropology, 27,000 specimens; botany, 13,000; minerals, several thousand; paleontology, 12,000; shells, 14,000; insects, 31,000; other invertebrates, 11,000; fishes, 1500; amphibians and reptiles, 5000; birds, 1000.

IN IDAHO.—*University of Idaho.* Located in Moscow. The university museum was destroyed by fire in 1906, with the exception of the mineral collections. There are collections of value in the different departments of the university.

IN UTAH.—*Deseret Museum.* Located in Salt Lake City. Contains important collections as follows: Anthropology; archaeology, native, 500; foreign, 50; ethnology, native 100; foreign, 500. There is a large collection of desiccated human remains and artifacts from the cliff dwellings of Utah. Geology, several hundred specimens, including a large collection of geodes from Wayne County; also more than 4000 fossils. Zoology, shells, 2500; insects, 1000; many other invertebrates and some 800 vertebrates.

AGRICULTURAL DEVELOPMENT OF THE PACIFIC COAST

BY E. J. WICKSON
Professor of Horticulture, University of California

ALTHOUGH the region of the United States west of the Rocky Mountains is rather new in the eyes of the present generation, there are several grounds upon which its agriculture may be claimed to be old—possibly older than what we now regard as "American agriculture," which proceeded westward from settlements by Europeans upon the Atlantic Coast.

THE PREHISTORIC PERIOD.—The Pacific Slope has, in its southern parts, vestiges of prehistoric agriculture in irrigation canals and connections which indicate the existence of irrigation systems of undetermined origin and antiquity.* But such vestiges did not alone remain. Professor George F. Freeman of the University of Arizona makes this statement:

"Among the native economic plants of this region may be found varieties of agricultural plants which have been grown within the confines of Arizona for hundreds or perhaps even thousands of years—years when the ruins that now crumble in the desert sands were populated with a happy and prosperous race: years when canal systems which still can be distinctly traced, ran on higher levels and covered more lands than those which at the present time distribute the waters of the Gila and Salt rivers. Here, among the Pima and Papago Indians, descendants of or successors to these former builders, may be found varieties of corn, beans, pumpkins and squashes which have survived the race under whose husbandry they originated.†

Professor Freeman has isolated forty-seven types of such prehistoric beans among the Papago Indians —the very name of their tribe signifying "beanmen" from remote antiquity; therefore to call the Bostonese of the Atlantic side "bean-eaters" is merely recrudescent. Perhaps the original use of the term provoked resentment as keen as that of the present day.

One gets a broader view of the antiquity of Pacific Coast agriculture from Professor Mead's study of the

* Irrigation Institutions, by Elwood Mead (Macmillan & Co., 1903), p. 41.

† "Southwestern Beans and Teparies." Bulletin 68 Univ. of Ariz. Exp. Station.

"beginning of irrigation" in the course of which he writes:

"Even modern irrigation is comparatively old. It began seventy years before the English colony landed at Jamestown, when Spanish missionaries gained an enduring foothold in the valley of the Rio Grande. They built churches which still stand, and planted gardens which still flourish, but in watering these gardens they taught nothing new to the native inhabitants. The Spanish explorers, who rode up the valley of this river, in the first half of the sixteenth century found Pueblo Indians irrigating the thirsty soil as their forefathers had done for centuries before them and as their descendants are still doing. * * * The ditches of Las Cruces, New Mexico, have an unbroken record of three centuries of service the history of which is written in the banks of the canals by the sediment with which the waters of the Rio Grande is laden. Year after year this has been deposited on the sides and bottoms of these ditches, until from being channels cut out below the surface, they are raised two or three feet above. It is here that one can yet find agriculture almost as primitive as that of the days of Pharaoh, where grain is reaped with the sickle and threshed by the trampling of goats."*

When one gets behind the trenches at Jamestown he surely precedes the birth of "American agriculture" of the Atlantic type, and when he storms the Pharaonic line he challenges the antiquity of the world. It was on the Atlantic side that the tourist bemoaned the absence of ruins. It is on the Pacific side that the claim can be established that, even for antiquities, one should "see America first."

THE SPANISH PERIOD.—The allusions by Professor Mead to the incursion of Spanish explorers and missionaries upon the vestiges of the prehistoric period, which may be said to have been found surviving amidst its ruins, serve to mark the beginning of a new period in the development of Pacific Coast agriculture—the achievements of the Spaniards. But the greatest agricultural work of the Spaniards was not accomplished in the valley of the Rio Grande nor among the most ancient ruins of Arizona. They accomplished most in California where they found no signs of preexisting agriculture and where the only antiquities were the mounds of the clam-diggers—a low grade of aborigines who knew not whence they came nor where they were going, until the missionaries advised them! This work

* Elwood Mead, loc. cit., p. 42.

was begun in Lower California in 1697; and, in 1769, Junipero Serra and his Franciscan associates coming from Lower California established their first mission at San Diego. Thence the padres proceeded northward along the coast and established their twenty-first and last California mission in Sonoma valley, north of the Bay of San Francisco in 1823. At all these missions agriculture was invoked as a sustaining industry. They grew a large variety of fruits, made wine in such quantities that exports thereof were made to Mexico from one of the Lower California missions in 1707—thus establishing the export trade in California wine. In addition to fruits and their products, the missions produced vast quantities of grains and accumulated very large herds from which hides and tallow went to Europe in trading ships which combed the California coast of such properties, following the visit of Sir Francis Drake to San Francisco Bay in 1759, until the forceful advent of Americans in 1849—when California was really born to the world, with a golden spoon in her mouth.

Many of these missions still remain in good condition and are very interesting to tourists, but their agriculture practically disappeared with the secularization of their properties by the Mexican government in 1834. The large field properties then passed from the ownership of the padres but the gardens attached to their churches remained in their possession and these still contain a few worshipful fruit trees and grape vines which are venerated as the pioneer plantings of the million acres of fruits which are now growing in California.

The Spanish occupation of the southwestern district of the United States, whether parochial or secular in its character, was not widely significant in the subsequent agricultural development of the region. It is chiefly interesting historically. The animals and plants they introduced were probably good, according to the Spanish standards prevailing when the missionary expeditions departed from Spain early in the eighteenth century; but the agriculture established with them was too distant and isolated to profit by later European improvements and it was not at all affected by the progress made by the colonials and early citizens of the American republic. The local agriculture had become anachronistic before the American occupation and nothing was learned from it except the very important suggestion of the wide adaptation of California to fruit growing. All the plants grown by the padres have been abandoned except one variety of grape which is of little value and one variety of olive, which happens to be the best we have. Even their methods of tillage and irrigation were wrong, as will be cited in another connection later. Their spiritual labor and sacrifice are rightly venerated, but their agriculture had permanent value only in its suggestiveness.

During the mission rule, and after the secularization especially, men from Spain and from Mexico secured large grants of California land in return for personal services and otherwise, but the rude feudal system which was thus inaugurated was of no permanent value to the possessors nor to the development of the country—in fact the flock of Mexican grants which were ratified by the admission of California to the United States were birds of ill-omen for decades after the American occupation. The agriculture on these old grants was primitive and unworthy of the land which it encumbered.

Included in the Spanish period are the ventures of the Russians to establish themselves on what is now the Pacific Coast of the United States, but they contributed practically nothing to agricultural development.

THE AMERICAN PERIOD.—From a modern point of view the true pioneers of the development of the Pacific Coast as we now see it, were the continent-crossing stalwarts, who braved the perils of the "Great American Desert," during two decades previous to the gold discovery in 1848. Technically the "pioneers" included all who arrived in California by any means of locomotion "during '49 and the spring of '50." All the histories of the Coast States record their names and describe their exploits. Three names lead in all narrations: Fremont for California; Lewis and Clark for the north coast regions. Accompanying or following them practically all the pioneers of the first class were explorers, hunters and trappers. Some were actuated by patriotism, some by peltry, some by pure adventure. Agriculture was not in their thoughts, and although many did take a quick suggestion from what they saw at the California missions, the prevailing idea was that California was not a farming country. This was a pardonable mistake because they had never seen such a country before. Knowing what havoc a few weeks of summer drouth would work with crops on the mid-continent prairies, they could not conceive how the same crops could endure months without rain and really be the better for it. The latter fact was slowly recognized, and retarded the development of California agriculture even after the State was thronged with gold-seekers. Oregon was more fortunate in impressing strangers. Oregon did have able farm-seeking pioneers a decade, perhaps, before California began to be recognized as agriculturally desirable, and western Oregon had grains, stock, fruits, and even fruit trees to sell when the earliest agricultural awakening came in California. Those were the true agricultural pioneers who first saw that one was surer to get gold with the plow in the new land of the valleys than with a pickaxe in the rocks and gravel of the foothills; and some who were pioneers in Oregon and took their hint of fruit-adaptations from seedlings planted by the Hudson's Bay Company's agents near the mouth of the Columbia, came to California where the hungry market was to be found and took some new hints from the missions and from a few plantings which their influence had previously induced. Thus in the light of the gold-gleam California became the real planting-place for American agriculture on the Pacific Slope; drawing farming wisdom, energy, and enterprise from near and far; bringing the best materials from everywhere; and devising methods of husbandry to meet new conditions. Thus, too, men were found wise to forget all they thought they knew when its ill-adaptation showed clear, demonstrating new uses for old principles, discovering new principles involved in new conditions and materials; in short, manifesting the American spirit—bold, venturesome, and alert—seeing large and implanting that quality in the minds of all with whom they came into contact, no matter what corner of the world they came from; for the pioneers of the Pacific Coast were the true cosmopolitans. Even the farm implements and machines manufactured at the east for shipment to the Pacific Coast had to be made larger than those commonly used elsewhere, so that the California or Oregon types of farm wagon, plow, or threshing machine were generally recognized as such. It was because such things were used in a large way, with large teams on large lands. Pacific Coast people had no time for small things. This attitude was manifested in all which they thought and did and has resulted in the occurrence of what is sometimes called: "The Pacific Coast point of view."

But while such agencies were laying the foundation of agricultural development on the western rim of the Pacific Slope, an event was transpiring on its eastern edge which pointed the way and demonstrated the method by which the development would include the thirstiest lands and banish the term "American Desert" from the map. Professor Mead writes:

"For the beginnings of Anglo-Saxon irrigation in this country we must go to the Salt Lake valley of Utah, where, in July, 1847, the Mormon pioneers first turned the clear waters of City Creek upon the sun-baked and alkaline soil. Utah is interesting not only because it is the cradle of our modern irrigation industry but even more so as showing how important are organization and public control in the diversion and use of rivers."*

Thus are suggested the conditions and agencies which are fundamental in the development of agriculture upon the Pacific Slope. To specifically enumerate them and even briefly outline their operation would pass the limitations of this writing. A few only can be emphasized, namely:

First: the Climatic Adaptations of the Area.—These will be mentioned only in terms of economic plants which produce commercial crops. The list comprises all that are grown in the United States in the classes of grains and forage plants and field crops, while in some of the latter, and especially in the categories of commercial vegetables and fruits, large values are secured from some plants which thrive in the semi-tropical parts of California and Arizona and not elsewhere in the United States.

Second: the Superiority of the Soils of the Arid Region.—This matter has been technically demonstrated by analyses made by Professor Hilgard and those associated with him during his forty years of activity at the California Experiment Station, and by other investigators in the several States of the Pacific Slope, as well as by the practical demonstrations which the crops themselves have made by their acre-averages so freely published. The superiority of soils formed under arid conditions when compared with those formed elsewhere, even in tropical regions, is, however, more broadly demonstrated in the ancient and modern history of mankind, as stated by Professor Hilgard in these words: " * * * On both sides of the Mediterranean Sea, we find that, instead of the humid forest-country, it was in the arid but irrigable coast countries * * * that noted centers of civilization were developed and maintained * * *. In humid countries, as is well known, cultivation can only in exceptional cases be continued profitably for many years without fertilization. * * * No such need was felt by the inhabitants of the arid regions for centuries, for the native fertility of their soils, coupled with the fertilizing effects of irrigation water bringing plant-food from afar, relieved them

* Elwood Mead, loc. cit., p. 42.

of the need of continuous fertilization; while in the humid regions, the fertility of the land is currently carried into the sea by the drainage waters, through the streams and rivers, causing a chronic depletion which has to be made up for by artificial and costly means. What with the greater intrinsic fertility and the great depth of soil available for plant growth, much smaller units of land will suffice for the maintenance of a family in arid countries: a fact which is even now being illustrated in the irrigated regions of the United States * * * in what we are in the habit of calling 'deserts;' the very sands of which usually need only the life-giving effects of water to transform them into fruitful fields and gardens."*

Specific superiority of arid land soils will be cited in connection with tillage, below.

THIRD: THE ACHIEVEMENTS OF IRRIGATION ENTERPRISE.—The local application of the teaching of the world's experience concerning irrigation as an agricultural art was at first believed to be indispensable to the development of agriculture on the Pacific Slope. This early conception was soon found to be defective, as will be noted later. Irrigation is not essential everywhere on the slope, though in some locations it may be; nor is it essential to all crops, though for some crops it may be. And when it is remembered that somewhere on the slope may be found every food crop grown in civilized countries except those of strictly tropical climates, it must be realized that the artificial use of water, with reference to natural conditions of climate and soil, and with reference to the requirements of the particular crop undertaken, is perhaps the broadest and most needful of wisdom of all the agricultural arts. The fact is that Anglo-Saxon people, born to the farming of the humid countries of the world and unused to any artificial use of water, except perhaps in the irrigation of brandy, have within half a century not only mastered an art unknown to them, that of farming an arid country, but are producing food products to a farm-value upwards of half a billion dollars a year—not to pursue the value thereof to the market places of the world. Moreover, these people have not only mastered an art to which they were not born, but have discovered truer policies and devised improved methods in the use of water to such ends that representatives of the most ancient irrigated countries attend American irrigation congresses to learn American ways with water. There is probably nothing in American agriculture

* Soils, by E. W. Hilgard (Macmillan & Co., 1906), pp. 417-420.

more striking, dramatic, and economically significant than this achievement. Let it be briefly measured:

In its consideration of what is designated as "the arid region as a whole" the United States Census of 1910 determines the total irrigated area to be 13,738,485 acres, of which the Pacific Slope States include the following:

	Acres
Arizona	320,051
Utah	999,410
Nevada	701,833
Idaho	1,430,848
Washington	334,378
Oregon	686,129
California	2,664,104
Total	7,136,753

In addition to the above States the "whole arid region" includes Montana, North and South Dakota, Wyoming, Colorado, Kansas, Nebraska, New Mexico, Oklahoma and Texas, and the aggregate area is about 1.8 millions square miles, of which the six Pacific Slope States enclose .7 of one million. By comparing areas it appears that about 40 per cent of the area has more than 50 per cent of the irrigated acreage.

In view of the impression created in the public mind by popular publications, that irrigation development is largely due to the beneficent work of the government in the "reclamation of arid lands," it should be noted that, of the 13,738,485 acres of land irrigated in 1909, the government enterprises irrigated in that year, directly or indirectly, but 857,111 acres, or one-sixteenth.

It is important to emphasize this fact lest the visiting observer should entertain the thought that the wonderful achievements, of which he may see the operation or the results, are the product of paternalistic, promotive generosity on the part of the general government. The sources of irrigation achievements are very accurately measured by the census of 1910 in this way, with reference to the "whole arid region:"

PERCENTAGES OF ACHIEVEMENTS BY PUBLIC AND PRIVATE ENTERPRISES.

	Acreage capable of irrigation 1910	Acreage of capacity of all projects
U. S. Reclamation Service	4.1	6.3
U. S. Indian Service	1.9	2.8
Corey Act enterprises	5.6	8.3
Irrigation districts	4.1	5.1
Co-operative enterprises	32.0	28.4
Individual and partnership enterprises	39.6	32.6
Commercial enterprises	12.5	16.5

The first three items are, directly or indirectly, government enterprises, the last four otherwise.

The lesson of the figures is, of course, that the building up of the far west is due to individual, corporate, and co-operative enterprise—just as other parts of the country have been developed and built up by the American spirit and purpose. The government projects are professedly to cover conditions which can not be subdued by individual or associated enterprises, and they are therefore grandly supplementary to various forms of private enterprise in the development of the country, but to the people, either individually or in a self-organized way, is due the credit of bringing the American Desert to its present estate of prosperous and progressive commonwealths.

Fourth: the Mastery of Tillage.—Tillage may be characterized as the one indispensable thing and therefore most fundamental in Pacific Coast agriculture. It sustains the closest possible relations both to irrigation and to farming by natural moisture, or "dry-farming," as it has come to be called. Tillage is the sheet anchor of dry farming and optimistic estimation of its services is naturally leading to some misconceptions and possibly to disappointments and hardships. Because some are claiming that tillage will produce water and gather to the soil moisture which does not fall in rain or snow, and are, therefore, undertaking farming operations in places where the total precipitation is less than the requirements of even the most drought-enduring crop. The fact is, of course, that tillage does not produce water, but saves the greater part of it for the uses of the crop—the greatest possible part of it, if the tillage be the best and most timely. The recent agitation of the subject is calculated to advance a notion that tillage is of enormously greater value in its contribution to dry farming lands than to lands cropped by irrigation. Possibly it may produce a greater total value because the area which must be farmed in that way, if profitably farmed at all, is much greater than the area which can be brought under irrigation even if all flowing waters and available subterranean waters are brought upon the land by gravity ditches and by pumps. It must, however, be claimed that tillage has as important relations to irrigation in general as to dry farming, and, when the measure is made by equal acreage, tillage and irrigation will produce immensely more than tillage and dry farming can produce—and this will be found true in regions where the rainfall is ample for certain crops—so great is the difference in the ability of different plants to transform water into "dry substance" during an exceedingly long growing season.

The Spanish irrigation farmers of the southwest, both in the interior and at the missions on the coast of California, did not understand the efficacy of tillage in increasing the duty of water. They ran the water on the land and when it baked and cracked they turned on more water, and when the whole soil mass became hateful, they either hewed it out with mattocks and hauled in fresh soil from the outside (in the case of fruit trees and vines) or they turned the water some other way upon new land which natural processes had made loamy and friable. The early American settlers in California soon found that by the use of the cultivator and hoe, as practiced in eastern cornfields, they could get a crop by using less water and at the same time keep the soil in good condition. They also found that they could get crops of plants which would grow during the rainy season, without irrigating at all; or, on some retentive soils, they could conserve the winter rainfall by cultivation so as to use it for summer crops and bring them through also without irrigation. And so there were in California many "non-irrigators," who made a virtue of their creed and their practice, and though they often claimed too much relatively, they did demonstrate the feasibility of dry farming by tillage, and for half a century or more, grain crops (which at one time made California the greatest grain State of the Nation), forage crops, winter truck farms, summer crops of beans, tomatoes, etc., and the greater area of orchard and vineyard, except of citrus fruits and raisins, were grown by dry farming with an average rainfall of 15 to 18 inches, taking the whole area together. This was the earliest large scale demonstration of the efficacy of tillage to render a small rainfall enough to produce a valuable crop. It was incidental to the progressive demonstration of the relations of tillage to irrigation, as has already been claimed, but it was fundamental in the dry farming movement which has recently attained such prominence in the interior. California is probably capable of doing more by dry farming than the interior States because the season of precipitation is the season of growth, through the high temperatures prevailing during the so-called "winter months"—hardy grains and grasses and in some places potatoes, etc., do not encounter frost enough to injure them. This brings maturity of grain, hay, etc., in April and

May—before the dry season acquires its cutting-edge. For these reasons a crop of ripe barley can be made with an annual rainfall of ten inches, well distributed from December to March. The practice of bare-fallowing and alternate year cropping, with its saving of moisture by tillage, has also prevailed in California for half a century.

But great as are the advantages of tillage in the effort to grow a crop with a scant precipitation, it is an interesting fact, which is not sufficiently well known, that the supreme efficacy of tillage in moisture conservation was demonstrated in the west upon irrigated areas and not upon dry lands, and that tillage as a substitute for irrigation was an incidental, though immensely valuable, suggestion from experience in irrigation. The popular understanding of the matter is probably otherwise. It can be safely claimed that farmers operating by irrigation are more diligent and thorough cultivators than those operating by rainfall. In an investigation made by the writer for the Irrigation Investigations of the United States Department of Agriculture, and published in Bulletin 108 of the Office of Experiment Stations, the experience of about 225 individual fruit growers is given in detail and the following conclusion is drawn: "Very diligent cultivation is practiced both by those who rely upon local rainfall and by those who irrigate. Irrigators cultivate more frequently. Frequency of irrigation is in itself not desirable if it can be avoided; frequency of cultivation with irrigation simply indicates that so often as the soil is thrown out of good condition for moisture retention, so often must such good condition be restored."

The efficacy of tillage in moisture retention, which is the secret of arid land production, either from rainfall or irrigation, has been accurately determined. Dr. Samuel Fortier, who has charge of the Irrigation Investigations of the United States Department of Agriculture, has recently shown by actual test on the University Farm, Davis, California, that land allowed to become compacted by drying after irrigation lost by evaporation more than one-third of the water applied within a month after the application, while land which received good tillage to the depth of nine inches lost less than 1 per cent by evaporation. Nine inches depth of finely pulverized surface layer is greater than desirable in orchard or vineyard practice, but it is desirable to know what it will accomplish. Similar experiments conducted by Dr. Fortier at Wenatchee, Washington, in June, 1908, showed the following losses in twenty-one days, with and without a soil-mulch by tillage: No mulch, 14 1/3 per cent of water applied; 3-inch mulch, 4 per cent; 6-inch mulch, 2 per cent; and 9-inch mulch, 1 per cent.

Dr. Fortier concludes: "From the foregoing it is evident that western orchardists can prevent the greater part of the evaporation losses by cultivating orchards to a depth of at least six inches as soon as practicable after each irrigation."

These results give quite sufficient reason to insist upon the mastery of tillage and irrigation in moisture conservation. Besides there is, of course, the efficacy of tillage in giving the plant soil aeration and other conditions essential to vigorous and free root action—including restoration of fertility by action of soil bacteria which in the arid region has been demonstrated by Dr. C. B. Lipman of the University of California, to be in operation "at much greater depth in soils of the arid than in soils of the humid region.* Dr. R. H. Loughridge, of the same institution, demonstrated "the distribution of humus-nitrogen through twelve feet, thus giving the soil in the arid region a higher total of humus-nitrogen than is found in humid soils."

The distinctive characters of the soils, and the relations thereof to irrigation and tillage, are of determinative importance in the development of the arid region, as may be readily inferred even from the foregoing fragmentary discussion.

Fifth: the Quality of Manhood.—Of course the ruling factor in the development of the far west has been the quality of manhood involved in the achievement, but this need only be suggested in this connection. The earliest of the pioneers were chiefly natives of the middle west, where they had been born to heroism, adventure, and unprecedented achievement. They were strong in initiative, resourceful, venturesome, full of the American spirit and cherishing American ideals of equality of manhood and of opportunity. Those who followed the first run of pioneers were also possessed of an exceptional average of spirit and capacity—the very difficulties of the approach to the arid region set up barriers of exclusion against both physical and spiritual weakness. Though the venture for gold in California brought a motley crew, the weaklings were soon excluded by the

* University of California Publications in Agricultural Science, Vol. 1, No. 1, pp. 17, 20; Idem, Vol. 1, No. 8, p. 179 et seq.

selective processes of pioneer life and the strong remained to build up the State. Of these either the first comers themselves, or their offspring, figured largely in the upbuilding of the interior states of the Pacific Slope. It was a common way among those seeking their fortunes in the farthest west to throw themselves straight at the Pacific seaboard, even if some of them did bounce backward from it to homes east of the Sierra Nevada Mountains. Even the Mormons made a trail to California after the gold discovery, but they retired later to what was at that time the seclusion of the Salt Lake region. Of course many from foreign lands joined the ranks of the pioneers and helped notably to develop and populate the country; but it is a fact that free immigration has always been prevented by distance and cost of transit—so that in direct foreign immigration a rigid selection has always prevailed: only the best, and relatively few of them, passing this barrier. Of indirect immigration, Americanized aliens and their offspring, we have received a large percentage of our present population, but with them the same selective process prevailed as with native-born Americans, and with the same results. Without argument, then, it may perhaps be conceded that the Pacific Coast States have a population incidentally selected for purpose and efficiency, and this has proven a ruling factor in development.

Statistics of Pacific Coast Development in Agriculture.—Those who have preceded me in this "Division of Natural Resources and their Development" have emphasized achievements which have a mineral basis. The relative percentage of rural population in the Pacific States and the value created by farming is determined by the United States Census of 1910 as follows:

POPULATION OF PACIFIC STATES AND AGRICULTURAL VALUE.

	Population*	Per cent rural	Value of all farm property*
Arizona	204	69.0	75,124
Utah	373	53.7	150,795
Nevada	82	83.7	60,399
Idaho	326	78.5	305,317
Washington	1142	47.0	637,543
Oregon	673	54.4	528,244
California	2378	38.2	1,614,695

* Expressed in thousands, three figures being omitted.

The last five years have been very active in development in the Pacific States, and present attainment is much greater than that of the last census year, but no authoritative measure of it is available for all the territory in the above table.

Agricultural Development

The farm products of the several States, and the values of the farm animals therein, in the following table are mainly from the Year Book of the United States Department of Agriculture for 1913, and the figures are for that year, except as noted otherwise in the footnotes:

VALUES OF VARIOUS FARM CROPS AND OF FARM ANIMALS IN PACIFIC COAST STATES.

(In thousands of dollars, three figures being omitted.)

Crop	Ariz.	Utah	Nev.	Idaho	Wash.	Ore.	Calif.
Corn	524	238	40	305	762	419	1,597
Wheat	1,021	3,358	302	5,351	23,652	9,229	3,990
Oats	150	1,656	307	4,836	5,700	5,787	3,982
Barley	1,082	635	443	3,629	3,791	2,310	22,542[4]
Rye	....	122	....	38	101	262	90
Potatoes	101	2,088	1,197	2,890	4,428	3,915	5,664
Sweet Potatoes	....	....	....	....	....	....	1,020
Hay	5,940	8,272	7,106	14,717	19,555	15,588	48,600
Cotton	....	....	....	....	....	....	1,119
Rice	....	....	....	....	....	....	293
Beet Sugar[1]	....	57,231	....	29,620	....	....	171,208
Horses and Mules	8,424	12,555	6,525	22,300	32,890	28,908	54,827
Milch Cows	2,368	5,192	1,432	7,818	17,316	12,740	31,930
Other Cattle	24,018	12,638	16,999	14,585	7,104	17,860	46,530
Sheep	5,764	7,683	6,826	12,520	2,226	10,413	9,694
Swine	230	926	416	2,696	3,607	3,300	8,368
Hops[2]	....	....	....	....	665	2,839	1,731
Beans[2]	45	10	....	76	9	23	6,295[3]
Peas[2]	....	6	....	9	116	16	101
Fruit Crops	250	1,000	....	1,000	5,250	4,000	50,500[4]
Vegetables[2]	379	717	204	1,007	2,988	2,448	6,886

[1] Thousands of tons; California product second only to Colorado.
[2] From U. S. Census, 1910.
[3] Second only to Michigan.
[4] Greatest state product in United States.

All the valuations in the preceding table are "farm values:" that is, no increment is attached for transportation or trade handling, and they do not therefore represent the market values which are usually included in statements of this kind. The table shows, however, the classes of farm products produced in each of the states and thus serves as an index to the kinds of farming which are chiefly followed and their relative importance, in each State and in the group of States.

Obviously the limitations of this writing do not admit specific characterizations of the physical features of the States which determine products and determine also their geographical distribution. Condensed descriptions along these lines may be found in volume I of the Cyclopaedia of American Agriculture. Published descriptions can also usually be obtained through application to the agricultural experiment station in each State, *i. e.:* Arizona at Tucson; Utah at Logan; Nevada at Reno; Idaho at Moscow; Washington at Pullman; Oregon at Corvallis; and California at Berkeley.

SOME NOTABLE IRRIGATION & HYDRO-ELECTRIC DEVELOPMENTS

BY C. E. GRUNSKY
President, American Engineering Corporation, San Francisco

The water resources of the Pacific Slope are of exceptional importance. The conservation and use of the water obtainable from streams, underground sources and lakes contribute in no small degree to its prosperity. Vast developments have resulted from irrigation. The light and power so generously supplied and so widely distributed often have their source hundreds of miles away, where human ingenuity has converted the power in the flowing water into electric energy and transmitted it to far distant places of use.

Such streams as the Columbia and the Willamette in the North, the Sacramento and the San Joaquin in California, and the Colorado River, between California and Arizona, attracted attention first by their navigability. But with the improvement of other methods of transportation, some of these streams, such as the Colorado, lost importance as navigable waters but gained enormously, as population grew, in importance for irrigation.

Space will not permit enumeration of the many successful irrigation enterprises in California or the other Pacific Coast states. The visitor who will stop off for a day or two in any irrigated section can easily find local works of note.

Underground Water Supply.—The extensive use of water for irrigation from sub-surface sources can not be noted here except to say that there is a growing draft upon sub-surface waters with ingenious artificial replenishment of sub-surface sources, involving sometimes the spreading out of the freshet flow over pervious areas that it may find its way into the natural underground reservoirs. So important has this matter become that Los Angeles County, for example, is at work on a project that will be of general benefit both in controlling floods and in safeguarding and increasing the subterranean supply of water.

The Imperial Valley Irrigation System.—The Colorado River, commanding the depressed area now known as the Imperial Valley, has there made a phenomenal development possible. Several hundred thousand acres of land have been brought under cultivation in an almost rainless region, the mean annual rainfall being only three to five inches.

The irrigation canal which has here transformed the desert into a highly productive region, now under intense cultivation, has its head in the southeastern corner of California. A concrete structure controls the flow into the canal. A few hundred yards below, the canal enters Mexico, but re-enters California forty miles farther west. The capacity of the canal is several thousand cubic feet per second. The region irrigated is nearly all below sea level, the lowest point being about 280 feet below the sea. In 1905 and 1906, as the result of open unprotected cuts from the river to the canal and unusual high waters, the river changed its course, cut a new channel, and discharged its entire flow for a time across the Imperial country into the Salton basin, where the water accumulated to a depth of about eighty feet. The turning of the river back into its original channel at a time when its flow was about 20,000 cubic feet per second, and with works that rested upon an unstable sand and silt foundation, was a notable feat, for which the engineer in charge, Mr. H. T. Cory, and the Southern Pacific Company, which financed the enterprise, deserve particular credit.

UNITED STATES RECLAMATION SERVICE IRRIGATION PROJECTS: *Salt River Valley Project.*—In the Salt River Valley, Arizona, near Phoenix, the disastrous shortage of water in the irrigation canals, due to the irregular water supply from an unregulated river, has been relieved by the construction of a great masonry dam, sixty miles up stream, which has converted the Tonto Basin into a great reservoir which holds back the entire flow of ordinary freshets and makes the water, under natural conditions wasted, available for use as needed. This Roosevelt Dam was constructed by the United States at a cost of about $3,000,000, under the coöperation authorized by the United States Reclamation Act, which permits the Secretary of the Interior to undertake such works with the understanding that their cost, without interest, will be repaid in the course of twenty years.

Phoenix, population in 1910 was 11,134.

Sources of water: Salt and Verde rivers, and wells.

Reservoir: Roosevelt on the Salt River at the Tonto Basin has an area, when full, of 16,320 acres. Its capacity is 1,284,000 acre feet. The Roosevelt Dam has been constructed of rubble concrete masonry. It is arched, has a crest length of 1125 feet, a maximum height of 280 feet and a volume of 342,000 cubic yards of masonry. At the Granite Reef on the Salt River is a rubble concrete diverting weir which has a maximum height of 38 feet, is 1000 feet long, and required 40,000 cubic yards of masonry in its construction.

The canals of the system aggregate 32 miles with capacities greater than 800 cubic feet per second; 64 miles with capacities 300 to 800 cubic feet per second; 71 miles with capacities 50 to 300 cubic feet per second, and 409 miles with capacities less than 50 cubic feet per second.

Tunnels: There are twenty-three tunnels connected with the project works, aggregating two miles in length.

Power development: The project will ultimately yield about 19,000 horse power; the present power development exceeds 6000.

The area under rental contracts for water or other arrangements, including 10,000 acres of Indian lands, aggregates about 170,000 acres.

The net cost of this Salt River Project was reported in 1912 as $9,508,831.

Yuma Project.—Another notable irrigation work carried out by the United States Reclamation Service, in which both Arizona and California are interested, is the Yuma Project. Some ten miles up-stream from Yuma a low masonry diverting dam has been constructed across the broad bed of the Colorado River and out over the adjacent submersible flats to the base of granite hills. The length is over four-fifths of a mile. It sends enough of the river to meet the irrigation requirements into a large canal, which is crossed by the railroad just west of the river at Yuma, where a glimpse may be had of the entrance to the concrete inverted siphon, probably the largest of its kind in the world, which carries the canal water under the Colorado River from the California to the Arizona side.

Truckee-Carson Project.—In Nevada the traveler coming west on the Central Pacific may note on the Truckee River, about twenty-five miles after passing Hazen, a concrete structure which turns water from this stream south into the region of Fallon, near Carson Sink, where this supply, together with the water of the Carson River, is being used to conquer the desert. A feature of this Truckee-Carson irrigation project is the great Lahontan Dam on the Carson River, about eighteen miles above Fallon. This is an earth and loose rock structure with elaborate and well-constructed spillway and outlet works. There have already been expended on the Truckee-Carson Project about $5,000,000.

Source of water: Truckee and Carson rivers.

Reservoirs: Limited control of Lake Tahoe and Lahontan on the Carson River. The Lahontan Dam of earth and gravel will be 124 feet high, 1600 feet long and will require 770,000 cubic yards of material in its construction. Its water surface area will be 11,000 acres and its storage capacity 290,000 acre feet. The estimated cost is about $8,500,000. The first unit being brought under irrigation is 96,500 acres and the total area which it is hoped ultimately to irrigate, 206,000 acres. About 50,000 acres are now covered by water right application and rental contracts.

Orland Project.—At Orland, in California, some of the results of co-operation with the United States may be seen from the car windows. At Orland the soil is gravelly, and owing to the scant rainfall, only about ten inches in an ordinary year, it is unproductive under natural conditions. The United States Reclamation Service was requested to undertake the construction of irrigation works. Finding that Stony Creek, under some regulation by a storage dam at East Park, would afford ample water and that the soil would respond, the work was undertaken. Lands that had a speculative value of about $20 per acre are now worth several hundred dollars per acre, and comfortable homes have been established where but a few years ago the land was used for grazing and here and there for a little unprofitable dry farming.

Orland, population about 1200.

Source of water: Stony Creek. A storage reservoir has been constructed at East Park. The dam at this point is of concrete. Its maximum height is 139 feet, the length of its crest 250 feet. It contains 12,200 cubic yards of concrete. The capacity of the reservoir formed by it is 45,600 acre feet. About 14,000 acres are to be irrigated by this project, the irrigable land being located on both sides of Stony Creek. The total estimated cost of the project is about $600,000.

Klamath Project.—In southern Oregon, lapping over into California, is another enterprise undertaken with some success by the United States Reclamation Service. The problem here was to utilize for irrigation the water of the Upper Klamath Lake, to supplement the water supply of this lake with water from a reservoir constructed at Clear Lake, and to reclaim by drainage, or by the interception of inflow, some of the marsh lands around Tule and Lower Klamath lakes. The growth of Klamath Falls, stimulated by the improved use of the lands in the surrounding country, speaks for itself.

Klamath Falls, population about 3000.

Sources of water: Upper Klamath Lake and Clear Lake. Upper Klamath Lake, area 60,000 acres, storage about 200,000 acre feet. Clear Lake, area 25,000 acres, capacity 462,000 acre feet. The dam at Clear Lake has a height of 33 feet, is 790 feet long and is built of earth and rock aggregating 46,600 cubic yards in volume. A notable structure is the diversion dam on Lost River. It is constructed hollow of reinforced concrete. Its maximum height is 40 feet. The length of masonry is 290 feet, the length of earth fill 385 feet. It contains 5550 cubic yards of concrete and 13,100 cubic yards of earth fill. The tunnel through which water is drawn from Upper Klamath Lake is 3300 feet long.

The irrigable area of the first unit of the project is 30,000 acres; the reclamation of Tule Lake will add 35,000, and the entire project area is 72,000 acres. The irrigable lands opened exceed 30,000 acres, nearly all in private ownership. Upwards of $2,000,000 have been expended on this project.

The Yakima Project and the Okanogan Project, Washington.—In Washington the United States Reclamation Service has invested in the Yakima project about $6,000,000, and in the Okanogan, about $600,000. Space will not permit inclusion of a description of these works nor of others on the Pacific Slope. Nevertheless, they will repay a visit.

SAN JOAQUIN VALLEY IRRIGATION DEVELOPMENTS: The irrigation development on the Kern and the Kings rivers, typical of that on other streams in the southern San Joaquin Valley, California, is a special credit to the engineers who directed the early enterprises. Here irrigation commenced half a century ago, at a time when the products of the soil were not as valuable as at present and when to make a success of irrigation the cost had to be kept down. Massive masonry structures were out of the question. Weirs and dams were constructed of brush, cobbles, and wood, and though of only limited life, admirably served their purpose and the foundation was laid for prosperous development under irrigation, which has gradually extended from the region of least rain northerly until now all east-side streams of the San Joaquin Valley are under draft for irrigation water. The extension of irrigation was accompanied, of course, with the substitution of more permanent structures, and fine examples of good engineering practice can be seen on almost any of the rivers.

Irrigation Districts in California: The right to use the water required for irrigation should go with the ownership of the land. To carry out this idea the law permits the formation of irrigation districts. Many such districts have been formed and some of them are in successful operation. Notable in California are the Alta Irrigation District on the south side of Kings River, Turlock Irrigation District on the south side and Modesto District on the north side of Tuolumne River, and the Oakdale and the South San Joaquin Irrigation districts on the two sides of Stanislaus River. The LaGrange Dam, 127 feet high, with a crest length of 300 feet and containing 30,000 cubic yards of rubble concrete masonry, on the Tuolumne River about thirty miles above Modesto, is at the head of the irrigation canals which supply the Modesto and Turlock districts. A bold double arch dam, six miles above Knights Ferry on the Stanislaus River, diverts the water of this stream into the canal which supplies Oakdale and South San Joaquin districts.

Hydro-Electric Developments: As in the case of the irrigation works, so in the case of the hydro-electric installations, the notable achievements are too many to be here enumerated. Mention can be made of a few only. Long distance transmission of power over the electric wire was first successfully demonstrated on this coast, and some of the most notable enterprises in the world are to be found here.

The Spaulding Dam, Pacific Gas & Electric Company, California.—The Pacific Gas & Electric Company operates through a wide field in central portions of California and the power which is developed at a number of points in the Sierra Nevada is widely distributed and may at times be used hundreds of miles from its point of origination. Among the latest additions to this system is the Spaulding Dam, a massive concrete structure, which closes a gorge in solid granite on the South Fork of Yuba River, about two miles northeasterly from Emigrant Gap on the Central Pacific Railroad, and forms a storage reservoir from which the water will flow through a succession of power houses as it descends from the Spaulding Lake, at an elevation of 5050 feet, to the Sacramento Valley, which is but a little above sea level. The dam will ultimately have a height of 305 feet. It has been completed to a height of 225 feet and will remain in use at this height until additional storage is needed. (See Pl. XXV.)

The importance of this installation will be appreciated from the bare statement that the ultimate generator capacity in these several stations will aggregate about 116,000 kilowatt, or about 155,000 horse power.

The Mount Whitney Power Company, California, supplies most of its power to irrigation plants. In the San Joaquin Valley, as elsewhere in the arid West, the area that is irrigated with water pumped from sub-surface sources is rapidly increasing. The pumping by the use of steam or gasoline is in many localities being superseded by the use of electric power. The Mount Whitney Power Company develops power at three stations in the Sierra Nevada on the headwaters of Kaweah River and another on Tule River, and the power there generated is carried westerly into the valley for use. The generator capacity on this hydro-electric system aggregates about 11,000 horse power and this will be doubled by contemplated additions.

The San Joaquin Light & Power Corporation, California, was the first to successfully transmit power by electricity a distance of thirty-six miles. The old plant of this corporation came into use in 1896. The hydro-electric power output of this plant is used from Bakersfield as far north as Snelling. The power generating stations are on the San Joaquin River and on the Kern River. The Kern River power station is located at the point where Kern River breaks from its granite gorge out into the San Joaquin Valley. This station is located about twelve miles easterly from Bakersfield.

The Great Western Power Company, California, has found its source of power in Feather River. This river in its descent from the higher mountains, at one point of its course, makes a great horseshoe bend. A dam at the upper end of the horseshoe and a tunnel through the narrow neck make a fall of about 430 feet available, which will at some time be increased by a higher dam to 535 feet. This fall has been utilized. The diverting and intake works and the power house are pointed out to travelers on the Western Pacific. In the power house there were originally installed four 10,000 kilowatt generators, to which further additions have recently been made.

Feather River has a large low-water flow, some 800 cubic feet per second, but even this can be increased as required out of storage, there having been constructed a large storage reservoir at Big Meadows on the North Fork of Feather River. The dam forming this reservoir is an earth dam with concrete core.

Other Hydro-Electric Developments in California.—Other notable hydro-electric developments in California are those on the southern streams which supply power to Los Angeles and vicinity, as also in the northern part of the State the Northern Electric Company and the Snow Mountain Power Company. Reference may be made, too, to the power development proposed for the Los Angeles water supply system. On the new city aqueduct, which has a length of 235 miles and a capacity of about 400 cubic feet per second (250,000,000 gallons per day) there are several points where the fall in the line is to be utilized for the generation of power. Some 80,000 horse power are to be thus ultimately made available.

Washington Water Power Company, Washington.—In the State of Washington at Spokane, easy of access, is a noteworthy hydro-electric plant. There are three developments in operation and another in course of construction. The Spokane River has a minimum or low-water flow of about 1500 cubic feet per second. This is considerably increased by controlling the outflow from Coeur d'Alene Lake above Spokane, in which Spokane River has its source. The controlling works are located about ten miles below the lake at Post Falls. Here the river separates into three channels, on the southerly of which is the power house. The four turbines installed at this point operate generators which have a combined capacity of 8800 kilowatts. At Little Falls, about thirty miles northwest of Spokane, the company has another power station at which the water wheels, also four in number, can develop a maximum of 44,000 horse power. In the same vicinity there is being added to the system the Long Lake development where the water power installation will reach 89,000 horse power.

The Portland Railway Light & Power Company, Oregon.—Electricity for light and power are supplied to Portland, Oregon, by the Portland Railway Light & Power Company. This company has five hydro-electric and five steam generating plants. These have a combined capacity of 76,980 kilowatts. The hydro-electric plants have a capacity of 53,230 kilowatts, and produce over 90 per cent of the power consumed. The oldest of the hydro-electric plants is located on the Willamette River, at Oregon City, where five units have been in service since 1894, seven since 1897, and two since 1903. The combined generating capacity of these fourteen machines is 7230 kilowatts. Another hydro-electric plant is at Cazadero, on the Clakamas River. The installation is here for 14,250 kilowatts. The River Mill plant is on the same river several miles farther down stream and is notable for the fact that the first hollow concrete dam of the Ambrusen type on the Pacific Coast was constructed here. The station capacity is 9900 kilowatts. A fourth hydro-electric plant is at Bull Run, about forty miles from Portland. The capacity of this station is 11,250 kilowatts of hydro-electric power.

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CHEMICAL RESOURCES AND INDUSTRIES

BY HARRY EAST MILLER
Consulting Chemist and Metallurgist, San Francisco

A DESCRIPTION of, and comment on, the chemical industries of any region should precede the enumeration of its chemical resources. The chemical resources are, of course, all important; but the climatic conditions, shipping and transportation facilities, cost of fuel, electric power and labor, all play a very important part, and if these are favorable for manufacturing, the raw material may be brought in from other sources. And then the capitalist or manufacturing chemist would surely want to know who was in the field before contemplating starting an industry. California has been especially blest by its natural advantages. It has a climate, shared to some extent by its sister states on the Pacific Coast, which permits operating a factory 365 days of each and every year. It produces an abundance of cheap fuel oil, crude petroleum, not only cheap as to initial cost, but effecting a great saving of labor in the firing of boilers, furnaces or kilns. It may be said that in all manufacturing plants fuel oil has replaced coal and that in virtually all office buildings and apartment houses, and even in some private residences, either the crude oil or heavy distillate is now being used for heating purposes. Fuel oil is also used in locomotives and steamships where the radius of travel does not take them away from a source of supply.

It would not be out of place to give here some statistics regarding the production of petroleum in California. In 1895 the amount first exceeded the million mark, namely, 1,245,339 barrels. In 1900 there was produced 4,329,950 barrels; in 1905, 34,275,701 barrels; in 1910, 77,697,568 barrels; in 1912, 89,689,250 barrels, and in 1913, 98,494,532 barrels, the output of the wells increasing every year. Again a number of large corporations are now operating extensive hydro-electric plants and power may often be advantageously purchased. Where steam is not required for drying or heating, a saving can often be effected by operating the machinery by a motor.

SULPHURIC ACID.—Sulphuric acid plays a very important part in a great many of the chemical industries. However, its production on this coast can not be taken as an index of the chemical activities, as a very large portion is used in the refining of petroleum. There are, at the present time, seven different companies with a total daily production equivalent to 400 tons of monohydrate or 100 per cent sulphuric acid. Large capital has been invested in its production and there can be no question as to the possibility of the shortage of this acid. Many large plants are burning pyrites and it is safe to say that from 90 per cent to 95 per cent of the acid produced is derived from this source. The pyrites are mined either in Shasta or Alameda County, and in 1913 there was shipped for the manufacturing of acid 79,000 tons. This amount will not account for the estimated production of acid from this source alone, but it must be borne in mind that both mines and smelters are now shipping pyritic ores and concentrates to be roasted by the acid works and that this source must be taken into consideration.

During the last few years the public has been paying considerable attention to smelter fumes, and the smelters are endeavoring to turn over all their roasting ores to the acid works which also increases the revenue of the smelter. On the other hand, the acid works are purchasing a cheaper sulphur, but the ores should not have too high values in gold, silver or copper contents, for the cinder or roasted ore must be returned and any loss paid for. The large plants are all operating the contact system and all three, the Schraeder-Grillo, Mannheim and the Badische, have been tried out around the Bay of San Francisco. Two separate Mannheim installations are still operating, and a third corporation has developed the Badische-Herreshof, which is said to be the best of them all. The high explosive works and oil refineries are now using almost anhydrous and fuming acids, respectively, and such acids can only be produced by the contact system, which is at present responsible for at least 90 per cent of all the sulphuric acid.

Practically the entire production of nitric acid is taken by the high explosive works, and on the recovery of the spent acid (the mixed acid which has been used for nitration) the nitric acid is recovered as a weak acid or as ammonium nitrate. The nitre cake, which remains in pot or retort after distilling the nitric acid, is thrown away and daily some seventy-five tons are disposed of in this manner. The nitre cake is almost a bisulphate of soda, having one free acid valance, and at one time a small quantity was used for producing muriatic acid by a very simple process of roasting this cake with the proper amount of common salt. The small oil refineries throw away the spent sulphuric acid. One large refinery is operating a recovery. Owing to the large amount of carbonaceous matter retained by the spent acid the yields are very poor unless the recovery is run in conjunction with a separate contact system unit. The carbon reduces the sulphuric acid to sulphurous acid gas and the recovery of an oil refinery must also comply with the acid fume regulations. The sulphuric acid industry has been developed to a high degree on this coast and presents but few unsolved problems. An economic use of the nitre cake should be sought.

PETROLEUM REFINING.—There is one very large plant and a number of smaller ones engaged in the production of the various grades of gasoline, kerosene, lubricating oils and paraffine and in the compounding of greases. The process of distillation is not as a rule carried on until the "cracking" of the oil, which then yields unsaturated compounds, and these are not desirable. By proper regulation of the distillation, the residuum may be made to yield several grades of an excellent asphaltum and a large trade has been worked up for this product. It is used in a number of roofing compounds, forms the basis of roofing paints and the better grades make printers' ink. It is brought on the market under various names, maltha being the first name by which it was known. Maltha has excellent acid and alkali resisting qualities. The California petroleums belong to the marsh gas or paraffine series; but it is interesting to note that from some localities petroleums have been obtained in which were found members of the benzol or aromatic series. Some of these members have been separated and characterized, the whole investigation being carried on solely as of scientific interest.

HIGH EXPLOSIVES.—There are, in this State, three plants manufacturing high explosives, two black powder mills, one cap or detonator factory and one fuse factory; these supply not only the demands of the Pacific states, but also some of the contiguous territory. These different works manufacture nitroglycerine, nitrocellulose both as collodion and gun cotton, nitrostarch, nitroglycol, nitromannite and at times fulminate of mercury. The Bureau of Mines, which is gradually regulating the explosives employed in coal mines, has created a Permissible List of explosives, and it is the endeavor of all the factories to have some of their products pass and be entered on this list. Dynamite or straight nitroglycerine explosives freeze at a temperature a number of degrees above the freezing point of water, and the high explosives factories are now vying with each other in producing "low freezing" high explosives. Great strides have been made in the manufacture of all explosives and a good deal of pioneering in this field has been done on this Coast. The explosives are now built on a much better balance, giving the minimum amount of fumes. They can not only be had in various grades or degrees of strength but also of various speeds or velocity of detonation for the same grade, filling all requirements.

CEMENT INDUSTRY.—California is the third State regarding its output of Portland cement and the productive plants are fairly well scattered all over the State, the locations depending more on transportation facilities than the source of raw materials. There is no dearth of lime or clay. For a number of years it was thought that certain constituents of the cement had to be held within very narrow bounds, for instance the magnesia content. There is a chemical ratio for the different ingredients which must not be lost sight of; but experience has shown that a greater latitude may be given to the magnesia content of the limestone and that a variety of alumina silicates may be used for the clay. The necessity of burning to a proper clinker has always been recognized, but it has been found that it is essential that the raw materials must be first ground to an impalpable powder, and of course also the finished product.

In some parts of the State the cement industry has been threatened with litigation on account of the cement dust nuisance. This nuisance has been abated, the flues lead to a chamber in which are hung a number of iron plates, electrodes. A silent, very high tension electric discharge rids the gases of all solid particles, the dust adheres to the cathode, which is cleaned by a simple device from time to time. The writer has used the following simple method of judging of the chemical activity of a cement which only requires a pair of letter scales and a few six or eight ounce oil sample cylindrical bottles. Weigh off one ounce of cement, put into a bottle and fill the bottle with water which will be in large excess. Shake from time to time and finally note increase in volume of cement.

LIME AND MAGNESIA.—There is an abundance of limestone on the Pacific Slope, and in California the country rock of one of the counties is almost entirely composed of limestone. This State produces all the lime it needs for home consumption and also much for exportation. About the only special comment needed on the industry here is that it first successfully introduced crude oil in firing the limekiln. Magnesite, in commercial quantities, is only found in California and this gives the State peculiar advantages over the rest of the Union regarding all magnesia products. There are a great many different deposits and it is unfortunate that some of the best are quite a distance from a railroad. For a number of years there has been considerable activity in magnesia cement products such as floorings, tiles, wash trays, etc., but it is only within the last year that a factory has been producing light magnesia carbonate which is almost indispensable for steam pipe covering where the highest degree of heat insulation is to be maintained. Light magnesia carbonate is being produced in the East from dolomite. This process is not only more complicated and expensive, but the disposal of the huge piles of dirty and impure lime has been a problem.

Manufacture of Gas.—The manufacture and consumption of gas has increased enormously of late years despite the inroads of electricity. Electricity is gradually replacing gas for lighting, but gas is more than keeping pace, making rapid strides with the introduction of heating and cooking appliances. The old coal bench, in the far West, has disappeared, and in turn the water gas is fast vanishing and being displaced by the oil gas. The whole industry has received its impetus from the petroleum production, and the development of the oil gas may be credited to California. Oil gas has an excellent illuminating power and it is interesting to note that the illuminants contain a small amount of acetylene. Ammoniacal liquor and tar are no longer a by-product of the gas works. A small amount of tar is produced, but this is not separated from the large quantities of lampblack and serves as a binding medium when briquetting the latter. The disposal of the lampblack became a problem until it was briquetted and sold for fuel and it has now become a source of profit to the gas company. During the early stages of the development of the oil gas, the gas companies had considerable trouble due to the filling up of service pipes and small mains with naphthalene. It was all a question of temperature, the runs had been made at too high a temperature and this nuisance was abated. What was once a nuisance may be turned into a source of profit, and some day the companies may modify the process so as to produce naphthalene as a by-product. Some petroleums are rather high in sulphur and a large amount of this sulphur finds its way into the resultant gas. A process has been devised but not generally introduced which relieves this situation, for a large proportion of the sulphur exists as organic compounds and is not removed by passing the gas through the purifying boxes. The gas is reheated, breaking up the organic compounds, and then again passed through the purifying boxes and all excess of sulphur is thus removed and this operation is accomplished with only a very slight loss in the illuminating power of the gas.

COMMON SALT, BORAX AND SODA.—Most of the salt is obtained by evaporation of sea water and by the plants situated around the Bay of San Francisco or at Long Beach and San Diego. The salt produced in this manner represents a large quantity of mother liquor or bittern and some day an economic use may be found for the same. The writer has seen a very small gold bead which was worked up from one of the bitterns from Alameda County and gives this fact merely as a chemical curiosity. The total production of salt in California for the year 1913 was 204,407 tons.

This State produces all the domestic borax in this country and at present obtains the same from colmanite ore deposits which are easily mined and treated. There appears to be no limit to the quantity of colmanite mineral and the three different companies which are mining and working the same are endeavoring to find new uses for borax and its products. The pure food law has been a blow to the industry. The production of borax for 1913 was 58,051 tons.

Soda is produced both in California and Nevada and the former State has 1861 tons to its credit for the year 1913. There are several companies working up the natural soda and imported soda which is brought in as soda ash, producing washing soda, for which there is still a demand, and bicarbonate nearly all of which is taken by the baking powder factories. Caustic soda is not manufactured on the Coast and what with the large quantities of salines and cheap electric current there should be a field for electrolytic caustic soda. A strong competitor to the present borax and soda industries has lately appeared in the field, namely a large corporation operating at Searles Lake. It is rumored that already over half a million dollars have been spent, and this does not include the cost of acquiring title or for the railroad which has been built. The products are obtained from the water of the lake and the process was worked out and demonstrated with an experimental plant having a capacity of 20,000 gallons per day. The working plant will consist of four units, each treating 500,000 gallons per day or with a total capacity of 2,000,000 gallons. One of these has already been constructed and the other three will be finished before the end of 1915. Based on yields of the experimental plant the yearly output of the entire plant when completed should be 90,000 tons of borax, 170,000 tons of muriate of potash and 185,000 tons of soda ash.

SULPHITE PULP.—The paper industry on this Coast consumes a large amount of bisulphite pulp and it has been estimated that 95,000 tons are being annually produced. The paper mills are in California, Oregon, Washington and British Columbia, the location depending on an almost unlimited water supply and proximity to a forest of conifers, the hemlock being preferred. A bisulphite of lime and magnesia is now being used for the liquor in the digester cooks and ground magnesite as a paper filler. The ground magnesite must be free from spicules of silica as they cut the fine wire screens on the paper machines. This industry, save for the aniline dyes and perhaps these fine wire screens, is entirely independent of all foreign supplies, obtaining all the raw materials from this Coast.

BEET SUGAR AND CANE SUGAR.—Before the new tariff went into effect California was producing from 100,000 tons to 120,000 tons of beet sugar annually. This production might still be kept up if the sugar factories would maintain the same chemical control as in Europe and prosecute the same intensive farming. In Europe from 15 to 16 tons of beets are grown per acre, while here the factories are satisfied with 8 tons per acre. Of the 550,000 tons of cane sugar produced by the Hawaiian Islands some 300,000 tons are refined in California.

FERTILIZERS.—Sugar plantations of the islands have always drawn on the fertilizer industry and now the orange and lemon groves, asparagus and other agricultural interests are making an ever increasing demand. It is a little over ten years since there has been a State fertilizer control. Manufacturers and dealers are compelled to furnish guaranties showing actual composition of all goods sold, and the consumer may verify the same by having an analysis made at the Agricultural Experiment Station at Berkeley, at a nominal cost. The phosphate rock on this Coast is too rich in limestone to be worked, and the southern States must be given credit for more than 99 per cent of the production of this entire country. There are a number of fertilizer works, some producing their own sulphuric acid. Most of the packing houses and abattoirs are putting bone meal, dried blood and tankage on the market. The bone and fertilizer works are at present the sole producers of sulphate of ammonia.

CARBONIC ACID.—The manufacturers of liquid carbonic acid gas have again commenced using magnesite rock. For a time the calcined magnesite could not be sold and the companies were forced to use limestone as there was a ready sale for the quick lime.

CREAM OF TARTAR AND TARTARIC ACID.—The California wine industry does not furnish sufficient lees and crude argols for the one factory producing cream of tartar and tartaric acid, and raw goods have to be imported. It may be said that the entire output of this factory is made into baking powder.

TREE SPRAYS, INSECTICIDES AND COPPER SULPHATE. —A number of different companies are manufacturing tree sprays, insecticides, deodorizers, sheep dip, etc. Some have small plants while others are a part of a large factory. One large establishment producing acid from pyrites contrives to save some of the arsenic and utilizes it in the manufacture of insecticides. A smelting works on the bay saves all its copper in the ores as bluestone or copper sulphate.

BARIUM PRODUCTS.—There are a number of deposits of barytes in California and the production for 1913 amounted to 1600 tons, this being principally used for, and as an adulterant of, white lead paint. One company is producing barium peroxide which in turn is used for producing hydrogen peroxide.

MINERAL RESOURCES.—A great many mineral resources are identical with the chemical resources of the locality. Mineral spring waters, and there are a great many in the State and some of decided medical value, if evaporated and the salts brought on the market would come under the latter class. In 1913 there were produced 2,350,792 gallons of mineral water, actually bottled and sold and the greater part for drinking purposes.

Metallurgy is the chemistry of those minerals or ores yielding metals; but when metals are won as metallic salts, that part of the industry may be claimed by the chemist. In 1913 there was produced in this State 7592 tons of tungsten ore; still a factory making incandescent electric light bulbs obtains its entire supply of tungsten filament from the East. All the chromite, 1180 tons mined in 1913, was shipped East. The old California prospector sought only gold, and then silver and copper and after that halted. The mineral riches of the far West are only just being uncovered and will lead eventually to all kinds of metallurgical and chemical activities.

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MOUNTAINEERING ON THE PACIFIC COAST

BY JOSEPH N. LE CONTE
Professor of Engineering Mechanics,
University of California

TRUE Alpine climbing may be found in America only among the great Cordilleran Ranges of the West. Of these ranges none surpass the Cascades of Washington and Oregon and the Sierra Nevada of California. These magnificent mountains have been little frequented as compared with the Swiss Alps. Hence the difficulties of penetrating their wilder portions are still great, though the facilities for travel are increasing yearly.

The Cascades consist of an extensive though rather low series of complex mountains roughly paralleling the coast of Washington and Oregon. Rising far above the general level are a number of high extinct volcanic cones of great interest to the mountaineer.

The most northerly group of peaks is that dominated by Mounts Baker and Shuksan. The former, a typical volcanic cone, 10,827 feet in height, has been ascended frequently of late by the Mazama and Mountaineer clubs. The usual route, by way of Bellingham, Washington, gives the easiest approach to the base, though the ascent from this side is rather difficult. If approached from Baker Station on the Great Northern, the ascent is easier. The mountain is a true snow peak, covered with glaciers to its very foot. About sixteen miles northeast of Baker rises Mount Shuksan (10,000 feet). Very difficult of approach, it has been ascended but once.

Next southward is the magnificent Mount Rainier, easily first among the mountains of the United States when height, bulk, and Alpine character are all considered. A perfect volcanic cone, 14,408 feet in height, it towers a clear 10,000 feet above all the surrounding country. It has the largest and most perfect glacier system of any of our mountains, the twelve or more great ice tongues radiating from the summit névé field being barely included within a circle twelve miles in diameter. Some 320 square miles about Mount Rainier constitute a National Park. The mountain is usually reached by the Tacoma and Eastern railway from Tacoma to Ashford, whence a good road leads easterly to Longmires' Springs hotel, within the park. The new Government road runs thence to Paradise Park

(5600 feet). Here there is a public camp. The usual route of ascent, by way of Gibraltar Rock, starts there. The ascent, long though not dangerous, is well worth while. A night is sometimes spent among the rocks at Camp Muir, though a good climber can make the entire trip in one day. (See Pl. XXVIII.)

Half way between Rainier and the Columbia River is Mount Adams (12,470 feet), also a volcanic cone. It may be reached by the White Salmon railway station on the north bank of the Columbia, and by stage to Guler or Glenwood, twelve or fifteen miles from the snow line. The actual ascent is made without difficulty by either the north or south slope.

West of Mount Adams stands the beautiful St. Helen's, a wonderfully symmetrical cone rising 10,000 feet above the sea and 8000 or 9000 feet above the surrounding country. This mountain is generally reached by way of Castle Rock station on the Northern Pacific, whence an excellent wagon road runs to Spirit Lake. Trails lead to the camp ground at the snow line.

The Olympic Range is a fine group on the peninsula between Puget Sound and the ocean. While not of great height—Mount Olympus being but 8250 feet—the snowfall is exceptionally heavy, and the glacier system very fine.

Crossing the Columbia southward, the highest and by far the finest peak in Oregon is Mount Hood—11,225 feet. It may be reached by automobile from Portland to Government Camp on the southwest side, or by rail to Hood River station and thence by stage to Cloud Cap Inn on the northeast side. The ascent from Government Camp is comparatively easy and is over smooth snow for the most part. The last 250 feet is extremely steep and may require step-cutting. The route by Cloud Cap Inn, over the Eliot Glacier, is shorter, but has a long stretch of very steep snow at the top. Mount Hood, more easily reached than any other volcanic cones of the Northwest, has been ascended hundreds of times.

Crossing the California boundary, the next important mountain is Shasta (14,162 feet), one of the highest and finest of the volcanic cones. It is the only mountain in California which boasts a real system of glaciers. In spring and early summer, clad with snow, it is the most imposing mountain in California. Rising from a rolling plateau, whose altitude averages 4000 feet, it lifts clear 10,000 feet above its base. Shasta is usually ascended from

Sisson, on the main line of the Southern Pacific. There guides, horses, and camp equipment can be obtained. The trail from Sisson runs easterly for eight miles through a deforested area, rising from 3550 feet at the railway station to about 8000 at Horse Camp, the extreme timber line. The night is usually spent there and the ascent of the mountain and return to Sisson made next day. The climb of 6200 feet is not dangerous, but very fatiguing, being all over snow or yielding volcanic material.

At Mount Lassen, an active volcano of the steam explosive type, 75 miles southeast of Shasta, the Sierra Nevada begins. (See Pls. I and VI.)

This magnificent Sierra extends along the eastern border of California as a single isolated mountain mass. For 385 miles the crest line—the hydrographic divide between the Pacific Ocean and Great Basin—is nearly straight, as also the lines, about eighty miles apart, which terminate its slopes upon the east and west. The range is one of the grandest known examples of the "Basin type" of formation. It is a single block of the earth's crust, upheaved along its eastern edge. Westward, a long, gradual rise covers nine-tenths of its entire area; eastward projects a precipitous front of imposing dimensions. Southward the crest line rises while the range becomes narrower, so that the most rugged portions are at the extreme south, about Lat. 36° 30′.

Space forbids even mentioning more than a very few of the abundant points of interest in this range.

From Mount Lassen to Lake Tahoe, the range is relatively low, and in most places the forest belt crosses the main crest. Though beautiful, it offers few attractions to the mountaineer.

Lake Tahoe is a famous and easily accessible resort just south of the main line of the Southern Pacific. Its northern end is reached by rail. Thence steamers ply. Several excellent automobile roads lead in from both the California and Nevada sides. The lake, 22 miles north and south by about 12 wide, lies between two parallel ridges of the Sierra. The main crest to the west contains several fine peaks, notably Mount Tallac (9785 feet), Pyramid Peak (10,020 feet), Rubicon Peak (9193 feet), Squaw Peak (8960 feet), Tinkers' Knob, and many others. On the eastern ridge are Job's Peak (10,600 feet), Freel's Peak (10,900 feet), and others lower to the north. Numerous hotels and taverns on and near the lake make the spot particularly attractive to the tourist or automobilist.

Passing southward, the next easily accessible point is Yosemite Valley, on the Merced River.

This famous spot, a starting point for exploration of the higher portions of the range, well deserves several days of climbing about its rim. To reach the head-waters of the Merced and Tuolumne rivers, which drain the summit peaks, saddle and pack horses must be hired, usually a packer too, and a regular camping trip undertaken, since, except for the Sierra Club camp in the Tuolumne Meadows, no public stopping places of any kind, nor even shelter huts, will be found. Horses and guides can sometimes be found in Yosemite Valley itself, or better at Sequoia post-office, 23 miles to the northwest, on the Big Oak Flat road, or at Wawona, 30 miles south.

Starting from Yosemite the usual route is by trail to the Tuolumne Meadows (8500 feet). Here a central camp can be made, and higher points in the vicinity visited. Directly east is Mount Dana (12,-990 feet), very easily climbed from the southwest. North of the meadow is Mount Conness (12,550 feet), commanding a splendid view over the northern portion of the Tuolumne watershed. By following the main Tuolumne River to its source, ten miles southward, Mount Lyell is reached. Its ascent is preferably made the day following. Mount Lyell (13,090 feet), the highest point on the Tuolumne watershed, is altogether the roughest and most interesting climb in this district. The ascent is directly across the small residual glacier on the northern face.

From the Tuolumne Meadows one can "knapsack" (but not take pack animals) down the cañon of the Tuolumne River 22 miles to Hetch Hetchy Valley. This rough scramble generally requires two or three days, so the mountaineer should go prepared. The cañon, one of the finest in the Sierra, in some places is over 5000 feet deep. Hetch Hetchy Valley, the "Yosemite" of the Tuolumne River, is well worth visiting. It can be easily reached by road and trail from Sequoia.

The most magnificent portion of the Sierra Nevada is south of the Yosemite in the wild region drained by the San Joaquin, Kings, Kern, and Kaweah rivers. This region is practically devoid of wagon roads, and the higher portions even of trails, so it can not be visited without a complete camping equipment, and generally a guide, or at least a packer familiar with the country. The only access is by mountain trails. The range here reaches its greatest elevation, and the river cañons cut to their greatest depths.

The first stream south of Yosemite is the San Joaquin River, which breaks through the foothills near Fresno. Near its source it divides into two great branches, the Middle and South Fork. The Middle Fork region is best visited by way of the Mammoth Trail, starting from Wawona, near Yosemite. The finest mountain group in the Yosemite region is on the watershed of the Middle Fork. This consists of Mount Ritter (13,156 feet) and Banner Peak. South of this splendid group the range drops off toward Mammoth Pass, but soon rises again toward Red Slate Peak (13,067 feet).

The great area drained by the South Fork of the San Joaquin is one of the least frequented portions of the range. Along the main crest for a distance of 30 miles there is no gap or pass lower than 11,400 feet, and the great peaks such as Mount Abbott (13,736 feet), Seven Gables (13,066 feet), Mount Humphreys (13,972 feet), Mount Darwin (13,841 feet), and Mount Goddard (13,555 feet), are the very finest summits the Sierra affords. The South Fork region is best reached by way of Fresno. An automobile to Shaver or Big Creek brings one to the beginning of the Mono and Red Mountain trails. It may also be reached by way of the Mono or Piute passes from the town of Bishop on the east. At least two weeks should be allowed for a trip into the San Joaquin Sierra.

Still southward is the Kings River Basin, the climax of the California High Sierra. This great stream is formed by the junction of a South and Middle Fork. The latter drains a wonderful region from the Goddard Divide to Mount Pinchot. Its basin contains such peaks as North Palisade (14,254 feet), Mount Sill (14,128 feet), Split Mountain (14,067 feet), Mount Pinchot (13,471 feet). The basin of the South Fork is almost as rugged as that of the Middle, particularly the southern portion, where a wonderful group of peaks at the head of Bubb's Creek is easily accessible and comparatively well known. The Kings River Basin is generally reached by way of Fresno from the west; the Middle Fork through Shaver and the Tehipitee Trail, and the South Fork by way of Hume and the Independence Trail. A regular automobile stage runs from Sanger, near Fresno, to Hume, where pack outfits can be obtained for the trip into Kings River Cañon. This latter is a good starting point or permanent camp for the South Fork region. Here also is located a public camp, as well as a small supply store. The Kings River Cañon is also reached from the town of Independence via the Kearsarge Pass.

The cañons of the Kings River Basin are among the finest in the Sierra. That of the Middle Fork contains Tehipitee Valley, with its great dome rising 3700 feet above the river, while below Tehipitee the cañon is 7000 feet deep. The South Fork Cañon, or Kings River Cañon, is of the Yosemite type, though by no means so fine. It averages 3000 feet in depth, has a fine level forested floor, but lacks the splendid waterfalls and meadows of the Yosemite.

The basin of the Kern contains the highest peak in the United States, Mount Whitney (14,501 feet). Mount Williamson (14,384 feet), Mount Tyndall (14,025 feet), Mount Langley (14,042 feet), Kaweah Peak (13,816 feet), and a host of other high points fringe the rim. The basin is reached either by way of Visalia, Three Rivers, and Mineral King on the west, or by Lone Pine and the Hockett Trail on the east.

The mountaineer who wishes to visit these glorious mountains and who is unfamiliar with routes and topography should consult the Mountaineers' Club of Seattle (522 Pioneer building), the Mazama Club of Portland (Chamber of Commerce building, or the Sierra Club of San Francisco (402 Mills building). The excellent contour maps of the United States Geological Survey will be of the greatest possible assistance.

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OUTDOOR LIFE AND THE FINE ARTS

BY JOHN GALEN HOWARD
Director, School of Architecture, University of California

PEOPLE have been busy so long making shelter for themselves that houses of one sort or another have come to seem a necessary condition of life. Doubtless they are. But Californians believe that a good many things can be done just as well or better out of doors. In this favored region everything contributes to make outdoor life not only readily possible but enchantingly agreeable, and those who live here manage to spend a large portion of their time in the open air. All existence is affected by this. You admire the brilliant complexion of the women; they have their fresh-air life to thank for it. You honor the breezy down-rightness of the men; it comes from camp and ranch and mountain forest. You wonder at the proportion of talent in writing and in other arts which California has sent out to fame and fortune; it is the natural result of plenty of room. It seems hardly too much to say that a new type of civilization is being developed on this coast, one which is built up out of much the same cosmopolitan elements as the rest of the country, but under conditions of rare isolation and freedom, new as compared with the earlier American life, along the eastern seaboard, new in contrast with later European history, but strangely like the old Greek life, in its isolation, its place over against the Orient and in touch therewith, its study of problems on its own account and without precedent. But, most of all, this life resembles Hellas in its combination of open-air existence with fresh intensity of feeling. Californians are not jaded. The world is new and keen for them. And whencesoever it may come, the art impulse, the impulse to express emotion, is supreme.

Everywhere up and down the State, and in only a less degree northward to Puget Sound and beyond, the people are extraordinarily fond of celebrations. These are not considered religious rites, naturally, as the festivals of the Greeks mostly were; but they arouse and satisfy the spirit of the people in much the same way, and perhaps they arise from not unlike psychological causes. Joy of existence, impulse for expression, freedom from the trammels of precedent—these are classical conditions. And similar conditions, even though operating on an unlike people, are bringing about results which in certain respects remind one of Greek achievement. It is of course easy to carry the analogy too far. Californians themselves would be the first to protest against any attempt to set them up, or their art, as Greek. Yet they have aspirations that way.

The dry season, when fine weather is to be counted on, is the time for long outings. The genuine Californian returns as near to a state of nature as he may. He finds it good to feel the hard earth under his bones at night and to gaze upon the wheeling stars. Even at home he may sleep in the yard by preference; or, if the yard is too exposed, he will have a sleeping porch. Old houses fairly sprout with these excrescences, and no new country house seems quite fit without enough such provision for every member of the family.

It is in these and like features that the fresh air cult has made its mark on California architecture most ubiquitously. But here and there motive has been given to more monumental expression, as in the open-air theater, of which there are now several examples, at Berkeley, Bakersfield, Pomona College and elsewhere. The largest and earliest of them all is the Greek Theater, at Berkeley. The history of this building recalls the development of the ancient theaters. It consisted of the regularization and treatment with permanent masonry, of a hollow in the hills which had become in its natural state a traditional place for holding dramatic performances. The students of the University of California had been accustomed every year to give the "Senior Extravaganza" in what was known as "Ben Weed's Amphitheater," a nook in the woods named after the man who discovered its fitness for the purpose. Miss Jessica Peixotto, now Professor of Social Economics in the University of California, Gelett Burgess, the unquenchable contributor to the joy of nations, and the late Frank Norris, the famous novelist, were among the rare group of enthusiasts who participated in the first performance on the site, in 1894. An altar for that production, which was based on the German Vehmegerichte, was the stump of a great eucalyptus tree which was cut down for the purpose. This stump became the center of the orchestra when, nearly ten years later, President Wheeler, soon after he came to the University, saw the possibilities of the site and urged the importance of developing it. Funds were provided for the construction through the munificence of Mr. William Randolph Hearst.

The first ceremony held within the still unfinished building was on Commencement Day, May 14th, 1903, when the address was made by President Roosevelt. The theater was finished and dedicated on September 24th, the same year, with a student performance, in Greek, of "The Birds" of Aristophanes. Since that time the "Eumenides" of Aeschylus, and the "Ajax" and "Oedipus Tyrannus" of Sophocles, have been produced by the students; the first two in Greek, the last in English. A magnificent performance of the "Antigone" of Sophocles was given in English by Margaret Anglin and her company of players, who later produced the "Electra" of Sophocles, with equal success. The Greek Theater has also twice witnessed superb productions in French, of Racine's Greek play "Phèdre," with Sarah Bernhardt in the title role. Among other noteworthy events here have been the appearance of Mr. Crane in "She Stoops to Conquer;" Miss Nance O'Neill in "Ingomar;" Miss Crawley in "Midsummer Night's Dream;" Mr. Ben Greet in "Hamlet;" Miss Maud Adams in "L'Aiglon" and "As You Like It;" and Mr. E. H. Sothern and Miss Julia Marlowe in "Macbeth."

The above have, of course, been professional productions, and of the highest order. But the amateur work in the Greek Theater has been hardly less important. The English Club of the University has since 1906 given two performances a year; among them: Shakespeare's "Merry Wives of Windsor," "Winter's Tale," "King Henry Fifth," "Twelfth Night," and "Much Ado About Nothing;" "The Little Clay Cart," an ancient Hindu drama by King Shadruka; "Abraham and Isaac," "Thersytes," and the "Hue and Cry After Cupid," three Old English plays, the last by Ben Jonson; Dr. Van Dyke's "House of Rimmon;" "The Shoemaker's Holiday," by Dekker; "Nero," and "Paolo and Francesca" by Stephen Phillips; Shaw's "Caesar and Cleopatra;" Schiller's "Mary Stuart," in English; Ibsen's "Vikings of Helgoland;" Sudermann's "Teja;" and Yeats' "Countess Cathleen." These productions have been brought out under the eye of Mr. Garnet Holme, as "coach," and owe much of their success to his good counsels. To this great body of dramatic work of the first rank should be added, to give a fair idea of the significance of the Greek Theater, the long line of orchestral, choral, vocal and instrumental concerts, which have made it an ever richer place of pilgrimage.

The Greek Theater did not mark the *beginning* of such performances, but it established the tradition, and gave it dignity. Its influence on the development of drama and pageantry through the State is very great. California, fertile, humanly speaking, for celebrations, only needs such a lofty and stable standard as the Greek Theater has long maintained under the wise chairmanship of Professor William Dallam Armes, to raise the festivals of the State to a higher and higher level. The University and State owe Professor Armes a great debt of gratitude and recognition for his untiring efforts to keep this work on the loftiest possible plane.

Nearly every county in the State, and many a town, holds an annual fair for the display of its products of field or range, and at not a few of them there are features which come fairly within the limits of the fine arts, such as music, drama, pageantry and the dance. Not all of these affairs are of a high order of merit; strangers must not be shocked or disappointed if they find some of them poor or commonplace. They are, however, at least sincere strivings toward adequate expression on the part of a people young and inexperienced in art, to be sure, but who must do and say something to give vent to their feelings; and here and there, when conditions are favorable, these local fêtes flower into charming naive affairs, great in promise if not in performance. It is from this rich soil of joyous revel that the better art, in favored spots, will grow.

Many places make the harvest the motive of a festival. Thus Bishop, Elmhurst, Healdsburg, Santa Rosa and others celebrate autumnal rites. Vacaville has its Fruit Carnival; Cloverdale, Oroville, San Bernardino, have Orange Fairs; Concord waxes festive over its walnuts, Escondido and St. Helena celebrate their grapes, Fresno its raisins, San Leandro its cherries, Sebastopol and Watsonville their apples, while Ukiah makes merry over its hops. Festivals of Spring and flowers are held at Haywards, Holtville, Los Baños, Santa Cruz and Santa Rosa; Pasadena, Redlands and Portland glory in their Tournaments of Roses, and Los Angeles in its Fiesta de las Flores. San Jose and Saratoga dedicate several days to the enjoyment of their magnificent show of fruit blossoms, when the Santa Clara Valley is snowy white with bloom; and later in the Spring San Jose gives a Poppy Carnival. Water Carnivals are held at Crescent City, Monte Rio, Oakland, and Victoria, British Columbia. Truckee, high in the Sierras, enjoys an Ice Carnival, for California is not to be outdone even in winter sports. Salinas holds an interesting Rodeo; Pendleton, Oregon, a Wild West Show. And so on—every little community has its fling.

On a higher plane artistically are the Historical Pageants of Carmel Mission, at Carmel-by-the-Sea, that of the Southwest at Los Angeles, and that of Fra Junípero Serra at Monterey. The religious or Mission plays, too, at San Gabriel, San Jose and Santa Clara are events of genuine artistic importance. Oakland is planning a Pageant of the Landing of Columbus for October, 1915, which should be well worth seeing. The Cabrillo Celebration at San Diego, the Aztec Sun-Fête at Phoenix, Arizona, the Montamara Fiesta at Tacoma, the Golden Potlatch at Seattle, the Lantern Festival at Pacific Grove, and the Portolá Festival at San Francisco are variously interesting and distinctive. The last named celebration takes place every four years and is becoming more spectacular and popular at each recurrence.

Not a little of the freer opportunity for art to develop in the open comes from the growing custom of "tramping" and "camping." There are many clubs, large and small, whose chief interest is in social excursions afoot. Perhaps the most important are the Mazamas of Portland and the Sierra Club of San Francisco, both of them mountain-climbing clubs with summer outings of a month or more in the Sierra, whose activities include many day or week-end walks as well. The "camp fires" of these organizations in the wild are famous for song and story, bringing out much artistic talent among the membership.

No visitor can gain a full insight into Pacific Coast life who has not seen a typical summer camp. Reference is made not so much to the tent hotels, like those which are established in the Yosemite and elsewhere, as to the private or club camps which abound everywhere, from San Diego to Seattle. In these establishments there may be tents or shacks, for the more fastidious and old-fashioned to live or sleep in, but not a few sleep absolutely in the open, screened from profane eyes by canvas or boughs, but roofed only by the sky. These camps are often veritable fairy-lands, with dancing Japanese lanterns, and gay canvas. In the midst the camp-fire offers cheer and welcome warmth, for the evenings and early mornings are often cool, even during the hottest spells of dry day-heat. The camp-fire, here again, is the scene of many an evening of delightful entertainment.

There are numerous clubs which have made the summer camp a special feature of their life. The greatest function of this sort, and one which is a veritable "date" for the whole local community, is that of the Bohemian Club in its grove at Bohemia near

Guerneville, in Sonoma County. This "grove" is a redwood forest of two hundred and eighty acres on the Russian River and running back something more than a mile of level valley floor between steep hills. The heart of the grove is one of the finest of the few remaining stands of virgin redwood timber. It is open throughout the year for club members, but the annual "Encampment" proper is for two weeks previous to the Saturday night nearest the full of the moon nearest the first of August. On that night the "High Jinks" takes place. Since 1878 these celebrations have been held annually in the open air, and from comparatively simple and informal entertainments have gradually developed into dramatic and musical productions of a very high order. In 1902 the Jinks assumed for the first time the character of an organic poetic drama, in the hands of three of the members of the club who have most contributed to the evolution of the tradition; the play was written by Charles K. Field, the music was composed by Joseph D. Redding, who was also musical director, and the Sire was Richard M. Hotaling. The play is presented on an exquisitely lovely sylvan hillside "stage," which lends itself with singular charm and impressiveness to such productions. The attendance has been keeping pace, in point of numbers, with the increasing beauty of the performance; last year (1914) the Jinks was witnessed by some eight hundred members and guests of the club.

It is impossible to speak too highly of the artistic character of these Grove Plays. Written, composed and performed entirely by members of the club they stimulate to vigorous activity and give an opportunity for expression to the best gifts of a large group of artists in various lines, such as few organizations afford. An occasion for the emergence of talent is offered by the frequent informal camp-fire entertainments, at which singing and instrumental music, poetry, story-telling, recitations, etc., play a prominent part. Some of these "camp-fires" have shown a tendency of late years to assume a special character of their own, in the same way as the High Jinks, but with different color. Thus the Friday night preceding the Jinks has established itself as a definite type; lighter and less unified, but scarcely less lofty in tone than the Jinks themselves. Similarly the impressive ceremony of the "Burial of Care," originally an epilogue to the High Jinks, has set up for itself as a separate evening, being now given usually on the Saturday night a week before the play, appropriately ushering in the period of abandon, instead of terminating it. Thus are the traditions of the club established, little by little, the fitting and significant form and time being found for each element of the great revel.

Not the least enjoyable and satisfying feature of the Bohemian Encampment is the orchestral concert which is always given in the grove on the Sunday morning following the play. Classic pieces are interspersed with compositions by musician members of the club. Notably successful selections from former Jinks music are repeated thus from time to time under the baton of the respective composers. In this way a choice repertory of Bohemian music has been built up and a body of tradition established which serves as a point of departure for future work.

While there are naturally ups and downs in the quality of the Jinks from year to year, the standard of the performances is always high and the tendency constantly upward. The blend of professional and amateur talent is productive of extraordinarily good results. The character of the club membership is largely artistic, using that term in its widest sense. Professional musicians, writers, actors, painters, sculptors, and architects form the nucleus round whom are grouped an equally enthusiastic throng of men whose central interest in life is supposed to be business or a learned profession, but whose artistic sympathies and talents render them not less effective as true Bohemians than the artists par excellence. The influence of the club has perhaps done more than any other single thing to preserve and develop the artistic festival spirit that is inherent in California life. And while the club's activities are year-long, and are not confined to its open-air celebrations, yet these latter, and most of all the Jinks itself, are the culmination of all its entertainments; so much so, that it seems almost distinctively to be an open-air organization. Those who desire a more extended knowledge of these most important activities are referred to Mr. Porter Garnett's excellent illustrated treatise on "The Bohemian Jinks."

The Family Club, a somewhat similar organization on a smaller scale, is a direct descendant of the Bohemian Club. The Family owns a tract of fifty-five acres among the redwoods near Woodside, where in addition to various sports, it enjoys each year, usually in September, a "Farm Play" as it is called, written and orchestrated by club members. The Nile Club of Oakland, too, claims kinship. Its yearly symbolic plays and pageants, Egyptian in motive, are presented among the redwoods of Santa

Cruz. Other clubs, too numerous to mention specifically here, devote themselves to similar affairs.

Important and significant as is the work of the organizations mentioned above, they are of a private or semi-private nature, and their fêtes are open solely to club members, and those holding guest-cards. The enjoyment of this sort of thing, however, is by no means limited to so small a public. Of late years two important movements have manifested themselves toward public open-air performances of a like character—"The Forest Theater" at Carmel-by-the-Sea, and "The Mountain Play" on Mount Tamalpais.

The idea of the Forest Theater was conceived by Mr. Herbert Heron, and developed by Mr. Perry Newberry. The first play presented was "David" by Constance Skinner, followed a year later by Shakespeare's "Twelfth Night." Since that time the following plays have been produced: "The Toad" by Mrs. Perry Newberry, "Runnymede" by William Greer Harrison, "The Sons of Spain" by Sidney Coe Howard, and "Fire," and "The Arrow Maker" by Mary Austin. These Forest Theater plays have been under the direction of Mr. Garnet Holme. Last year "Montezuma," a poetic drama by Herbert Heron, was produced by Mr. Porter Garnett. An amusing series of children's plays has also been given here,—"Alice in Wonderland," "Aladdin," and "Shockheaded Peter." All these plays are numerously attended and have aroused wide interest.

The Mountain Play has been given twice, in May, in a natural theater high on the flank of Mount Tamalpais. The founder of these plays was Mr. John Catlin. Last year "Shakuntala," an ancient Sanskrit play by Kalidasa, charmingly translated by Professor A. W. Ryder, was presented with great splendor. The year before "Abraham and Isaac" and scenes from "Twelfth Night" were given under the management of Mr. Garnet Holme assisted by the late Austin Ramon Pohli, being repeated here after an initial performance in the Greek Theater at Berkeley. This year the play will be "Rip Van Winkle." It is hoped that these presentations will be continued in the future. The site is one of extreme beauty, commanding magnificent views over the wooded hills and valleys to the Pacific, the Bay, and San Francisco, and lending itself readily to the accommodation of the several thousand spectators who on these occasions quite people the mountain.

Several of the colleges and universities up and down the coast bring out *al fresco* plays or pageants, usually about Commencement time. Thus Pomona

College celebrated its twenty-fifth anniversary last year by the presentation of a fine historical pageant. Among the most notable regularly recurring events of this kind are the May-Day Fête and the College Play given at Mills College in the spring and autumn respectively. Since 1908 the students have given Lyly's "Alexander and Campaspe," Tennyson's "Foresters," Yeats' "Countess Cathleen," Shaw's "Dark Lady of the Sonnets," Rostand's "Romancers," Shakespeare's "Love's Labor Lost," and Jonson's "Sad Shepherd;" a list of exceptional breadth and interest. In the May-Day Fête great attention is given to expressional dancing in the Greek spirit, with allegorical interpretation. Appreciative mention must be made, as well, of the very noteworthy Pageant of May, produced in 1913 at Walla Walla, Washington, by Mr. Porter Garnett.

But the most important and unique artistic event of the sort in this part of the world is undoubtedly the "Partheneia" at the University of California,—most important at any rate among those to which the public may gain admittance, and in its own way ranking with the Bohemian Jinks, exclusively reserved as that function is to the favored few. The Partheneia, the Maiden Rite, as its name signifies, was originated in 1912 by Miss Lucy Sprague, then Dean of Women in the University, now Mrs. Wesley Clair Mitchell, of New York. It may be described as a Pageant Masque, and is given annually by the women students of the University in a beautiful oak-grown glade within the campus. An original composition is used each year, selected by a special jury from schemes submitted in competition by any of the women students who desire to do so. The title of the first performance has been perpetuated as the general name of the celebration, in recognition of its special fitness and beauty. "The Partheneia, a Masque of Maidenhood," was written by Miss Anna Rearden; it was accompanied by music appropriate to the theme by McDowell, and presented on April 6th, 1912. It portrayed symbolically in poetry, music, pageantry and the dance the blossoming of the girl into the woman. This theme has become established as the motive of all succeeding productions. On April 12th, 1913, Miss Evelyn Agnes Steel presented "The Awakening of Everymaid," with music by Edward Stricklen, and on April 14th, 1914, Miss Helen Marion Cornelius gave "The Dream of Derdra, a Celtic Masque," with music by Miss Ruth Cornell. The Partheneia for 1915, on April 9th, is "The Queen's Masque," by Miss Mary Van Orden, with music by Professor Charles Louis Seeger, Jr.

Nothing could well exceed the charm of these "games." The loveliness of the young women themselves, hundreds in number—the beauty, brilliancy and fitness of the costumes—the sweetness of the music—the grace and dignity of the interpretative dancing and pageantry, combine with the sylvan beauty of the scene to make up an experience rare indeed. All of the special artistic aptitudes and opportunities of California life seem here to reach their finest expression.

The Bohemians have created a genre by the exclusive participation of men, such as could hardly have come about if women had been concerned. The University has created a genre exclusively for women. For the perfect result these two phases of the poetic drama must sooner or later be united in a symmetrical form to which men and women will contribute equally, and in which all the arts will be blended and combined into a rounded whole. Meantime these two great organizations are preparing the way, by working each in its own province and training an ever increasing number of devoted neophytes. The augury for the future is bright indeed, and it must not be forgotten that this flower of artistic promise, and already indeed of artistic achievement, springs and necessarily draws its nourishment from the countless celebrations which have a kindred purpose, even when they are crude and misdirected. Ignore the poorer manifestations and you lose the clue to the significance and true greatness of the most successful ones. They are all genuine social expressions.

Note.—Strangers who wish to obtain further information may do so by applying to the California Celebrations Committee, 590 Pacific Electric Building, Los Angeles. Following is a partial list of celebrations endorsed by this committee:

JANUARY

Tournament of Roses	Pasadena, Jan. 1.
Mission Play	San Gabriel, entire month
Polo Games	Coronado, 1st week in month
Opening of a series of fiestas and celebrations to be given by the City of Los Angeles and covering every month, 1915	Los Angeles

FEBRUARY

Citrus Fair	Cloverdale, date unset
Orange Show	San Bernardino, Feb. 17-24

MARCH

Mission Play	San Gabriel, entire month, cont. throughout year
Annual Blossom Festival	Saratoga, March 17-29
California Orange Day	Entire State, March 21
State Poppy Day	San Diego, March 30
State Poppy Day	San Francisco, March 30

Outdoor Life and the Fine Arts

APRIL

Poppy Carnival	San Jose, April 1-2-3
Orange Fair	Riverside, April 13-17
Raisin Festival	Fresno, April 30
Spring Flower Show	Redlands, April 8-9
Historical Pageant	Redlands, April 10-11
Celebration 40th Anniversary of Navel Orange Industry	Riverside, April 13-17
Homecoming Week	Bakersfield, middle of April
California Raisin Day	Entire State, April 30

MAY

May Day Celebration	Los Baños, May 1
Rice Festival	Oroville, 1st week in month
Rose Festival	Santa Rosa, date unset
Spring Festival	Berkeley, date unset
Kings Kounty Karnival	Hanford, May 20-21-22
Mountain Forest Play	Mount Tamalpais, May 27
Redwood City Flower Festival and Carnival	Redwood City, May 8

JUNE

Cherry Festival	Santa Clara, June 2-6
Water Pageant	Santa Cruz, June 22-27

JULY

Historical Pageant, Forest Theater	Carmel-by-the-Sea, July 2-3-4
Lantern Festival	Pacific Grove, July 25
Fiesta de las Flores in connection with Elks' Grand Lodge	Los Angeles, July 12-16
Russian River Water Carnival	Healdsburg, date unset
Big Week and California Rodeo	Salinas, July 28 to Aug. 2
Meeting State Music Teachers' Association and Water Carnival	Oakland, 2nd week in month

AUGUST

Gravenstein Apple Show	Sebastopol, Aug. 18-24
Historical Pageant and landing of Junípero Serra, Pilgrimage to the Tomb of Serra	Monterey, Aug. 28-31

SEPTEMBER

Harvest Festival	Santa Rosa
Vintage Festival	St. Helena, Sept. 6-7-8-9
State Fair	Sacramento, Sept. 12-19
Poultry Show	Petaluma
Cabrillo Celebration	San Diego, Sept. 26-27
Grape Day Festival	Escondido
San Miguel Day	Ventura, Sept. 29
Annual Fair	Pleasanton, Sept. 21-26
Ventura County Fair	Ventura, Sept. 28-30

OCTOBER

Riverside County Fair	Riverside, Oct. 12-16
California Apple Show	San Francisco, Oct. 1-11
Owens Valley Harvest Festival	Bishop, Oct. 2-3-4
Kings County Fair	Hanford, Oct. 6-11
Landing of Columbus	Oakland, Oct. 12
Portola Festival	San Francisco, Oct. 22-25
California Apple Day	Entire State, Oct. 3
Flower Show	Redlands, Oct. 29-30

NOVEMBER

Imperial County Fair	El Centro, 2nd week in month
Yucaipa Apple Show	Yucaipa, Nov. 1-2

DECEMBER

Olive and Orange Exposition	Oroville, 1st week in month

PLATE XXVIII
Mount Rainier, Washington, From Paradise Park. Elevation of Mount Rainier, 14,408 Feet.
Photograph by Joseph N. LeConte.

PLATE XXIX

The Stevenson Monument, Portsmouth Square, San Francisco. Bruce Porter Designed the Little Ship, and Willis Polk the Pedestal.

Photograph by Gabriel Moulin.

LITERARY LANDMARKS ON THE PACIFIC COAST

BY S. S. SEWARD, JR.
Assistant Professor of English,
Stanford University

When we prosaically count the years, the space of California's literary history is absurdly short. But when we set foot on a literary pilgrimage, the earlier scenes we would recall seem to retire to a surprisingly remote distance. A few years, and a swarming mining camp is deserted; but its empty houses and abandoned diggings seem older than the scarred hills themselves. American occupation soon sweeps away the hacienda life of Spanish days; but the memory, after that brief time, gropes back as if to an almost legendary past. And when a whole city burns—.

Perhaps the most distinctive of California's literary traditions are linked with the section that we think of as the Bret Harte country. It lies along the slopes of the Sierra sixty miles or so south of the railroad route across the mountains, and is penetrated by a branch line that runs up the valley. Hither Bret Harte came, about the middle fifties, to Sonora, the county seat, and then to the hamlet at Tuttletown, where he is said to have taught in the little country school. But it was the whole district that he knew,—not only the mining camps that straggled up the valley of the Stanislaus, but those that lay in the cañons farther north,—a half-open country of oaks and cedars and magnificent sugar pines, with roads scratched roughly in the red soil. The names of the camps in Bret Harte's stories are those that he found: Poverty Hill, Whisky Diggings, Rough and Ready, Red Dog, Poker Flat, Gouge-eye, and so on; but he owned no obligation to geographical accuracy. Some of the names remain, and the region still shows the scars from the primitive placer mining that a later law has abolished. But Jimtown has now become respectable as Jamestown, and the important mines today are the deep shafts that penetrate the hills about Angels. We have cause to remember one of the men for whom Jimtown was named, for it was Jim Gillis, "Truthful James of Table Mountain," who, tradition has it, first told Bret Harte the story of the Heathen Chinee, and from whom Mark Twain, during a later visit, heard the diverting episode of the Jumping Frog.

But it was not in the mountains that these tales of mining life were written. It was after some years of knocking about northern California, especially about Eureka, that Bret Harte drifted back to San Francisco, and as compositor, then contributor, for the *Golden Era* brought out M'liss and some of the Condensed Novels. During this time Mark Twain came to the city from Nevada, and while reporter for the *Call* contributed to the *Era* and met Bret Harte. The two men became interested in starting the *Weekly Californian,* which appeared in 1864 and held the center of the stage for over three years. When the *Overland Monthly* was founded, in 1868, Bret Harte was the editor, and it was in an early number of this magazine that he shocked California, and delighted Boston, by bringing out The Luck of Roaring Camp.

It is impossible, of course, in the newly built city of San Francisco, to find physical traces of this pioneer literary life, but the city has its magazines still, whose names recall this interesting past. The *Argonaut* carries one back to the vigorous traditions of Pixley and Harte; and with the *Wave* we connect the brilliant work of Ambrose Bierce and the stories with which Frank Norris began his literary career. And even if the *Lark's* career was a brief thing of months, has not the Purple Cow made that joyous little sheet the sharer of its own immortality?

Then there is Stevenson. That is truly a loss, that we cannot now visit the haunts of his brief visit in the city. But instead, San Francisco expresses its affectionate loyalty in the annual commemorative dinners of the Stevenson Fellowship, and keeps fresh whatever memory it has of the crude, quaint city Stevenson knew. Very different from the Bush Street of today was the little street in which he lodged at number 608, with a quiet, cheap restaurant conveniently by. And if we go south of Market street in search of the Rincon Hill that he used to explore—the Rincon Hill of aristocratic traditions, the scene that Gertrude Atherton used later, from her own girlhood memory, as the setting for The Californians—we find today not even a hill, only a dreary district of warehouses. Stevenson's description of it is in The Wrecker; that "place of precarious, sandy cliffs, deep, sandy cuttings, solitary ancient houses, and the butt-ends of streets." There it was that he used to search out Charles Warren Stoddard's little house for friendly chat, and where first he was roused to longing for the South Seas.

But Portsmouth Square, another haunt of Stevenson's, we have still and will always have; and with it the first monument ever erected to him, and perhaps the most beautiful. In the center of that dingy little park, oddly set between Chinatown and the old courthouse and jail, a place that seems provided for the down and outers to drift to and rest in, the swelling sails of a little Spanish galleon take the breeze in search of brave adventure, and on a pedestal are graved the words of Stevenson's well-known message of kindliness and fortitude. (See Pl. XXIX.)

We can follow Stevenson, too, to Monterey, where he came on first reaching California to be near his future wife, and though the town is somewhat changed, Simoneau dead, and the little restaurant gone where he used proudly to display his autograph set of his patron's works, the Stevenson home is still pointed out; and, what is best, the old adobe Custom House still stands at the point, exactly as Dana found it in his Pacific voyaging before the American occupation. The woods are there, too, where we can wander in hearing of the beating surf. But it would not do to set fire to one of the forest redwoods!

A Stevenson pilgrimage would take us also north of San Francisco to Calistoga, near St. Helena, whither he went in May, 1880, to spend the first months of his married life. A little shack,—"three rooms plastered against the hill," in a "deserted mining camp eight miles up the mountain," now reduced to a few boards marked by a memorial tablet,—was the house that later he described under the title of The Silverado Squatters. And one does not know California until he knows at first hand the effects of hill and fog so vividly described in those sketches.

Here and there through central California are other places that we connect with well known or well remembered names. On the crest of the hills overlooking Oakland, Joaquin Miller built the characteristic home in which he lived his later years. And it was in Oakland that Edwin Markham presided over his influential little school; here also that Edward Rowland Sill served in the high school, before he took the chair of English literature in the State University. Beyond the upper stretches of the bay is Martinez, where John Muir lived on his farm; though it is the whole Sierra range, particularly the region about Yosemite, that we think of as more truly his home. Jack London has a residence at Glen Ellen, some miles north of San Francisco; while on the coast, a few miles below Monterey, is Carmel, where in recent years has gathered a little colony of writers including in its number George Sterling and Mary Austin.

The literature of southern California has its own individuality, through having interpreted the distinctive features of that unique locality. It was from her earlier home in the Inyo desert that Mary Austin wrote The Land of Little Rain, and it has been through a long residence in and about Los Angeles that Charles F. Lummis has made himself an authority on the Indians of the Southwest. But it is chiefly through Ramona that the early days in southern California are remembered. Fortunately there are some places remaining that not only are connected definitely with the story itself, but, more than that, carry into our own times some of the flavor of the old life of which the story tells. Camulos lies in a fertile valley, through which a branch railway line penetrates the mountains back of Ventura. It was to this rambling adobe *casa,* true to the old Spanish type, with its courtyard and bells hung in their frame, that Helen Hunt Jackson paid a brief visit in 1884, when eagerly planning her novel; and though legend has gone far beyond the truth in ascribing historical actuality to the characters of the story, the description of Ramona's home was written from the accurately recorded memory of this old rancheria. Throughout the southern country are ancient Indian villages that have furnished yet other scenes for the story; and San Diego points to the old Estudillo estate in Old Town, as the place of Ramona's marriage.

Very slight at best are the remains that carry down to us the memory of California's colorful youth; but what we have we cherish. For although our coast may, and probably will, later develop new aspects of literary interest, never again will it be isolated. And that is much the same as saying that it will never again be unique.

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LEGAL AND POLITICAL DEVELOPMENT OF THE PACIFIC COAST STATES

BY ORRIN K. MCMURRAY
Professor of Law, University of California

THE legal and political conditions of a State are to a large though undefined extent the product of a multitude of social and economic forces. These forces are themselves, in turn, the result of the operation of others, often purely physical, such as climate, geographical location, geological structure and the like. It is a fascinating task to attempt to trace a particular institution to the social conditions which called it into being, and from thence to the natural forces which determined these social conditions. But by reason of the complexity of the problem, because of the ever present personal element, which eludes classification, it is a task fraught with the danger of rash generalization.

It is believed that the legal history of the Pacific Coast States, and particularly that of California, affords excellent material for the study of the influence of natural conditions upon legal and political institutions. Take, for illustration, the fact that gold existed in a free form in the creeks and river beds of the State. Its discovery found the community in the pastoral stage of civilization, without fixed legal principles or definite institutions; it transformed the social system, as if by magic, into a group of vigorous, independent units, struggling for some sort of law and social order. As free gold created the mining camp, so the mining camps gave birth to law all their own. Their popular courts, administering a rude criminal justice, and framed to meet only a temporary exigency, left, it is true, little trace on the future jurisprudence of the State. But the customs evolved in the camps with reference to property rights had more permanent results, and were unique contributions to the legal development of the entire United States. The American law with respect to the discovery, location and development of mining claims owes its character and form to these customs; the law with regard to the appropriation and use of water in the arid and semi-arid States, west of the Mississippi Valley, has been evolved from them. The miner's needs required that water be taken from the streams and carried in flumes, often a considerable distance, to enable him to work his placer claim. The rule of the older States and of England, whereby the use of running water was limited to him whose land was bounded by the stream, was unsuitable to economic needs and yielded to the greater force. The evolution of vague and indefinite custom into positive law finds no better illustration in modern times than in the process by which the unwritten usages of California gold miners became a most important part of the law of mines and waters.

In many other branches we may trace the direct influence of the frontier civilization which resulted from the sudden settlement of the State by adventurous gold-seekers. The criminal law, as laid down in later statutes and judicial decisions, affords illustrations of miners' conceptions of justice. For many years, the theft of any horse, regardless of its value, was grand larceny, though, generally, to constitute this crime the property stolen must have been worth at least fifty dollars. Even to the present day, the law of California sustains the right of self-defense to an extent not countenanced in most of the older communities—the right of one feloniously attacked to maintain his ground, even if he has to take his assailant's life to do so, rather than to flee, if possible.

These illustrations from the field of criminal law may be supplemented by others from the law which deals with the rights of the citizen. People, including lawyers and judges, are often heard to speak of the right of property as if it were an absolute right, the same in all times and places. A little study of legal history would convince them that property does not mean the same thing in all places and at all times, and its concept is based on social forces. For example, any elementary treatise on general law will point out that under the common law of England and of the States of the American Union any unauthorized entry upon one's land by another, or by another's cattle, gives the right to an action at law in favor of the land owner. But the land owner's property right was never so extensive as this in California. It never was the common law of that State that a man was liable for his cattle's trespasses. The pastoral conditions which preceded the stage of the gold miners, and which continued to exist side by side with the miners' social system, would have made the application of the common law to the situation in California intolerable, and the courts early recognized that fact. It is only as the agricultural interests have become predominant that the law with regard to trespassing cattle has, by gradual statutory amendment, been placed on a basis similar to that in communities where agriculture was always an important industry.

Even with respect to the other branch of the land owner's fundamental right—his right to sue in a court of record for another's mere entry on his land, though the entry be effected by mistake and without actual damage—the law of California has never been precisely like that of England, which prevails in most of the States. It is true that, theoretically, one may sue in a court of record for a trespass on his land against another who enters even without doing actual damage, and may recover nominal damages. But nominal damages recovered in a district or superior court in California never have carried the right to costs in actions of trespass, as was the case under the common law of England. On the contrary, the party who is awarded only nominal damages must pay the trespasser's costs of suit. Moreover, no general right exists to have the appellate court reverse a case where the jury refuses to give a verdict for the plaintiff, who has only technically suffered an infringement of his right. For a mere trespass, therefore, the land owner may justify his right only at the expense of paying his own and his adversary's costs, and even that slight satisfaction is accorded him at the uncontrolled discretion of a jury of his neighbors. He can not review a jury's refusal to award such damages. The practical absence of legal remedy has a tendency to cause the remedy of self-help to be invoked at the risk of provoking quarrels and breaches of the public peace. The rule as to costs has discouraged resort to the courts for the redress of slight injuries not only in respect to property but to personal rights, such as assaults, slanders and the like. Its effect is practically to remove from the domain of positive law a large and important class of rights. This attitude of the law indicates the frontier influence, the spirit of the gold miner and the herdsman, the willingness to sacrifice legal forms to "rude justice."

We may almost date the beginnings of legal history in the Pacific States from the coming of the gold-seekers to California. Their incursion was so sudden, their personalities so vigorous, that most of the half-formed and primitive institutions of the Mexican era were swept away. So far as concerns the constitution and frame of government and fundamental rights of the citizen, the older system has contributed nothing to legal history. The political institutions are, it is believed, as if Spain and Mexico had never been. Some elements, however, of the older system in the field of private rights survived the shock of the American invasion, the most important of which are in the field of family law. Considering the disparity between the male and female population in 1850, it was natural that a system of marital rights, fairer in its treatment of woman than the English common law, should have been left undisturbed by the pioneers. Had the settlers come with their wives and families, they would probably have brought with them the common law, as well as the social conditions of the older States, based upon the English law. But the remoteness of the new Eldorado was such that those who came were either young, single men, or they left their families at home—transient gold-seekers. They found already existing a tolerably well established system of marital rights. Neither selfish instincts nor a desire to improve conditions prompted them to change the property rights of the few women in the State. Consequently the Spanish law of the community of goods remained a permanent part of the legal system of California. The wife became to a certain extent a partner with her husband in the gains made during the marriage—an idea far removed from the conception then at the basis of the American law generally, that the husband was the sole owner of such property. To attribute, however, the permanent adoption of the community system in California exclusively to social conditions, based upon the discovery of free gold and the geographical isolation of the territory by ocean, mountains and deserts from the center of population, would, perhaps, be unwarranted. The vitality and force of the system, inherent in the fact that it is based upon more humane conceptions, has enabled it to conquer the common law under conditions not so favorable for its triumph as those that existed in pioneer California. In Washington, for instance, though French and Spanish institutions had but little opportunity of striking root, the State adopted this system of property between the spouses.

The same causes that contributed to perpetuate the community were operative with respect to the subject of marriage in general. Each of the constitutions of California, that of 1849 and that of 1879, has a provision that marriage is a civil contract, enunciating in this respect the theory of the Spanish-Mexican law, which, like the early canon law, permitted the establishment of marriage without either civil or religious ceremony. Until 1895, the statutory law of the State remained in this condition. Since that date solemnization is required to constitute a valid marriage. In the matter of the legitimation and adoption of children, also, Spanish law has had an important influence.

The Spanish-Mexican law theoretically governed the civil rights of all persons in California from the conquest in 1846 until the formal adoption of the common law of England in 1850. Many questions, therefore, have necessarily come before the courts involving rights acquired prior to 1850, especially with reference to land titles, and neither the historian nor the lawyer can afford to neglect the system. But it has affected private rights rather than the main outlines of the law, save in respect to the important survivals noticed.

The work of lawyers and publicists played an important part from the beginning in the moulding of juristic ideas, and the formal bases of the written law were laid by men of experience and learning in public affairs. But these men themselves were colored by the opinions and prejudices of the society in which they lived; they were young, vigorous, untrammeled by precedent, adventurous. The constitution of 1849 was, it is true, an instrument pretty much of the traditional kind. The overshadowing importance of the slavery question made the time one unfavorable to political or social innovation. It was not in the Constitutional Convention, but in the legislature of 1850, that the vigorous and independent public men of the infant State found their expression and tried experiments. From New York came the idea of reform in legal procedure, just introduced by the efforts of David Dudley Field, whose brother, Stephen J. Field was one of the dominant personalities of early California. The distinction between forms of proceeding at law and in equity was abolished, and a fusion of the two systems effected. California was the first State outside of New York to try this experiment, a tremendous forward step in jurisprudence, fundamental in all true legal reform. In the development of its jurisprudence, the State, thanks to this reform, has from the beginning been unhampered by the existence of forms which stand in the way of complete justice. New York also provided the model for the law of real property and conveyancing in the statutes adopted upon this subject. The desire was for greater simplicity and for greater restrictions upon the power of the individual to withdraw land from commerce by complicated wills and settlements. Traces of New England influence may be found in the laws relative to commercial matters, such as the liability of directors in corporations. The South, too, contributed its share. The system of administration of estates of decedents came from Texas. From the South also came what some foreign jurists regard as one of America's most important contributions to legal concepts—the laws providing for an exemption from execution for debt of a portion of the debtor's property, an application on the positive side of the conception which underlies the principle of the abolition of imprisonment for debt. Homestead and exemption laws are now found in nearly every civilized country in the world. Perhaps, however, the most important statute of the first legislature was that adopting the common law of England rather than the civil law of Spain as the fundamental law of the State.

Professor Royce in his story of California has pointed out how the development of the mechanical methods of the miners reacted upon social conditions, how the evolution from the "pan" through the "rocker" and "cradle," to hydraulic mining and lastly to quartz mining caused a corresponding evolution from a disorganized, anti-social individualism into an economic and political organization which might serve as a true basis for a State. The period of the 50's was that during which this process was taking place. Out of the wreck and chaos of unrestrained individualism, something like order had been brought by the beginning of the Civil War. California was ceasing to be the land of the gold-seeker. The era of agriculture had begun.

The rich soil of California's great plains formed the basis of the State's next era of development, that of the great farms, of railroad building, of commercial expansion. The climate had much to do with the history of this period. The large farm, before the application of irrigation, was an economic necessity. The uncertainty of the rainfall, the dangers of drought, the necessity for transportation to distant markets, required the farmer to be a financier, a man of affairs. Often he was neither. The element of chance controlled almost as it did in the days of gold; the wheat farmer was the slave of the elements. Nor were the great farms conducive to a satisfactory social development. They tended to the encouragement of a class of wandering laborers, undesirable in the structure of the State, to the employment of the Chinese and the alienation of the white population from agricultural labor, to the intensification of race hatred. The period was not fertile in improvement of legal and political institutions. One of the most notable events during the period was the adoption of the codes in 1872. The attempt to state the law, especially the complicated portion which deals with respect to civil rights, in the form of a code has not often been made in English-speaking countries. The willingness to try experiments which has always characterized the Pacific States is illustrated by the readiness with which the codes were adopted in California, and, once adopted in rather crude form, subsequently neglected.

This readiness to resort to new ideas so characteristic of the optimism of the people, an optimism perhaps in part the result of the even and moderate climate, is well illustrated in the constitution of 1879, the most striking political document of the agricultural era. This instrument is frankly expressive of the farmer's point of view, the farmer who had been the victim of natural and economic forces. The legislature, for example, is directed "to encourage by all suitable means the promotion of intellectual, scientific, moral and agricultural improvement." The temper of the constitutional convention found nothing absurd in the climax. The crude theory that the legislative department should be manacled in order that it may be honest finds full expression. Thirty-three cases are enumerated in which the passage of special laws is forbidden. To prevent fraud, every act must contain the true title, and must deal with only one subject under penalty of being void. No gift of public moneys can be made, no power shall exist to pledge the public money in favor of any private or municipal enterprise. We may smile at these remedies for the purpose of making the people's representatives honest, but the document is a tragical commentary on the public corruption that preceded the date of the convention.

Hostility towards corporations is the keynote of this constitution. It perpetuates the radical provisions of the civil code of 1872, which forbade the creation of corporations with strictly limited liability, and made each stockholder liable for his proportion of the debts of the corporation. An aggregation of persons with strictly limited liability, which the most eminent jurists tell us is an essential for the proper conduct of modern undertakings, is theoretically impossible under this constitution. Practically, however, the provision regarding stockholders' liability has proved ineffective. Though it has doubtless deterred capital from investment in the State, it has not restrained reckless finance or protected honest creditors.

In spite of its defects, the second constitution of California is instructive to one interested in the larger problems of legal development. The creation of a State Railroad Commission with the power of fixing rates was an innovation in American law. That the commission failed of practical result was due in large part to the fact that the office was elective, and the commissioners for the most part incompetent. It served, nevertheless, as a guide for future legislation, not only in the Pacific States, but throughout the nation. But the most revolutionary feature of the new constitution was its fundamental theory. It recognizes the written constitution as a means of direct legislation. The original theory of the federal and early State constitutions is repudiated, and from a negative instrument defining the powers of the departments of government, the constitution developed into a code of law adopted directly by the people. That the people came to regard it as such a code is apparent from the fact that between 1898 and 1911, one hundred and one amendments were made. Since then the initiative and referendum have become a part of the fundamental law. The line between constitutional amendment and referendum or initiative law is shadowy, and will doubtless become even more vague. In effect, it may be said that California, as well as Oregon and Washington, are living under a system of government far removed from that of New England. The earlier period of legal development had been marked by independence of thought in the field of private law, the more modern period by the same characteristics in the field of public law.

In the latest phase of the development of her law, California has passed out of the economic stage of the wheat farmer into the stage of intensive cultivation of the soil, of the irrigated farm. Horticulture and dairying have become more important than agriculture and mining, while the discovery of petroleum has served to develop many new industries. A marked tendency towards urban growth has come with improved means of transportation. A more complex state of society has been evolved, and with it have come new and different problems.

The recent years have produced the initiative, referendum and recall; woman suffrage; a commission to supersede the former ineffective railroad commission, with powers extending over public utilities other than railroads; workmen's compensation legislation; a direct primary election law; a minimum wage law. The last decade has been an era of fundamental reorganization. We have traveled far from the individualism of the first "diggings" to modern "social insurance." But the daring and venturous character of the miner that, carried too far, often led him to offenses against society, is at the basis of the social and political experiments of the present day—the spirit of optimism, of faith in the future, of trust in humanity.

It would perhaps be unprofitable here to trace the legal history of the other States of the Pacific Coast in detail. Their settlement has been more recent, their development more regular, their departures from normal types generally less marked, and they have largely fallen under the influence of California, so that the history of the law of that State is the key to most of what is novel in their law. In the more recent developments in the line of radical legislation, it is true that Washington and Oregon have in many respects preceded California. The most radical and fundamental piece of modern popular law-making, however, that providing for the making of laws directly by the people, was, as we have seen, the product of the California constitutional convention of 1879.

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SCENIC EXCURSIONS

BY A. O. LEUSCHNER
Professor of Astronomy,
University of California

NORTHERN TRANSCONTINENTAL ROUTES. The *Grand Trunk Pacific Route* from the eastern part of the United States and Canada to the Pacific Coast at Prince Rupert, British Columbia, is the most northerly and the newest of the several transcontinental routes, and has been completed for through travel in time for the season of 1915. The low altitude of the pass, 3700 feet, enhances the grandeur of the peaks of the Canadian Cordillera on either side of the railroad. From Prince Rupert, connections are made by steamer with Vancouver and Seattle, as well as with nearby Alaskan ports.

The route from Prince Rupert northward by steamer skirts the south shore of Digby Island, enters Chatham Sound, and continues through Dixon Entrance and the sheltered waters of Portland Arm to Stewart, near the dividing line between British Columbia and Alaska, or to Anyox and Granby Bay on Observatory Inlet, past the Indian village of Metlakahtla, to the east, and then to Port Simpson, thirty-seven miles from Prince Rupert. There is a fine glacier near Stewart. Port Simpson was established as a Hudson's Bay Company post more than one hundred years ago. Round trip fare from Prince Rupert $10.00, including meals and berths; two sailings each week; length of trip twenty-six hours.

The Queen Charlotte Islands are extremely picturesque, rich in minerals, forests, and fisheries products. The totem poles of the Haida Indians of these islands are especially fine. Round trip fare from Prince Rupert approximately $20.00, depending on the number of points visited; two sailings per week; length of trip twenty-eight hours. (See below for trip to Juneau and Skagway.)

Some of the wildest and most beautiful mountain scenery in the world is to be seen from the *Canadian Pacific Railway,* which passes for 600 miles through the Canadian Rockies of Alberta and

NOTE.—This chapter gives in a condensed form authoritative information kindly furnished by transportation companies, chambers of commerce in the several cities of the Coast, and by tourist associations. Further information may be obtained from books mentioned in the list of references appended.

British Columbia. Banff, on the eastern margin of the Canadian Rockies, is the station for the Canadian National Park, which covers 6000 acres. (Hotel rates, $4.00 per day, American plan; bath house at the Hot Sulphur Springs near the hotel.)

About one hour's run west of Banff is the Chateau, on the border of the beautiful Lake Louise, one of the "Lakes in the Clouds." The Victoria Glacier lies two miles from Lake Louise.

The tourist may also visit Paradise Valley, Moraine Lake, and the Valley of the Ten Peaks. Just west of Lake Louise the train crosses over the Great Divide and shortly afterwards reaches Field (Mt. Stephen House, $4.00 per day, American plan). Seven miles from Field is Emerald Lake (Swiss Chalet and two tent camps), and nearby the Yoho Valley (rates at Chalet and camps, $3.50 per day, American plan). The Yoho Valley reminds one of the Yosemite, with the Takakkaw Falls 1200 feet high, the Twin Falls, and the Wapta Glacier.

The finest scenery on this route lies west of Field in Kicking Horse Cañon, Illecillewaet Cañon, and in the cañons of the Thompson and Fraser rivers. Near Glacier (Glacier House, $3.50 per day, American plan) are two of the largest valley glaciers in the world, the Illecillewaet and the Asulkan.

The Glacier National Park, with its main entrance at Glacier Park Station on the main transcontinental line of the *Great Northern Railway,* is a reservation of 1525 square miles in a splendid portion of the Rocky Mountains. Within its borders are eighty glaciers, 250 mountain lakes and scores of beautiful mountain streams and cataracts. Trips about the park made by auto-stage and horseback. The Park season extends from June 15th to October 1st. Two large mountain hotels, Glacier Park and Glacier, and a chain of chalets, $3.00 per day, American plan.

Spokane, Washington. Within the city limits of Spokane are two falls on the Spokane River, totaling 150 feet in height. An hour's ride from Spokane by the electric trains through the well-developed agricultural lands of the Inland Empire System, is Hayden Lake in the Coeur d'Alene Mountains (Bozanta Tavern).

Lake Chelan, Washington. Reached by a Great Northern branch line thirty-seven miles from Wenatchee, a beautiful mountain lake, sixty miles long, of great depth and hemmed by peaks 7000 to 8000 feet in height in the Cascade Mountains.

Excellent hotel resorts, and good bear and deer hunting, and fishing.

Scenic, Washington, is the station for that delightful mountain resort among the western spurs of the Cascades, Scenic Hot Springs. Round trip week-end rail rate from Seattle $2.80, daily rate $3.20.

The Cascade Tunnel, elevation 3375 feet, nearly three miles long, is the highest point of the Great Northern Railway in central Washington.

A direct route from Chicago and the Middle West across Montana, Idaho, and Washington to Puget Sound ports is offered by the *Chicago, Milwaukee & St. Paul Railway*, which runs through magnificent portions of the Rocky Mountains and the Cascade Range.

The *Northern Pacific Railway* follows a similar route, and is one of the roads leading to the Yellowstone National Park.

The Yellowstone National Park may be reached by a branch line of the Northern Pacific from Livingston to Gardiner at the northern boundary of the Park. An excursion has been provided by the Northern Pacific Railway for a trip of five and three-fourths days through the Park, at an expense of $53.50. The Park is also reached by a branch line from the Union Pacific Route, terminating at Yellowstone on the western border of the Park. A four-day tour of the Park, starting from Yellowstone, is provided at an expense of $45.00 in addition to the transcontinental fare. A six-day excursion from Yellowstone is also provided.

The Wylie Permanent Camping Company offers a six-day tour from Gardiner or Yellowstone for $40.00, and a five-day tour from Yellowstone for $35.00. The round trip fare from Livingston on the Northern Pacific Line to Gardiner is $3.20, and the additional charge upon the transcontinental rate for the digression to Yellowstone from the Union Pacific Line at Granger, with return to Ogden, is $9.25, Pullman reservations extra. The eastern entrance of the Park is reached by stage (ninety-four miles to Yellowstone Lake) from Cody, which is reached from Billings on the Northern Pacific Route or from Cheyenne by a line of the Chicago, Burlington & Quincy.

Trips in the Vicinity of Puget Sound. A beautiful ten-day trip may be made from Seattle or Vancouver to Skagway and other Alaskan ports (round trip $66.00 and up). This is the famous Inside Passage trip, among the inlets, canals and fjords of southern Alaska, with a side trip into

Taku Bay to view the Taku Glacier. Passengers have two days at Skagway, which is sufficient time for going up over the White Pass Road to Bennett or even as far as White Horse.

From Tacoma and Seattle, on Puget Sound, a number of interesting trips may be made into the Cascade and Olympic ranges, with their great forests and interesting botanical and geological features; by steamer to Victoria, and to Vancouver by the Great Northern Railway along the shore of Puget Sound, or by the somewhat more inland route of the Northern Pacific Railway; to the United States Navy Yard at Bremerton on Port Orchard Bay; through Hood's Canal near the Olympic Mountains; to Snoqualmie and Electron falls, which are used to generate electricity for the Puget Sound cities, and to the Mt. Rainier National Park.

The Rainier National Park may be reached from Tacoma by the Tacoma Eastern Railway (fifty-five miles) to Ashford, and thence by auto stage (thirteen miles) to the National Park Inn ($3.25-$3.75 per day, American plan), at Longmire Springs. (Round trip fare from Seattle $6.50; from Tacoma $5.00.) An automobile road extends also from Tacoma to Longmire Springs at the base of Mt. Rainier and to Paradise Park farther on, where there is a tent hotel (rates $2.00-$2.50 per day). The Park season is from June 1st to September 30th. The system of glaciers radiating from the peak of Mt. Rainier (elevation 14,408 feet) is remarkable for the great extent of ice-field. Many evidences of past volcanic activity can be seen. From the National Park Inn it is a short climb to Eagle Peak and the summit of the Ramparts, where the view is exceptionally fine. Trips may be made on horseback to Indian Henry's Hunting Ground, Mirror Lake, Van Trump Park, etc. The round trip (twenty-eight miles) from National Park Inn to Paradise Valley and the Camp of the Clouds may be made by auto stage.

The Olympic Range lying on the west side of the Sound, and reaching up to the Strait of Juan de Fuca, affords some of the most rugged mountain scenery in this country. The railroad engineering work and the reclamation work of the United States Government in the Cascade Range deserve particular attention. Lakes Kachess, Keechelus and Clealum have been turned into enormous reservoirs for irrigation for the Yakima Valley on the east side of the Cascade Range. A number of fine peaks rise in the western part of Washington, among them: Mt. Baker (elevation 10,827 feet), Glacier Peak (elevation 10,436 feet), Mt. Olympus (elevation 8250 feet), Mt. St. Helens (elevation 10,000 feet), and Mt. Adams (elevation 12,470 feet).

Excursions in Vicinity of Portland. For the student of history, a trip by street car or train to Vancouver, on the Washington side of the Columbia River, will be of great interest. Fort Vancouver was a refuge for the whites during the Indian uprisings, the scene of important trade and barter between white and red men during times of peace, and the starting point for expeditions which used the Columbia River as a highway.

On the Oregon side, fourteen miles from Portland and reached either by trolley or river steamer, is Oregon City, formerly a trading post of the Hudson's Bay Company, home and now the resting place of John McLoughlin, who, with Marcus Whitman, exerted a great influence on the civilization and development of the entire Columbia Valley.

Astoria, founded in 1811, lies west of Portland at the mouth of the Columbia River. Near Astoria is the site of the camp of Lewis and Clark used during the winter of 1805-6 and called by them Fort Clatsop, and here are also ancient shell mounds, or "kitchen middens," in which may be found a variety of horn, bone and stone implements made by a people probably contemporaneous with the mound builders of the Ohio Valley.

Mt. Hood, elevation 11,225 feet, sixty miles from Portland, is reached either by electric car and stage, or by automobile direct from the city.

The Columbia and Willamette rivers present many interesting features: overhanging forests, numerous waterfalls, the Tertiary lava flows seen in the form of cliffs and pinnacles, the Cascades, The Dalles, the ship canals, and the Celilo Falls, named by Lewis and Clark the "Great Falls," which are now spanned by a steel and concrete railway bridge 4000 feet long. The Oregon Trunk Line Railway, of which this bridge is a part, follows the Deschutes River through cañons cut in lava into central Oregon. From White Salmon, a station on the Spokane, Portland & Seattle Railway, a good road leads through the forest up to the base of Mt. Adams.

The part of the Columbia River below The Dalles may be reached in several ways: by river steamer; by train, over the Spokane, Portland & Seattle Railway on the north bank of the river to Fallbridge, or by the Oregon-Washington Railroad & Navigation Company on the south bank to The Dalles; or by a combination of a morning railway trip going up the river and an afternoon steamer trip coming down; or by automobile over the recently completed Columbia River Highway.

In western Oregon the Tillamook and Newport branches of the Southern Pacific Railway to the coast cross the Coast Range Mountains, passing through dense stands of timber, "Oregon pine" *(Pseudotsuga taxifolia)*. From Medford in the Rogue River Valley to the Crater Lake National Park a tri-weekly motor stage is operated, connecting with a second motor stage from Crater Lake to Chiloquin, which is near the terminus of the Klamath branch of the Southern Pacific, which in turn joins the main line at Weed. The stage fare from Medford to Chiloquin via Crater Lake is \$15.00 After crossing the summit of the Siskiyou range the Shasta Route affords ever-changing views of Mt. Shasta (elevation 14,162 feet) for 150 miles, descending to the central valley of California through the picturesque cañon of the Sacramento River. Lassen Peak (elevation 10,437 feet), at present the only active volcano in the United States, is in plain view from the train.

Central Transcontinental Routes. The *Denver & Rio Grande Route* through Colorado affords magnificent scenery in the Grand Cañon of the Arkansas River and on either the Leadville Pass (elevation 10,000 feet) or the Marshall Pass (elevation 10,858 feet) over the Rocky Mountains.

In Salt Lake City the Mormon Temple, the exhibit in the Chamber of Commerce Building, the Tabernacle and Assembly Hall are well worth seeing. A public organ recital in the tabernacle is given at noon on week days. The Great Salt Lake may be reached by steam railway at the bathing resort called Saltair, eighteen miles from Salt Lake City. At Garfield, fourteen miles west of Salt Lake City, is situated the smelting plant of the American Smelting & Refining Company, with a capacity of 10,000 tons of ore per day.

The *Western Pacific Railway*, the "Feather River Route," forms with the Denver & Rio Grande Route the newest transcontinental line entering California. In Utah the Western Pacific line crosses the southern portion of the Great Salt Lake. From the summit of the Toano Range, a good view is obtained of Salt Lake Basin. In Nevada this route follows the famous old trail of the overland emigrants along the Humboldt River through Nevada's mining and ranching country. Crossing the Sierra Nevada by the Beckwith Pass, elevation 5118 feet, the route into California traverses the Feather River

Cañon through the Sierra Nevada for ninety miles. Near Oroville, in the Sacramento Valley, one may see placer dredges at work. This is also one of the centers for orange and olive production in California.

The route of the *Los Angeles, San Pedro & Salt Lake Route* from Salt Lake City to Los Angeles passes through the agricultural region of central Utah, the copper mining region of southwestern Utah, and the typical desert areas of the Great Basin. Bingham Cañon, with wonderful copper mines, is one hour by train from Salt Lake City. En route are the great mills of the Utah Copper Company and Bingham smelters.

From Las Vegas, Nevada, in the fertile, artesian-watered valley of the same name, a side trip may be made over the Las Vegas & Tonopah Railroad to the famous mining camp of Goldfield. Death Valley, the floor of which is 250 feet below sea level, may be reached on this trip from Beatty. Vast deposits of borax and many other salts and minerals are found in this desolate valley.

The *Union Pacific Railroad* follows from Omaha to Ogden almost the identical trail of the earliest explorers—the gold seekers and Mormon disciples—and the overland stage coach, and pony express.

Wyoming is known to scientific men as a rich field for fossil deposits. Laramie is the usual outfitting point for exploring parties. An unusually fine display of fossil remains of Mesozoic animals is shown in the University Museum at Laramie.

Near Rawlins, in the Wind River Mountains farther westward, are the Great Lye Wells of Wyoming, and the Shoshone and Arapaho Indian Reservation, comprising 1,125,000 acres in the Wind River Valley. The Continental Divide lies 720 miles west of Omaha and 289 miles east of Ogden. Near Rock Springs are rich coal mines, and the scenery is very fine. About three miles west of Green River is the famous Fish Cut in which Professor O. C. Marsh of Yale University in 1890 found extensive Mesozoic remains of fishes, and giant reptiles. Granger, in the heart of the sheep-raising district; is the point of junction of the Union Pacific and the Oregon Short Line which traverses Utah, Wyoming and Idaho. From the Oregon Short Line a branch road goes to Yellowstone on the western border of the Yellowstone National Park.

Beyond Ogden the Southern Pacific trains cross the Great Salt Lake on thirty-five miles of trestle and fills. In Nevada the line follows the trail of the forty-niners along the Humboldt River, and crosses the Sierra Nevada at an elevation of 7018 feet. From Truckee, near the summit, a fifteen-mile narrow-gauge railroad leads to Lake Tahoe. The excursion from Truckee to Tahoe, including a steamer ride of seventy-five miles around the crystal lake, can be made in a day (round trip fare \$5.00). Beyond the summit the railroad descends to the central valley of California along the upper rim of the American River cañon, through the Mother Lode gold mining region.

Trips About San Francisco. Triangle Trip through Marin and Sonoma counties. By the Northwestern Pacific Railway from the Ferry Building, foot of Market Street, San Francisco to Sausalito, Monte Rio and return. (Round trip, \$2.80.) A full day's trip into the Russian River country in the Coast Range Mountains, interesting on account of rivers, redwood forests, mineral springs, outing resorts, and prosperous orchards and vineyards. Santa Rosa, the home of Luther Burbank, the plant wizard, is the principal city along this route.

To the Mare Island Navy Yard and Vallejo. By Monticello Steamship Company boat from the north end of the Ferry Building, San Francisco (9:45 a. m. daily). Ferry connections from Vallejo to the United States Navy Yard, Mare Island. The return boat leaves Vallejo at 3:20 or 6:00 p. m. Cost, including ferry to Mare Island, \$1.20. Permission is obtained at the gate of the Navy Yard to visit all portions of the Yard, including the barracks, officers' quarters, machine shops, etc. Luncheon may be obtained on the boat or at Vallejo. No cameras are allowed in the Navy Yard. This is a twenty-five-mile trip through the northern portion of San Francisco Bay and its arm, San Pablo Bay.

To Napa Valley and the Petrified Forest. By Monticello Steamship Company boat from the north end of the Ferry Building, San Francisco (9:45 a. m.). At Vallejo transfer to the Napa and Calistoga electric train. If returning on the same day, leave Calistoga at 3:40 or 6:05. Cost, \$2.65 round trip. Napa Valley is a center for fruit growing. Vineyards occupy the upper end of the valley, at the head of which stands Mt. St. Helena (elevation 4343 feet). The petrified forest (admission fifty cents) lies five miles beyond Calistoga.

Auto Trip along Highland Drive (Oakland, Berkeley, Piedmont). By sightseeing automobile from San Francisco, by Southern Pacific Ferry to Oakland. Round trip fare from San Francisco, \$1.50; from Oakland, \$1.25. The trip may be made in half a day. This is the Oakland-Berkeley-Piedmont sightseeing trip by automobile, along the famous Highland Drive to Berkeley and the University of California, to Piedmont Park, Lakeside Park, and Oakland.

Key Route Trolley Trip in Alameda County. Leave San Francisco, foot of Market Street, Key Ferry, 10:00 A. M. and 1:00 P. M. daily. Leave Oakland, Twelfth and Broadway, 10:00 A. M., Twenty-second and Broadway, 1:35 P. M. daily. Time of complete trip about seven hours. Cost, $1.00. A comprehensive and satisfying trip through the cities of Berkeley, Piedmont, Oakland and Alameda, on the east shore of San Francisco Bay. Opportunity is given to visit the University of California at Berkeley, and Piedmont Art Gallery in Piedmont Park.

Orchards and Gardens of Alameda County. From San Francisco take Southern Pacific or Key Route boat at Ferry Building; transfer to electric train on other side of the bay; get off at Seventh and Broadway, or Twelfth and Broadway, Oakland. Board Hayward trolley (frequent cars) at Twelfth and Broadway. Return at leisure. Cost, round trip, San Francisco to Hayward, 50 cents; Oakland to Hayward, 30 cents. An attractive rural and interurban trip through the towns of Oakland, Fruitvale, Melrose, San Leandro, San Lorenzo and Hayward.

The "Blossom Trip" in Santa Clara Valley. Leave San Francisco by Southern Pacific Railway from Third and Townsend Street Station 7:00 A. M., arrive Palo Alto 8:07. Stanford University is reached by electric car from Palo Alto. Leave Palo Alto by Peninsular Electric Railway at 10:00 A. M. for the "Blossom Trip" through the Santa Clara Valley, arriving at San Jose 11:58 A. M. Frequent Southern Pacific trains return to San Francisco. Cost (separate tickets must be purchased for the different stages of the trip), round trip fare from San Francisco to Palo Alto and additional one way fare from San Jose to Palo Alto, $1.60; "Blossom Trip," $1.00. This trip may be extended to Mt. Hamilton (elevation 4250 feet) and the Lick Observatory (round trip auto-stage fare from San Jose to Mt. Hamilton, $5.00); to Saratoga. where the annual "Blossom Festival" is held in March; or to the charming foothill towns of Los Gatos, Congress Springs, and Gilroy. At Santa Clara is the University of Santa Clara, and the Santa Clara Mission founded in 1777 by Father Junipero Serra. Hotels at San Jose: Vendome (American plan,

$3.50); Montgomery (European plan, $1.50 up); St. James (European plan, $1.50 up).

Mission San Jose, Alameda County. Leave San Francisco from Southern Pacific ferry at Ferry Building, foot of Market Street, 9:00 A. M., or board the connecting train at Oakland, First and Broadway Station, 9:34 A. M. Buy a round trip ticket to Niles. From Niles the journey of five miles by automobile may be made to the old Spanish Mission, founded in 1797 by Franciscan padres: "Palmdale" with palm gardens, one-hundred-year-old pear and fig trees, planted by the padres. Cost, round trip railroad fare, $1.10.

To San Mateo, Burlingame, Hillsboro. By San Mateo electric car from Fifth and Market streets, San Francisco, service every thirty minutes. Upon return, transfer at Daly City to the Ocean View street car line, No. 26, marked "Ferries and Daly City, via Mission, Guerrero Street and San Jose Avenue." Total fare, 50 cents. An eighteen-mile trip from San Francisco into the fashionable country-home communities of Burlingame, San Mateo, and Hillsboro. At San Mateo, automobiles or motor buses may be secured for a ride through the most attractive sections. (Peninsula Hotel, American plan, $3.50 up.)

Santa Cruz Beach and Big Trees. By Southern Pacific from Third and Townsend Street Station, San Francisco; several trains daily. Cost, special season rate, round trip, $4.00. Saturday to Monday, $3.00. Those remaining over at Santa Cruz to visit the California Redwood Park may take the train next morning to Boulder Creek, and automobile stage from Boulder Creek to the Park.

Among the many attractions of this trip are a popular seaside resort, with good hotels, bathing beaches, yachting and fishing in Monterey Bay, trout fishing in the mountain streams, tramping and camping in the solitudes of the redwood forest, and driving through productive valleys; also views of a magnificent grove of Big Trees *(Sequoia sempervirens)* six miles from Santa Cruz. From Santa Cruz northwesterly extends a series of elevated old ocean terraces. Two railroads (Southern Pacific and Ocean Shore) run to Davenport, eleven miles, on the lowest of these old ocean strands, and afford an excellent view of the others. The California State Redwood Park in the "Big Basin," a public park of 8000 acres of redwood forest, is twenty-eight miles from Santa Cruz. Hotels: Casa del Rey (European plan, $2.00 up); St. George Hotel (American plan, $3.00 up).

California State Redwood Park in Santa Cruz County. By Southern Pacific from Third and Townsend Street Station, San Francisco; connection from Boulder Creek by motor stage for the "Big Basin," fourteen miles. Return to Boulder Creek and San Francisco next day. Cost, round trip, railroad and stage fare, $5.00. From Oakland take Southern Pacific train from First and Broadway, which makes connections at San Jose.

Monterey, Del Monte, Pacific Grove, and Carmel. By Southern Pacific from Third and Townsend Street Station, San Francisco; through service with observation car. All coast trains, each way, also connect at Del Monte Junction for Del Monte, Monterey and Pacific Grove. Cost, special summer stop-over ticket, $4.75 round trip from San Francisco; Sunday only, no stop-over, $2.75; Saturday to Monday, no stop-over, $3.25.

Monterey is the Mission County of California, and contains the missions of San Antonio, La Soledad, and San Carlos; nearby, in San Benito County, is Mission San Juan Bautista.

Other objects of historical and dramatic interest in and near Monterey are the old custom house over which Commodore Sloat raised the first American flag in California; Colton Hall, where met the State Constitutional Convention on September 1, 1849; the first theatre of the State, where Jenny Lind sang in 1847; the first sawed lumber house in California; the Sloat monument; the Sherman rose tree; the Father Serra oak, and the Presidio. On the shores of Monterey Bay are several fish canneries and one for packing the abalone. In and near Pacific Grove are the municipal museum, the marine biological station of Stanford University, the groves of Monterey cypress, and the government lighthouse at Point Pinos. Beyond Pacific Grove is Carmel, a secluded summer resort, and the Mission of San Carlos Borromeo de Monterey. The cost of carriage for the Seventeen Mile Drive over the Monterey Peninsula is from $5.00 to $10.00. At Del Monte is the Hotel del Monte, a famous pleasure resort, with 125 acres of landscape gardens, polo and golf grounds, tennis courts and a natatorium.

Sixteen miles southeast of Monterey is the prosperous Pajaro Valley. Salinas, the county-seat, is reached over an excellent road through a charming pine and oak district. A few miles from Salinas, at Spreckels, is one of the largest beet sugar plants in the State.

There is a beautiful drive down the coast, in a southerly direction, from Monterey to Idlewild, Arbolado, and Slate's Springs, some fifty miles. Many summer camps and hotels offer accommodations along this route. Hotels: Hotel Del Monte (American plan, $5.00 up); Hotel Monterey (American plan, $2.50 up); Pacific Grove Hotel (American plan, $2.50). Salinas: Hotel Abbott (American plan, $2.50); Barden Hotel (American plan, $2.50); Jeffry Hotel (American plan, $1.50).

The Vancouver Pinnacles, San Benito County. By Southern Pacific, Third and Townsend Station, San Francisco, for Tres Pinos, via San Jose and Hollister. Half day stage ride from Tres Pinos to Cook. One day should be spent at the Pinnacles, returning to San Francisco on the third day. Cost, round trip to Tres Pinos, $5.60. Stage fare round trip, $3.00. Special arrangements may be made for lodging, meals and guide at Cook. These Pinnacles are in the heart of the Coast Range Mountains, 125 miles south of San Francisco. Formed of volcanic rocks, they are grouped and isolated in fantastic shapes and with beautiful colorings, and rise to heights of many hundred feet. Among them are El Machette, or Knife Blade Rock, Pallisade Rock, and Jordan's Amphitheatre.

The Yosemite National Park may be reached directly from San Francisco by either the Southern Pacific or Santa Fe lines, connecting at Merced with the Yosemite Valley Railway. The trip from El Portal, the terminus of the railway, into the valley (14 miles) is made by auto stage. Round trip from San Francisco, including auto stage fare, $22.35.

The Yosemite Valley may also be reached as a side trip from the Valley lines of either the Santa Fe or the Southern Pacific, by transferring at Merced. The additional round trip fare from Merced to the Valley and return is $18.50; and to the Wawona Big Tree Grove, $33.50; if by way of Glacier Point, $37.50. All first-class tickets carry a ten-day stop-over at Merced for Yosemite National Park.

The Indians called the Yosemite Valley the "Heart of the Sky Mountains," and referred to themselves as the "Children of Light." Hence the late John Muir has renamed the Sierra Nevada, the "Range of Light."

First day. Arrive Yosemite, by auto-stage at 9:30 in the morning. The round trip over the floor of the valley is quite easily made before evening.

Second day. Visit the Happy Isles, thence to Vernal and Nevada falls, a half-day trip, with the afternoon for resting or for little wanderings to the foot of Yosemite Falls and about the floor of the valley.

Third day. Up to the rim, above Yosemite Falls, and on to Eagle Peak and perhaps the crest of El Capitan, with a view of the southern wall of Yosemite.

Fourth day. The trip of trips, past Vernal and Nevada falls to Glacier Point. A full day's journey ending at the Glacier Hotel. The next morning can be devoted to the unparalleled panorama. From Glacier Point the auto-stage for the Big Trees may be taken in the afternoon, reaching Wawona in the evening of the fifth day, staying overnight at the Wawona Hotel, going through the Big Tree Grove *(Sequoia gigantea)* in the morning, and reaching Yosemite again at the Sentinel Hotel, the starting-point of the auto-stage, in the early evening of the sixth day. It is advisable to remain over and take a full day for the Big Trees, which will involve no extra charge for stage service.

Seventh day. Mirror Lake at sunrise and later a ride along the South Wall by the Pohono Trail past the Fissures.

The itineraries may be infinitely varied including Tenaya and Indian cañons, and high mountain trips to Cloud's Rest, Little Yosemite, Big Meadows, etc.

Visitors to the Yosemite Valley should take few extras in clothing, etc.; but such should be for use. Overcoats and wraps will be needed according to the season. Wear rough clothing and strong shoes. In summer, the Yosemite is pleasantly warm during the day, but decidedly cool after sundown. Hotels: Hotel del Portal (American plan, $4.00); Sentinel Hotel (American plan, $3.50 to $5.00); $21.00 to $30.00 per week; Glacier Point Hotel (American plan, $4.00); Camp Curry, Camp Ahwahnee, Camp Lost Arrow ($2.50 per day, $15.00 per week, open during summer only).

SOUTHERN TRANSCONTINENTAL ROUTES. West of El Paso the *Southern Pacific line* from New Orleans traverses typical stretches of the desert of the Southwest.

By leaving the main line at Bowie, the holder of a through ticket may travel over the Arizona & Eastern Railway without extra charge to the mining town of Globe, thence by motor stage 120 miles through the mountains of the Arizona National Forest to Roosevelt Dam, built by the U. S. Reclamation Service, and to Phœnix in the semitropic Salt River Valley. The auto route (fare $20.00) passes a group of prehistoric cliff dwellings, distant 20 minutes walk by trail. From Phoenix, through sleepers are operated to Los Angeles.

Tucson contains the Desert Laboratory of the Carnegie Institution for the study of plants living under arid conditions. Nine miles from Tucson, reached by frequent auto-stages, is the ancient Mission San Xavier del Bac founded by Father Felipe Segesser in 1732 and still in use. From Casa Grande, Arizona, extensive prehistoric ruins may be visited by auto-stage. In California a few miles beyond the Salton Sink, more than 200 feet below sea level, the Department of Agriculture has successfully established groves of Algerian date palms. The ancient beach lines of an extension of the Gulf of California are plainly visible on the naked hills.

The Coast Line of the Southern Pacific through Santa Barbara, follows El Camino Real, the King's Highway, established by the Franciscan padres to connect the chain of missions along the California coast. The Franciscan Mission at Santa Barbara is one of the best preserved examples of Spanish architecture on the Coast. (Principal hotels at Santa Barbara: Potter, $5.00 and up; Arlington, $3.50 and up; American plan.)

On the San Joaquin Valley line the Big Tree *(Sequoia gigantea)* groves of General Grant and Sequoia National Parks are accessible, the former by stage from Sanger, the latter by trolley and connecting stage from Visalia and Lemon Cove. Magnificent scenery of the Kings River and Kern River cañons in the High Sierra is reached by pack train from the parks.

The *Atchison, Topeka & Santa Fe Railway* follows closely the old Santa Fe Trail through the Southwest. In Colorado from Pueblo to Denver, the trains run near the Rampart Range of the Rockies and afford a magnificent panoramic view. The many resorts of Colorado may be reached by connections with the Moffat Road, the Colorado & Southern Railway, and the Denver & Rio Grande Railway.

A stop-over at Lamy may be secured in order to visit the school and museum of the American Institute of Archaeology at Santa Fe.

More than a score of pueblos are scattered over New Mexico, the most important being Isleta, Laguna, on the main line, and Acoma. Many aboriginal inhabitants of the pueblos are housed today in the self-same structures which their forebears used. At Albuquerque is the railway hotel, the Alvarado. Here is found a very complete collection of Indian relics and products, from the Hopi, Navajo, Zuñi, Apache, and Pima handicrafts. The pueblos of the Hopi Indians may be reached by a short journey from Cañon Diablo, Holbrook, or Winslow, in Arizona.

The Petrified Forest of Arizona, containing remains of some trees 200 feet in length, comprises five separate deposits all reached by good roads from Adamana station. (Forest Hotel at Adamana, $2.50 per day, American plan.)

In Arizona the chaotic gorge of the Grand Cañon of the Colorado, 217 miles long, nine to thirteen miles wide, and cut in places more than 6000 feet below the level of the plateau, is reached by a branch railway from Williams. Additional round-trip fare from Williams, $7.50. Rates at "El Tovar," on the rim of the Cañon ($4.00 to $8.00 per day, American plan); Bright Angel Hotel ($1.00 to $5.00 per day, European plan, meals á la carte in the Harvey Café.)

Trips in the Vicinity of Los Angeles. From Los Angeles several hundred miles of interurban electric railway lines extend throughout the coast plain and the San Gabriel Valley like the spokes of a great wheel, to the mountains, beaches, orange groves, and to thriving little cities.

Attractive places in the city, reached on street cars, include the alligator farm, botanical exhibit at Eastlake Park, Cawston Ostrich Farm, aviary and aquarium, Exposition Park, art gallery, Museum of History, Science and Art, Southwest Museum, Mission Los Angeles, State Exposition building, Elysian Park (548 acres in natural state), and Chinatown (in heart of city, fee for guide, etc.).

Mt. Wilson, on which is the Carnegie Solar Observatory containing the largest reflecting telescope in the world, may be reached from the suburban electric line at Sierra Madre. Horses or burros ($2.50-$2.00 each) may be secured for the last part of the trip. Auto stages also make the round trip in a day from Pasadena from the office of the Mt. Wilson Hotel Company, 173 East Colorado St., Pasadena (round trip fare $3.00).

From Altadena, a suburb of Pasadena, an inclined cable railway ascends Echo Mountain, where is situated an observatory open to visitors. An electric railway continues to Alpine Tavern, 5000 feet above sea level and close to the summit of Mt. Lowe (round trip fare $2.50.)

Throughout the year 1915 the Mission Play will be given weekly at the San Gabriel Mission (admission to Mission Play, 50 cents, 75 cents and $1.00.) The mission at San Fernando is on the northern line of the Southern Pacific Railway.

The remarkable Pleistocene fossil deposits in the asphalt pits of Rancho La Brea are reached by a few minutes walk from Rosemary station on the Santa Monica line of the Pacific Electric Railway Company.

Universal City is a large motion picture plant managed as a municipality (round trip 25 cents).

Special Trolley and Railway Trips in the Vicinity of Los Angeles. *Triangle Trolley Trip.* From the Pacific Electric Station in Los Angeles through the southern portion of Los Angeles County and Orange County, including ten of the beaches and many of the suburban towns of the coast plain. A stop of two hours is provided at Long Beach. (Round trip fare $1.00.)

Old Mission Trolley Trip. From the Pacific Electric Station in Los Angeles to the San Gabriel Mission, the Cawston Ostrich Farm, Pasadena, and foothill towns. (Round trip fare $1.00.)

Balloon Route Trolley Trip. From the Pacific Electric Station in Los Angeles to the beaches west of the city, Hollywood and Cahuenga Valley, the Soldiers' Home, Santa Monica, Ocean Park and Venice. A stop of an hour and a half is provided at Redondo for lunch. (Round trip fare $1.00.)

Kite-shaped Track Excursion. A one-day excursion (158 miles) through the San Gabriel and Pomona valleys to San Bernardino, Redlands and Riverside, returning to Los Angeles by way of Corona and Fullerton. (Round trip fare $3.00.)

Orange Belt Special. A one-day trip over the Salt Lake line to Riverside and Redlands. (Round trip fare $3.00.)

Inside Track Trip. A one-day excursion over the Southern Pacific lines to Pomona, San Bernardino and Redlands. (Round trip fare $2.75.)

Santa Catalina Trip. Connections with steamers from San Pedro to Santa Catalina Island, twenty-three miles from the coast, may be made by either Pacific Electric Railway or the Salt Lake Route. (Round trip fare $2.75.) The submarine gardens here are of special interest. This is the center of marine sports in southern California.

Automobile sight-seeing trips are also provided about Los Angeles and through the suburbs. (Round trip fare $1.00.)

The trip from Los Angeles to San Francisco may be taken by the coast line of the Southern Pacific or by the San Joaquin Valley lines of the Southern Pacific or Santa Fe railroad, or by several lines of steamers.

Excursions in the Vicinity of San Diego. Going southward to San Diego by the Santa Fe Railway one passes through regions rich in fruit and within a stone's throw of the mission-ruins of San Juan Capistrano.

The Panama-California Exposition at San Diego in 1915 emphasizes the products and development of the Southwest and especially the archaeology of the region. The Exposition grounds cover 615 acres on the west side of Balboa Park. This park contains, all told, 1400 acres, and lies almost in the center of the city.

All transcontinental excursion tickets during 1915 will be made to include this trip from Los Angeles to San Diego if so desired.

One of the most interesting trips about San Diego is that to Point Loma, made preferably by automobile or sight-seeing auto. This trip includes the Theosophical Institution with the Raja Yoga College and Aryan Memorial Temple, and the U. S. Wireless Station. From the old Spanish light-house at the end of the point a fine view is to be secured of the Quarantine Station and Fort Rosecrans below the point, and the harbor and city of San Diego.

La Jolla, with sea-beach caves and rocks of much interest, is reached by an interurban steam railway. The Scripps Institution for Biological Research, attached to the University of California, with a museum of marine life, is situated two miles up the coast from the town of La Jolla.

Typical adobe buildings of the days of the Spanish regime and other relics are preserved in Old Town, reached by street car from this city. The Mission of San Diego, founded in 1769 is located in the San Diego River Valley north of the city.

Automobile tours are arranged to include Tia Juana just across the Mexican boundary line, returning by way of the Coronado peninsula. Hotel del Coronado and the Coronado Tent City may also be reached directly from San Diego by ferry connecting with street cars.

Fishing and excursion trips may be taken to the group of rocky Coronado Islands, sixteen miles south of Point Loma.

San Diego County possesses many fine automobile roads. Stages lead to mountain resorts and other points of interest. Among these is the Imperial Valley, on the Colorado Desert side of the southern Coast Range Mountains.

Hawaiian Islands. Steamers of several lines connect the Hawaiian Islands with San Francisco (sailing time in either direction about six days.) Among these lines are the American-Hawaiian Steamship Co., the Matson Navigation Co., the

Scenic Excursions

Oceanic Steamship Co., and the Pacific Mail Steamship Co. (Round trip rates from $110.00 up.) From Honolulu, inter-island excursions may be easily arranged, the most interesting of which, perhaps, is that to the island of Hawaii on which is Mauna Loa, the largest volcano in the world.

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APPENDIX

INDEX AND MAPS

INDEX

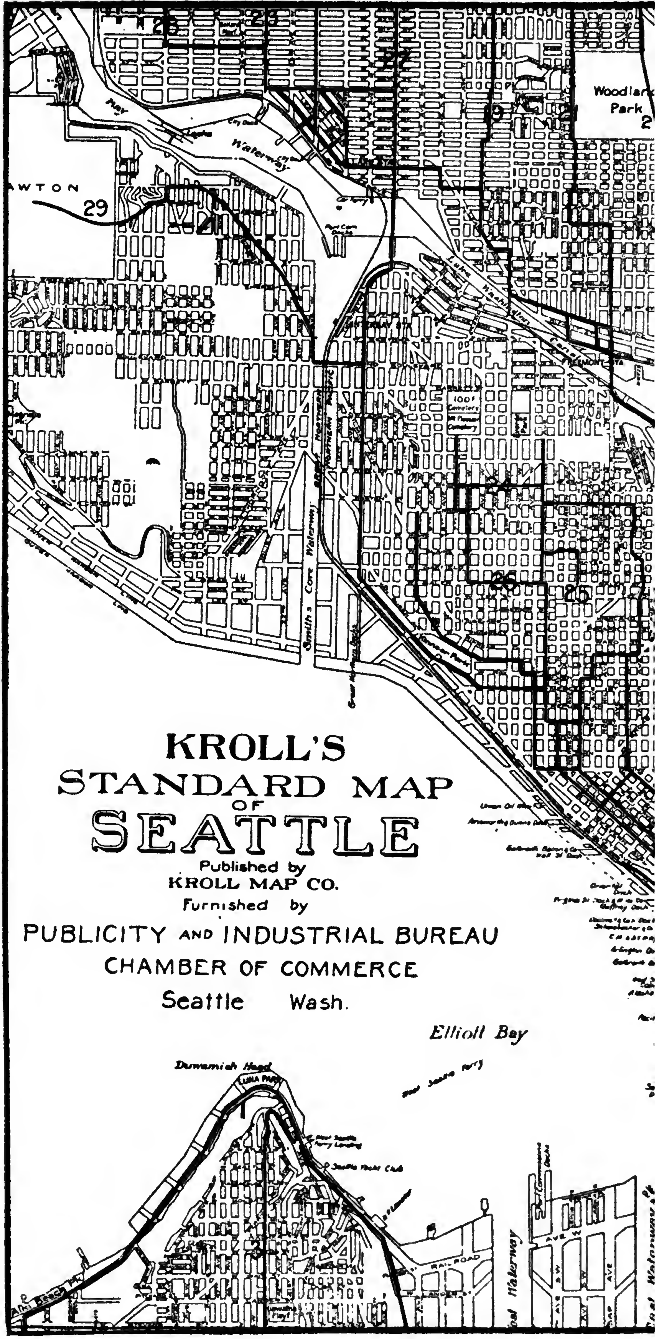
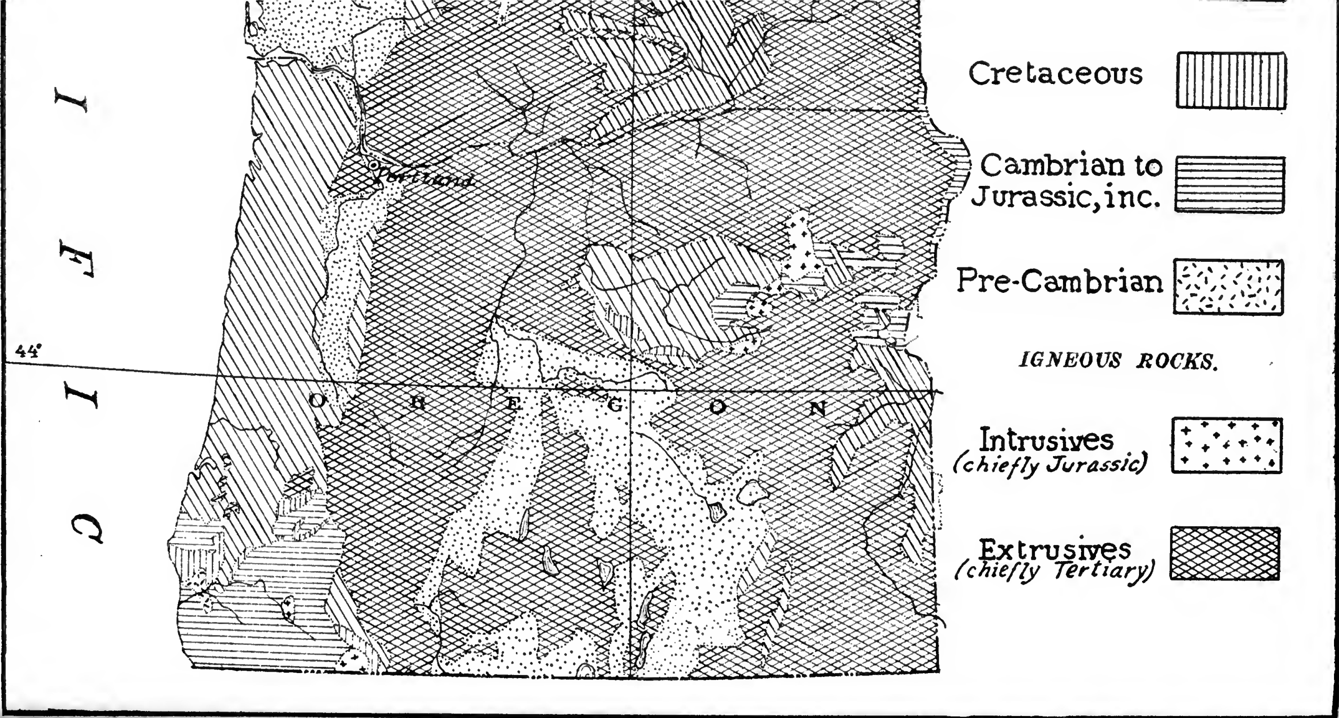

KROLL'S
STANDARD MAP
OF
SEATTLE
Published by
KROLL MAP CO.
Furnished by
PUBLICITY AND INDUSTRIAL BUREAU
CHAMBER OF COMMERCE
Seattle Wash.
Elliott Bay
Duwamish Head
LUNA PARK
West Seattle Ferry
Smith's Cove Waterway
Lake Washington Canal
FREMONT STA
IOOF Cemetery
Alki Beach Pk
29
25

PLATE XXXI.



I
F
I
C
44°
Portland
O R E G O N
Cretaceous
Cambrian to Jurassic, inc.
Pre-Cambrian
IGNEOUS ROCKS.
Intrusives (chiefly Jurassic)
Extrusives (chiefly Tertiary)

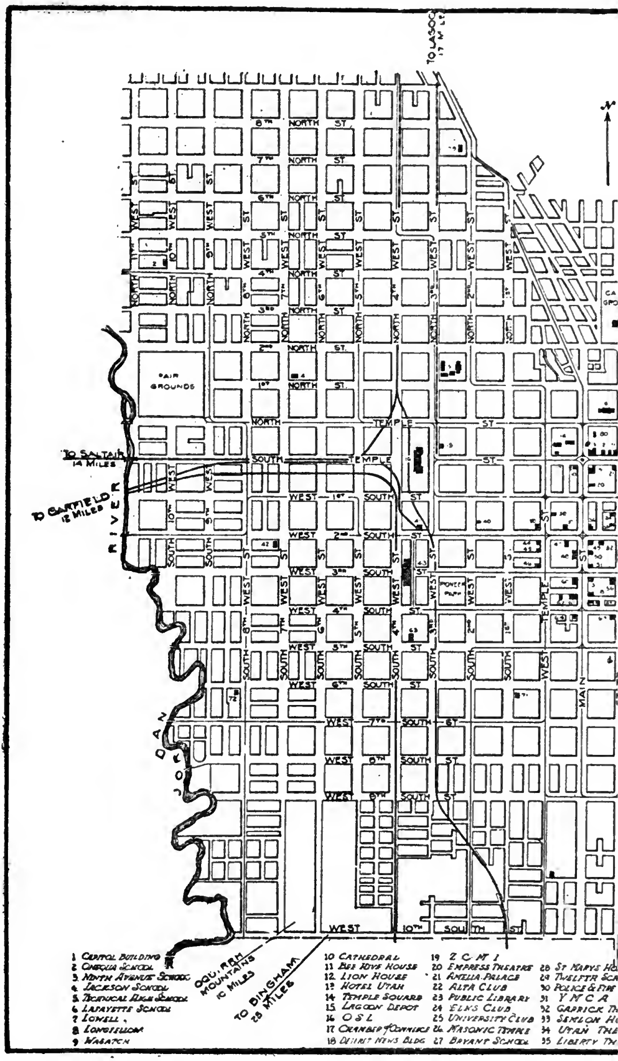
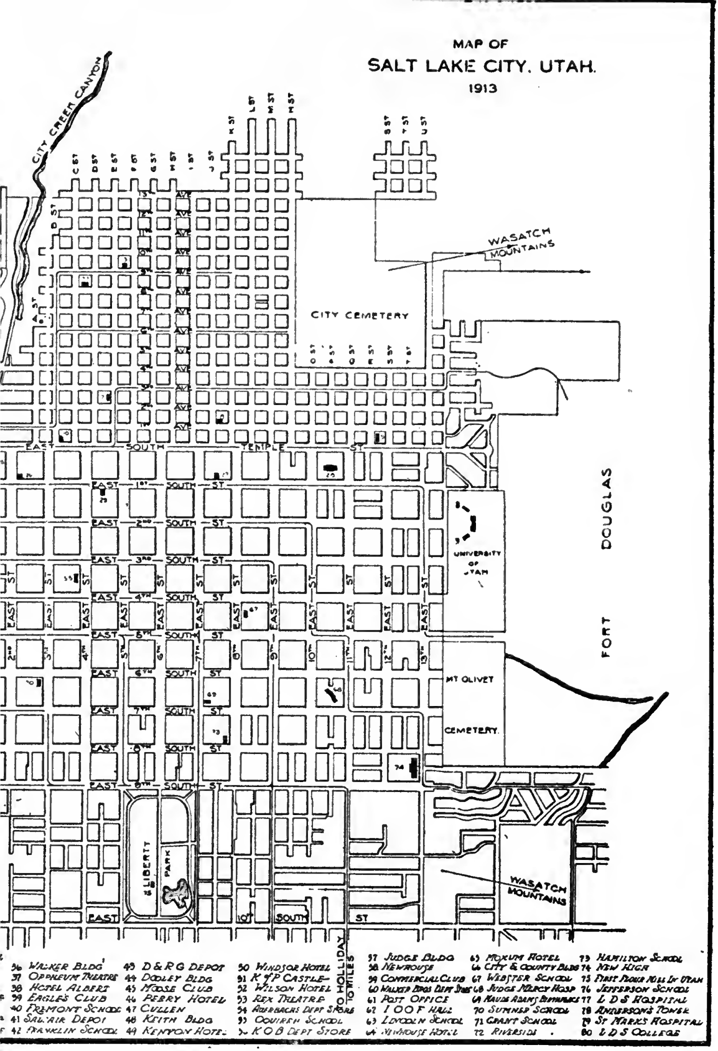
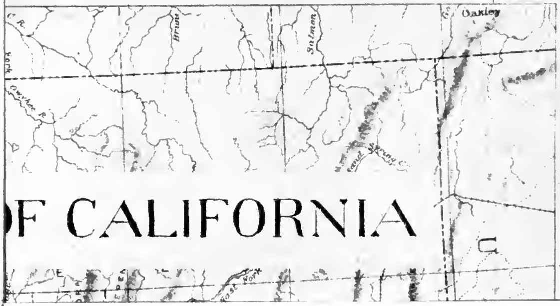
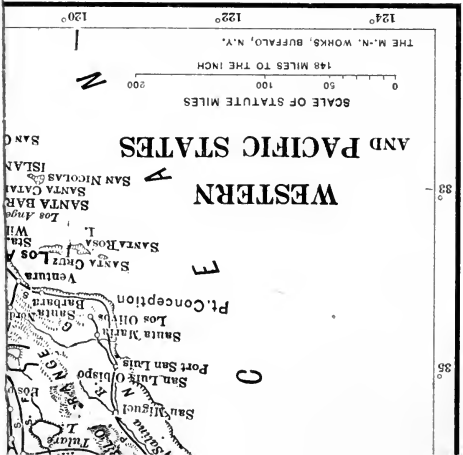

TO SALTAIR
14 MILES
TO GARFIELD
12 MILES
JORDAN RIVER
FAIR GROUNDS
NORTH TEMPLE ST
SOUTH TEMPLE ST
WEST 1ST SOUTH ST
WEST 2ND SOUTH ST
WEST 3RD SOUTH ST
WEST 4TH SOUTH ST
WEST 5TH SOUTH ST
WEST 6TH SOUTH ST
WEST 7TH SOUTH ST
WEST 8TH SOUTH ST
WEST 9TH SOUTH ST
WEST 10TH SOUTH ST
8TH NORTH ST
7TH NORTH ST
6TH NORTH ST
5TH NORTH ST
4TH NORTH ST
3RD NORTH ST
2ND NORTH ST
1ST NORTH ST
MAIN ST
WEST TEMPLE ST
PIONEER PARK
OQUIRRH MOUNTAINS
10 MILES
TO BINGHAM
28 MILES
1 Capitol Building
3 Ninth Avenue School
4 Jackson School
5 Technical High School
6 Lafayette School
7 Lowell
8 Longfellow
9 Wasatch
10 Cathedral
11 Bee Hive House
12 Lion House
13 Hotel Utah
14 Temple Square
15 Lagoon Depot
16 O S L
17 Chamber of Commerce
18 Deseret News Bldg
19 Z C M I
20 Empress Theatre
21 Amelia Palace
22 Alta Club
23 Public Library
24 Elks Club
25 University Club
26 Masonic Temple
27 Bryant School
31 Y M C A

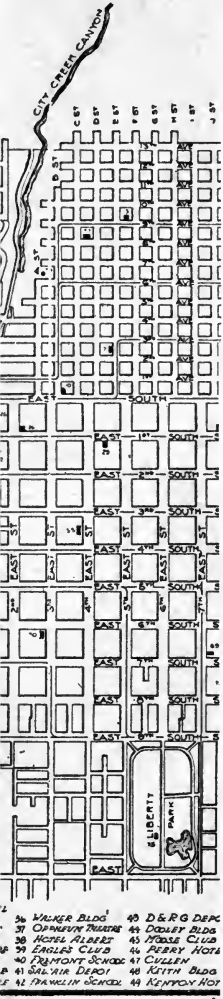
PLATE XLI.



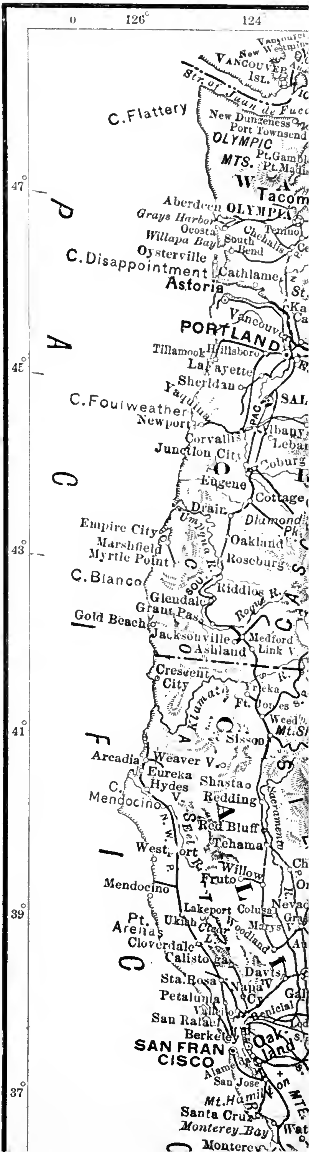
By courtesy of the Utah Chamber of Commerce, Salt Lake City.


F CALIFORNIA
Oakley
Salmon
Bruneau
Owyhee R.
42°
41°

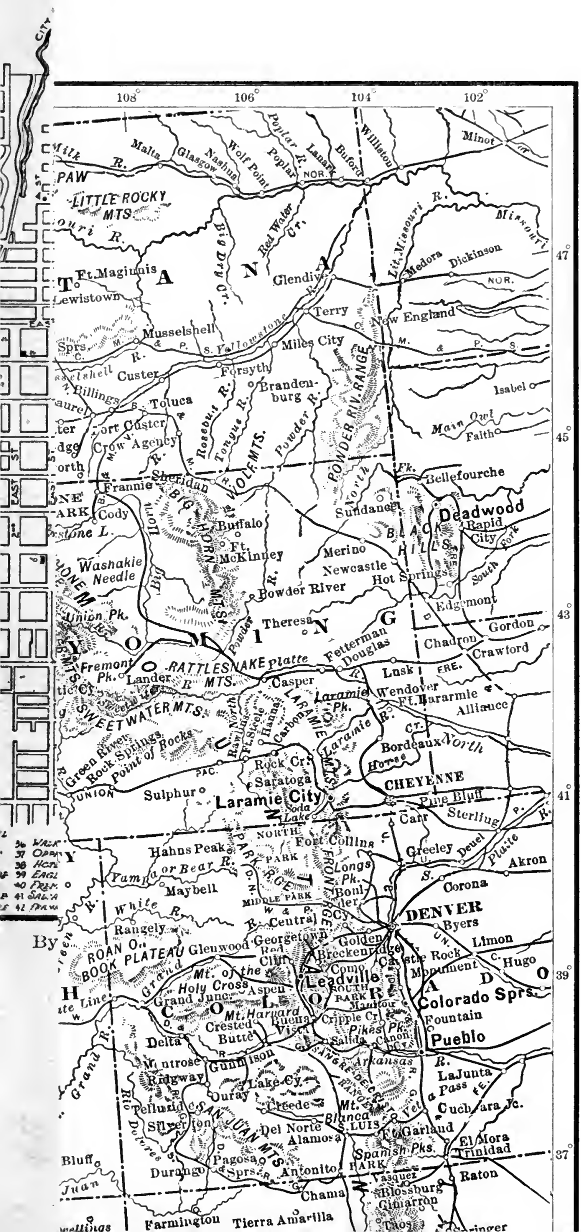

WESTERN
AND PACIFIC STATES
SCALE OF STATUTE MILES
0
50
100
200
148 MILES TO THE INCH
THE M.-N. WORKS, BUFFALO, N.Y.
124°
122°
120°
Pt. Conception
Santa Barbara
Los Olivos
Santa Maria
Port San Luis
San Luis Obispo
San Miguel
Ventura
Santa Cruz
Santa Rosa
San Nicolas



By courtesy of the




120°
118°
116°
114°
112°
110°
C A N A D A
Mt Baker
Conconully
Hamilton
Vernon
Monte Cristo
Cascade Tunnel
Rossland
Kalichem Falls
Columbia R.
Chelan
Coulee Cy.
Spokane
Castle
Wenatchee
Davenport
Cheney
Northport
Priest L.
Bonners Ferry
Sand Point
Newport
Pend d' Oreille L.
Rathdrum
Murray
Burke
CABINET MTS.
Jennings
Libby Cr.
Troy
Columbia Falls
Marion
Kalispell
Flathead L.
Heron
Thompson Falls
Horse Plains
Flathead R.
GLACIER NAT. PARK
Blackfoot
Shelby Jc.
Coutts
Sweet Grass Hills
Pacific Jc.
Havre
Assinniboine
BEAR MTS.
Marias R.
Choteau
Benton
Teton R.
Sun R.
Great Falls
Sand Coulee
Ft. Shaw
Barker
Neihart
LITTLE BELT MTS.
White Sulphur
Smiths R.
BIG BELT MTS.
Wilsons Cr.
Sprague
Ritzville
Farmington
Ellensburg
Rockford
Coeur d'Alene L.
Mullan
Clarkes Fk.
Missoula
Marysville
HELENA
Mullan
Garrison
Washtucna
Colfax
Moscow
BITTER ROOT MTS.
Philipsburg
Deer Lodge
Wickes
Boulder
Townsend
Connell
Pasco
Yakima
Pomeroy
Dayton
Lewiston
Walla Walla
Wallula
Goldendale
Columbia R.
Umatilla
Athena
Pendleton
Arlington
Heppner
Elgin
Joseph
BLUE MTS.
La Grande
Union
Mount Idaho
Grantsdale
Anaconda
Silver Bow
Butte
Gallatin
Big Timber
Bozeman
Livingston
Virginia City
Red Lodge
Glendale
ROCKY MTS.
Salmon R.
Salmon City
Dillon
Lima
Cooke Cy.
Cinnabar
YELLOWSTONE NATIONAL PARK
Baker City
Mc Ewen
Huntington
Canyon City
Snake R.
Meadows
Challis
SAW TOOTH MTS.
SALMON RIV. MTS.
Beaver Canon
Camas
Shoshone L.
Jacksons L.
Weiser
Payette
Crystal
Lost R.
Galena
Egin
Market L.
Beulah
Harney
Ontario
Evergreen
Malheur L.
Idaho Cy.
Atlanta
Ketchum
Hailey
Caldwell
BOISE CITY
Rocky Bar
Idaho Falls
Snake R.
TETON RGE.
Riverside
Harney L.
Mountain Home
Medbury
Shoshone
Blackfoot
American Falls
STEINS MTS.
Summer L.
L. Albert
Silver City
Salmon Falls
Minidoka
McCammon
Soda Springs
Warners L.
Lakeview
Owyhee R.
Bruneau R.
Shoshone Falls
Albion
Oxford
Paris
Montpelier
Malad City
Preston
Coke V.
Franklin
Bear L.
Logan
Fossil
Goose L.
Ft. McDermitt
Mountain Cy.
Willow Cr.
Quinn R.
Paradise Valley
Raft R.
Kelton
Terrace
Promontory
Box Elder
Granger
Almy
Tuscarora
Tecoma
Ogden
Piedmont
Evanston
Humboldt R.
Winnemucca
Mill Cy.
Battle Mountain
Halleck
Elko
Carlin
Wells
Cobre
GREAT SALT LAKE DESERT
Farmington
SALT LAKE CITY
Park City
Ashley
Amedee
Rye Patch
Palisade
Ft. Halleck
Franklin L.
Lehi City
Heber
Lewis
Tooele
Utah L.
Provo City
Ouray
Brown
Pyramid L.
Humboldt L.
Ruby L.
Springville
Thistle
Reno
Humboldt & Carson Sink
Vaughns
Mineral
Cherry Creek
Eureka
Tintic
Pleasant Valley Jc.
Price
Stillwater
Austin
Eureka
Leamington
Nephi
Juab
Virginia City
Dayton
Ruby Hill
Cleveland
Manti
Castle Dale
CARSON CY.
Kingston
Hamilton
Ely
Sevier L.
Deseret
Salina
Green Riv.
Walker L.
Grantville
Hawthorne
Belmont
Duckwater
Frisco
Richfield
Cainesville
Bridgeport
Bodie
Mono L.
Belleville
Candelaria
Tybo
Tonopah
Bristol
Reveille
Milford
Beaver
Bullion Cy.
Junction
Dirty Devil R.
Sonora
YOSEMITE VALLEY
Mt. Lyell
Benton
Goldfield
Pioche
Bullionville
Parowan
Silver Reef
Panguitch
Escalante
Merced
Raymond
Owens R.
Bishop Cr.
Gold Mountain
Hico
Gold Mt. Pk.
St. George
Kanab
Colorado R.
Independence
Berenda
Pollasky


108°
106°
104°
102°
47°
45°
43°
41°
39°
37°
Malta
Glasgow
Nashua
Wolf Point
Poplar
Poplar R.
Lanark
Buford
Williston
Minot
Milk R.
NOR.
LITTLE ROCKY MTS.
Big Dry Cr.
Red Water Cr.
Lit. Missouri R.
Missouri R.
Medora
Dickinson
Ft. Maginnis
Lewistown
Glendive
Terry
New England
Musselshell
Yellowstone R.
Miles City
M. & P. S.
Custer
Forsyth
Brandenburg
Billings
Toluca
Powder R.
POWDER RIV. RANGE
Isabel
Main Owl
Faith
Fort Custer
Crow Agency
Rosebud R.
Tongue R.
WOLF MTS.
Sheridan
Frannie
Cody
Bellefourche
Deadwood
Rapid City
BIG HORN MTS.
Buffalo
Ft. McKinney
Sundance
BLACK HILLS
South Fork
Washakie Needle
Merino
Newcastle
Hot Springs
Powder River
Edgemont
Union Pk.
Theresa
WYOMING
Chadron
Gordon
Crawford
Fetterman
Douglas
Lusk
Fremont Pk.
Lander
RATTLESNAKE MTS.
Platte
Casper
Laramie Pk.
Wendover
Ft. Laramie
Alliance
SWEETWATER MTS.
Rawlins
Ft. Steele
Hanna
Carbon
LARAMIE MTS.
Laramie R.
Green River
Rock Springs
Point of Rocks
Bordeaux
North
Horse Cr.
Rock Cr.
Saratoga
CHEYENNE
UNION PAC.
Sulphur
Laramie City
Soda Lake
Pine Bluff
Carr
Sterling
NORTH PARK
Fort Collins
Hahns Peak
Greeley
Deuel
Platte
Akron
Yampa or Bear R.
Longs Pk.
FRONT RGE.
Maybell
Boulder
Corona
White R.
MIDDLE PARK
Central Cy.
DENVER
Byers
Rangely
Georgetown
Golden
Limon
ROAN OR BOOK PLATEAU
Glenwood
Red Cliff
Breckenridge
Castle Rock
Hugo
Mt. of the Holy Cross
Como
Leadville
Monument
COLORADO
Grand R.
Aspen
SOUTH PARK
Colorado Sprs.
Grand Junc.
Mt. Harvard
Manitou
Crested Butte
Buena Vista
Cripple Cr.
Pikes Pk.
Fountain
Delta
Salida
Canon Cy.
Pueblo
Montrose
Gunnison
Arkansas R.
LaJunta
Ridgway
Lake Cy.
Ouray
Creede
Mt. Blanca
Cuchara Jc.
Telluride
SAN JUAN MTS.
Silverton
Del Norte
Alamosa
S. LUIS
Ft. Garland
El Moro
Trinidad
Bluff
Rio Dolores
Spanish Pks.
Pagosa Sprs.
Durango
Antonito
Raton
Vasquez
Blossburg
Chama
Cimarron
Farmington
Tierra Amarilla
Taos

By