helps to keep them so. Their levelness and dampness further fit them for agriculture. In many arid regions the river water is led out over the floodplains for the purpose of irrigation, and in some arid regions, as along the Nile, the overflows themselves take the place of rainfall.

A floodplain is usually highest near the river, because this part is most frequently reached by floods. This higher portion is known as the *natural levee*. On it are farms, towns, and cities; for example, New Orleans; but behind it is a low, swampy tract, too wet for habitation. At New Orleans, the natural levee is only a few feet above the river level and the swamp. To protect the towns and farms from overflow, men build still higher embankments, or *levees*, which serve to hold back many of the floods. When, however, a great flood breaks through the levee, vast areas are inundated, property is destroyed, and lives lost. Along the Mississippi, such a break is known as a *crevasse*.

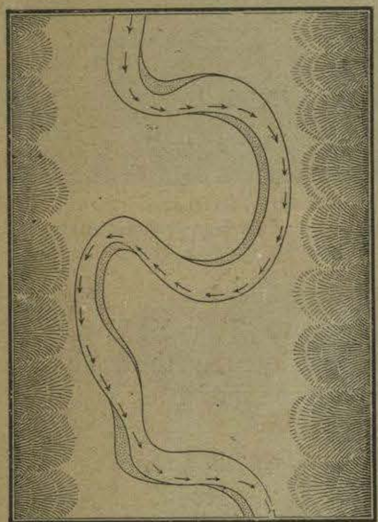

Fig. 97. — To show by arrows how, in meanders, a river current cuts against one bank and deposits on the other. The bluffs are shown on the two sides of the floodplain.

No river flows in a perfectly straight line. On the contrary, irregularities in the bed, and other causes, turn the current toward one side, and cause the stream to cut first at one bank, then at the other (Figs. 70, 102). This starts a curving or swinging of the river, known as a *meander* (Fig. 97), named after a river in Asia Minor (Fig. 345) whose lower course is very meandering. Floodplains are peculiarly favorable to the development of meanders because of the low, level land and the loose sediment, which is easily moved by the water. While

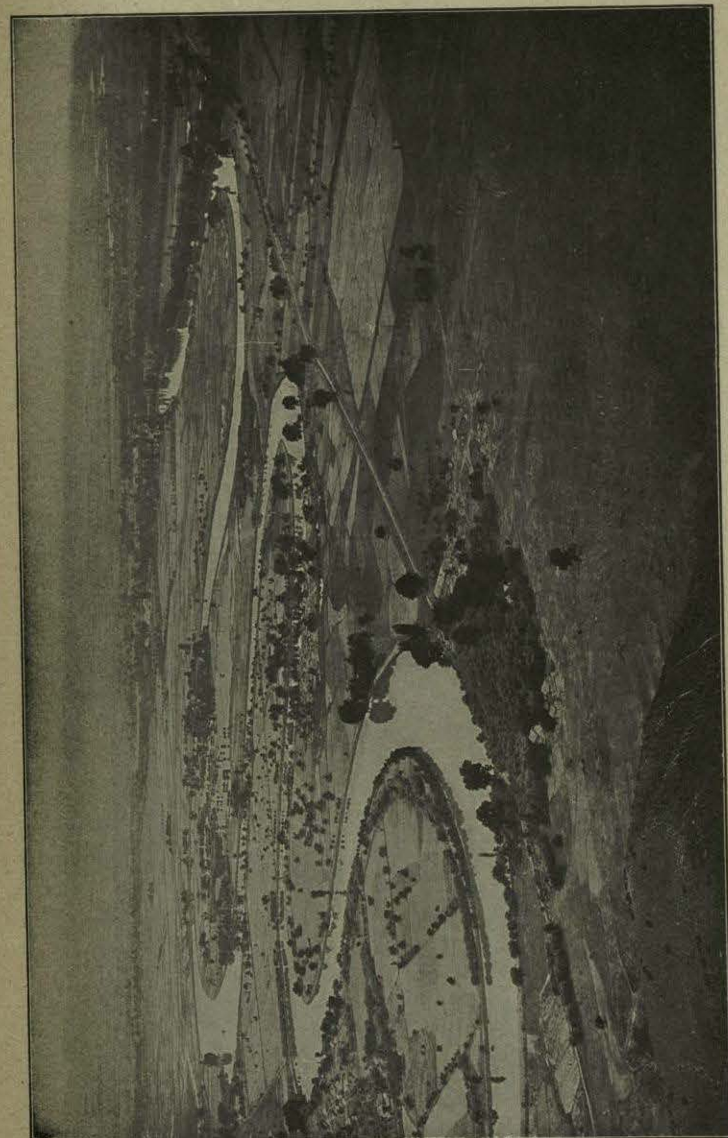

Fig. 98. — A meandering river in India, swinging in broad curves through its floodplain.

FIG. 99.—The Ohio River in flood near Parkersburg, West Va. Notice that the water rises to the first-story windows.

FIG. 100.—An abandoned ox-bow curve in the Connecticut valley near Northampton, Massachusetts.

FIG. 101.—River terraces being cut by a degrading stream in the Andes of Peru.

the stream cuts on one bank it deposits sediment on the other (Figs. 97, 102), and thus forms a broad, sweeping curve known as the *ox-bow curve* (Fig. 98). The curves vary in size with the volume of the river (Figs. 93, 98), being in the Mississippi fully five miles in diameter. As the meandering continues it often happens that the stream cuts across the neck of a curve and abandons it (Figs. 94, 95). The lake thus formed is called an *ox-bow cut-off* (Fig. 100). Floodplains have many such abandoned meanders in all stages of destruction by filling. On the Mississippi floodplain there are places where the river course has been shortened fifteen miles by a single cut-off.

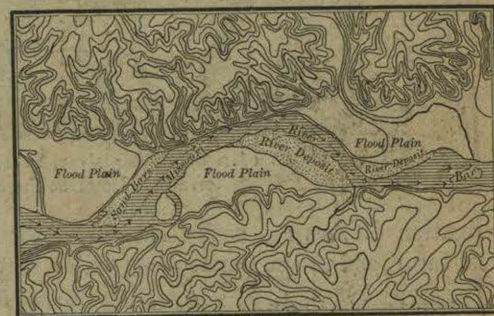

FIG. 102.—The Missouri, a meandering river bordered by floodplain, and cutting at the base of its bluffs, wherever the current swings against them.

Summary.—*Large floodplains are level tracts of fertile alluvial land bordering rivers. They are built during floods by the deposit of sediment, and are usually bordered by bluffs cut by the river. They are highest near the river, at the natural levee, on which artificial levees are built. Over the floodplain the river swings in meander-curves, sometimes abandoning them, forming ox-bow cut-offs.*

42. River Terraces.—The swinging of a river causes it to be first on one side of its valley, then on the other. If it is degrading, it cuts downward, now in one place, now in another. This leaves *terraces*, or narrow, flat-topped strips, each faced by a steep slope on the side toward the stream (Figs. 101, 103).

If an unlift elevates a floodplain so that the river cuts down into it, a series of very perfect terraces is carved in the soft floodplain deposits. During the removal of any other kind of soft deposits, such as glacial and lake deposits, rivers also carve perfect terraces.

River terraces are often excellent farm land. The soil is good; they are well drained; the surface is level; and, in arid countries,

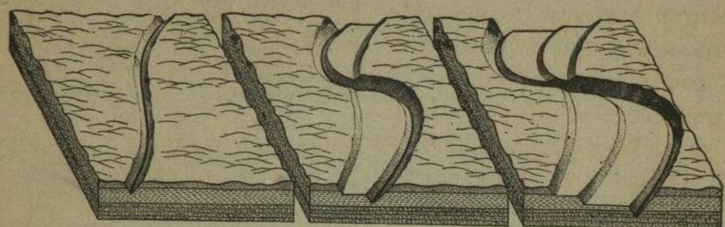

FIG. 103.—Three stages of a degrading river, to illustrate the formation of terraces. Describe these.

irrigation ditches are easily led over their tops. Some of the best farm land in the Connecticut valley is terrace land.

Summary.—*River terraces are flat-topped strips of land with steep front, bordering rivers. They are formed during the removal of materials, especially soft materials, by a degrading stream.*

43. Deltas.—On entering the sea or a lake, a river finds its current suddenly checked. Some of its sediment is removed by waves and currents, but much is deposited in the quiet water near its mouth, building up land. To this land the name *delta* is applied, because of the resemblance to the Greek letter delta (Δ), as seen in the Nile (Fig. 104).

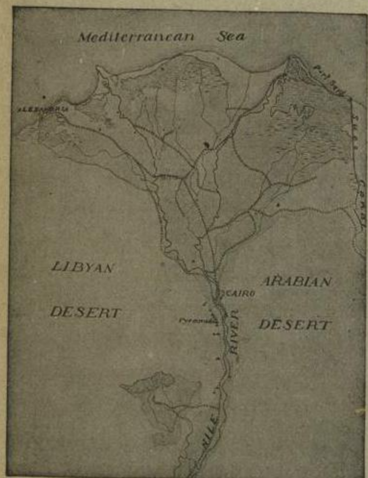

FIG. 104.—The delta of the Nile. The shaded area is reached by floods.

Deltas have the triangular shape because a single channel will not carry all the water over their level surface. For this reason the river divides into channels, or *distributaries* (Figs. 104–106), which spread apart and enter the sea by separate mouths. The delta surface, though very level, has a gentle grade down which the river water can flow.

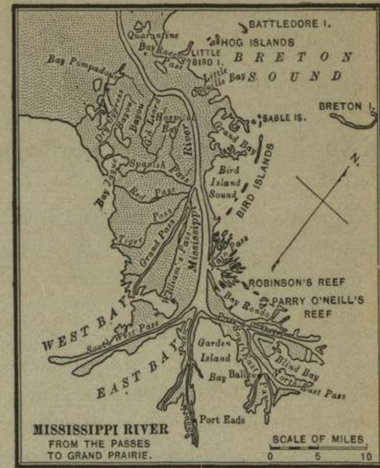

FIG. 105.—The Mississippi delta.

Deltas are absent from many coasts; for example, northeastern America and northwestern Europe. This is because there has been so recent sinking of the land that there has not yet been time enough to build deltas. It is where the sea bottom is remaining at one level, or slowly rising, that deltas are most common. They are more easily built where the water is shallow than where it is deep, and this is one reason why they are so common in lakes (Figs. 107, 297). Absence of tides and large waves is another reason for so many deltas in lakes.

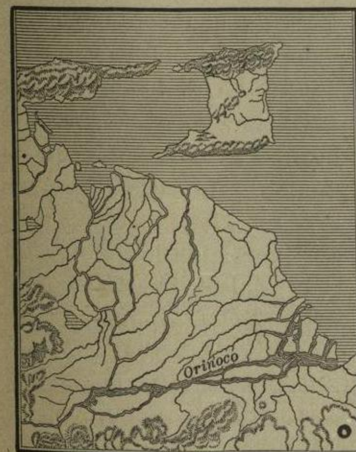

FIG. 106.—The Orinoco delta. Notice its triangular form between the outer distributaries.

Rivers meander on deltas, as on floodplains. Indeed, deltas are so like floodplains that, as they grow outward, their upper parts are commonly called floodplains They make excellent farm land, and a large percentage of the human race is now living on deltas and floodplains.

The densest population of China and India is centered on the deltas and floodplains of the great rivers, and a large part of Holland is on the delta of the Rhine. The low ground, and the danger of floods from sea and river, make living in such situations dangerous. Millions of people in India and China have been drowned during floods; but the other attractions are so great that these river-made plains are densely settled.

Summary. —*Deltas are level plains, built up by the deposit of sediment at river mouths; they are commonly triangular in shape because crossed by branching distributaries. They are especially well developed in lakes and other places where the water is shallow, the bottom not sinking, and waves and currents not strong. Like floodplains, they form excellent farm land, and are densely settled.*

44. Alluvial Fans. — A stream flowing from a steep to a more gentle slope has its velocity checked. If it has much sediment, some may be deposited where the slope changes (Fig. 109). Such a deposit is called a *cone delta*, or *alluvial fan*. Some are small, with steep slopes (Fig. 108); in fact, they may be seen forming at the base of clay banks after a rain; and some are very large and fairly level, covering areas of thousands of square miles. They resemble deltas in their triangular outlines, and some of the larger ones are difficult to distinguish from deltas (Fig. 110).

As in a delta, the water flows over an alluvial fan in numerous shifting distributaries (Figs. 108, 110, 111). As soon as one channel becomes too high, it is abandoned and a lower portion of the fan is built up. Thus the fan is built up regularly, because all parts of it are reached by the water.

Mountainous arid lands are especially favorable to the formation of alluvial fans, because there are many steep slopes, much sediment, and usually a small amount of water. At times there are heavy floods, bringing much sediment; but at other periods the water disappears by evaporation or by sinking into the gravel.

FIG. 107. — A delta at Menaggio, on Lake Como, Italy. Here a town is built, because on the mountainous coast of this lake few other places than the deltas are level enough for towns.

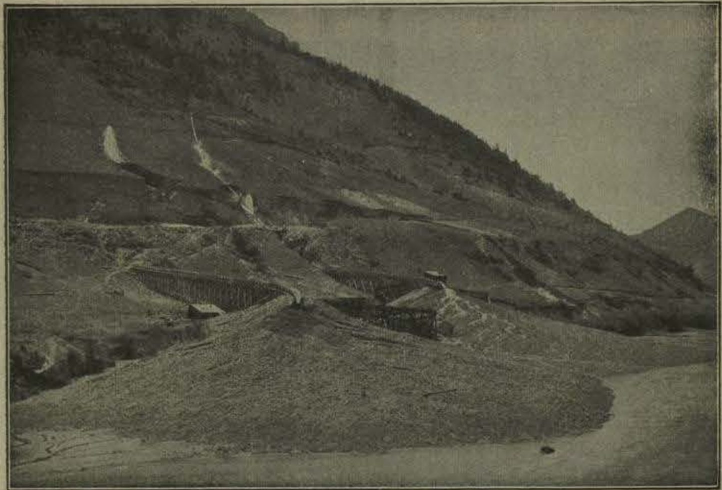

FIG. 108.—Two alluvial fans being built of gravel dropped at the end of sluices in the process of washing gold from the gravels. Notice the numerous branches of the stream on the farther fan. These are so rapidly depositing and building up the fan that they must frequently change positions.

FIG. 109.—An alluvial fan at Chamonix in the Alps, built at the mountain base by torrents bringing materials from the steep mountain slopes.

Alluvial fans sometimes grow out across a valley, damming the main stream and forming a lake (Fig. 113). Tulare Lake in California (Fig. 114), for example, is caused by the low alluvial fan of King River, which descends from the Sierra Nevada to the plain of the valley of California.

Large alluvial fans are excellent farming land. In arid regions, like western United States, they are often irrigated because (1) the soil is good; (2) there is a supply of water at the upper part of the fan; and (3) there is a good grade down which to lead the water. The large, delta-like alluvial fan at the mouth of the Hoangho of China (Fig. 110) is the seat of a dense agricultural population. The frequent shiftings of the river over this fan have caused enormous loss of life by drowning, and by the famines that have resulted from the destruction of crops. Even in a single flood over a million people have been killed. The Hoangho has even been used as a weapon of war, being turned out of its course to prevent an invading army from approaching.

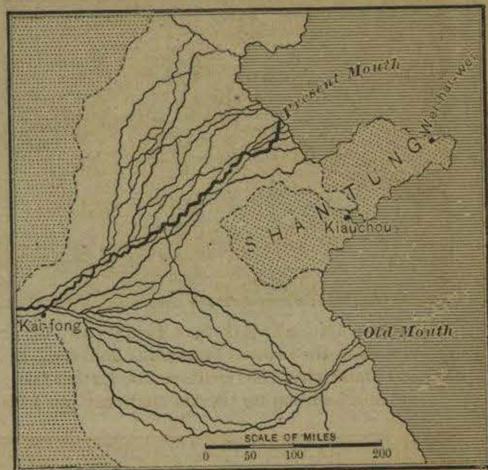

FIG. 110.—Map of the immense alluvial fan of the Hoangho. Measure with scale of miles the distance between the old and present mouth.

Summary.—*Alluvial fans are delta-like deposits made where streams descend from steep to gentle slopes, as at the base of mountains. Large alluvial fans are important agricultural lands.*

45. The Filling of Valleys.—Many valleys are having their bottoms raised by the wash of sediment from their sides (Figs. 111, 113). This is especially true in arid regions where there is much sediment and too little rain to carry it off to the sea.

The valley of California, 400 miles long and 50 to 80 miles wide, furnishes a good illustration (Fig. 114). From the Coast Ranges and the Sierra Nevada the rain wash and the streams are dragging sediment down the mountain slopes. This action builds broad, flat, alluvial fans (Fig. 113) near the mountains, and still more level deposits farther out in the valley.

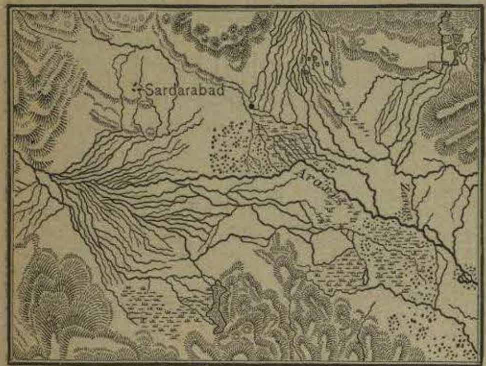

Fig. 111. — The distributaries of several alluvial fans, filling a valley among the mountains near Mt. Ararat.

A similar case is that of the Po valley in northern Italy. It was once an arm of the sea between the Alps and the Appennines, but it has been filled by wash from these mountains, and is still being built out into the Adriatic. The many mountain streams are forming low alluvial fans of coarse gravel near the mountains; but near the Po the sediment is finer and the river is bordered by fertile farm land, which is readily irrigated by water from the mountain streams and the Po. It is necessary to build dikes along many of the streams to prevent their overflowing the plain. Thus confined to their channels, the rivers are obliged to deposit sediment in their beds. In consequence of this, the surface of the Po is now well above the level of the surrounding country.

Summary. — *The wash of rock fragments from inclosing mountains sometimes deeply fills valleys, especially in arid lands.*

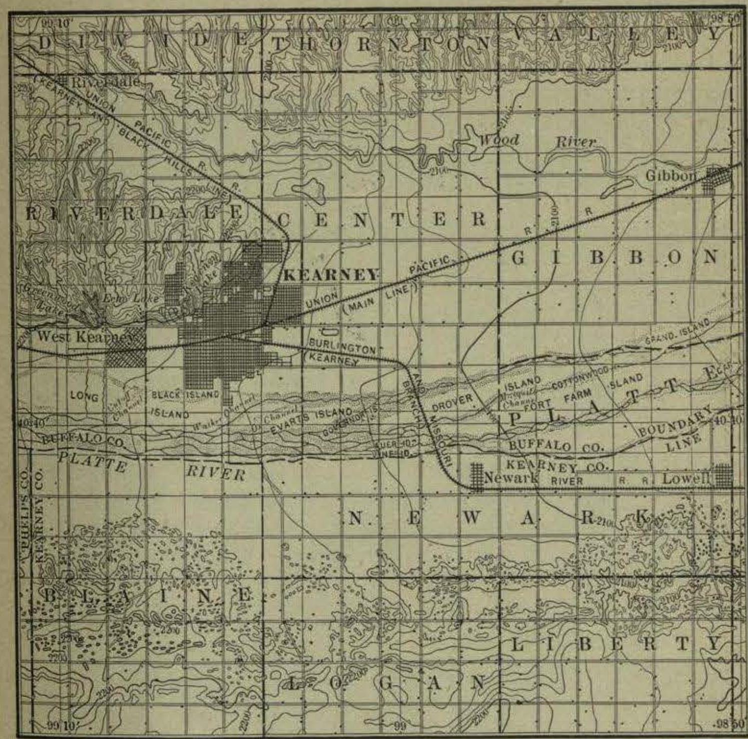

Fig. 112. — The branching course of the Platte River in Nebraska, which has so much sediment that it is aggrading its bed, and doing it so rapidly that it flows not in a channel, but in a braided series of branches. (Part of Kearney, Neb., Topographic Sheet, U. S. Geological Survey.)

Fig. 113. — To illustrate valley filling, as in the California valley.

FIG. 114.—Valley of California. The flat-bottomed valley is deeply filled with sediment washed in from the bordering mountains. Notice Tulare Lake formed by the low alluvial fan of King River. (From model made by N. F. Drake.)

TOPICAL OUTLINE, QUESTIONS, AND SUGGESTIONS.

TOPICAL OUTLINE.—30. **Supply of Water.**—Underground supply; run off; variation in run off; regulation of river volume.

31. **Rain Sculpturing.**—Conditions favoring; results; Bad Lands.

32. **The Rock Load of Rivers.**—Dissolved mineral; rock fragments; variation in size; tools of erosion; great load carried.

33. **Erosive Work of Rivers.**—Nature of work; corrosion; corrasion; lateral cutting; causes for variation in rate; influence of sediment; degrading; aggrading; influence of joint planes; of ice.

34. **Waterfalls.**—Relation to rock; pot-hole work; water power.

35. **Young Stream Valleys.**—(*a*) Initial drainage on a plain: lakes; divides; tributaries; consequent course. (*b*) Early stages of development: steep-sided valley; waterfalls; broadening of valley; base level; removal of lakes; narrowing of divides. (*c*) Meaning of youth: characteristics; illustration; age in years; comparison with plants.

36. **The Grade of a Stream.**—Nature of grade; degrading streams; aggrading streams.

37. **Mature Valleys.**—Broadening of valleys; absence of lakes; of waterfalls; development of tributaries; of divides; of floodplains.

38. **Old Valleys.**—Peneplains; reasons for general absence.

39. **Importance of Valley Form.**—Young valleys; mature valleys.

40. **Springs and Underground Channels.**—(*a*) Springs: causes; situation; mineral springs. (*b*) Caverns: cause; underground drainage; outlets; stalactites; stalagmites; columns; sink holes; natural bridges.

41. **River Floodplains.**—Where found; the bluffs; cause of floodplains; fitness for agriculture; natural levees; levees; meanders; ox-bow cut-offs.

42. **River Terraces.**—Cause; form; frequency in soft deposits; value.

43. **Deltas.**—Cause; name; origin of form; distributaries; surface slope; favoring and opposing conditions; settlement; dangers.

44. **Alluvial Fans.**—Cause; size; form; building of the fan; location; formation of lakes; agriculture; shifting of stream.

45. **The Filling of Valleys.**—Favoring conditions; valley of California; valley of the Po,—filling, farm land, effect of dikes.

QUESTIONS.—30. In what ways are rivers supplied with water? What causes variation in run off? What serve to regulate the volume?

31. What are Bad Lands? Where are they most common? Why?

32. In what two forms is river load carried? How is each supplied? What is the effect of differences in current? What effect have the rock fragments on erosion? Give an illustration of river load.

33. By what two means are rivers wearing at their channels? What effect have they on their banks? State the several causes which influence the rate of river erosion. Define degrading and aggrading rivers.

34. What is the most common cause for waterfalls? Give an illustration. What causes pot holes? Of what use are falls and rapids?

35. What are the characteristics of new drainage on a plain? What changes occur in valley form, lakes, tributaries, and divides? What is a consequent course? Base level? State the characteristics of young valleys. What does the term *youth* mean?

36. What is grade, and what causes it to vary?

37. What changes in valley form occur after a stream has reached grade? What about lakes and falls? What changes occur in tributaries? What influence does this have on sediment?

38. What is a peneplain? Why are they so uncommon?

39. What influence have young valleys on man? Mature valleys?

40. State the causes for springs. What causes caverns? What deposits are made in them? What are sink holes? Natural bridges?

41. What causes floodplains? Why are they level? Of what importance are floodplains? What is the natural levee? What causes meanders? Ox-bow cut-offs?

42. What is the cause of terraces? Of what value are they?

43. What is the cause of deltas? Why so named? What gives the delta form? What conditions favor and what oppose their formation? What about the population of deltas and floodplains?

44. What are the characteristics and causes of alluvial fans? Where do they occur? Of what importance are they?

45. In what manner is the valley of California being filled? The Po valley? Of what importance is this valley filling?

SUGGESTIONS. — (1) What is the source of the water of your nearest stream? Does it vary? Why? If there were no underground supply would it in any way affect you? (2) Where does the water run off most rapidly, on a road, a grass-covered lawn, or in the woods? Answer from your own observations. Why does it run off faster in one place than in another? From which place is most sediment washed to the streams? (3) Make a little channel in the ground and pour water into it, varying the amount from a small flow to a flood. Now make a small pond, say, five feet long, with the little channel for its outlet. Pour the same amount of water into the pond that you did into the channel. Does the outflow channel show the same variation in volume? (4) Weigh a stone in the air with a spring balance. Weigh the same stone submerged in water on the end of a string. What does the result show? (5) Make a little trough of rough wood and let water run through it from a faucet. On the bottom of the trough place small pebbles, sand, and clay. Vary the velocity of the water to see what happens. Record your results. (6) Has the stream nearest you a rapid or slow flow? What

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is the size of the rock fragments that it carries at ordinary times? At times of flood? Why the difference? Is the material at the bottom coarser than that suspended in the current? Where do the rock fragments come from? (7) Are the streams near your home aggrading or degrading? If degrading, are they aggrading in some parts? Why? What differences in work do you see from time to time? Does rock structure influence the work? Observe the stream in winter and spring to see if ice helps. Do you know of any places where they are cutting against the banks? (8) Are there any falls or rapids? What causes them? Are there any pot holes? Find what is in the bottom. What does this show? (9) Look for evidences of rain sculpturing on roads, in plowed fields, or under gutters. Place some flat pebbles on some clay and wash it away with a sprinkling pot. Are any columns formed? (10) Has the stream nearest you reached grade? Is the valley young or mature? Study and describe the valley, — its form, tributaries, divides, and falls and lakes (if present). What influence has the valley on roads, railways, and industries? (11) Has your river a floodplain? Is the plain ever flooded? If so, go after the next flood to see if deposits of sediment have been made. Does the river meander? Have there been any changes in the meanders? (12) Terraces are common in sections where streams are cutting away glacial deposits. Are there any near your home? If so, study and describe them. (13) If there is a pond or lake near by, see if there are not deltas opposite the mouths of both the large and small streams. If so, report on what you observe concerning their form and the material of which they are made. (14) Are there any alluvial fans? Look for them in mud puddles at the base of a clay cliff, for example in a railway cut. You can make one by building a pile of clay with steep slope and washing the clay down to the base with a sprinkling pot.

Reference Books. — RUSSELL, *Rivers of North America*, Putnam's Sons, New York, 1898, $2.00; TARR, *Physical Geography of New York State*, Chapter V, Macmillan Co., New York, 1902, $3.50; HOVEY, *Celebrated American Caverns*, Robert Clarke Co., Cincinnati, 1896, $2.00; SHALER, *Aspects of the Earth*, Chapters III and IV, Scribner's Sons, New York, 1900, $2.50; HUXLEY, *Physiography*, Macmillan Co., New York, 1891, $1.80. See also Chapter XVI of this book.