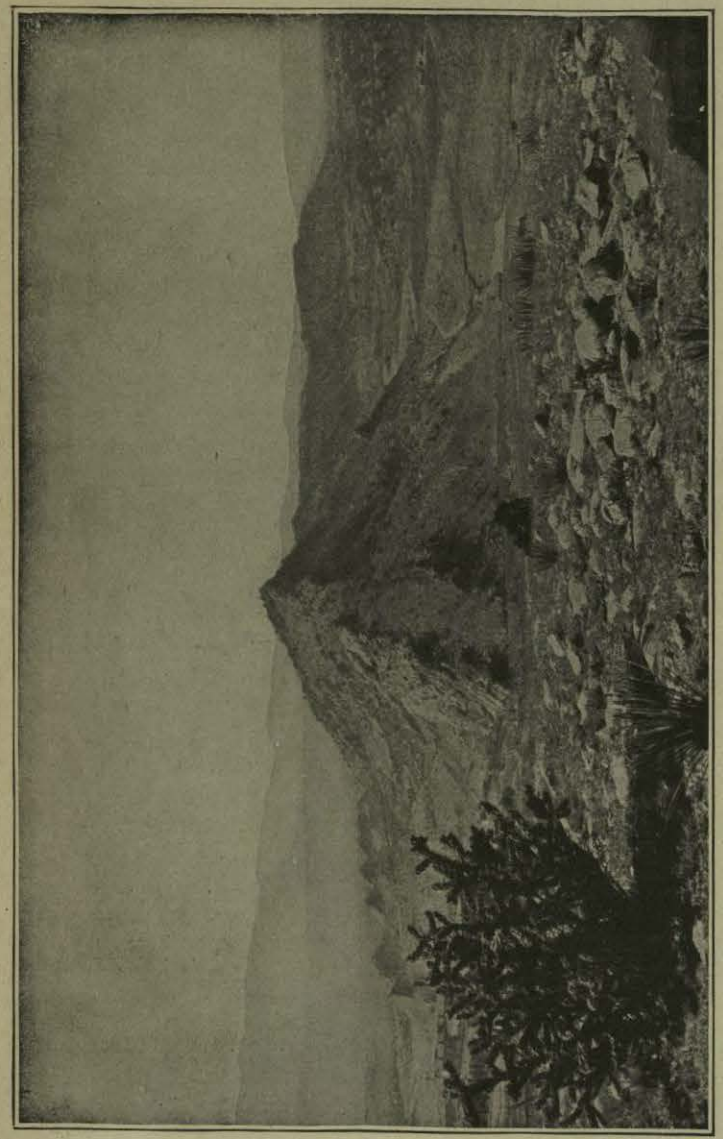

Fig. 154. — A ridge in Colorado, showing the inclined hard strata extending almost vertically into the earth. This is an arid region, and therefore the vegetation is sparse. A cactus bush is seen in the lower left-hand corner, and Spanish bayonet plants farther to the right.

CHAPTER VI.

MOUNTAINS.

64. Introductory. — Mountains contrast strikingly with plains, but resemble dissected plateaus in irregularity of form. The ruggedness and coldness of lofty mountains make them barriers rather than attractive homes. Mineral wealth often induces men to live among mountains, and, in summer, people are attracted to them by the cool climate and beautiful scenery. But, not being suited to extensive agriculture, mountains are never densely settled.

These and other facts furnish reasons why mountains are worthy of study. There are many questions of interest which such a study will answer. Why, for example, are the Alps so high and rugged, the Appalachians so low and ridge-like, and the New England mountains so low and hilly? Why do rivers sometimes cross mountains in narrow gaps while other mountain valleys are broad and flat-bottomed? The following pages answer some of these questions.

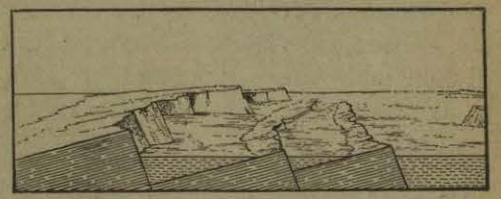

Fig. 155. — Fault block mountains.

65. The Mountain Rocks. — Unlike those of plains and plateaus, the strata of mountains are almost never horizontal. All kinds of folds and faults (p. 37) are found. Some mountains, like many in the Great Basin, are simply faulted and tilted blocks of strata, with the layers inclined in a single direction (Fig. 155). Others, like the

Jura in Switzerland, consist of strata folded into regular anticlines and synclines (Fig. 168). Still others, like the Alps, are very complexly folded and faulted (Fig. 156). The strata of the Appalachians were originally horizontal,

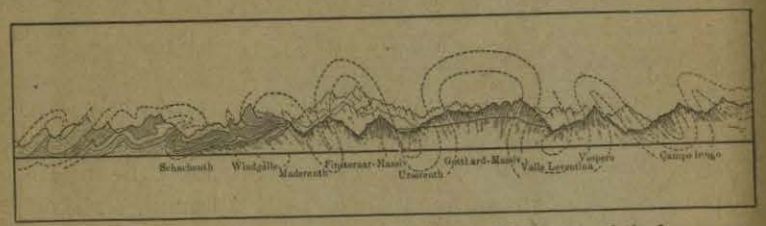

FIG. 156. — Complex folding of the Alps. The dotted lines extend the layers upward, as they would extend if nothing had been removed.

but are now complexly folded. If they could be straightened out to their original condition, they would occupy fully six times as much area as now. That is to say, 120 miles of rock strata have, by folding, been crowded into twenty miles of mountain.

Such complex folding often so alters, or metamorphoses, the rocks that it is very difficult to tell their original condition (p. 34). Igneous rocks often cut across the mountain strata (Fig. 34), and, therefore, one may in a short distance find many kinds of rock — granite, gneiss, sandstone, limestone, etc. — occupying many different positions. This complexity gives denudation an opportunity to sculpture mountains into many irregular land forms that are not possible on plains and plateaus.

Summary. — *Mountain rocks are inclined at various angles by folding and faulting, and they are also very complex in kind. In these respects mountains contrast strikingly with plains and plateaus.*

66. Names applied to Parts of Mountains. — A mountain *system* is a series of mountain folds, raised by the same uplift and forming a single group. A mountain system consists of minor portions, or *ranges* (Fig. 153). A group of mountain systems is

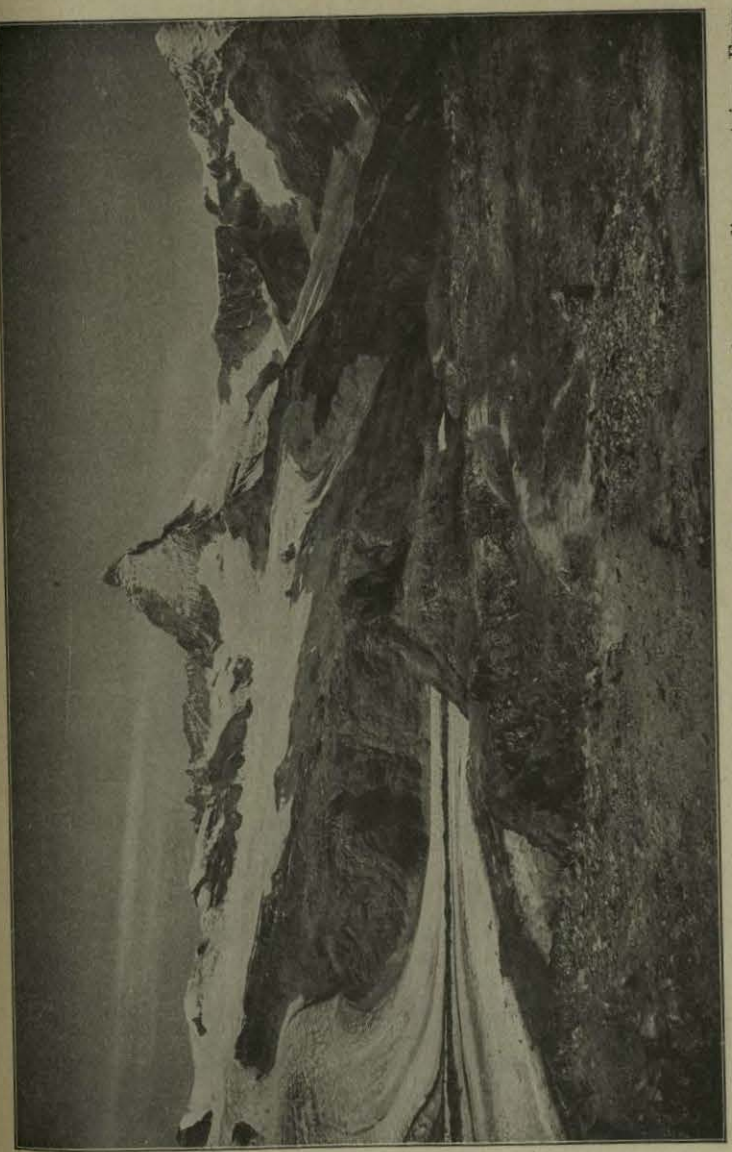

FIG. 157. — The Matterhorn, a steep and lofty peak in the Alps, rising above the surrounding mountains. From this region of high mountains a number of glaciers descend through the valleys, some of which are seen in the picture.

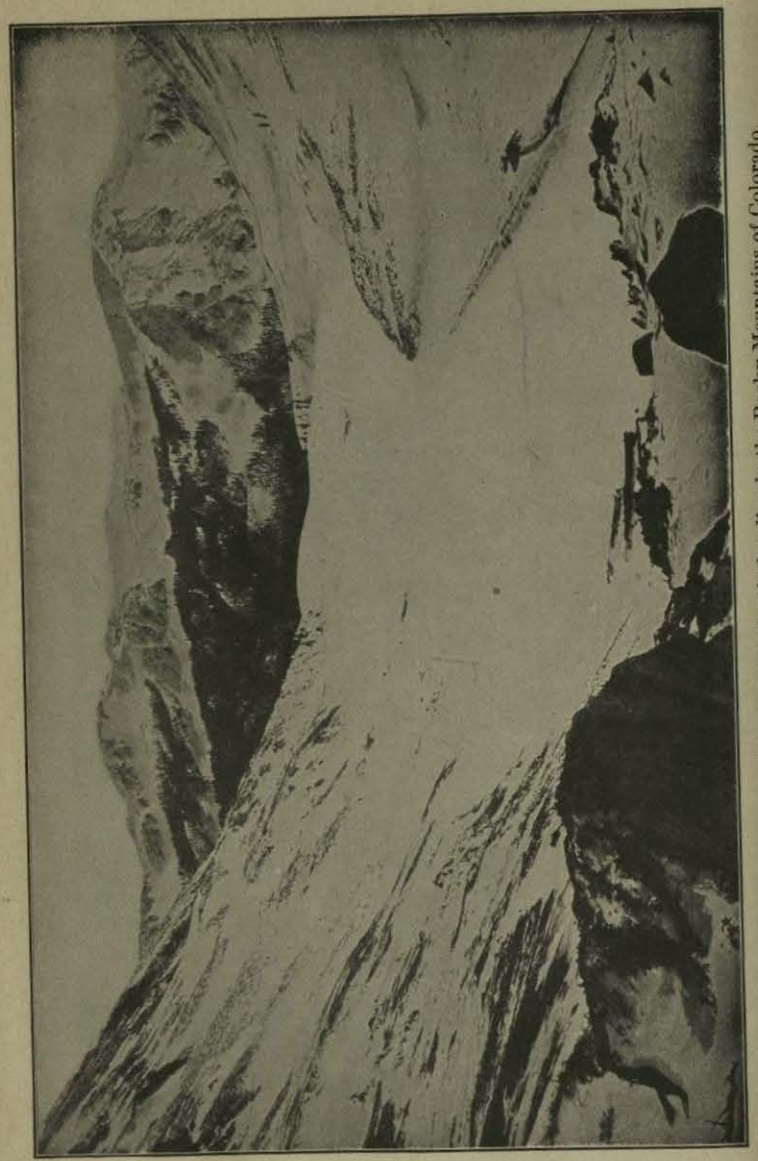

FIG. 158. — A snow-covered pass above the timber line in the Rocky Mountains of Colorado.

called a *cordillera*. For example, the cordillera of western United States includes four systems, — the Coast Ranges, the Sierra Nevada-Cascade system, the Basin Range system, and the Rocky Mountain system. Each of these systems consists of a number of ranges; for instance, the Rocky Mountain system has many ranges, such as the Wasatch and Uinta ranges.

Denudation, wearing away the ranges, leaves some of the hard rocks standing above the general level. If these elevated portions are long, they are called *ridges* (Figs. 38, 154, 159); if not greatly elongated, *peaks* (Fig. 157). There may be many peaks and ridges in a single range (Fig. 153). More rarely ridges and peaks are formed by folding or faulting (Fig. 155).

FIG. 159. — Diagram to show mountain ridges where denudation has etched inclined hard strata into relief.

There are different kinds of valleys among mountains. The largest of these are the broad plateaus between mountain systems. When they have no outlet to the sea, as in the Great Basin of the West, they are called *interior basins* (p. 22). Smaller basins without outlet are formed between mountain ranges by downfolding. Broad valleys in the Rocky Mountains, some due to folding, others to denudation, are commonly called *parks* (Fig. 165). In the Appalachians, narrow gorges cut by streams across ridges, are called *water gaps* (Figs. 172, 463, 467). A mountain *pass* (Figs. 158, 187) is a low portion of a mountain divide. Passes are usually caused by denudation, where streams head together on opposite sides of a divide. Their position is often due to the presence of a weak rock.

Summary. — *The names cordillera, system, range, ridge, and peak are applied to mountains or parts of mountains. The names interior basin, park, water gap, and pass are applied to mountain valleys.*

67. Climate of Mountains. — The temperature of the air decreases 1°, on the average, for every 300 feet of elevation.

Therefore, high plateaus and mountains rise into the cool upper layers of the air. Indeed, many mountains rise so high that there is perpetual snow on their summits, and glaciers in their valleys. The line above which there is perpetual snow is called the *snow line* (Figs. 153, 157). Below this is a belt with a climate too cold for tree growth. The line above which trees cannot grow is known as the *timber line* (Figs. 158, 166). These lines are lower on the shady than on the sunny side of mountains, and in the temperate than in the tropical zone.

Mountains in the path of vapor-bearing winds have abundant rainfall on the slopes against which the winds blow (p. 287). The opposite slopes, and the country beyond, are dry, because so much vapor is lost in passing over the mountains. This is well illustrated in northwestern United States, where winds from the Pacific cause abundant rain on the western slopes, but reach the eastern side so dry that the country is arid.

Summary. — *On high mountains there is a line, called the timber line, above which no trees can grow; higher still is a zone of perpetual snow. Mountains are well watered on the side from which vapor-bearing winds blow, and often arid on the opposite slopes.*

68. Denudation of Mountains. — The climate and great elevation of mountains give high power to the agents of denudation. Because the rivers are well above base level, they are able to cut deep gorges (Fig. 167) and canyons. Weathering is also very active, especially on steep slopes above the timber line (Figs. 54, 160), where there is little vegetation to offer protection to soil and rock. In such situations the rock is exposed to sharp contrasts in temperature between day and night; frost action is vigorous; and the strong winds, heavy rains, and melting snows all help to move rock fragments down the steep slopes.

Among high mountains the slopes are often so steep that the rock fragments fall to their base (Figs. 54, 183). Some of this rock waste is carried away by streams, but very often more falls

Fig. 160. — Bare rock slopes above the timber line in the Alps, with streams of waste forming talus slopes and alluvial fans. Here weathering is very rapid.

FIG. 161. — Paths of avalanches through the forest on Hayden Peak, Colorado.

FIG. 162. — Surface of the avalanche that crossed the Simplon Pass road, coming down the valley in the background.

than can be thus removed. In time this forms a mantle of rock waste, or *talus* (Figs. 66, 160), which covers the lower slopes, and, by its smooth, curving outline, forms a striking contrast to the rugged, irregular slopes above. As the talus grows, its slope becomes more gentle, till rocks no longer roll down over it. Then the decay of the fragments forms a soil in which trees may grow and on which farms may be located. Where wet weather streams descend the mountain sides, these talus slopes grade into steep alluvial fans and *débris cones* (Figs. 109, 160).

At all times small fragments of rock are falling from the steep mountain slopes; but, in addition, there is an occasional fall of large masses, forming an *avalanche* (Fig. 161) or a *landslide*. In an avalanche thousands, and sometimes millions, of tons of rock, mingled perhaps with ice, come tearing down the mountain side, destroying everything in their course. Rivers are dammed, villages destroyed, and roads ruined. In the spring of 1901 an avalanche of rock and ice from an Alpine valley descended across the road which Napoleon built over the Simplon Pass (Fig. 162). It ruined a mile or two of the road and utterly destroyed a mountain village. About a century before, a similar avalanche occurred in the same place. Mountains supply many instances of such destructive landslides. They are usually started by frost, or by the effect of rain or melted snow, which saturates the soil or rock, making it so heavy that it can no longer stand in its position.

As a result of rapid denudation, acting on the complex rocks, mountains are cut into a great variety of rugged forms, — peaks, ridges, precipices, gorges, and passes. There are peaks almost impossible to scale, some so steep and sharp-pointed that they are called "needles" and "horns" (Fig. 157); there are ridges that no roads cross; and, in fact, a surface often so rugged that large areas are uninhabited.

Summary. — *River erosion and weathering are very active among mountains, especially above the timber line. Rock fragments, falling from steep slopes, accumulate at their base as talus, débris cones, and alluvial fans; and occasionally larger masses descend as avalanches. By this rapid denudation high mountains are made very rugged.*

69. Resemblance between Mountains and High Plateaus. — Some plateaus are more elevated than many high mountain peaks; it is only very lofty mountains that rise higher than 10,000 feet, and yet there are plateaus which reach that level. These high plateaus are often so carved by vigorous denudation as to closely resemble mountains (Fig. 146). They are, in fact, sometimes called mountains.

The Catskill Mountains, for example, are not mountains in the true sense, but dissected plateaus. In the Catskills, denudation has carved out peaks and deep valleys with precipitous sides; but the nearly horizontal strata prove that they were uplifted as

FIG. 163. — A section showing folded mountain strata (on the right) grading into the horizontal strata of a plateau (on the left). Compare the two portions in ruggedness and elevation.

plateaus, not as mountain folds. Such mountain-like plateaus are usually near mountains, and gradually merge into them (Fig. 163).

Summary. — *Vigorous denudation so sculptures high plateaus, like the Catskills, as to make them resemble mountains in ruggedness; but their strata are horizontal.*

70. Distribution of Mountains. — Although mountains are typical of continents, there are ranges in the open ocean; for example, the New Zealand and Hawaiian islands. The latter are volcanoes rising from the crest of a submarine mountain fold, having a length of 1500 miles. There are many other ranges in the ocean, especially in the South Pacific.

Mountains are common at or near the border of continents (Figs. 20–27). They sometimes fringe the coast, as in the case of the Kurile, Japanese, and Philippine islands, and the East and West Indies. Mountain chains also extend from the land into the sea, forming peninsulas; for example, the peninsulas of Lower California, Kamchatka, Malay, Greece, and Italy. In other places mountain systems form the very border of the continents, rising directly out of the sea. Such a condition

is well illustrated by the Coast Ranges of western North America and the Andes of South America.

Mountains are also found far from the coast; for example, the Appalachians, Rocky Mountains, Sierra Nevada, and the mountains of central Europe and Asia. But most mountains of the interior, when first formed, rose from the sea.

A large number of the mountain systems extend from north to south (Figs. 20–25). It is to this fact that several of the continents owe their shape, — that of a triangle, with the long direction from north to south (p. 23). There are, however, many ranges running east and west, especially in Asia and Europe (Figs. 26, 27). No regular law has thus far been discovered regarding the distribution of mountains.

Summary. — *Mountains occur on continents, both in the interior and along the border, where they form chains of islands, peninsulas, and systems which rise at the very margin of the land. They also form island chains in the open ocean. Some extend north and south, others east and west.*

71. Cause of Mountains. — The explanation of mountains most widely accepted is that of *contraction* (p. 20). As the heated interior of the earth cools and shrinks, the cold crust settles; but it cannot fit the constantly shrinking interior without wrinkling. This causes mountains, which are wrinkles in the earth's crust. You can illustrate this by covering a ball with a thick flannel cover a little too large for the ball, then trying to press it down on the ball. Some parts of the cloth must wrinkle.

There is evidence that mountain folding has occurred again and again in the same place; also that this growth has been slow. Several times, mountain systems have risen in eastern and western United States; but, in the plains between, there has been practically no mountain formation at any period. The same is true of other parts of the earth.

Summary. — *Mountains are wrinkles of the earth's crust, caused by its settling on the cooling and contracting interior. They have been formed slowly and by successive uplifts.*

72. Types of Mountains. — Perhaps the simplest type of mountain is that in which a block of strata has been uplifted, along a fault plane, and tilted (Fig. 155). Such a mountain has one moderate and one steep slope, while the crest is a ridge parallel to the fault plane. Mountains of this type are found in southern Oregon and other parts of the Great Basin. These tilted block mountains may reach a height of 4000 or 5000 feet, a width of 10 to 20 miles, and a length of 50 to 100 miles.

Another simple mountain type is the dome, in which the strata have been raised by the intrusion of lava (p. 127). In

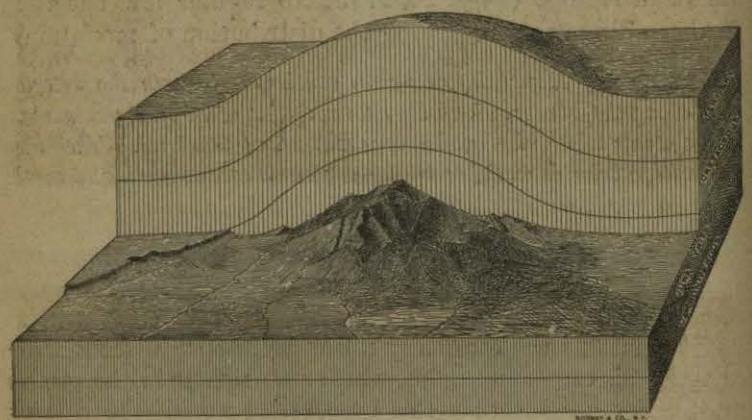

FIG. 164. — The Henry Mountains, 11,000 feet high, with the dome restored as it would probably exist if denudation had removed none of the strata.

such a mountain there is no ridge, but a central area from which the surface slopes in all directions. This type is illustrated by the Henry Mts. (Fig. 164) and others in the West.

A third simple type is the evenly folded mountain, illustrated by the Swiss Jura (Fig. 168) and parts of the Appalachians. When such mountains are formed the surface is thrown into a series of regular waves, like the waves of the sea, the anticlines forming mountain ridges, the synclines, valleys

FIG. 165. — A park, or broad, open mountain valley in the Rocky Mountains. Sultan Mountain is in the distance.

FIG. 166. — The timber line on Alpine Pass in the Rocky Mountains of Colorado.

FIG. 167. — A deep, narrow gorge in the Alps. There are pot holes just above the path on the left, showing that the stream bottom was once at that level. This gorge is being rapidly deepened.

(Fig. 168). When denudation cuts deeply into these, as in the Appalachians, each hard layer is left as a ridge (Fig. 172).

Mountains whose strata are greatly contorted (Fig. 156) and metamorphosed, with much igneous rock, have a far less simple form. Denudation, discovering differences in the rocks, sculptures them into very irregular and rugged outlines. The Rockies and Alps (Figs. 153, 157, 165) are types of such mountains.

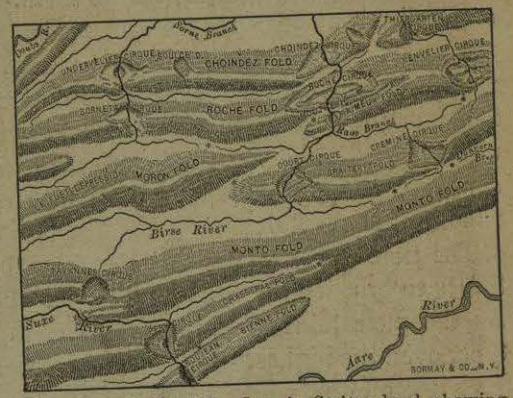

FIG. 168. — Folds of the Jura in Switzerland, showing streams parallel to the folds and crossing them in deep valleys.

Summary.—*There are simple faulted block mountains; domes raised by the intrusion of lava; evenly folded mountains; and very complexly folded mountains. The latter are carved into very irregular and rugged forms.*

73. Life History of Mountains. — Let us assume that the strata of a plain are being folded to form a mountain system. As the strata slowly bend, the surface becomes irregular; and, when the strain becomes too great, the rocks slip along fault planes. This jars the earth, forming earthquake shocks, which may be very severe. Through the deeper fissures, lava may rise, building volcanic cones. Such earthquakes and volcanoes are common in regions of growing mountains (pp. 125, 132).

From the very first the rising land is attacked by the agents of denudation; but this attack increases as the mountains grow higher. Since the mountains are not worn down

as rapidly as they are elevated, they continue to grow higher, reaching above the timber line and even into the zone of perpetual snow. Then glaciers extend down the valleys.

Down-folding forms broad valleys between the ridges; and streams cut narrow gorges across them. The durable rocks are etched out into ridges and peaks, the weak rocks are cut away, forming valleys and passes. In this stage the surface is so irregular that few people are able to live among the mountains. Such mountains, illustrated by those of western North and South America, the Himalayas, and the Alps, are *young mountains*. Find pictures of young mountains in this chapter.

The time comes when uplift ceases; but denudation continues to broaden the valleys and lower the peaks and ridges. As the mountains are lowered, glaciers disappear, and, in time, even the highest peaks may come below the timber line. Such mountains, which have lost the ruggedness of youth, may be called *mature;* the Appalachians and the mountains of New England, Norway, and Scotland, are examples (Figs. 170, 172, 188, 189, 192, 193, 455). Their slopes are forested, their valleys tilled.

Further lowering may continue until the mountains are reduced to a series of low, rolling hills; or, further still, to a surface almost as level as a plain. Such a surface is known as a *peneplain* (almost plain) (Fig. 171). The mountains are then *old*, and are, like plains, adapted to dense settlement. New York City, Philadelphia, Baltimore, and Washington are situated on such old, worn-down mountains. These ancient mountains, known as the Piedmont belt, extend from New England to Alabama, east of the Appalachians.

After being worn to low relief, a mountain region may be reëlevated, and caused to start on a new life history, as has been the case with the Appalachians. Then denudation may etch the ridges of hard rock into relief again, and form broad valleys where the strata are weak (Figs. 172, 173, 192, 193). The broad

FIG. 169.— A rugged cliff, ridge, and peak in the Alps, carved out by the active denudation in these young mountains. The house is a summer hotel for tourists.

FIG. 170. — Mature mountains in the Lake District of northwestern England made famous by the poet Wordsworth. The lake is Derwentwater.

FIG. 171. — The upland, or "peneplain," of New England; a worn-down mountain region, uplifted again so that the streams have had new power given them (rejuvenated). This has enabled the streams to sink their valleys into the "peneplain."

FIG. 172. — Ridges of the Appalachian Mountains crossed by the Susquehanna. (Harden's model.) (See also Fig. 192.)

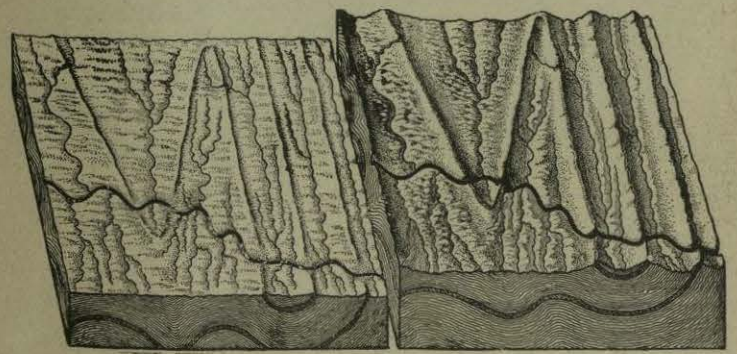

FIG. 173. — To illustrate the origin of the Appalachian ridges. The mountains were worn down to low relief, as in the left-hand figure; then, after uplift, the ridges were etched out. The streams crossing them have cut water gaps, while broad valleys have been developed between the ridges in the weaker strata.