CHAPTER XVII.

DISTRIBUTION OF PLANTS.

CONDITIONS INFLUENCING PLANT LIFE.

209. Importance of Air. — Without air, both plants and animals die. Carbon dioxide from the air is taken into plant cells and changed to carbon and oxygen, the carbon being built into the tissues. A large portion of the plant tissue is made of carbon, supplied mainly by the air.

Air is present everywhere on the earth's surface, even in soil and water (p. 180); therefore, as far as this vital substance is concerned, it is possible for plants to be present on every part of the earth's surface. The fact that there are some places where plants are absent, — for example, underground, in the deep sea, and in central Greenland, — is proof that there are other things of vital importance.

Summary. — *Air is of vital importance to plants, supplying most of the carbon, of which a large part of plant tissues is made.*

210. Importance of Temperature. — Plant activity is impossible where the temperature is below freezing, for then the liquid parts are frozen and cannot move about. In the ice-covered interior of Greenland, therefore, where the temperature is always below freezing, all plant life is absent. Many plants are not injured by being frozen for part of the year, but are able to resume growth when the frost is gone.

All plants, even the lowest forms of bacteria, are killed when subjected for a short time to temperatures near the boiling point. This is because such heat causes changes in their tissues which destroy their power of action.

FIG. 486. — A view in Greenland, showing the prevailing bare rock surface with lichens clinging to it. Small areas of soil are present in the depressions between the ledges. There is a group of Eskimo women in the middle of the picture.

FIG. 487. — Open forest of the East late in the fall. Notice how short the lower limbs have become because of the lack of light when in full leaf.

FIG. 488. — A view in the forest of large trees in western Washington. A rank growth of ferns thrives in the forest shades.

FIG. 489. — Negro woman gardening in the tropical zone.

FIG. 490. — A banana tree in the tropical zone.

FIG. 491. — A view of the savanna of Africa, a negro village in the foreground.

FIG. 492. — A banyan tree, in tropical India, with roots descending from the lower branches.

FIG. 493. — A cocoanut palm.

FIG. 494. — The dense tangle of the tropical forest. The opening in the middle is where a path extends through the forest.

A low form of plant lives on the lower parts of the Greenland glacier, being frozen all the year excepting a few weeks in summer, when it lives in ice-cold water. Certain lowly plants thrive in the hot springs of Yellowstone Park, whose water, though hot enough to destroy most plants, is not up to the boiling point. These instances show that plants may become adapted to very unfavorable surroundings. They could not live under any other conditions; yet no other plants could live where they do.

Summary. — *Even the lowest plants are unable to live where the temperature always remains below freezing, or where it rises to the boiling point even for a short time; but many survive a period of freezing, and some live in the water of hot springs.*

211. Importance of Sunlight. — Sunlight is also of vital importance to plants, for by its aid the green cells change carbon dioxide to carbon and oxygen. The branches and leaves of plants are, therefore, arranged to secure air and sunlight; and many forest trees lose their lower limbs (Fig. 487), or even die for lack of light.

Plants growing in dark places, like potatoes sprouting in a cellar, are weak and tender, and their lack of color shows the absence of the important chlorophyl of the green cells. It is because of absence of sunlight that no plant life exists on the ocean bottom.

Yet some low plants do grow in darkness. For example, a weird-looking, pale white fungus lives in coal mines and caverns, where no ray of sunlight has ever entered. This is another instance of how life may adapt itself to very unfavorable surroundings.

Summary. — *Light is needed for the change of carbon dioxide to carbon and oxygen; therefore very few plants live in dark places.*

212. Importance of Water. — No plant can live without water; for it circulates among the tissues, bearing food and other materials from one portion to another, as man's blood does. In trees this plant blood is commonly called sap; and when it rises in spring, the plant awakens from its long winter sleep and bursts into leaf and flower.

Plants living in water have a supply ever at hand; but most land plants obtain water from the soil, though in damp tropical forests some species secure enough from the air. If the soil dries, plants wither; but in arid and desert regions plants have fitted themselves to survive long periods of drought.

Summary. — *Water, needed for the sap of plants, is obtained from the water, air, and soil.*

213. Importance of Soil. — Soil is not necessary to plant life. Water plants, both fresh and salt, may secure all necessary substances from the surrounding water. Thus many float freely about, while others have roots solely for the purpose of anchoring themselves in place. Some land plants, called *epiphytes*, are also able to live without roots, securing all necessary substances from the air. The great majority of land plants, however, depend on the soil for most of their water, part of their food, and for anchorage.

The plant food in the soil is of so great importance that, where it is almost absent, as in sand, the soil is called sterile, and most species of plants do not flourish. Plants remove so much mineral matter from the soil that, where crops are raised year after year, it is necessary to use a fertilizer to replenish the plant food.

Plants are adapted to different kinds of soils, some needing loose, open soil, others compact, clayey soil; some requiring one kind of plant food, others another. A very little study of wild flowers or crops shows that plant life varies with the soil.

Summary. — *Most land plants depend on soil for water, mineral food, and anchorage; but some land, and most water plants do not need soil. Land plants differ greatly according to the soil.*

214. Importance of Gravity. — Plants send their roots into the ground, seeking water which gravity has drawn into the earth. Seeking sunlight, they send their stems straight up from the ground. This is the easiest way for them to resist the pull of gravity; if they were inclined, for example, they would fall far more easily. To aid in withstanding the pull of gravity and the force of the wind, large plants build strong, woody trunks and branches. Water plants, on the other hand, are usually weak, loose-textured, and flabby, because they live in a denser medium, which buoys them up so that they do not need great strength to resist gravity. Such plants as sea weeds, which are exposed to waves, require a tougher texture.

Summary. — *The influence of gravity causes plants to send roots downward, and strong, woody stems straight upward.*

DISTRIBUTION OF PLANTS.

From what has been said, it is evident that the distribution of plants is influenced by surrounding conditions; and since there is much difference in the climate and soil of the earth, there are great differences in plant life.

215. Influence of Climate. — Climate is the greatest factor in determining the distribution of plants. Some species, especially the more lowly, have a wide distribution and are adapted to many climates; but most plants of higher orders are fitted for only one set of surroundings. For example, sugar cane requires a warm, damp climate beyond the reach of frost; cotton grows best in a slightly cooler, though still warm, sunny climate; corn, though requiring a long, warm summer, grows much farther north than cotton; and wheat may be raised in a climate too cold for corn. Wild plants are limited in distribution in similar ways.

There are, therefore, zones of plant life similar to the zones of temperature. An Arctic plant will die amid tropical heat as certainly as a tropical plant will perish when exposed to the frosts of a temperate winter. The plant life, or *flora*, of moist climates also differs from that of arid climates. These differences may be best understood by studying the plant life in several climatic zones.

Summary. — *There are zones of plant life, similar to those of climate; for, while some lowly plants are adapted to several zones, higher plants are usually fitted for life in only one.*

216. Arctic Flora. — In the Arctic, plants spring up as soon as the frost melts, and quickly flower and bear fruit, for the season is short. Lichens in great variety cling to the rocks (Fig. 486), and many mosses and water-loving plants live in the swampy soil. There are grasses, numerous flowering plants, and species with woody tissue, including dwarf willows and birches — true trees in all respects but size. They cling close to the ground, not rising high because it is important that the first snows shall cover and protect them from the cold blasts of winter. The short growing season, and the bitter winter cold, prohibit the growth of trees.

For more than two thirds of the year, while the temperature is below the freezing point, plant life is dormant; but in the brief summer season the sap flows, the plants grow, and the tundra is covered with a mat of green, dotted with bits of color. Yet only the surface soil is free from ice, for at depths greater than two or three feet frost is ever present.

Summary. — *In the short Arctic summer, when frost melts from the upper layers of soil, plants grow rapidly, clinging close to the ground to secure protection from the winter cold.*

217. Temperate Flora. — Near the margin of the temperate zone in both hemispheres is a timber line of low, scraggy trees struggling for existence amid unfavorable surroundings. The trees are all of hardy varieties, some *evergreen*, others *deciduous*, that is, shedding their leaves in autumn. The evergreens have tough, needle-like leaves which withstand the cold of winter, falling only in spring, when new ones take their place. Among the common evergreens are spruce, hemlock, balsam, fir, and pine.

In the warmer part of the temperate zone deciduous trees increase in number and variety, including the beech, birch, maple, oak, elm, chestnut, hickory, ash, walnut, and many other species. There are also many fruit trees such as apple, pear, peach, and cherry. These trees, which spring into leaf

and blossom in spring, and bear fruit in summer and fall, are checked by the autumn frosts. Their sap then ceases to flow, the leaves assume brilliant colors, then fall, and for a time the trees are dormant. They lay aside their activity during the season when active life is impossible.

Other plants, called *perennials*, die down to the ground when the frosts come, growing again in spring from roots or bulbs in which nourishment has been stored during the active season. Still others, called *annuals*, die completely in the fall, leaving only seeds to reproduce their species when growth is again possible.

The flora of the temperate zone varies greatly according to temperature, exposure, humidity, and soil. There are places where trees do not grow, for example on dry plains, and on prairies (p. 77), on which, however, grasses and many flowering plants grow luxuriantly. In other places tree growth is scrubby and of few kinds, as in sandy soils which support only pines and oaks. On the other hand, there are places where the climate and soil favor a luxuriant forest growth. Every part of the land is occupied to its fullest extent by plants fitted to live there.

One of the most remarkable instances of plant growth is in the region of "big trees" on the west coast of United States (Fig. 488). There, a fertile soil, a damp, equable climate, and absence of strong winds encourage the growth of enormous trees. Only in southeastern Australia, where similar conditions exist, are there trees rivaling these in size. Some of the California trees are 300 feet high, 40 feet in diameter, and fully 2000 years old.

Summary. — *Near the frigid zone, tree growth ceases, the timber line being marked by scraggy trees, both evergreen and deciduous. Deciduous trees increase in number and variety in the warmer parts of the temperate zone. Plants are adapted to the winter season in several ways: by suspending activity, by dying down to the ground, and by dying completely, leaving seeds to continue the species. There are many differences in flora according to temperature, exposure, humidity, and soil.*

218. Tropical Flora. — In the warm, humid portions of the temperate zones, near the tropics, the abundant and varied flora is more like that of the tropical than of the cool temperate zone. It is therefore called subtropical. Both here and in the humid tropical zone the warmth and dampness favor the luxuriant growth of a great variety of species. Among these are long-leaved pines, broad-leaved evergreens, palmettoes, and palms (Figs. 493, 499); also such valuable trees as the teak, mahogany, rosewood, cocoa, banana (Fig. 490), and the rubber tree.

There is no one season of growth, and no dormant period; blossoms may appear at any time, and there is no period when all the leaves fall. The trees grow to great size, and, in their struggle for light, to great height. The undergrowth is dense (Fig. 494), trailing vines hang from the limbs, and epiphytes abound.

Summary. — *The subtropical flora of the warm temperate zone and the tropical flora are quite alike in variety and luxuriance of growth, and in the absence of a dormant period.*

219. Flora of Savannas and Steppes (pp. 283, 285). — In regions where there is a season of drought, as in the savannas (Fig. 491) and steppes, trees cannot grow excepting along the streams. Many grasses and flowering plants bridge over the period of drought by means of roots, bulbs, and seeds, springing into life when the rains come, as plants of the cool temperate zone do at the close of winter. Therefore, such regions are excellent pasture lands.

Summary. — *Regions having a period of drought are treeless; but annuals and perennials thrive, making these good pasture lands.*

220. Desert Flora. — In deserts there is too little moisture for a great number of individuals. Therefore, instead of having a complete cover of vegetation, the desert is scantily clothed with a scattered flora (Figs. 154, 498). Every possible effort is made by the plants to secure and retain enough moisture for life. Some plants have enormous roots, extending deep into the ground and spreading far about in search

of water; the mesquite, for example, has several times as much woody matter below ground as above it. Water is stored in these roots for use during the long droughts.

Desert plants have many devices for existence amid their unfavorable surroundings. In order that the surface for evaporation may be reduced to a minimum, no more leaves are produced than are absolutely necessary; and in many cases the leaves are small and tough, or are even reduced to spines. In the cacti (Figs. 495–497), which are especially well fitted for desert life, water is stored in the tissues; there are no true leaves; and the plant has a hard, shiny, varnished surface, through which evaporation is almost impossible. Some species are globular in form, thus exposing the least possible surface to evaporation; and the sharp-irritating spines protect them from many kinds of animals which might otherwise devour them. Many desert plants repel plant-eating animals, as the common sage brush does, whose tough, pale green leaves have a disagreeable odor and taste.

Sunlight, temperature, and much of the desert soil are favorable to abundant plant life; but water is lacking. It is remarkable that any plants should be able to adapt themselves to life where rain comes at intervals of months or even years. That this is the only unfavorable condition is proved where oases exist in the desert, or where irrigation is introduced. Then the watered desert supports plant life in great variety and luxuriance.

Summary. — *Because of lack of water, the desert flora is scattered and many devices are adopted to store enough water to last through the periods of drought. The luxuriance of growth on oases and irrigated sections proves that water is all that is lacking for plant life.*

221. Mountain Flora. — In every zone the flora varies with altitude. A temperate flora is found on mountain slopes in the tropical zone; and an Arctic flora on mountain tops in temperate zones. Thus, species growing in Labrador and Greenland are also found on the top of Mt. Washington.

Even in the tropical zone there is a line, the *timber line* (p. 96), above which it is too cold for trees to grow. This line, marked

by stunted, scrubby trees, is not regular, but extends highest on those slopes which furnish most protection from winds or longer exposure to the sun (Figs. 158, 161, 166). Above the timber line, wherever there is soil, the surface is covered with low bushes and flowering plants (Fig. 181), forming the mountain or *Alpine flora*, famed for the variety and beauty of its flowers. The cool summer air, damp soil, and long, cold winters resemble conditions in the Arctic; but there is more sunlight.

Mountains and high plateaus rising from desert lands may have rainfall enough for forest growth. On the lower slopes the trees are stunted, scrawny, and scattered, showing the struggle with drought; but higher up the forest becomes dense. If the mountains are high, tree growth may be checked above by cold, as well as below by drought.

Summary. —*Because of changes in temperature, the flora varies with altitude. On mountain slopes the forest disappears, and in the upper portion is replaced by the Alpine flora.*

222. Water Plants. — Wherever conditions favor, both in salt (p. 195) and fresh water, there is a varied flora, some species floating on the surface, others anchored, and still others having true roots. Lower forms, such as algæ and mosses, are especially adapted to life in water; but higher forms, even trees, are not absent. Rushes, reeds, mosses, and lilies are among the common fresh-water and swamp plants; and among trees the cypress, black gum, willow, and mangrove are common, the latter living in salt water (Fig. 379).

Most trees die if their roots are submerged, because air is cut off; but water-loving trees have special provision for securing the necessary air. For example, mangrove roots start from above the water surface, and even from the lower limbs; and knobs, or knees, grow upward from cypress roots till they project above the water surface (Fig. 307).

Summary. — *Plant life is abundant both in fresh and salt water, the lower forms being especially common, though even some trees are adapted to life in water.*

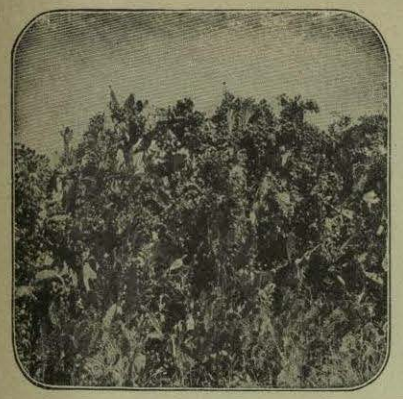

FIG. 495. — The prickly pear, one of the spiny cacti.

FIG. 496. — The tree Yucca of southwestern United States. The man on the right gives an idea of the size of this plant.

FIG. 497. — A group of cacti, showing rounded forms and spiny surfaces.

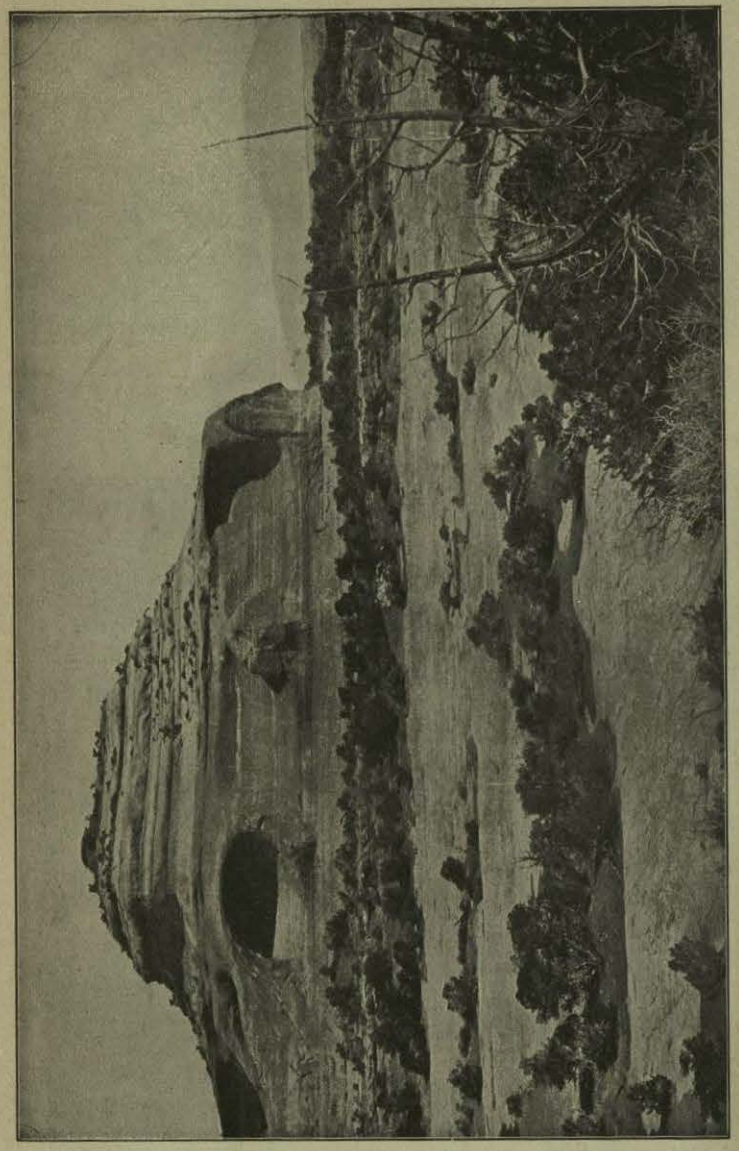

FIG. 498. — A view on the desert of southwestern United States. Note the general barrenness, with vegetation here and there in clusters.

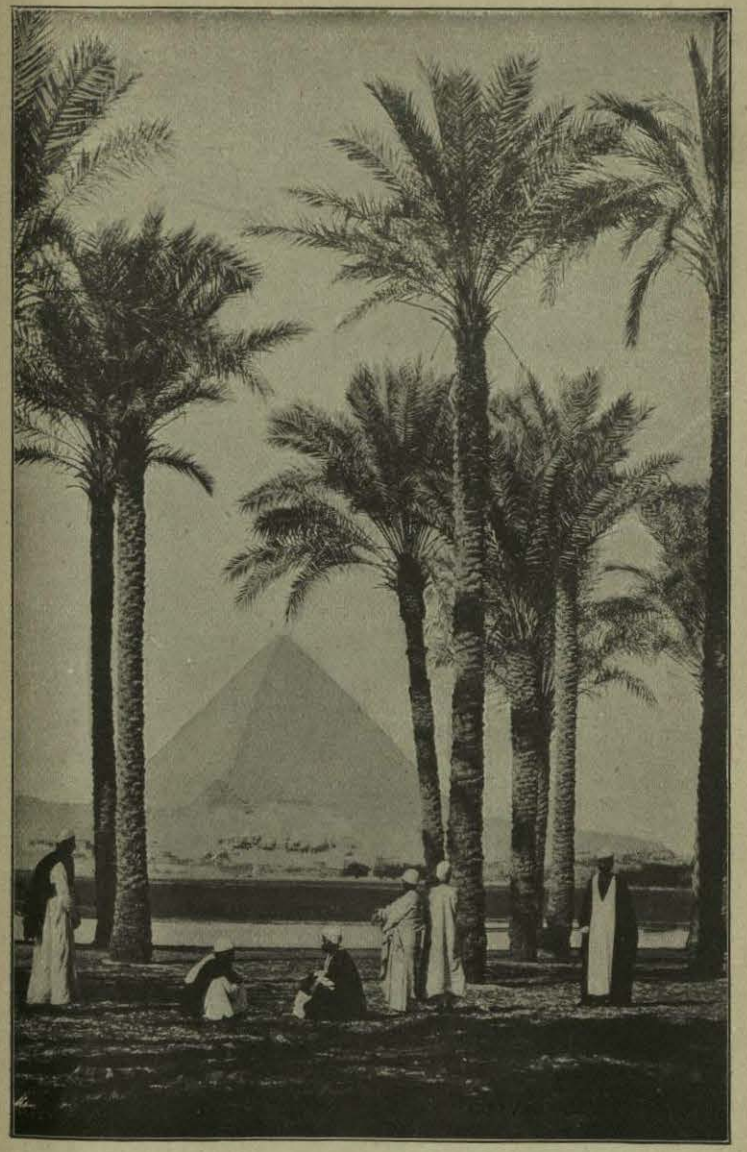

FIG. 499. — A cluster of palms near the Pyramids in the desert region of Egypt.

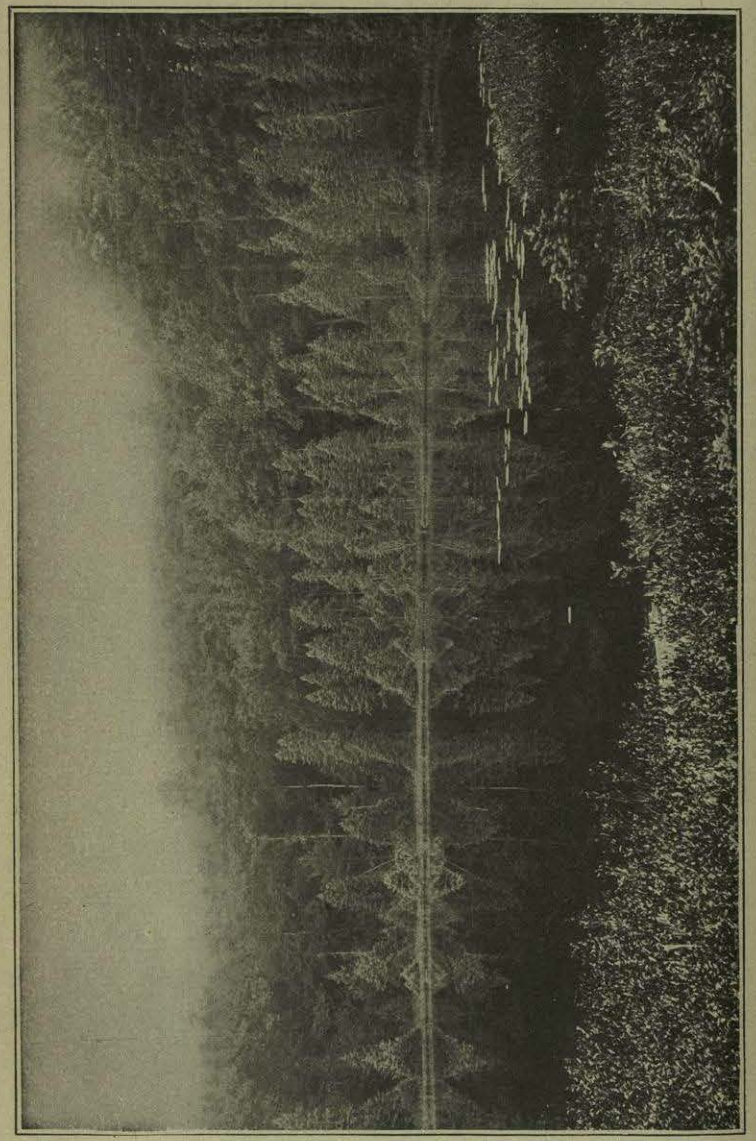

FIG. 500. — Plant life in the water. Describe the vegetation in this picture.

223. Means of Distribution. — Since the land is so well occupied that it is difficult for a new plant to gain a foothold, it is necessary that adequate provision be made to insure the spread of plants. Seeds are the principal means of insuring this spread. It is necessary to produce far more seeds than can possibly find a chance to grow, for some are eaten, some decay, some fall where they cannot sprout, and some that sprout find conditions so unfavorable that they die.

In order that they may have every chance for a start in life, seeds are provided with many ingenious devices to aid in their spread. Some are so light that they are drifted about by the slightest breeze; some, like the maple, have wing-like projections that catch the wind; some, like dandelion seeds, have a light, feathery float; some, like the many burs, have hooks that catch upon the fur of animals; and some, like the apple or peach, are covered with an edible coat. Animals eat these fruits, often depositing the hard, protected seeds far away from the parent plant.

The wind and animals are the two agencies most important in spreading plants. Because light seeds are so easily carried by the wind, light-seeded plants are most widely distributed. Rivers also float seeds and plants from one place to another, and ocean currents may drift them even to oceanic islands. Man has become an important agent in distributing plants over the earth. He carries cultivated plants from one region to another, and also distributes many weeds. In this way the Canada thistle and the white field daisy, now common weeds, were brought to the United States.

Summary. — *Plants are distributed mainly by seeds; and since many seeds are destroyed, far more are produced than could possibly grow. They are largely distributed by wind and by animals, with the aid of many interesting devices; also by rivers, ocean currents, and by man. Light-seeded plants are most easily and widely distributed.*

224. Barriers to the Spread of Plants. — If seeds from the land fall upon water, they do not grow unless drifted ashore.

In other words, water is a barrier to their spread; it is, in fact, the greatest barrier to the distribution of land plants, especially if it is a large body like the ocean. It would be under very rare conditions, for example, that even a single seed could be carried from South America to Africa by winds, currents, or birds.

Yet even the ocean is not an absolute barrier, and plants from the mainland are found on all oceanic islands. Only the seeds of certain plants find their way there, however, and island floras are, therefore, far less varied than those of the mainland. The most common plants are those with seeds so light that they are easily carried by wind; or those that birds eat and carry; or those, like the cocoanut, that will float for a long time in the sea.

Deserts are barriers because no plants, except those adapted to desert conditions, can spread across them, unless carried entirely over. A tropical forest is an equally good barrier for plants that are adapted to desert life. Mountain chains are also barriers, because plants at their base will not spread into the cold climates above; but gaps or passes often are pathways for the spread of plants across mountains. The wind, although an aid to distribution in one direction, is a very important barrier to spread in the opposite direction. For this reason European plants are not likely to reach America against the west winds; but these winds aid American plants in their spread to Europe. Ocean currents and birds also aid in the same direction.

Summary. — *The ocean is the greatest barrier to the spread of land plants; but even this is not an absolute barrier, for plants whose seeds can be carried by winds, birds, and ocean currents are found even on remote oceanic islands. Deserts and mountains are also barriers; and wind checks the spread of plants against it.*

225. Variation in Plants. — Among plants there is a struggle for air, food, light, water, and opportunity to reproduce their kind. This struggle is going on everywhere; it may be seen in a neglected flower garden, where weeds

spring up from chance seeds, and, being better fitted for the struggle than carefully nourished, cultivated plants, take complete possession of the garden. They tower above the cultivated plants, shutting out light and robbing the roots of water and mineral food. Under such conditions the cultivated flowers are small and imperfect.

Because of this struggle for existence plants are steadily changing; and those that best fit themselves for the struggle have the best chance of surviving and spreading. This has been called the survival of the fittest. In this struggle plants have fitted themselves to survive the cold of winter; to live amid the unfavorable surroundings of the desert; in fact, to grow among most conditions on the earth's surface. Fossils in the rocks prove that similar change, or *evolution*, has been in progress for ages.

The following will serve as illustrations of how plants are forced to vary with environment, that is, to undergo evolution. A mountain, rising above the timber line and bearing an Alpine flora, is slowly worn down to the low, hilly condition of maturity. If the plants cannot adapt themselves to the changes in climate, slope, and soil, they must give place to forms better fitted.

The effect of the ice sheet offers another illustration. As it advanced over the land, it either drove out or destroyed all life; and near its margin the climate was changed from warm to cold, so that the plants living there either had to adapt themselves to the changes or die. When the glacier melted away a new soil was uncovered, and a struggle ensued for possession of it. The light-seeded plants came first, and even now the heavy-seeded plants are slowly advancing northward. These changing conditions have forced some species to evolve new characteristics. The history of plant life during past ages has been a succession of changes by which plants have become better adapted to their surroundings.

Plants undergo many changes as a result of their relation to animals. Since animals depend on plants for food, some means must be provided to prevent complete destruction. For this purpose hard wood, thorns, bitter taste, and other means have been

evolved. Many plants make use of animals, for example, in spreading seeds and in distributing pollen. Honey, odor, color, and many interesting forms of flowers are provided to attract insects and to secure from them the service of carrying the pollen.

Man is now one of the most important agents in changing plants. By giving them better care, with plenty of light and food, and removing weeds, thus relieving them from the struggle with other plants, he is able to secure far larger seeds and fruits than grow naturally. For example, a good apple tree, left to itself, soon has to struggle with weeds and bushes, and its fruit becomes sour or bitter. By much care and many devices, men are constantly producing new varieties of flowers and fruit. This is done by forcing evolution to work more rapidly than it does naturally; and, in this way, changes may be caused in a few years which, by natural processes, might require centuries.

Summary. — *The struggle of plants to adapt themselves to their surroundings, that is, the struggle for existence, which is everywhere and always in progress, causes weaker forms to die out and results in the survival of the fittest. Slow changes in climate or in land form cause variation, or evolution, in plants. Changes are also brought about for the purpose of protection from, or making use of, animals; and man is now causing changes at a far more rapid rate than evolution naturally works.*

226. Plants of Value to Man. — Man, like other members of the animal kingdom, depends for food upon plants. Even though he may feed on meat, the animal from which it came receives nourishment, directly or indirectly, from plants. In a warm climate so great an abundance of plant food may be easily obtained, at all seasons, that there is little need of special provision. But in climates with a dry or cold season it is highly important to provide a store of food for use during the unfavorable season. This need has led to the cultivation of food plants.

The portions of plants most useful for food are those in which nourishment has been stored to aid in the propagation of the species. Among these are seeds, like wheat; fruits, like bananas; bulbs, like onions; and tubers, like potatoes. Some of the food plants, like dates, cocoanuts, bread fruit, and bananas, used extensively in warm climates, have been changed very little.

Others, especially those cultivated in the temperate zones, have been so improved that they are now quite unlike the original plants which savage man first ate. The most important of these, including the orange, apple, pear, peach, cherry, grape, wheat, barley, oats, and rye, have been carried to many parts of the world. In the case of many, the source is not now known; but most of our food plants apparently came from Asia, where they have been cultivated for thousands of years. America has added the potato, tomato, pumpkin, and Indian corn, or maize, as well as tobacco.

Plants also supply us with materials for shelter, clothing, medicine, and other purposes. Cotton (Fig. 503) is the most valuable of the several plant fibers used for clothing. In all lands wood is used both for shelter and for ornamental purposes. Sugar (Fig. 501), coffee, tea (Fig. 502), cocoa, vanilla, tobacco, quinine, and many other plant substances, not of vital importance, are much used by men. The list of valuable plants is a very long one.

For food and clothing, plants are carefully cultivated; but for shelter it has been customary to depend upon the forest, which grows without care. In parts of Europe, however, so much of the forest has been removed that it has become necessary to cultivate even the forests, planting the trees, weeding out the poor ones, and carrying on lumbering with great care. The time has now arrived in America, when the forest needs to be cultivated. Accordingly, both the national and state governments have set aside large tracts as forest reservations. A division of the national government is known as the Bureau of Forestry, and a

number of states have forestry bureaus. There are also schools of forestry, like those at Cornell, Yale, Wisconsin, and Michigan universities, where men are scientifically trained to be foresters.

Summary. — *Man and all animals rely for their food, either directly or indirectly, on the vegetable kingdom. In regions with a cold or dry season, it is necessary to provide food for the unfavorable season, and this has led to the cultivation and improvement of a number of plants for their seeds, fruits, bulbs, and tubers. Many plants are also used to supply materials for clothing and shelter; and now even forests are cared for by methods of scientific forestry.*

Topical Outline, Review Questions, and Suggestions.

Topical Outline. — 209. **Importance of Air.** — Carbon dioxide; carbon in plant tissues; extent of air; places where plants are absent.

210. **Importance of Temperature.** — Effect of freezing; temporary freezing; effect of boiling; plants on Greenland ice; in hot springs.

211. **Importance of Sunlight.** — Its use; plant life in dark places.

212. **Importance of Water.** — Use of water; sap; source of water.

213. **Importance of Soil.** — Water plants; epiphytes; dependence of most land plants on soil; plant food; effect of differences in soil.

214. **Importance of Gravity.** — Roots; stems; wood; water plants.

215. **Influence of Climate.** — Lowly plants; higher plants; illustrations; effect of temperature; of moisture.

216. **Arctic Flora.** — Rapid growth; kinds of plants; clinging to ground; winter; summer.

217. **Temperate Flora.** — Timber line near Arctic; evergreen trees; kinds; deciduous trees; kinds; dormant condition in winter; perennial plants; annuals; treeless regions; sandy soils; "big trees."

218. **Tropical Flora.** — Subtropical flora; tropical trees; the forest.

219. **Flora of Savannas and Steppes.** — Drought; plant growth.

220. **Desert Flora.** — Scattered growth; large roots; nature of leaves; cacti; plants with disagreeable taste; proof that water alone is lacking.

221. **Mountain Flora.** — Tropical zone; temperate zone; timber line; Alpine flora; flora of desert highlands.

222. **Water Plants.** — Position; kinds; adaptation of trees.

223. **Means of Distribution.** — Abundance of seeds; devices for their spread; distribution — wind, animals, rivers, ocean currents, man.

224. **Barriers to the Spread of Plants.** — The ocean barrier; ocean-island flora; desert barrier; mountain barrier; wind barrier.

225. **Variation in Plants.** — Cause of struggle; illustration; struggle for existence; survival of the fittest; evolution; illustrations of causes for evolution; evolution in past; securing protection from animals; making use of animals; effect of man on evolution.

226. **Plants of Value to Man.** — Dependence on plants; plant food in warm climates; in places with an unfavorable season; parts of plants used; improvement; important food plants; source of food plants; American food plants; plants used for other purposes; care of the forest.

Review Questions. — 209. What do plants take from the air? Where are plants absent?

210. What is the effect of cold? Of heat? Give an illustration of adaptation of plants to cold. To heat.

211. Of what importance is sunlight? What effect has darkness?

212. Of what importance is water? How is it obtained?

213. What plants are not dependent on soil? Of what importance is soil to land plants? Why is fertilizer used?

214. State the effects of gravity on land plants. On water plants.

215. How are plants influenced by climate? Give illustrations.

216. State the peculiarities of plant life in the Arctic.

217. What are the conditions of tree growth near the frigid zone? In the warmer temperate zone? In what ways are plants adapted to winter conditions? How does the flora of the temperate zone vary? What conditions favor the "big trees"?

218. What is the subtropical flora? Name some of the tropical trees. What are the characteristics of the tropical forest?

219. What are the characteristics of the flora of savannas and steppes?

220. How are desert plants fitted to survive periods of drought? How are they protected from animals? What do the oases prove?

221. What changes occur in the flora of mountains? Compare Alpine and Arctic flora. What are the conditions on highlands in deserts?

222. What kinds of plants thrive in water? How are trees adapted to water life?

223. Why are so many seeds produced? What devices are there to aid in the spread of seeds? By what agencies are plants spread?

224. Why is water a barrier? How is it certain that the ocean is not an absolute barrier? What other barriers are there?

225. For what are plants struggling? Give an illustration. What is the result of the struggle? What do fossils prove? Give two illustrations of how changes on the earth may influence evolution. What is the effect of the relation between plants and animals? How is man influencing evolution?

226. How is man dependent on plants? What is the condition in

warm climates? In regions with cold or dry seasons? What parts of plants are used for food? What effect has cultivation had? Where have the cultivated plants come from? For what other purposes are plants used? What is now being done with the forest?

SUGGESTIONS. — (1) Place a hardy plant, such as moss, in boiling water for a few minutes, and plant it to see if it will grow again. (2) Freeze the same plant for a night and see if it will grow. Freeze a delicate plant, for example a geranium, and see if it will continue to grow. (3) Place a plant, say a geranium, in the cellar and let it grow for a few weeks, and note the change. (4) Leave a plant in its pot without water and see if it grows. Keep water up to the top of the earth (a swamp) and see if it kills the plant. Get a cactus and see if it will live in dry soil. Study the cactus. (5) Using the same kind of seed, try growing plants in several different kinds of soil, — sandy, fertile loam, etc., and see which thrives best. (6) Try to burn ash. Perhaps the teacher of chemistry can suggest an experiment to prove that there is mineral matter in ash. (7) Put a plant in a pot, inclining it at an angle to the surface. Will it keep on growing in that direction? (8) Collect and study seeds to see what devices they use for distribution. (9) Plant a bean in a flower pot in absolutely dry earth (a desert). Does it sprout? Place one in a jar of water. Does it grow after it has used up the nourishment in the seed? This illustrates why deserts and water are barriers. (10) Study the flora of your vicinity to see if the plants vary in kind from one soil, or exposure, to another. If there is a swamp, find how the swamp plants are different from those on dry slopes. (11) What crops are raised in your vicinity? What crops cannot be raised? Why? Is there a difference in crops according to the soil? (12) Make a list of plants valuable to man, their principal uses, and the localities from which they come. Let each student make a list, then combine it for the use of the whole class.

Reference Books. — COULTER, *Plant Relations*, Appleton & Co., New York, 1899, $1.10; MERRIAM, *Life Zones and Crop Zones of United States*, Department of Agriculture, Biological Survey Division, Bull. 10, 1898, Washington, D.C.; BAILEY, *Plant Breeding*, Macmillan Co., New York, 1895, $1.00; *Survival of the Unlike*, Macmillan Co., New York, 1896, $2.00; FERNOW, *Economics of Forestry*, Crowell & Co., New York, 1902, $1.50; GIFFORD, *Practical Forestry*, Appleton & Co., New York, 1902, $1.20.

FIG. 501. — Cutting sugar cane in Louisiana.

FIG. 502. — Picking tea in India.

FIG. 503. — Picking cotton in southern United States.

FIG. 504. — A pineapple field in the Hawaiian Islands.

CHAPTER XVIII.

DISTRIBUTION OF ANIMALS.

227. Influence of Surroundings. — Plants and animals are alike in being dependent for life on their surroundings. Like plants, all animals, even those on the sea bottom, need air to breathe ; all require water for their blood and tissues ; and for all it is necessary that the temperature shall be neither too high nor too low. Temperatures near the boiling point, or long continued below the freezing point, are fatal to animal tissues. Many, especially the lower animals, are able to survive a period of freezing ; others protect themselves by a coat of fur, feathers, or fat ; and some, such as bears, lie dormant in a protected place during the cold season.

Most water and many land animals are cold-blooded; that is, their temperature changes with their surroundings. They require so little air that many of them obtain all they need from the water. Other animals, the birds and mammals, are warm-blooded, the warmth being due to slow combustion caused within their bodies by the oxygen they breathe (p. 229). Such animals require much oxygen and, even if they live in water, as the whales do, must rise to the air to obtain it. Those that live in water, or in cold climates, need to protect themselves by a warm covering in order to keep the warmth in their blood.

Animals differ from plants in the way in which they secure food. While some remain fixed in one place, depending on supplies brought to them, as plants do, most animals seek their food. They need carbon and mineral substances, but are unable to secure them directly from air and earth. They depend upon plants to perform this work, and the basis of animal food is, therefore, plant life. Even the food of flesh-eating animals may be