AMERICAN MUSEUM OF NATURAL HISTORY

THE BIG TREE AND ITS STORY

GUIDE LEAFLET SERIES No. ~~41~~ 42

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OF THE

AMERICAN MUSEUM OF NATURAL HISTORY

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SOME OF THE LEAFLETS

NORTH AMERICAN RUMINANTS. By J. A. Allen, Ph.D., Curator of Mammalogy and Ornithology. *Revised edition,* February, 1904. *Price, 10 cents.*

Describes the rapidly disappearing large game of North America, such as the Bison, Elk and Mountain Sheep.

THE METEORITES IN THE FOYER OF THE AMERICAN MUSEUM OF NATURAL HISTORY. By Edmund Otis Hovey, Ph.D., Curator, Department of Geology and Invertebrate Palaeontology. December, 1907. *Price, 10 cents.*

THE BIG TREE AND ITS STORY

Guide Leaflet Series No. 42

THE FALL OF "MARK TWAIN"

THE BIG TREE AND ITS STORY

The Sequoia and the History of Biological Science*

The Story of the Big Tree as briefly told on the label

THIS Big Tree lived nearly 1400 years. It sprouted in its undiscovered mountain wilderness of the New World some 500 years after the time of Christ when the Roman Empire had only just come to an end. It witnessed the birth of Mahomet and was a good-sized tree in the reign of Alfred the Great. It was not far from 1000 years old at the time America was discovered. Three hundred and fifty years later when the pioneer life of America had spread from the eastern shores to the western and the lofty race of the sequoias had been found by civilized man (only sixty years ago), this tree was 1300 years old. It has thus held its crown steadfastly to the sky while some forty generations of men have lived and died.

A Big Tree may live 5000 years however, and perhaps longer if not destroyed by accident or disastrous climatic change. Those Big Trees of California averaging from 2000 to 3000 years old have lived no more than half, possibly only a fraction, of the time they might live. If they now escape fire and the ax, they are likely to continue to look down on the world for still other thousands of years, while some hundred more generations of men are born and die, while present weakened civilizations decline and others better founded triumph.

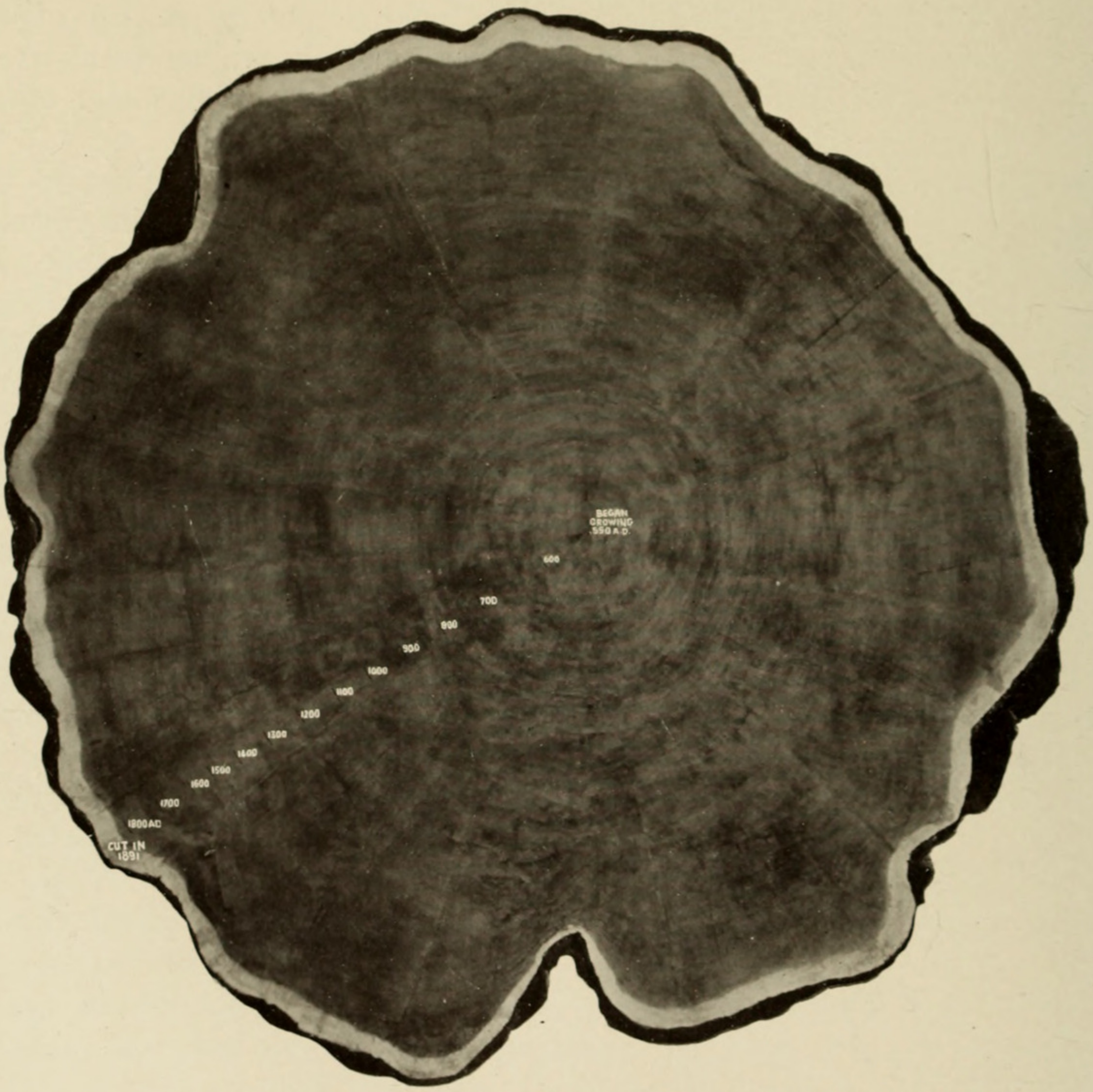
Moreover, as the centuries go on, these trees will seem increasingly remarkable, for not only are they godlike among trees in stature and length of life, but also they are as strangely out of place among the world's other trees as would be the mastodon and mammoth among our deer and oxen. They belong to an old race which flourished, especially in the Arctic regions, during Tertiary and Cretaceous times and was destroyed by the coming of the Glacial Period. But the destruction was not quite complete: two species, the Big Tree and the redwood, on the oldest, warmest parts of California's mountains succeeded in bridging the time of ice. There today—and nowhere else on the globe—the remnant of the ancient race stands. The peculiar distribution in groves separated by wide gaps was probably caused by ancient glaciers which lingered in these gaps.

The section of the Big Tree ''Mark

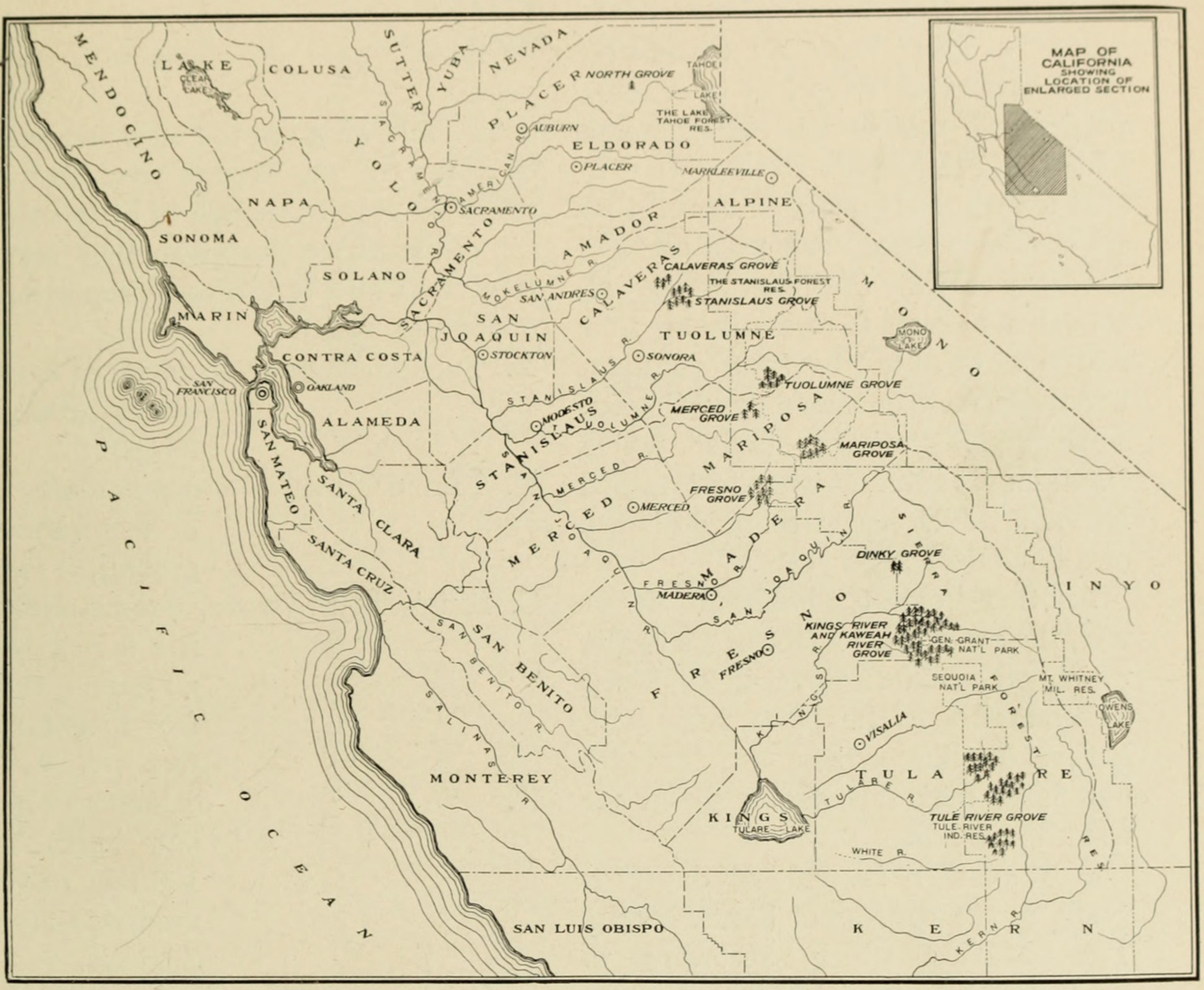
*The greater part of this leaflet was written by George H. Sherwood and appeared in Leaflet No. 8, The Sequoia. Additions and changes have been made by Henry E. Crampton and F. A. Lucas. The label is by Miss M. C. Dickerson.

Twain," shown below, was given to the Museum by Collis P. Huntington in 1891. It came from the Kings River Grove in Fresno County. The section measures 16½ feet in diameter inside the bark and was cut from the tree twelve feet above the ground. It was divided into twelve sections for shipping and after years of seasoning weighs nine tons.

The section immediately above this was presented to the British Museum by Mr. Huntington.



SECTION OF THE BIG TREE IN THE HALL OF FORESTRY



DISTRIBUTION OF THE BIG TREE

The relative sizes of the groves are indicated by the number of trees on the map. The shaded portion of the small map shows how limited is the area covered by these trees.

THE SEQUOIA

IT is fitting that the entrance to the Hall of North American Forestry should be flanked on either hand by the Redwood and Sequoia. Not only are these the noblest of trees, but they are strictly North American trees and their name perpetuates that of the old Cherokee Chieftain Seequoyah.

It is with the Sequoia, however, that we are concerned, the greatest and probably oldest of living trees, although its claims to antiquity are now and then disputed by some claimant like the Bo-tree or sacred fig of Ceylon, a scion of the tree under which Gautama Buddha sat when he attained Nirvana, which has a recorded history of a little over 2200 years.

Another ''oldest inhabitant'' is, or was, the great dragon tree of Teneriffe, which, when blown down in 1868 was ''estimated'' to be 6000 years old. Estimates, like artists, are however unreliable and this age is given for what it is worth.

Still another ancient of days, or years, is the cypress of Santa Maria, Tule, Mexico, which, according to Frederick Starr has a circumference of one hundred and sixty feet, four feet above the ground. It is however very irregular in outline and is possibly formed by the union of three trunks.

The Sequoia is not only the oldest of trees, but the mightiest and while from time to time there have been reports of rivals in Australia, yet these rivals when brought to the ultimate test, that of the tape line, have shrunk before it, leaving the Sequoia the monarch of them all.

The Kauri Pine of New Zealand, so far as size goes is a really dangerous rival, and two examples are on record having respectively diameters of twenty-four and twenty-two feet, and estimated ages of 1396 and 1280 years.

The following are the measurements of a few of the largest trees in the principal groves; though of little value for comparative purposes, they serve to give an idea of the vast proportions of the Big Trees:

A. Tuolumne Grove, diameter at 3 feet above ground, 23 feet.

B. Fresno Grove, circumference at 3 feet above ground, 81 feet.

C. King's River Grove, circumference near the ground 116 feet, height 276 feet.

D. " " " diameter (without bark) at 120 feet above ground, 13 feet 2 inches.

E. Calaveras Grove, (dead, without bark) diameter at 6 feet above ground, 25 feet, height 302 feet; circumference at ground, 96 feet.

F. " " (dead, without bark) circumference at base 84 feet, height 321 feet.

G. Calaveras Grove, (dead, without bark) diameter at 3 feet above ground, 23 feet 2 inches; height to present top 365 feet (estimated former height 400 feet).

H. " " diameter at 6 feet above ground 14.3, height 325 feet.

I. " " diameter at 6 feet above ground 12.7, height 319 feet.

J. " " diameter at 6 feet above ground 19.4, height 315 feet.

K. " " diameter at 6 feet above ground 15., height 307.

L. Stanislaus Grove, circumference at base 103 feet, height 311 feet.

M. Mariposa Grove, circumference at base 93.7 feet, circumference at 11 feet, 64.3 feet.

N. " " diameter at 6 feet, 21.4 feet, height 270 feet.

Curiously enough the decline of the big tree, like that of big states, is possibly due to the fact that it cannot stand prosperity. Shade and rich soil, factors conducive to the reproduction of most trees, are detrimental to the Sequoia; it demands sunlight and sandy soil from which leaf mold has been removed. For this reason there are practically no seedlings in the shadows of the untouched northern groves, but wherever in the southern groves lumbering and fire have opened up the forest and exposed the mineral earth, an abundance of young Big Trees is always found near seed trees, unless, of course, fire has destroyed them. The dependence of this tree for its reproduction on direct sunlight and open soil is particularly evident in the Tule River cañons where very open stands of large Big Trees have invariably seeded up the washed gravelly soil.

It is evident that under favorable soil and light conditions the Big Tree is not lacking in reproductive energy, and that under these conditions it is holding its own in competition with other trees. Although it is but meagrely represented in the few scattered groups now preserved, the species seems still to possess that strong inherent reproductive power that permits survival of the fit.

And yet, seen by itself, the Sequoia is not a particularly fine or beautiful tree; it is too largely trunk. To appreciate its true grandeur it must be seen in company with its fellows, when the eye travels from one massive trunk to another, each towering upwards to be lost in a mist of foliage.

Once spread over a large part of the Ancient World the Sequoia is now making its last stand on the Sierras of our western coast, where it is confined to a few isolated groves found at altitudes of from 4000 to 8000 feet above the sea. Thirty-one of these groves or groups are now known, numbering from half a dozen to several thousand trees each, occupying altogether an

THE STUMP OF "MARK TWAIN"

Ninety feet in circumference

area of only about fifty square miles. This area is bounded on the north by the American River, and on the south by Deer Creek, and the total distance from the most northerly group (North Grove) to the most southerly (Tule River Grove) is only 260 miles. The King's River and Kaweah River Grove is the largest both as to area and number of trees. The extent of this district is four or five miles in width, and eight or ten miles in length. It has a variation in altitude of 2500 feet. It is an interesting fact that as one proceeds from north to south the Big Trees flourish at higher and higher altitudes.

As might be inferred from its age the Sequoia is tolerant of injuries and its recuperative powers great, so that it recovers from damage done by fires, ancient and modern, that have destroyed many other trees. Our own specimen has suffered somewhat, but Prof. Dudley has recorded one whose troubles date back to 245 A. D., at the age of 516 when a forest fire inflicted a wound, it took 105 years to cover. The next 1200 years were years of peace, but in 1441 A. D., at 1712 years of age, the tree was burned a second time in two long grooves one and two feet wide, respectively. Each had its own system of repair. 139 years of growth followed, including the time occupied by covering the wounds. 1580 A. D., at 1851 years of age, occurred another fire, causing a burn on the trunk two feet wide, which took 56 years to cover with new tissue. 217 years of growth followed the burn. 1797 A. D., when the tree was 2,068 years old, a tremendous fire attacked it, burning the great scar eighteen feet wide. 103 years, between 1797 and 1900, had enabled the tree to reduce the exposed area of the burn to about fourteen feet in width. It is to be noted that in each of the three older burns there was a thin cavity occupied by the charcoal of the burned surface, but the wounds were finally fully covered and the new tissue above was full, even, continuous and showed no sign of distortion or of the old wound.

The wood yielded by the Big Trees while vast in quantity is rather indifferent as to quality, being light, soft and brittle, though it does possess one good quality, that of durability in contact with the soil.

The methods of lumbering the Big Trees are wasteful in the extreme, more or less, of necessity. These huge trees are usually shattered in falling, but when they are not, logs of ten or twenty feet in diameter are a little too large to handle, so the fallen Sequoia is by the use of dynamite reft into pieces large enough to handle, a process that wastes about half the timber in a tree. Still, as Mr. Huntington writes, "3000 fence posts, sufficient to support a wire fence around 8000 or 9000 acres, have been made from one of these giants, and that was only the first step towards using its carcass. 650,000 shingles, enough to cover the roofs of 70 or 80 houses, formed the second item of its product; finally there still remained hundreds of cords of firewood which no one could use because of the prohibitive cost of hauling the wood out of the mountains."

Thus far the Sequoia in general—our own particular tree which came from the Kings River Grove, was felled in 1891 and literally cut off in the 1341st year of its growth. This to be sure is a good old age, as things

TREE SHATTERED IN FALLING

go nowadays, but Dudley speaks of a tree "of moderate age" that when cut in 1900 had reached an age of 2171 years, and Huntington "counted the rings of 79 that were over 2,000 years of age, of 3 that were over 3,000 and of one that was 3,150," a sturdy sapling at the time of the Exodus.

Compared with this, our own tree was in the full vigor of middle life, though it had lived through many of the most eventful periods in the history of the world: the most eventful so far as we are concerned. It witnessed the death of old nations, the birth of new and might well be considered as ancient when Columbus discovered America and the history of the New World really began. And what progress has this, our Sequoia, seen during its long career! When it began, steel, steam, electricity and all that they make possible, were unknown factors in the progress of civilization. And as for that combination of belief, theory and knowledge of living things that we term biological science, our Sequoia saw all save its birth with the writings of Aristotle. And as this science lay dormant for many years it really saw all worth seeing.

To Prof. Ellsworth Huntington belongs the credit of having found a scientific use for the large stumps of the Sequoia. As is well known, in regions where there is a marked difference between the climate of summer and winter, whether there be heat and cold or moisture and dryness, the years of a tree's life are marked by rings of annual growth.

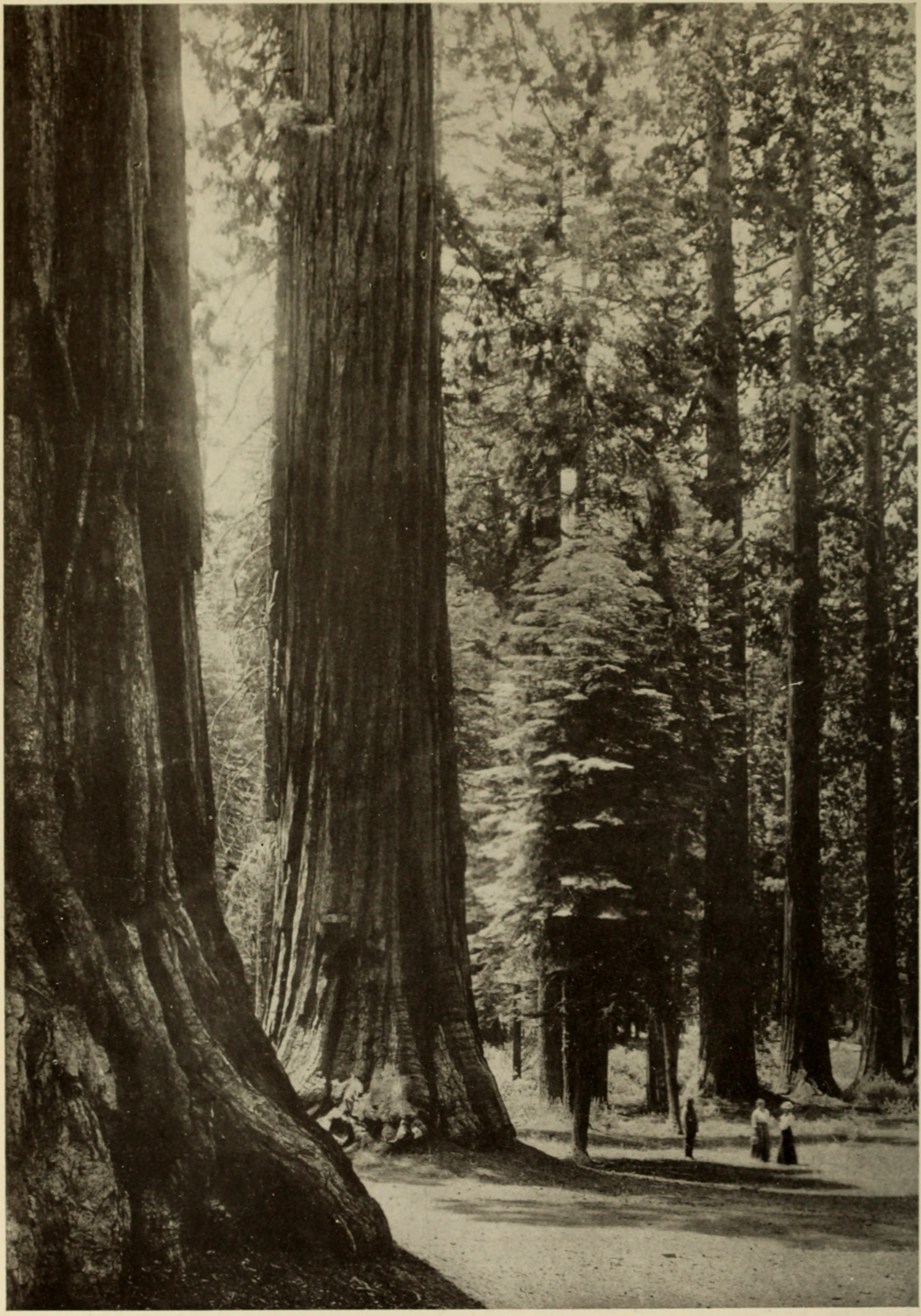
Moreover the width of these rings shows whether the year was favorable or unfavorable for growth, a thick ring, for example, indicating a moist season, a thin one a dry year.

Owing to the great age attained by these trees they must have passed through many vicissitudes of climate, and if there have been appreciable changes of climate during a period of a thousand years, they should be recorded in the Sequoia by a succession of wide or narrow rings. So reasoned Prof. Huntington.

And this reasoning is borne out by the facts; knowing certain changes that have taken place in the last thousand years or so, indicated by abandoned cities, shrunken lakes and the transformation of fertile plains into deserts, he was able to show what changes had taken place during historic times and fix the dates of long periods of drouth. Now by counting the rings of the Big Trees and noting the favorable or unfavorable conditions recorded by them, Prof. Huntington was able to show that the records of the Sequoia corresponded with the known facts of history.

This method of research has been carried into geologic times, and by observation of the rings on the trunks of fossil trees, it has been possible to obtain an idea of changes of climate that occurred long ages ago.

When the tree was a mere sapling, Europe was overrun by the Goths, Vandals and Franks, and a state of almost universal war prevailed. About twenty years later Mahomet was born and then followed the establishment of the Mohammedan religion, which, during the next one hundred and fifty years, reached the zenith of its power and threatened to overrun the whole world. This Saracenic invasion was checked at the battle of Tours (732),



VIEW IN MARIPOSA GROVE
"General Grant," "General Sherman" and "The Four Guards."

VIEW IN CALAVERAS GROVE
"Mother of the Forest," in background, 84 feet in circumference.

FELLING THE TREE

in which the Franks under Charles Martel overwhelmingly defeated the Mohammedans. The beginning of the next century was marked with the crowning of Charlemagne on Christmas day, 800. This monarch made a noble effort to educate his people by establishing a school at his court and inviting thither the few learned men of his time.

The climatic conditions in California during A. D. 800 and the year preceding must have been very favorable for the growth of our tree, which had already attained the size of a large elm. Its growth during these two years, indicated by the large rings, was phenomenal.

During this century occurred also the effort of King Alfred to establish schools in England. The hardy Norsemen began their bold voyages in quest of treasure and adventure, colonized Iceland in 874, discovered Greenland (981), and pushing farther westward probably sailed down along the eastern shore of America.

The Crusades, begun in 1096 and continuing for almost 200 years, brought the various European peoples into intercourse, which resulted in exchange of ideas and helped prepare the popular mind for the discoveries which were soon to follow.

The first half of the thirteenth century saw the founding of the universities. First, the University of Paris (1200), which became the center of theology; a few years later were founded the University of Bologna, famous for law, and the University of Padua, which attracted the greatest students in medicine. In England, Oxford University was founded in 1249.

The fifteenth century brought those marvelous discoveries which were of so much importance in the advancement of civilization, and which contributed to the growth of science. Printing with wooden block type was introduced by John Gutenberg in 1438, and his invention was followed in 1450 with the use of metal type, making the general dissemination of knowledge possible.

Columbus' discovery of America (1492) was followed by Magellan's famous trip around the world to the westward (1519-1522), during which he discovered the Philippines; and about the same time Cortez conquered Mexico. The New World was soon explored for its reputed hidden treasures, and astronomers' search of the heavens for an orderly movement of planetary bodies resulted in the elaboration of the system of Copernicus (1543). Keppler announced his laws of planetary motion at about the same time (1609), and in the latter part of the seventeenth century Newton enunciated the law of gravitation. The increasing freedom of thought was expressed in the American and French Revolutions.

The rapid course of invention during the nineteenth century is too familiar to require detailed mention. The period of the tree's growth, however, is represented by only a few inches in its total diameter.

Not only the scientific side of all branches of biology, but also the philosophical or speculative side, has been developed during the old age of the tree, or during the last 300 years. In fact, modern zoölogy and inductive methods may be said to have begun with William Harvey in the seventeenth century.

It is true that when the tree began its life, men had ideas and conceptions of the principles underlying nature, but most of these were crude and inaccurate, based on mere hearsay or tradition, and differing but little from those held before the beginning of the Christian era.

The science of anatomy had been at a standstill since the time of Galen (A. D. 130). This brilliant anatomist, it is true, advanced the study of anatomy by his careful dissections of apes and some of the lower animals, and he also wrote extensively on physiology; but accurate as some of his observations were, his errors, particularly in physiology, were many. His works, however, remained authoritative for fully 1400 years; his statements overruled the demonstrations of nature, and he was so reverenced that whoever had the courage to dispute him was liable to persecution and ostracism.

Physiology was not materially different from metaphysics, and both were affected with superstition. The ancient belief that the body contained *four humors*—"blood," "phlegm," "yellow bile," "black bile"—was held, and Galen had added to these a "pneuma," which pervaded the whole body, mingling with the humors and supporting life. The proper mixture of four elements—heat, cold, wetness and dryness—constituted the normal individual. The administration of drugs was in accordance with this belief. Systematic zoölogy did not exist. There was no true conception of species, no accurate description of animals, and no adequate system of classification. The naturalists were merely compilers and copyists of Aristotle and other ancient writers, a most curious feature of their point of view, even as late as the early part of the eighteenth century, being their readiness to rely on what was said or written and their slowness to observe for themselves. The modern attitude of scientific doubt seems not to have occurred to them and, like Sir Joseph Porter, they never thought of thinking for themselves at all.

The philosophical or speculative in biology was retained by the clergy, almost the only persons really interested in the conservation of documents, and as a class the only ones able to read and write.

Some of the Greeks had given explanations of the succession of organisms on the globe and Aristotle, born 384 B. C., believed that the first animals arose from the ocean, and that low forms of life were constantly springing into existence by spontaneous generation, a fallacy that was not completely eliminated from biology until the nineteenth century.

Aristotle also perceived the principle of adaptation in nature, and considered the universe as the result of Intelligent Design. Such ideas of the Greeks had a marked influence on Christian thought for many centuries. Augustine (fifth century) believed that a living substance had been made by the Creator, and that from this had developed all the diverse organisms of the present time. Two other famous churchmen advocated similar views, Erigena in the ninth century, and Thomas Aquinas in the thirteenth, each the foremost scholar of his day.

But naturally a wider and deeper knowledge of biological phenomena was necessary before philosophical biology could have a strong foundation. Hence the philosophy of zoölogy in its modern form, dates from the awakening of science in the seventeenth century.

From the time that the Big Tree was a mere seedling up to the time that it measured fully 13 feet in diameter, there was scarcely a single discovery in the field of natural science worthy of record. One event, however, which occurred when the tree measured only 12 inches in circumference is of some interest. Silk was one of the treasures obtained from the Far East. Its production was carried on solely by the Chinese, who jealously guarded the silkworms and their eggs. The story is that two monks travelling in China succeeded in smuggling some eggs out of the country by concealing them in a hollow cane, and brought them into Europe. In the warm climate of the south the eggs developed into strong healthy worms. From such a humble beginning arose the extensive silk industry of southern Europe.

The stagnation of the study of anatomy for more than a thousand years was due to an extravagant admiration of Galen, over-confidence in his writings, and the failure of men to make observations for themselves, or to believe what they saw with their own eyes. Vesalius (born in 1514) was the first anatomist to assert independence, and to him is due the credit of laying the foundations of modern anatomy. Vesalius dissected the human body and accurately described what he found. He established a school of anatomy at Padua, and among his students was Fabricius, the teacher of Harvey, who startled the world in 1619 with his discovery of the circulation of the blood. This discovery, which revolutionized the study of physiology, and gave new impetus to the study of anatomy, met with bitter opposition from the followers of Galen, but Harvey defended his views with success.

The opposition to Harvey set men to thinking, and investigation began. All forms of life were studied with all available means. Harvey, from an investigation of the development of the chick, laid the foundations of the study of comparative embryology, one of the four great supports of the theory of evolution; and he also propounded the theory of *Epigenesis*, a theory vigorously debated by philosophers for many years. The compound microscope, already mentioned, was applied to the study of organisms by Leeuwenhoek and Malpighi. The former demonstrated capillary circulation (1690) and discovered red blood corpuscles, infusoria and spermatozoa (1677). These spermatozoa were regarded by some as parasites of animal bodies, by others as embryos which only needed nourishment to develop into an adult form. Malpighi applied the microscope to the study of the chick, and his observations led him to announce the theory of *Preformation*, which was opposed to the epigenesis of Harvey.

The preformationists contended that a given organism contained within its sperm or ovum all the descendants of that individual with all organs and parts fully formed. In other words, embryos were only miniature adults, and were contained one within another like a series of Chinese boxes, in successive grades of size. The doctrine of epigenesis held that each sperm or ovum contained a relatively *homogeneous* living substance which became differentiated by gradual changes into a mature individual resembling the parent. Preformation was supported by Spallanzani, Bonnet, Haller and even Cuvier. Its absurdity was shown by the work of Wolfe (1759), who firmly established the doctrine of epigenesis as it is understood to-day.

The stimulus given to research by Harvey's discovery, the intercourse and exchange of views among men, and the voyages to all parts of the world resulted in an accumulation of a great mass of facts, which were of little value unless classified. Conrad Gesner (in 1551-1558) had given a complete bibliography of zoölogy, and was one of the most important of the earlier naturalists. About a hundred years later Ray, an English zoölogist (1670), made an attempt to establish a "system of classification," but he had not the true conception of species. It remained for Linnæus to complete a system which served its purpose so well that it has remained practically unchanged to the present time.

Linnæus (1707-1778) was far and away the leading naturalist of his day, and his system of classification in which plants and animals were placed in groups according to clearly designated characters, was a great advance over any scheme previously devised. His great service to science, however, was the perfecting of the binomial system of nomenclature, or method of definitely naming animals and plants. Up to his time animals were known by brief descriptions of their more evident characteristics written in Latin, as that was the universal language in science, and men of science (the term scientist had not then been devised). This descriptive method did very well so long as the number of known animals was small, but as the tide of commerce of the eighteenth century brought to Europe thousands of species before unknown, it became cumbrous. To overcome the difficulty Linnæus devised the plan of giving to each animal two names; the first, a general or generic name which should indicate the particular group to which the animal belonged; the second, a special or specific name to apply to that kind of animal alone. To fix the name still more definitely the name of the first describer of the species is now attached to the scientific appellation.

The Sequoia, for example, is known as *Sequoia washingtoniana* (Winslow), though, unfortunately this particular species does not offer a good, clear illustration of the principles of binomial nomenclature.*

Buffon (1707-1788) was the first of the great founders of the modern doctrine of descent with evolution. He supposed, like Bonnet, that the main groups of animals had arisen in a linear series, and he believed that the direct action of the environment brought about structural modifications that were inherited.

Erasmus Darwin (1731-1802),

*The name *Sequoia gigantea* is sometimes applied erroneously to the Big Tree, the correct name being *Sequoia washingtoniana* (Winslow) Sudworth. The question is considered at some length by Sudworth in Check List of the Forest Trees of the United States, Washington, 1908, pages 28, 29.

Briefly stated *Sequoia gigantea* is a synonym of *Sequoia sempervirens*, the Redwood and if for no other reason the rule "once a synonym always a synonym" would prevent its being used for the Big Tree.

grandfather of Charles Darwin, was another of the early evolutionists. He pointed out, among other things, that the universal struggle for existence involved plants as well as animals. Unlike Buffon, he emphasized the indirect or responsive modifications produced by the environment, thus anticipating Lamarck, but like his predecessor, he assumed the inheritance of such changes.

It was Lamarck (1744-1829), the contemporary and fellow-countryman of Cuvier, who was the first to express the blood-relationship of organisms, as is done to-day, namely, by means of the *genealogical tree.* This eminent anatomist and investigator held views much in advance of his time. He rejected entirely the fixity of species, and believed that all animals now existing had been derived from a common stock by a process of gradual change. In one place he affirms that "Nature needs only matter, time and space to produce all changes." The two factors which he believed most important in producing these modifications were the reaction of the organisms to their environment and the inheritance of the modifications resulting from this reaction and of the effects of use and disuse of organs.

Lamarck's theory was partially smothered in the ridicule which Cuvier heaped upon it. Cuvier was a firm believer in the immutability of species and his great authority in the biological field made him a powerful dictator of public opinion.

Among the naturalists of the eighteenth century, Goethe and Cuvier are conspicuous. The former (1796), although a great poet, made valuable contributions to science. He introduced the word "morphology" as a designation for the study of form or structure, and was the first to advance the *vertebral theory* of the skull, that is, that the skull represents modified vertebræ. He recognized the significance of vestigial organs, such as the gill slits in human embryos, hinder appendages in whales, etc., and predicted the discovery of the premaxilla in man—the supposed absence of which was considered to be a character which distinguished man from the apes.

It was, however, Georges Cuvier (born in 1769), the famous French naturalist, who was the recognized leader in zoölogical science for more than half a century. He stands as a striking example of a man who was remarkably correct in his observations of nature, but equally incorrect in his generalizations. His work on the Tertiary mammals of France marked the beginning of palæontology. He was the first to point out the resemblance between "*Anchitherium*" and the modern horse, a fact which is one of the strongest evidences of evolution. He was a preformationist and believed in *Catastrophism* (the theory that the earth as it is at present is the result of successive catastrophes), rather than *Uniformitarianism* (the belief that the present condition of the earth has been brought about by a gradual, uniform change). The work of Cuvier in comparative anatomy is also important, and he is called the founder of this science. He recognized the principle of correlated growth, and in "Le Régne Animal" improved the classification of animals.

The last century of our tree's life

was remarkable for the discoveries in all branches of natural science. De Blainville (1839-1849) and Lyell (1797-1875) made valuable contributions to palæontology and geology. Lyell's "Principles of Geology" (1830-1833) dealt a death blow to catastrophism, and is a work equal in importance in its own field to the "Origin of Species" in biology.

Milne-Edwards (1800-1818) enunciated the principle of the physiological division of labor. Von Baer (1828) announced the law that bears his name, namely, "individual development is a recapitulation of race development." Schleiden and Schwann (1838-1839) described cells in plants and animals, and propounded the cell theory. Valentin (1839) named the "nucleus," and was the first to speak of the "cell theory." Purkinje and von Mohl (1840) named the living substance of the cell *protoplasm*, a term in universal use to-day. De Barry (1843) observed the union of sperm and ovum. Kölliker (1846) demonstrated that spermatozoa develop in the tissues of the testes. Owen (1846) pointed out the difference between *homologous organs*, for example, the arm of man, fore limb of horse, and wing of bird, organs which are formed on the same structural plan, and *analogous* organs, for example, wing of bird and wing of butterfly, organs differing entirely in structure, but performing the same function.

Remak (1850) described "three germinal layers," and Huxley (1859) homologized them in the lower animals.

Rapid strides were made also in systematic zoölogy and in zoö-geography. The relations of the lower animals were worked out by Leuckart, Vaughn, Thompson, Dujardin, Agassiz and a host of others.

Expeditions were sent out to explore the earth and the sea. Famous among these are the voyage of the "Beagle," on which Darwin served and did some of his earliest biological work; and the voyage of the "Rattlesnake," on which Huxley was Assistant Surgeon.

In 1859 Darwin published his "Origin of Species," a book which is universally admitted to have had more influence on human thought than any other work of the century.

Darwin's theory of the "Origin of Species" may be stated briefly as follows: All species tend to vary. No two individuals of the offspring of a pair are exactly alike. On account of this variation in structure or function, certain individuals are better able to thrive than their fellows. These animals transmit these characters to their offspring, which in turn survive in the struggle with their fellows. Thus nature eliminates those variations which are disadvantageous to the organism, each individual being tested in its struggle to maintain its existence. The accumulation of these favorable variations through many generations is supposed to produce an organism quite different from the original stock, or, in other words, a new form.

Few works have been constructed with more care and skill. For more than twenty years Darwin collected facts from all available sources, and made innumerable observations himself. The evidence in support of his theory was drawn from many branches of natural science: comparative anatomy, embryology, palæontology and zoö-geography. So numerous were the facts that he presented, and so careful was the exposition of his theory, that in less than twenty years it became the working hypothesis of nearly every biologist.

Long before Darwin's time the resemblance between groups of animals had been recognized, indeed, even by Aristotle and others among the ancient Greeks, and many new facts made known by investigators from Vesalius onward emphasized the significance of these resemblances. In 1620 Bacon published "Novum Organum," in which he advocated the unity of nature. Descartes (born, 1596) attempted to explain the universe on natural laws. Leibnitz (born 1646) advanced a theory of the continuity of organisms. The term "*evolution*" was introduced by Bonnet as a name of the process by which organisms had become differentiated. He expressed this relationship by introducing the idea of a "scale of beings," which formed the links of a chain. This conception has persisted up to the present time, in the expression "the missing link."

In 1844 a book called "Vestiges of Creation" appeared and caused quite a sensation. That this was published anonymously by its author, Robert Chambers, is significant of the attitude of the public toward the idea of evolution.

Naturally the "Origin" met with a storm of opposition, but it was vigorously defended by many new-won adherents among whom was Huxley. He it was who perhaps more than any other scientist secured for the "Origin of Species" a fair and impartial consideration and thus aided the cause of truth.

Among the earlier champions of Darwin's theory, were Lyell, Tyndall, Hooker and Spencer.

The last decades of the great tree's life witnessed astonishing developments in all branches of zoölogy. The number of known species has increased enormously owing to the enthusiasm of collectors in all parts of the world, and especially through the work of expeditions sent out by governments and museums, one of the most noted of such expeditions being that of the English vessel, the "Challenger" (1872-1876), which brought back more than 8000 species new to science. Institutions established by civilized governments all over the world, like the United States Fish Commission, organized by Professor Spencer F. Baird, as well as the National Museum and Geological Survey, have made great contributions to pure and applied science. The famous seaside laboratory founded at Naples by Professor Anton Dohrn in 1870 is a prototype of those at Woods Hole, Plymouth and Roscoff, all of which have materially aided in the advance of biological investigation.

Palæontology too has had a rapid growth. Cope, Marsh and Osborn in this country discovered and described more than a thousand new species of vertebrates, many of which are on exhibition in the Hall of Fossil Vertebrates. In invertebrate palæontology James Hall was one of the leaders, and a large part of the material upon which he did his monumental work is displayed in the Geological Hall.

Zoö-geography, one of the foundations of evolutionary doctrine began with Wallace's publication in 1876 of the "Distribution of Animals," the first complete treatise in this department, and the base for all further work.

A complete revolution in the theory and practice of medicine has been brought about through the application of biological knowledge. The studies of Louis Pasteur upon yeast and its life were the beginnings of bacteriology and protozoology, which deal with the minute organisms causing numerous diseases of man and of lower animals. What biologists have discovered about the causes of malaria, yellow fever, small pox, and a host of other maladies has done more to alleviate human suffering than all of the researches made prior to the time of Pasteur.

Since Darwin's time, the all-inclusive doctrine of evolution has become better understood and more clearly formulated, especially as regards the central process of heredity. For a long time after the "Origin of Species" appeared, the main question in dispute was concerned with the supposed inheritance of modifications acquired during the lifetime of an individual. Spencer was the chief representative of those who adopted the Lamarckian dictum that such was the procedure in the transformations of successive generations. Those who upheld Darwinism contended that only the congenital factors were effective, and that the transmission of individually acquired characters was unlikely on *a priori* grounds. The work of many investigators on the minute structure of the cell, and especially that of Weismann in the last decade of the tree's life, provided definite evidence that there was a concrete physical basis of heredity which followed such a course during the lifetime of an individual and in the production of offspring as to render the Lamarckian interpretation untenable. In the nuclei of all cells including the germinal elements is the deeply-staining substance called *chromatin*, which is derived equally from the two parental germs, and which is transmitted during the course of development to the germ-cells from which the offspring of the next generation arise, in a continuous and uninterrupted course. The chromatin bears the hereditary qualities of the species, in a way that is unknown in all of its details, but the fact remains that it does. Even the varied qualities of sex can be assigned to a specific number of the chromatin bodies. The results of breeding experiments with plants and animals, like those obtained even in Darwin's time by the monk, Gregor Mendel in the obscurity of his Austrian monastery garden, are in entire accord with the fundamental tenets of Weismannism. In brief, such facts and many others lead inevitably to the conclusion that the essential things in inheritance and in evolution are the congenital qualities, and that the environment has only a limited value in a quantative way.

The whole doctrine of evolution, and its principal statement relating to heredity, are extremely important for all those subjects which are founded upon the study of the nature and biological relations of organisms, including man. Every department of human thought and life, social, religious, intellectual and industrial, has been profoundly influenced and modified by the marvelous discoveries of science which have occurred even since this Sequoia attained gigantic proportions.

What progress, material as well as

mental, has our Sequoia witnessed not merely in its life time, but in a small fraction of its life time. And what may the seedlings expect to behold, provided their career is not cut short by fire or ax? Which of Wells' two solutions of the World Problem will prove to be correct? Will mankind pass through existing conditions and, purged as by fire, rise to heights now undreamed of, or in the conflicts of jealous powers and principalities and the equally bitter conflicts of labor and capital under stress of economic conditions will existing civilization come crashing to an end and from the ruins of the present a future and better civilization evolve in the slow march of centuries to come? The Sequoia of the days to come will have lived through it all.*

*Written in February, 1914.

NEARING THE END

A Logging Camp in a California Forest.