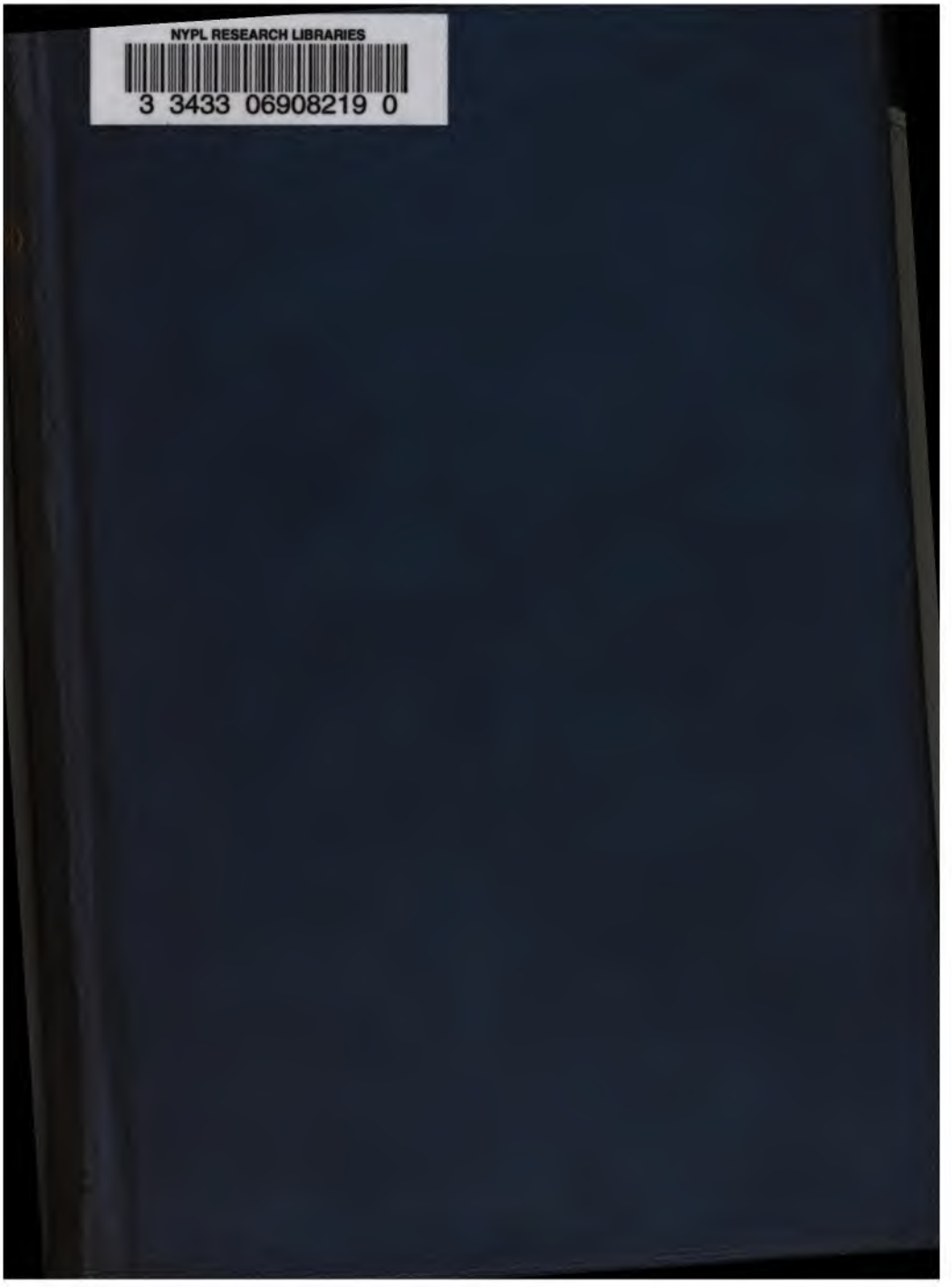

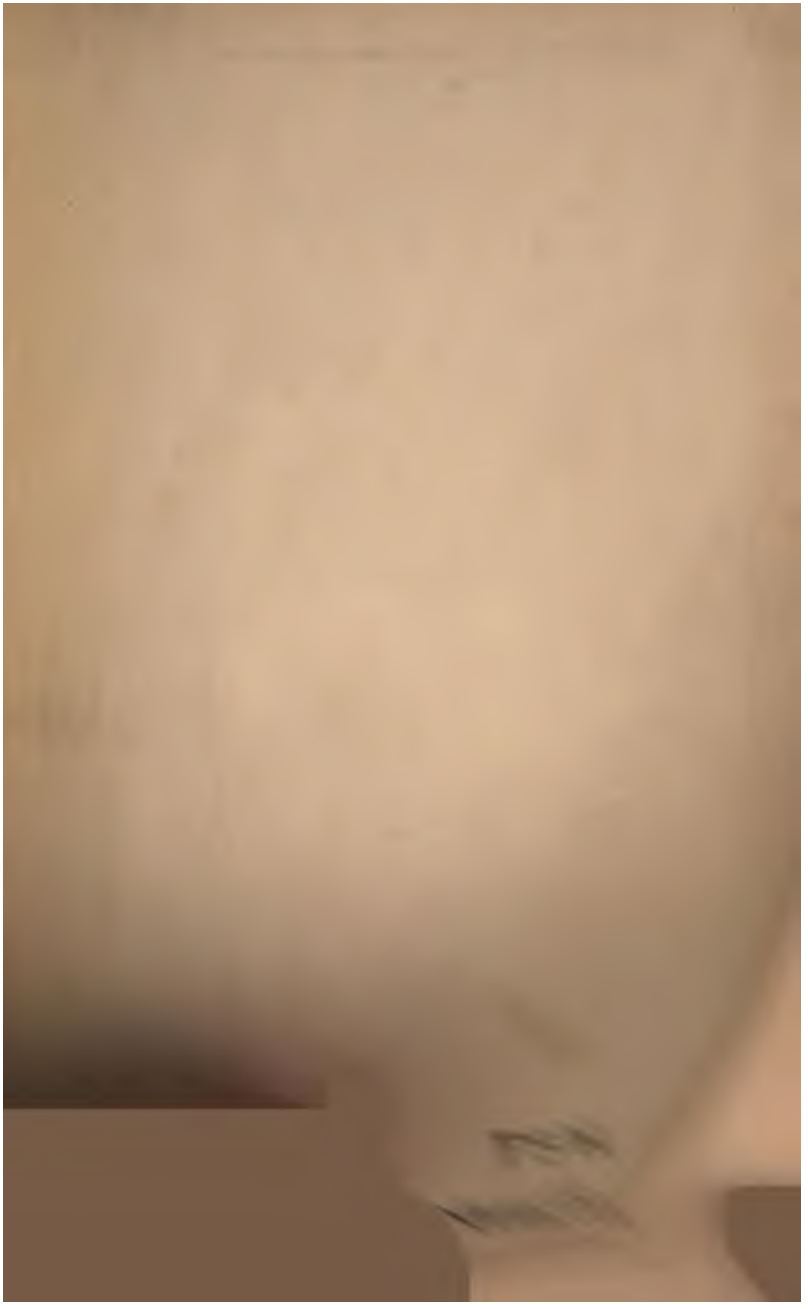

RIVERS AND THEIR MYSTERIES

Photo by Underwood & Underwood

RIVER LIFE IN THE FAR EAST

scene on a canal near Bangkok in Siam.

RIVERS AND THEIR MYSTERIES

BY

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"The Ocean and its Mysteries"
"Islands and Their Mysteries"

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ILLUSTRATIONS

skim swiftly over its icy covering on flashing skates or flying ice-boat. Even those poor unfortunate mortals who have no imagination and no romance in their makeup, who can see nothing attractive in nature unless it means dollars and cents in their pockets, look upon rivers with admiration and approval, for they represent wealth and profit. To such, the stream means busy mills and factories, cheap transportation, rich lands and bumper crops, log drives and fisheries, perhaps even riches to be won from the hidden hoard of gold within the river's bed, or maybe, the harvest of ice in winter. But whatever the reason,—whether seen through the rosy glasses of lovers drifting aimlessly as they gather water lilies and whisper soft nothings, whether viewed with the cold, calculating, matter-of-fact eyes of the practical business man or whether looked upon with the superstitious imagination of the savage, rivers are ever interesting and important things and have been so through countless ages, as they will continue to be through countless ages yet to come.

Nevertheless, most people know really very

little about rivers. They may have learned something about them in their geographies at school. They may know the rivers or the portions of the rivers about their homes or in their neighborhood, but they seldom realize how really interesting rivers are; how varied is the life within their waters, how important they are to the human race or why they are as they are.

It is to point out some of these matters, to explain the facts which to many are mysteries, to describe some of the more interesting features of rivers and to create an even greater and more widespread interest in them that this book has been written.

No attempt has been made to prepare a scientific treatise on rivers, no long and dry discussions of geological formations, meteorological conditions, or of botanical or zoological theories or technicalities have been included. Instead, the author has endeavored to describe in a clear, concise and easily understood manner how rivers are formed, why they flow, how they affect the land, the climate, the vegetation, the animal life and mankind; how

they form deltas and why; how they influence the ocean's shores and how the oceans influence them; the changes made in rivers by man and by other causes and why they are such fascinating things. In order to make the descriptions and explanations more realistic and to convey a more vivid idea to the reader, chapters have been prepared describing journeys on imaginary rivers,—one in the north, the other in the tropics—and while streams described in this way are fictitious and are in reality composites of many rivers, yet the conditions, the scenery, the life, the fauna and flora and the geology are all such as actually occur and are accurately described. Although, at times, in order to explain some feature of a river or to make a description clear, it has been necessary to digress and to discuss other matters than rivers, yet this has been avoided as far as possible.

In preparing any book on natural features of our globe it is at times difficult to confine oneself to the subject in hand, for everything is related and has a bearing upon something else. Thus, rivers have a direct bearing on

the ocean, the oceans upon rivers, the land upon both and both upon the land, while all have a bearing upon and a direct relation to climate, fauna and flora, winds and tides, and a score of other matters, and to cover the subject of rivers completely, to go into the most involved and scientific reasons for this, that and the other regarding them, would require volumes. It is the same way with individual rivers. A book much larger than the present volume might easily be written on the Amazon, another on the Orinoco, another on the Mississippi and so on with every great and important river. Therefore, in this book, the author treats of generalities and while a chapter has been devoted to certain facts and figures and interesting features of some of the most noteworthy rivers of the world, yet no attempt has been made to describe all the features of these streams in detail.

The author, who has spent much time voyaging upon rivers in the more unfrequented parts of the world and on scientific expeditions has travelled thousands of miles upon the great rivers of South America and has ex-

plored and traced the headwaters of many hitherto unknown, has always found rivers romantic and fascinating and he believes that many people will welcome a book of the scope of the present volume.

As many of the most important factors bearing upon rivers have already been described and treated in the author's two previous books of this series,—"The Ocean and Its Mysteries" and "Islands and Their Mysteries,"—only casual mention of such facts have been made and the reader will find the two other books useful and interesting in connection with the present work.

RIVERS AND THEIR MYSTERIES

flotsam and jetsam,—branches of trees, fragments of fences or of buildings,—perchance a boat or raft,—the toll of the river brought from no one knows where, to be borne, eventually, to the sea, carried for hundreds or maybe thousands of miles by this greatest and most important of transportation systems. And if a drop of the river's waters could but speak what a story of romance could it tell. What a tale of fascination and wonder! Hundreds, thousands, millions,—even billions of times perhaps,—has the same water made the long journey from source to ocean. Sucked up by the blazing sun from a brassy sea, carried by storm and wind across hundreds of leagues of mountain, hill, valley and plain, to fall at last as snow or rain and add its tiny quota to a trickling rill dripping among fern and bracken; joining with countless billions of other drops to form the little brook that in its course swells to the mighty river that flows ever onward to the sea. Who has not thought of such matters as he stood upon the river's bank or floated on its bosom? Who has not felt the longing and desire to travel up the

stream and track the river to its very source? Who has not felt a thrill as, at the river's mouth, he has thought of the long, long journey the stream had made, only to lose itself within the sea? Even among the most primitive of races there exists a reverence, a feeling of awe, a wonder at a great river and it is only natural that from the most ancient times many races have worshipped rivers and have looked upon them as gods, for, aside from the romance, the mystery and the respect which they inspire, they have always been of the utmost importance to mankind. There is no written history that does not deal very largely with rivers, no legend or fable that does not include rivers, no mythology in which rivers do not play a large part. To simple-minded, primitive man dwelling upon a river the stream was a living, mysterious thing. Its origin and oftentimes its final destination were unknown. It served him well and evidently possessed a good spirit, for did it not carry him safely on its breast; did it not provide water to quench his thirst and fish and other creatures for his food? In times of drought it watered his

crops and kept the lands along its banks green and fresh when all else was dry and parched. At times, to be sure, it rose in wrath and swept beyond its banks and perchance injured him, but it was ever repentant and, to pay for its temporary lapse, it enriched his land and left treasures in the form of driftwood and other things for him to gather up.

According to the Bible, the Garden of Eden was situated between the rivers Tigris and Euphrates. The Romans worshipped their Tiber and cast offerings worth untold fortunes into its waters. The Egyptians looked upon the Nile as a goddess, as well they might, for without it there would have been no Egyptian civilization. Our Indians considered the Mississippi as the Father of Waters and reverenced it accordingly. To the East Indian, the Ganges is sacred and to bathe in it or drink of its waters is a religious rite. The Germans wove countless fables, legends and poems about their Rhine; and everywhere, in history, in story, in folk-lore and in the progress of the human race, we find rivers playing a most important part. Indeed, much of our civiliza-

tion, much of man's success, much of prosperity has been due entirely to rivers. What would London be without the Thames; Paris without the Seine; Rome without the Tiber, or New York without the Hudson? So too, what would Huckleberry Finn have done without the Mississippi or would Mark Twain ever have become famous and given to the world his stories had his early life not been spent upon the Father of Waters? And finally, there was the Styx—the imaginary, mysterious, symbolical river over which Charon ferried departing souls, according to the ancients.

And now let us seriously consider what rivers *have* done for mankind, how they have helped the human race, how they have been such an important factor in the civilization of the world, how they have aided progress and how hopeless and helpless the world would be without them.

Wherever we find primitive man still existing in his natural state we find the strongest, most self-reliant, most progressive and most intelligent tribes dwelling on or near the

rivers. And there are many reasons for this. Along the streams, game is always more abundant and more easily secured. Within the waters there is always a plentiful supply of food to be had for the taking. Along the banks, or near them, is the most fertile land, and the man dwelling beside the river possesses many advantages over his less fortunate fellows. To move about, he is not compelled to travel wearily across mountains and plains, through brush and forest. He can move easily, and with little effort, upon the stream itself. Thus, he can see more of the world, he can reap greater benefits from a larger area of country, he can broaden and improve his mind and he has chances to exercise his brains and ingenuity which would never be presented to the dweller of the forest or the plain away from a river. Beyond a doubt, boats first originated among men who dwelt beside some stream, for no man can look across a river and not long to see what lies on the further bank. To the savage, a floating log or branch afforded a means of transportation, if the distance were too great to swim, and from a float-

ing, rolling log to a raft was an easy step. By accident, perhaps, or possibly by a glimmer of reason, the primitive navigator found that a log hollowed on one side was drier and steadier than in its natural state and thus the dugout came into being. Among other tribes a bit of floating bark,—with perhaps a squirrel or a rat upon it—suggested the bark canoe, while some savage hunter, soaking a dried hide in the river before his home, may have discovered that the skin floated and, by a little experimenting, he evolved the skin boat. And one can easily understand how a basket, accidentally lost and drifting down a river, might lead the savage to construct a basket large enough to hold himself and his belongings and which, daubed with pitch and gum to make it watertight, was the original coracle.

Then, once having solved the problem of moving at will upon the river, our primitive navigator was no longer satisfied with discovering what was upon the further shores. His curiosity led him to drift with the current to see what lay beyond the next bend and the next. And as he drifted along he discovered

that in his rude craft and moving silently, he could more readily approach and kill the game that came to the waterside to drink or bathe while, in midstream, he could secure more fish than from the banks. Gradually, day by day, he extended his sphere of exploration. He learned to propel his craft up stream against the current; he no doubt found better places for his home and for his crops. He found other men hitherto undreamed of dwelling beside his river, either above or below his own village, and he either fought with them and conquered or was conquered by them, or he found them friendly and bartered and traded with them.

At last, years or even ages later perhaps, the savage mind longed to see whence the river came and whence it went and having become a confirmed riverman he journeyed down stream to the sea, or upstream to the limits of navigation, subduing tribes less strong and powerful, trading with others, until, from source to mouth, the river formed a highway for mankind to travel,—a ready means of transportation and of trade and com-

merce. And just as primitive man in his bark or skin or dugout boat developed his crude commerce on his jungle-bordered river, so civilized man followed in his wake until the commerce of a nation depended almost as much upon its rivers as upon its ports and surrounding seas. Long before means of land travel were invented or dreamed of, boats plied upon the great rivers and carried the products of the interior to the coasts and distant lands and in return brought goods and products of far-off countries to the dwellers long distances from the coast. Thus we shall find that nearly every great commercial port is situated upon a river, or at a river's mouth, for the rivers are the commercial arteries of the land, the cheapest means of transportation and, with their branches, form a network of water highways penetrating to all parts of the country. So too, as the settlements and villages along the rivers were in more direct communication with the outside world than those at a distance from the streams, such places became more populous and prosperous and more and more people deserted their in-

terior homes and lived beside the rivers, while other places, too important or prosperous to be moved or abandoned, brought the rivers to their doors by constructing artificial streams or canals.

Not only did the riverside towns become more important and prosperous through commerce, but they had many other advantages as well. The streams provided water power to turn mill wheels and develop manufactures and industries, and even if the interior towns possessed streams which would serve this purpose, yet they were at a disadvantage and could scarcely compete with those which manufactured their goods close to a navigable river with no overland transportation charges to pay.

Even in agriculture the riverside settlements had the advantage, not only because they were so close to the flow of commerce, but also because the river bottom-lands were rich and fertile and suffered less from drought than lands further inland. And so, realizing all this, man, whenever able, followed the courses of the rivers when settling or develop-

ing a country and, after the coast, the first towns and villages always sprang up along the rivers' banks. From them, in time, roads and highways were built into the surrounding country, for mineral wealth, certain farm lands, timber and many another resource were not obtainable beside the streams and from all the surrounding country men sent their goods, their products and their manufactures to the nearest river town to be carried down the stream to the sea and to far-away markets. Of course, with the advent of railways and modern transportation systems, the importance of the waterways decreased somewhat, but despite all this the large rivers still hold their own as commercial highways, their banks are still dotted with prosperous, thriving towns, they are still the cheapest means of transportation, their water still supplies the most economical form of power and in many ways a country's prosperity, wealth and importance may be judged quite accurately by the size and importance of its rivers.

And now if we will look through any geography or atlas and glance at the maps we will

find that this is so. It makes little difference whether the country is old or new, whether it is an agricultural, a mining, a commercial or a manufacturing nation. China and India, —the most ancient of civilized lands,—show this. Aside from the coastwise ports, nearly every large or important city of these nations is upon or close to a river, while round and about each of these, the smaller towns cluster, with their size and importance becoming less and less as their distance from the waterways increases.

Look at the map of Europe and we will find the same thing true. Dotting the banks of the Danube, the Rhine, the Volga, the Seine, the Guadalquivir, the Rhone, the Tiber and all the other large rivers are big, important towns and while there are many other famous and large towns in every European nation yet they are far in the minority, and still Europe is so thickly populated, so thoroughly settled, so crossed and crisscrossed with railways and motor roads that the importance of rivers has been greatly reduced and it would be impossible for even a large proportion of the inhabi-

tants to find places to live along the river banks.

Even in little England, with its proportionately huge seacoast, its many splendid harbours, its tremendous ocean commerce and its wonderful system of railways we find the most noteworthy and most important towns and cities along the rivers. London on the Thames, Liverpool on the Mersey, Hull on the Humber, Glasgow on the Clyde, Newcastle on the Tyne, Dundee on the Tay, Bristol on the Severn, Cork on the Tee, and on the Continent Paris on the Seine, Berlin on the Spree, Bordeaux on the Garonne, Bremen on the Weser, Hamburg on the Elbe, Lisbon on the Tagus, Oporto on the Douro, Seville on the Guadalquivir, Turin on the Po, Bologna on the Reno, Vienna and Budapest on the Danube, all are splendid examples of the progress, the wealth, the prosperity and the importance of towns built upon rivers and of the value of rivers to a nation.

In our own country, too, we will find it the same. Throughout New England and the Atlantic States the principal, long-established

towns that made our country what it is are on rivers. Bangor, Concord, Boston, Worcester, Springfield, Providence, Hartford, and a score of others might be mentioned while along the Connecticut,—New England's longest river,—big busy towns and cities are strung like beads. From New York City to its source the Hudson is fringed with important towns; through Pennsylvania, Delaware, Maryland, Virginia and our Southern states it is the same. One can almost follow the march of progress and settlement of the United States by glancing at the rivers and we all know that the Mississippi and its tributaries led largely to the opening up and the settlement of our west and middle west and such towns as Memphis, Little Rock, Cairo, St. Louis, Cincinnati, Louisville, Peoria, Des Moines, Dubuque, St. Paul, Minneapolis, and many others came into existence and are still of importance mainly because they are on large rivers.

Finally, if we look at a map of a comparatively new or unsettled country we will find this even more apparent. Oftentimes the

country appears almost a blank except for the rivers and their immediate vicinity for in exploration and discovery rivers play a most important part and are often the only means by which a country can be penetrated. Especially is this true of the tropical lands where, to penetrate the dense forests and jungles is well-nigh impossible, where one must hew one's way at every step, where the bush is so dense that nothing is visible a dozen yards away and where no survey could be made. But by following the great rivers the explorer, the prospector, the scientist, the surveyor and the colonizer can make long journeys in comparative ease and can obtain a very good idea of the country, its fauna and flora, its resources and possibilities and most important of all, ample outfits and supplies may be carried to provide for trips of long duration. Indeed, in such countries as Guiana, Brazil and many parts of the East Indies and other tropical countries the land away from the rivers still remains unexplored and unknown although great steamships may ply up and down the rivers, big, busy towns may dot the banks and commerce on a tremendous scale may be carried on.

CHAPTER II

HOW RIVERS ARE FORMED

WE commonly speak of rivers "rising" and of the "sources" of rivers, but strictly speaking, rivers do not "rise" in any one particular spot and neither do they have any one source. Although it is quite true that if we look at a map of a river we will find that it appears to originate or "rise" at a definite location yet, if we should visit the locality, we would find it very difficult, if not impossible, to trace the river to its very beginning. Of course, as in the case of many things, there are exceptions and many rivers may be traced directly to some pond or lake which might be considered the source. But even then the question arises as to whether or not the lake really *is* the beginning of the river, for the lake or pond is formed by one or many streams flowing into a depression of land and the real source of the river would be the spot or spots

where these smaller streams have their beginnings. It is the same with rivers which are not fed from a lake or pond. As we approach the head-waters of the river we find, as a rule, that there are numerous brooks or creeks of

SOURCES OF RIVERS

1. Source from brooks and springs. 2. Source from lake. 3. Source from swamp.

nearly uniform size flowing from many directions to form the main stream, each of these in turn being formed by many more rills or tiny brooklets and oftentimes it is merely a matter of choice or individual preference as to which of the various waterways is considered the source of the river. Again, a river may appear to start from a bog, swamp or morass which is formed by the drainage of surrounding country and which is fed by

many small streams or even springs, and who can say which one of these is the real source of the river? Hence, when we say a river rises in a certain place or has its source in a definite spot we merely mean that it cannot be traced as a river beyond such a location. Indeed, strictly speaking, the source of every river is the ocean and it rises not in one spot, but in many, for a river is not a single individual stream, but is formed or built up by the confluence of myriads of other streams, one or more of which may be as long or as large or even longer and larger than the main river itself.

In fact rivers are merely natural drainage ditches or canals which carry off the superfluous rain which falls upon the country and which, by means of the rivers, is carried to the sea to be again drawn up by the sun and formed into clouds which fall as rain and is once more drained off by the rivers over and over again. Thus, we can judge of the character of a country by the number and size of its rivers as indicated on a map, for where there are few or no rivers we may be sure

there is little or no rain and where the rivers are large and numerous we may feel sure there is an abundant rainfall or snowfall. For example, if we look at the map of equatorial South America we find it covered with large rivers and their tributaries, such as the mighty Amazon, the Orinoco, the Essequibo, the Magdalena, etc., and judging from this we would at once assume that it is an area of heavy rainfall, which is the truth. On the other hand, if we study the map of northern Africa, or of our southwestern states, we will find few rivers and, even if we did not already know it to be the case, we would be quite safe in declaring that these districts were dry and desert-like. Many people, however, get the cart before the horse, as the old saying goes, and have an idea that the desert-like areas are due to the lack of rivers and vice-versa whereas, in reality, the lack of rivers or the presence of rivers, is due to the dry or rainy character of the country. Of course, a large river flowing through a barren, desert-like land would add to its fertility and to some extent to its rainfall; but the effect would

be very restricted and local for the amount of water evaporated or drawn up from even the greatest rivers is almost negligible and would scarcely be sufficient to fall as rain even in the immediate neighborhood, while the water absorbed by the soil along the river's course would affect the surrounding country for only a very short distance unless artificially carried across the land by ditches or irrigation canals. Indeed, where we do now and then find a large river flowing across an arid district we seldom find the country through which it passes noticeably affected by the stream and if we trace such a river to its headwaters we will always find that it originates or "rises" either in a mountainous country, where melting snows produce streams, or in a rainy, forested area and that the river flows across the arid country merely because it follows the direction and route of least resistance.

Excellent examples of how closely the character of a country may be judged by the rivers are the western coast of South America and Australia. Along the Pacific

coasts of South America west of the Andes we find practically no streams of any size, whereas on the eastern slopes of the Andes, large rivers and streams are numerous. So, too, in Australia, we will see that the country is almost equally divided into a riverless area on the west and an area crossed by numerous rivers in the east. Thus we at once assume that the western coast of South America and the western portions of Australia are dry and arid, while the eastern slopes of the Andean countries and the eastern portion of Australia are fertile and with an ample rainfall.

Reasoning from this we can judge still further of the character of the countries and we can safely aver that forests, luxuriant vegetation, rich agricultural land, teeming life and interesting and varied fauna and flora would be met with in eastern Australia and on the eastern Andean slopes, while barren, rocky, or sandy wastes, scant vegetation, dry lands and a limited variety of plant and animal life would be found in western Australia and on the Pacific slopes of South

America, although the only indications of this upon the maps would be the absence or presence of rivers.

As there is a good and simple reason for everything in nature, let us go a little further back and learn why certain portions of a country should be dry and riverless while other portions close at hand should have a copious rainfall and should possess many rivers.

The explanation is practically the same in all countries where such conditions exist, so we may take one example, and as it is always wise to begin near at home let us consider South America.

Blowing steadily across the Atlantic from east to west are the Trade Winds ladened with moisture drawn from the ocean's surface by the equatorial sun and sweeping inland across the vast continent. With no mountain ranges to interrupt its onward way, the damp air moves across the forest-covered interior where a portion of the moisture is condensed and falls as rain until, at last, the mighty barrier of the Andes bars further

progress and the sky-piercing peaks covered with snow and ice condense the last of the moisture in the air and bring it to earth in the form of rain and snow. Trickling down the mountain sides in thousands of rills and streamlets the water, borne by the Trade Winds from the far-off Atlantic, gathers in volume and at last forms the mighty Amazon which carries the water again to the sea. As the moisture-laden winds meeting the barrier of the Andes has resulted in a well-watered, luxuriantly forested area with its great river, so too, the forests which have been thus created have added to the rainfall, to the rivers and to their own luxuriance for, protected and sheltered by the forests the ground cannot become parched and dry while, from the vast area of thousands of square miles of damp, cool leaves, the sun draws enormous quantities of moisture which in turn is discharged when the winds reach the Andes. Thus the forests draw rain from the Trade Winds and also give up to take its place moisture which again reaches them by way of the rivers. And now, having learned

why the eastern portion of this continent is well watered and is rich in vegetation, let us see why the western coasts are dry and barren. The reason is very simple, for there are no moisture-filled winds blowing inland from the Pacific and thus no clouds drift against the western slopes of the Andes, no rain falls and no rivers are formed and no forests clothe the mountain sides with greenery. But travel a little to the north—to the coasts of Ecuador Columbia and Panama and we will find rivers, dense forests and fertile lands stretching from the shores of the Pacific to the higher portions of the mountain ranges. Why is this, you may well ask. Merely because in this area moisture-ladened winds *do* blow from west to east during a portion of the year and drop their precious store of water upon the western slopes of the continent.

So, wherever we find a country with rivers flowing from both sides of its mountain ranges we may feel quite sure that winds blow from various directions, which is the case with a large portion of the temperate

Photo by Underwood & Underwood

A RIVER FLOOD IN FLAT COUNTRY

This photograph of the Colorado River overflowing this country near Pueblo in July, 1921

countries of Europe and North America. As I have mentioned, when speaking of the Amazon district, the forests have a very great effect upon the rainfall, but the mountains and the prevailing winds were the original causes of rain and rivers in some places or lack of rain and rivers in others. Long ages before our present-day forests were known upon the earth, certain areas were well watered and were drained by rivers, while other areas were barren, dry and riverless, for while it is quite true that forests add to a country's rainfall and conserve the moisture yet rainfall and rivers must exist before forests can grow. But in the dawn of the earth's history conditions were very different from the present time. Then water covered most of the earth, the temperature was much higher; humid, moisture-filled air spread like an enormous blanket over the skies and rain fell almost ceaselessly so that what land that did exist was almost a swamp or vast morass and gigantic forms of vegetation sprang into existence. Probably, in those days, there were no true rivers and it was not

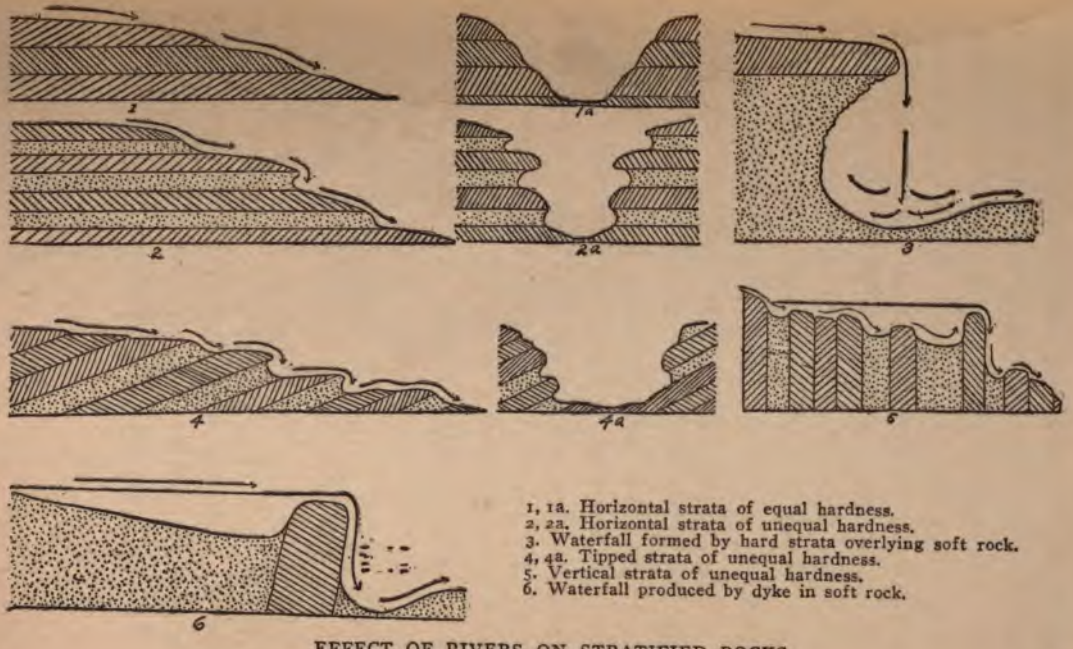
until the earth had greatly altered, until the waters had receded and the land with its mountains, plains and valleys had taken on more or less its present form that rivers, as we know them, came into existence and areas of dry riverless deserts and fertile, well-watered, river-cut areas were developed.

Now, having learned something of the origin of rivers and why some places are riverless and some are well watered, let us see how rivers affect the land itself, for in many ways rivers have a far greater influence upon the land that the land has upon the rivers. But even here again we find a sort of involved, endless chain of causes and effects, for the very changes and alterations which rivers produce upon the land are caused by the character of the land through which the rivers flow. If the country is mountainous or rocky the river will follow the valleys or ravines between the hills and will flow swiftly, in the form of rapids, will dash over ledges and cliffs in cataracts and waterfalls and will wear a deep, narrow course for itself. If the stream flows through

level land or meadows it will flow slowly, calmly and evenly and will broaden out and travel in a straight course or will sweep in graceful curves and turns while, if passing through a district of hills, or ridges, and valleys, it may form a series or chain of lakes. But no matter whether it dashes noisily through rocky defiles or flows majestically across plains, whether it sweeps onward towards the sea as straight as a canal or bends and twists and doubles on itself, there is always some simple explanation to account for it. Invariably a river flows through the lowest depressions of land in its course and invariably the water follows the way of least resistance, although at first sight we may not think so. Let us first consider a river rising in a mountainous district where the country is composed of hard rock. Here we will find the stream flows swiftly and follows the natural curves and twists of the defiles between the mountains. But we will also find upon a close examination that the rocky sides of the river's course have been cut and worn by the stream itself, that through countless ages the

water has carved its own bed many feet deeper than the original ravines and we will find the bed of the stream full of rounded, water-worn pebbles and boulders. These are the tools by which the stream has chiselled its way through the hard rock, for while water alone will in time wear through the hardest granite such action is exceedingly slow.

But the sand pebbles and stones, constantly kept in motion by the current, grind and cut and carve the rock very rapidly. Swept along by the stream they not only cut ever deeper and deeper into the rock, but they also wear away the sides of the river bed leaving overhanging or projecting ledges which at last crumble and fall into the stream. If the masses thus cut loose are small, or if they are cracked or shattered in their fall, they are soon broken up by the stream, their finer portions are carried along and the larger fragments take their turn at carving and cutting away the surrounding rock. But if the masses are so large or hard that the stream finds them an obstacle too



1, 1a. Horizontal strata of equal hardness.
2, 2a. Horizontal strata of unequal hardness.
3. Waterfall formed by hard strata overlying soft rock.
4, 4a. Tipped strata of unequal hardness.
5. Vertical strata of unequal hardness.
6. Waterfall produced by dyke in soft rock.

EFFECT OF RIVERS ON STRATIFIED ROCKS

great to be overcome it follows the direction of least resistance and either flows to one side or pours over them in a miniature cataract. In the latter case the mass of rock will in time be broken up, the fragments will separate and the cataract will become a series of rapids. If, on the other hand, the stream swings to one side, the stones and pebbles will at once commence cutting a new channel and in time the stream will flow in a curve or bend around the fallen mass which eventually may thus be left resting in the former river bed far above the water. Moreover, if, as is generally the case, the rock varies in hardness, or is in the form of strata or layers, the river will cut its way much more rapidly and will flow through picturesque cañons or deep ravines with numerous waterfalls, innumerable bends and turns and oftentimes with tunnels or natural bridges.

If the strata or layers of rock are perpendicular or vertical the stream, wearing away the softer rocks, may flow through a deep, narrow, precipitously-walled cañon

hundreds or thousands of feet below the edges of harder rock. If the strata is tipped or at an angle, we will find the bed of the stream deeply undercut in some spots, broadly sloping and worn in another and forming series of cascades or rapids in others, while if the strata is horizontal we will find the stream descending by means of stair-like waterfalls with the sides of its course often carved and eroded in grotesque, remarkable forms resembling castles, terraces and citadels. Such is the Grand Cañon of the Colorado and the wonderfully carved and picturesque sides are due to the water wearing its way through layers of rock of varying degrees of hardness.

The Grand Cañon is remarkable merely for its size and grandeur and we may often find, near at hand, some little mountain stream or river which has carved a cañon fully as beautiful on a miniature scale. I have already spoken of the pebbles carried by a stream cutting into the surrounding rocks and while moving stones and sand, combined with flowing water, will cut

rock as hard or harder than themselves—exactly as diamond dust will cut diamonds—yet when the boulders and pebbles and sand are of harder material than the surrounding rock their action as abrasives is far greater and more rapid. And, as a rule, the sand and pebbles carried by a stream are of much harder material than the bulk of the surrounding rock, for they represent the residue after all the softer portions have been pulverized and carried away. Moreover, it will easily be seen that when these ever-moving tools of the river strike a layer or strata of softer rock they will bite into it more rapidly than in other spots, with the result that deep basins, tunnels, natural arches and bridges, deeply undercut ledges and precipitous-sided ravines result. So too, if a hard rock finds a depression in which to lodge, or if by the action of a whirlpool or swirling current, it is turned around and around in one spot, it will finally wear a circular hole or cavity and will produce what is known as a pot-hole. The deeper these holes become the faster they wear down, for

more and more stones and gravel lodge within them, the whirling current is increased and the abrasion is ever greater and greater. In nearly every stream which flows over a rocky bed we may find pot-holes and where these are numerous and deep they play a very important part in the erosion of the river's bed. We may often find great areas of rock which have been cut away by being weakened by pot-holes until the whole mass crumbled, exactly as a carpenter might bore a number of augur holes in a plank and then, by chiselling the wood between them, remove a large piece of the material with little labor.

Very often, too, we find these pot-holes far above the present level of the water, showing how much the stream has cut its way downward into the rock since the pot-holes were formed.

At other times, these pot-holes may commence in a fairly hard layer of rock and wearing down through this reach a softer layer. In such cases the pot-holes may be curious affairs with their bottom portions far larger than their openings, or the softer

layer below may be entirely worn away leaving a projecting or overhanging layer of hard rock perforated by holes as smooth and regular as though bored with a gigantic augur. Occasionally such pot-holes may be the cause of a cataract or waterfall for the water, pouring through them, wears them ever deeper and larger until the rock breaks off along the line of holes and the stream, finding the new course easier, abandons its old bed and follows the new one. But as a rule, cataracts and waterfalls are due to horizontal layers of hard and soft rock or to vertical or nearly vertical layers or dykes of hard rock cutting though an area of softer rock.

If a river flows through a bed of hard rock and reaches a spot where softer rock begins, its water and its pebbles and sand cut away the softer rock and forms a shelf or terrace and the more the soft rock below is worn away the more rapidly the falling water and its increased force cuts and breaks it, until at last, the river drops in a stupendous waterfall from the bed of hard rock to

the bottom of the soft rock channel hundreds of feet below. If the harder rock is of great thickness the fall may be perpendicular or may slope slightly outwards at the base, but if it is comparatively thin the softer rock beneath will constantly wear back to form a huge cavern and the overlying harder rock will, from time to time, break off at the fall's verge so that the cataract will gradually recede further and further up the stream.

This is the case with Niagara, with stupendous Kaieteur Falls in Guiana and with many other large waterfalls. In many places, dykes of hard rock cut through areas of softer rocks and these invariably produce cataracts, rapids or huge waterfalls depending largely upon the comparative hardness of the two kinds of rock, the speed and size of the stream and the slope or character of the country through which it flows. If the banks above the dyke are low, the stream, backing up behind the dyke like a mill pond behind a dam, may find a new channel through soft earth or rock to one side, and

following this, may descend in rapids around the dyke. But if the banks are high, the water, pouring over the dyke, will rapidly cut away on the lower side and will form a waterfall which will increase in height as the years go by and the ceaselessly descending water wears the rock below the dyke deeper and deeper.

Very often, too, the very forces which produce a cataract may eventually destroy it, for as it is cut further and further back, as already described, the hard rock may be worn away until soft rock is reached when the river will rapidly cut down to the level below the original falls and in place of a glorious cataract only swift-flowing, tumbling rapids will remain. At other times, dykes or layers or projections of hard rock may form islands and such rocky islands are very common at or near the verges of cataracts and in rapids. Very often, too, islands are formed in swift-flowing mountain streams by accumulations of rocks, pebbles and gravel which pile up in the slack water between currents or deeper channels or where the

stream swings around a bend or corner. In such places the current always follows the outer or further curve of the banks and as it cuts deeper and deeper into this, material is constantly being piled up on the opposite side of the stream or between the two banks. In this way a river, even in a rocky district, may move about considerably and in the course of years it may change its channel and produce great alterations in the country.

This is particularly true of streams which are fed by melting snows in spring and which are subject to sudden rises or freshets. At such times, when the waters are swollen by rains and melting snows, the stream may find its channel too small to carry off all its volume and it may overflow its banks and dig a new bed which it will ever afterwards follow, leaving the original course to be overgrown with vegetation and to become a dry ravine or cañon. We often find such places, with their steep, rocky sides still showing the marks of being cut and chiselled by flowing water and grinding stones and yet

with a mere trickle of water—far too small to acount for the deep ravines—flowing along the bottoms. These are sure indications that at some time in the past a large stream or river cut its channel through the rocks and then, either by the erosion of some barrier or by the sudden onrush of a freshet, found an easier route towards the sea and deserted the bed it had taken so many ages to carve out for itself.

In addition to all this, there are the influences of ice and snow in the northern countries. Few forces in nature possess the power of eroism of ice and wherever a stream flows through rocky districts and tumbles over ledges and dykes in cascades, rapids and waterfalls, a vast amount of ice is formed from the freezing spray. Not only does this break and crack the rocks through expansion when freezing, but rocks already weakened by the stream may be brought crashing down through the weight of ice and snow upon them, while masses of rock which still withstand all this give way to the roaring, dashing force of the river increased to many times

its normal size by the melting snow and ice in the spring and with masses of floating ice acting like titanic battering rams. For these reasons rivers of the north do most of their cutting and moving and altering the face of nature during the winter and spring and in

HOW RIVERS BECOME CROOKED AND HOW THEY CUT NEW CHANNELS

1. Straight stream (shown by dotted lines) with log causing currents to be deflected and cut into bank thus producing bends.
2. Curved stream showing currents deflected to one bank and back currents allowing silt to settle on the other side.
3. Effect of cutting by deflected currents (dotted line shows old curve and accumulation of silt.
4. The currents cutting through bank (dotted lines show old channel and bank) and forming new channel.

a single season a river may change its course entirely or may work tremendous changes in the surrounding rocks and hills.

But by far the greatest changes of land wrought by rivers take place where the streams flow through a fairly level country of sand or clay or loam.

Here the river is not confined by hard durable rock which must be cut and carved a bit at a time through centuries, but flows through material which is easily and rapidly cut and moved, and as a result, such rivers are constantly shifting their courses, are ever making new land and carrying away old and are by no means the fixed and stable waterways we imagine them. If a river flowing through alluvial country runs fairly straight and follows the depression or valley between ranges or ridges of hills, it may continue in practically the same bed indefinitely, for it is following the course of least resistance. But it is seldom that a stream *does* run straight for any great distance. A very slight obstruction, such as a log, an old stump or snag, a boulder, or even an area of slightly firmer or more tenacious soil or a bunch of grass or tree roots, will produce eddies and currents in the flowing water. Then the river at once commences its work of tearing down and building up. Up stream from the obstruction, the current of the river will be slowed down while, on either side of it, the

speed of the current will increase in proportion. Where the current is checked, the sand, mud and sediment in the water has time to settle and gradually accumulates to form a bar and the larger this becomes the more the current is checked and the faster silt is dropped. Then bits of driftwood, leaves and waste matter of all kinds are cast upon the little bar; seeds find lodgment and take root and grow; the roots of the plants bind the soil together and protect it from washing away and in a short time a real island is formed in midstream. And on either side the current cuts deeper and further into the banks as the water is forced aside by the ever-growing island, until, at last, the islet is situated in a broad, lake-like expanse of river.

Or again, one of the side currents, in cutting its way into the bank, may break through a low ridge or hummock and find a way into another depression or valley and follow this toward the sea. Perhaps, if this new channel is large and deep, the entire river may follow it and abandon its old bed

or, in other cases, one portion of the stream may follow the new course while the other part continues in its original bed and thus two separate rivers are produced which may diverge so much that, by the time they reach the sea, their mouths may be many miles apart and no one would dream that a stranded log or bit of drift had altered one river and had formed the two. Oftentimes, too, the obstruction may bring about a very different sort of change. If near one of the banks of the river, it may throw the bulk of the water towards the opposite shore with the result that, instead of forming an island, it produces a point or cape of land and the current, swinging around this, will cut deeper and deeper into the opposite bank, ever piling up material on the outjutting point until, where the river had once flowed straight or in a slight curve, a great bend is produced.

Even if there is no obstruction, a river may change its course tremendously for the slightest curve or bend in its channel will result in the water flowing more rapidly

on the outer side of the curve and more slowly on the inner side and as soon as this occurs the outer banks are cut further and further back and the inner banks are extended further and further out by the constant accumulation of silt and drifting material. This may result in the river gradually altering from a nearly straight stream to a river sweeping in great, graceful bends, for in cutting and wearing away the bank a portion of the force of the current is exhausted, the speed of the flowing water is decreased and the more rapidly moving water in the centre of the stream is thus thrown over to the opposite bank where it commences to cut away the shore until a second bend is produced, and thus continuing, the river produces a series of curves to right and left until its course looks like a gigantic, writhing serpent.

On the other hand, a river which flows in curves may cut away the bank at one bend until it breaks through to a new hollow or valley in the land and thus the stream may be diverted and in a night may shift across

country for miles or it may cut through from one curve to another and thus straighten its course. This had often happened and where a river is used as a boundary between different countries, states or private lands it often causes great confusion, legal battles and even wars.

Particularly is this true in sandy districts and the Missouri and the Rio Grande are famous for such behavior. A man owning property on such a river may wake up any morning and find his land has doubled or trebled in area or he may find that his hundreds of acres have been taken from him in a few hours and delivered to his neighbors. So a person dwelling near the border of Mexico, where the Rio Grande is the boundary line, may be a resident of the United States one day and a resident of Mexico the next.

Another cause for rivers changing their course is the alteration of the land, either by man or by forces of nature. A bridge, pier, dock, dam or even a wall or post may entirely alter a river's course or change its width or depth and engineers, knowing this,

frequently turn rivers aside or make them deepen their own channels or cut away land to benefit man. Very often also, a river may change its character or course through the land rising or falling, although the alteration in the country may be so slight that it is not detected by human beings. Everywhere the land is gradually being pushed upward or is slowly dropping down and while this may go on for centuries without affecting the rivers, yet the time comes at last when a depression which has kept a river on its course is higher than some nearby spot, or a rise which has hitherto kept the stream within bounds is lower than the river level, and in either case the water, ever seeking the lowest levels and the path of least resistance, changes its course.

In many places as for example some of the West Indian islands where the land rises or falls comparatively rapidly, the alteration of river beds, due to such causes, may easily be seen. On some of the islands one portion of the land is rising much more rapidly than others and here one can trace the

steady movement of the rivers from north to south or from east to west as the case may be. In some of these localities we can find ancient river beds scores of feet above sea level and can find a dozen or more successive dry beds between the first and the present course of the river. Indeed, some of these rivers have moved so rapidly that the various courses they have followed are joined to form one enormous bed many miles in width with the present stream occupying the lowest point. At times, moreover, a slight earthquake may produce changes in the land which will entirely alter streams and rivers and in tropical lands, where earthquakes and volcanic eruptions are common, the rivers are constantly swinging from place to place and finding new outlets to the sea.

You may think, if rivers move about as I have described, that it would result in great damages to crops, lands and the inhabitants of the neighboring country and while rivers *do* cause damage in this way and may even destroy towns or villages, yet there are

compensations, for what rivers take from one place they give to another. Land made by rivers, either by forming islands or by altering their courses, is usually rich and fertile, for it contains large amounts of decaying vegetable and mineral matter carried by the water, while valleys or river bottoms which are inundated or flooded by rivers at times of freshets are noted for their fertility. The bottom-lands of many of our western rivers are marvelously rich while the meadows and "intervales" of our eastern streams produce wonderful crops, for with every overflow of the river a thin layer of fine loam, pulverized rocks, decaying leaves and vegetation and disintegrated minerals is left upon the land when the waters recede. Now, having seen how rivers are formed, how they change their courses and alter the face of the country, how they are constantly working and carving their way through stone or soil and how they both injure and benefit man, let us follow the rivers to the sea and discover how they affect the ocean and its shores.

CHAPTER III

RIVERS' MOUTHS AND DELTAS

YOU may think that rivers can have very little effect upon the mighty oceans and while in a way this is true to some extent, yet large rivers do have a very great effect upon vast areas of the ocean and all rivers have a great bearing upon the shores of the ocean.

Every river and stream, whether swift or sluggish, deep or shallow, wide or narrow, large or small, carries a certain amount of fine earth, sand and silt in its waters, to say nothing of the floating or drift material which is carried on its surface. The larger the river the more material it carries, as a rule, but a very large, slow-flowing, sluggish river may carry far less material to its mouth than a smaller swiftly flowing stream. The reason for this is that the slower a

stream flows the more opportunity there is for the suspended silt and sand to settle while, in addition, the sluggish stream does not disturb and stir up the mud and sand on its bed as does a swift-flowing stream. Thus, a very large but slow-flowing river may deposit nearly all its transported material long before it reaches the sea, while a rapidly flowing, smaller stream may carry practically all of its loose, transportable material along with it and not drop it until its onrushing flow is checked by the ocean. Therefore, a large, sluggish river is usually filled with bars and shallows along its upper course, but is deep near its mouth, whereas a smaller, swift stream may be deep and free from bars along its course and may have its mouth choked and shut off from the ocean by bars of sand and stones. On the other hand, the waves washing into a river's mouth or the tide flowing up it may carry the silt and sand back and forth and distribute it over a large area of the river's bed so that for many miles from its mouth a large river may be very shoal and filled with bars. This is

very common, especially on many of the big tropical rivers where the tides rise and fall and back the river up for over one hundred miles or to the first rapids. In such a case the entire length of river exposed to tidal action is really an estuary or mouth and the silt and sand is dropped all along its course until comparatively little remains to form a recognizable bar where the river finally joins the sea.

The amount of material which a river carries with it depends also upon the character of the land through which it flows. If the country is rocky or gravelly the water may be very clear, for the sand and stones settle too rapidly to be carried any great distance while, on the other hand, if the country through which the river flows is loamy or clayey the water may carry a vast amount of material in suspension, for so slowly does such material settle that water dipped from some rivers and placed in a bottle will remain cloudy or muddy for months. For this reason the larger and more sluggish rivers as a rule carry far more fine silt than

the smaller, swifter streams, for swift-flowing rivers usually indicate a rocky or gravelly district while sluggish rivers indicate a level district with deep loam or clay soil.

Thus, if you examine the bar at the mouth of a swift-flowing river you will find it composed largely of clear sand, rounded pebbles and bits of rock, while the bar at or near the mouth of a large, sluggish river will be found to consist of finely-divided ooze or mud.

So fine is this ooze and so slow to settle that much of it is carried far out to sea and is distributed over a wide area of the ocean's floor instead of in bars at the rivers' mouths. The waters of the Mississippi color the Gulf of Mexico for many miles beyond the river's mouth; the mud-colored waters of the Orinoco tinge the Caribbean sea for more than one hundred miles north of its delta, and the mariner, sailing towards the Amazon, can tell when he is off the mouth of that mighty river by the color of the water hundreds of miles from land. In some cases, however, the chemicals in the salt water

affect the silt and precipitates or settles it very rapidly as soon as it reaches the sea.

But whether the river carries fine silt and mud or sand and stones the ocean and its shores near the river's mouth are greatly affected and often altered and these changes often, in turn, produce other changes at considerable distances which no one would imagine had anything to do with the rivers.

The fine mud and silt, accumulating at the river's mouth, may be washed upon the nearby shores by the waves, or it may be carried by ocean currents for many miles, to be finally deposited upon some other part of the coast and thus a rocky or sandy beach may be transformed into an area of mud-flats, while the sand and gravel brought down by another river may be scattered and piled over a stretch of muddy coast and so alter it to sandy or gravelly beaches. In time, the mud or the gravel will accumulate and form bars, capes, islands or peninsulas and these, changing the direction of ocean currents, of tides and of beating surf may completely alter the coast line for many

miles. Moreover, the life, vegetation and character of the shores and the country for some distance inland may be completely dependent upon the rivers. Where the mud and silt gathers, animals which are fond of mud will find homes; sedges; certain salt water grasses and trees will find roothold and grow and gradually these will extend and protect the mud flats from washing away and in time a vast marsh or swamp may cover what was a bay or estuary of the sea. In the tropics where mangrove trees abound, such swamps are very common and often cover hundreds of square miles near the mouths of big rivers while, in the north, vast salt meadows or marshes are the usual result. On the other hand, a swamp may be destroyed and dry, firm land may result from sand and gravel brought down by a river being deposited upon it, thus destroying the life and vegetation peculiar to muddy places, or again, a gravel bar may form a barrier to the waves and sea and a beautiful lagoon may be formed behind it or the space back of it may become filled with sand and

gravel and transformed to a sandy area. In this case the stream may trickle across it in numerous rills, it may cut through it in rapids or cascades or it may seek a new outlet at one side, only to build up another barrier, to move yet further to one side and to repeat the operation until it has formed a steep,

1. Delta formed by silt carried to sea.
2. Delta formed by stream cutting through land.
3. Delta formed by islands in river's mouth.
4. Delta partly destroyed by docks (A).

gravel shore extending for miles and with the river's mouth far distant from its original position.

In a great many cases, too, the silt and sand carried to the sea by a river checks its own flow and acts as a sort of dam. Then the river, backing up behind this, forms a great lake-like estuary. From this, one or more channels may be cut through to the sea or the silt may be piled up in some spots and not in others—due to a variation in currents or to some obstacle which checks the

Photo by Underwood & Underwood

A BEND IN A RIVER

This picture taken on the Pucro River in Panama, shows the gradual cutting away of a sandy bank by the stream and the formation of a bar on the opposite side.

flow of water and allows the silt to settle—and thus deltas are formed. Many large rivers possess deltas while others equally large have only a single mouth, for the formation of a delta depends, not upon the size of a river, but upon a great many conditions, or combinations of conditions, which may or may not occur where a river flows into the sea.

Thus, if a river, even though it carries a great deal of silt, flows into a deep bay or gulf where there is a strong outflowing tide or other ocean current, the silt deposited by the stream may be carried away and out to sea as fast as it accumulates and there will be no bars built up to form a delta. Or again, several large rivers may flow into the same bay and the current from one may carry off the silt from the others. Such a condition as this exists on the coast of British Guiana where the Demerara and Essequibo Rivers join just before they reach the sea, with the result that neither stream has a delta and only a narrow bar across the river's mouth marks the silt deposited by the two great rivers.

In nearby Dutch Guiana the big Surinam River and the Courantyne lack deltas, but in these cases the silt brought down by the streams is carried off by a strong ocean current which sweeps along the coast and yet, only a short distance away in Venezuela, we find the Orinoco with a complicated, many-mouthed delta, although the former streams carry proportionately a much larger percentage of silt than the Orinoco.

Neither must we assume that deltas are confined to large rivers. We may often find very perfectly formed deltas at the mouths of very small streams, both where they flow into the sea and where they join other rivers. Oftentimes, too, a stream which does not possess a delta may suddenly develop one for, like islands in rivers, a delta may be produced by some very slight obstruction in the river's mouth. Indeed, a great many deltas are formed by islands growing or building up at a river's mouth. I have just mentioned the Essequibo River as an example of a big river without a delta, but, within a comparatively short time, if conditions continue as at pres-

ent, the Essequibo will possess a delta. Near the mouth of this river are several large islands, one of which, Dauntless Island, was formed by the stranding of a wrecked vessel, and these islands are very rapidly increasing in size and it is only a question of a few years until they join and extend to such an extent as to produce a true delta. Moreover, rocks, jetties, piers and other works of man are often built at or near a river's mouth and as these invariably affect the currents and the deposition of silt they may produce deltas where they did not naturally exist, or they may result in destroying a delta which existed naturally. Thus, if a river has a mouth or delta with three channels and the currents are so altered by docks, piers or other works as to partially obstruct the flow of water through one or two of these, it may result in these becoming choked and filled with silt and debris until all the water flows through one channel which becomes enlarged and deepened thereby. On the other hand, an interruption caused by docks or other works on a river with a single mouth may result in

the water backing up and finding other outlets through sandy or muddy land and thus a delta will be formed. Very often, too, especially if the river is large and navigable, the bar at its mouth, and the river for some distance from the ocean, may be dredged or deepened to permit large vessels to enter and leave the river. This will invariably affect the flow of water, the deposit of silt and the character of the nearby shores and a very slight deepening of one of the mouths of a river with a delta may result in the bulk of the water flowing through the deepened channel and filling up of the others.

In the past, a great deal of harm has been done by building jetties, piers, wharves and other obstructions, or by dredging channels, without realizing what results might follow, for, in order to be sure that the improvements made for man's benefit may not do more harm than good, it is essential that a deep study of the local conditions as to silt, currents, tides, freshets, character of shores and many other items should be made. Nowadays, engineers realize the importance of

such matters and our government does not permit anyone to dredge channels or build obstructions of any sort in navigable waters until competent engineers have been sent to examine into the conditions and make a report.

And now comes the question as to what is and what is not a delta. In our geographies we were taught that a delta is a river's mouth divided by land into several openings, but this is a very hazy and unsatisfactory definition. A river for example, may divide into two or more branches some distance from the sea, but could we consider this as a delta? Again, a river may flow in a single channel to the sea and yet there may be small side channels or creeks or bayous which lead from the sea to the river near its mouth, but we would hardly be justified in considering this as a delta. Then, there are rivers with rocky, sandy or muddy islands of varying sizes situated in their mouths and between and around which the rivers flow in well-marked channels, but no one would consider that be-

cause of this such rivers had deltas. Indeed, it is a very difficult matter to define the word delta so that it covers all conditions. In a way, it all depends upon the relative amount of land and water. If the land between the various channels is greater in area than the water we may safely consider it a delta whereas, if the water occupies more space than the land, it is not a true delta, regardless of whether the river itself has formed land—projecting into the sea, as is the case with the Mississippi, or whether it has cut through low-lying land as in the case of the Orinoco, the Nile and many other rivers.

But whether the river has a delta or not, the mouth is always a fascinating and interesting spot; the place where the river—after traveling hundreds or thousands of miles, comes to the end of its journey and loses itself in the ocean; the spot where fresh water and salt water join, where the river's life and work and purpose are accomplished and the mighty sea takes charge, the place where countless craft leave the

tranquil waters of the stream, and tossing to the ocean swell, set sail for far-distant lands, and the spot where the teeming animal and plant life of the river is replaced by the equally abundant but totally different life of the ocean.

CHAPTER IV

RIVER LIFE

WHEREVER we find a river, or even a stream, no matter how large or how small, we will find that it supports a fauna and flora of its own, a teeming little world of animal and plant life, many forms of which are found nowhere else. Moreover, many large rivers, and even some small ones, possess certain species of animal and plant life which are peculiar to themselves and are never found in other streams, even a short distance away. Where such conditions exist we may be very sure that the stream is very ancient, that through untold ages the river has flowed in nearly the same course and has been separated by land from other streams or lakes. But as a rule, the rivers and streams in one district have plant and animal life common to all and, in addition, many species which are also found in or about lakes, ponds,

swamps and springs, while certain salt-water forms of life also occur.

This is to be expected, for rivers travel through a great variety of country, they drain ponds, swamps and lakes, they are fed by springs; tributaries from far distant places flow into them and as they eventually reach the sea there is no reason why salt water species which can live in fresh water should not frequent the streams. Even in those rivers which possess a peculiar fauna of their own we will also find species common to other streams and for this reason rivers have had a vast influence upon the spread and distribution of plant and animal life. Moreover, many river plants and animals can exist in salt water and are common to both, even though they are normally fresh water or salt water species and so the rivers have even influenced the life of the ocean.

Aquatic animals and plants are not the only forms of life which are carried long distances and are distributed by rivers. Seeds, bulbs, shoots and fruits of plants may

fall into the stream and be carried thousands of miles before they are cast ashore to find roothold and grow. Indeed, many of them will even withstand immersion in salt water and thus, after having been transported for countless miles across a country they may reach the sea and be carried by wind and waves to far distant parts of the coast, or even to foreign shores, where they may grow and increase and eventually become of great importance and utility to man or may even influence the character of the country. Thus the coconut, which today is found on every tropical seacoast throughout the world, was undoubtedly first carried to the sea by some river. Few people realize the stupendous distances which trees, seeds, nuts or other floating materials may be carried. I have seen white birch stumps washed upon the coasts of the West Indies and South America and branches and roots of tropical trees quite frequently drift north and are cast upon the shores of New England. Thus you easily can imagine that a seed or nut, dropping into the upper waters of the Ama-

zon, might find its way to the sea and hence to Africa, the West Indies or even to our Southern States and yet, after its long journey, find roothold and grow in its new home.

We know that many plants have been distributed in this way and while countless millions of seeds and similar drifting things are destroyed or lost or die long before they are cast up in a locality suited to their needs, and while many millions more are stranded where the conditions are such that they cannot grow, yet out of the incalculable billions of such things which are yearly carried by rivers to the sea, a few must of necessity reach congenial spots while yet alive.

The same holds true, though in lesser degree, with forms of animal life. Insects, snails, crabs, crustaceans, reptiles and even mammals are often carried along by rivers. They may be upon some log or stump or branch which falls into the stream, and, being unable to swim or afraid to take to the water, remain upon their natural raft until fortune favors and they are swept to the shore. Here, if conditions suit them,

they thrive and multiply and in time add another species to the local fauna. But as animal life is not so adaptable to new climates, conditions and surroundings as vegetable life and as in order to progagate their species most animals must be present in both male and female form, whereas the majority of plants comprise both sexes in one flower, the chances for animal life being spread by rivers is much less than for plant life.

Nevertheless, there are certain species and orders of animal life which live in communities and these, if carried by a river to a new country, might spread with great rapidity. Such are the ants, the wasps and bees, many species of caterpillars, and many other insects. Moreover, the very habits of many such creatures add to their chances of being transported to new localities. They usually dwell in dead or dying wood and such trees as they inhabit are far more likely to be broken off and to be carried by streams than are sound trees. In addition, when they are cast upon a strange land they are not compelled to adapt themselves to new sur-

roundings immediately, but can continue living in their old homes until they have located new quarters. Neither must we assume that only those forms of life which thrive beside the stream are carried by the current to new homes. When the river rises or floods and covers large areas of surrounding country it often picks up drift material from many miles away from its banks, and thus, forms of life which normally occur far from a stream may become common along the banks or may be carried to some distant spot where the river again overflows and drops its load as it recedes.

If we examine the apparently lifeless and uninteresting bits of drift which we find upon a river, we will be greatly surprised to find what a quantity of life it supports. If it is a log or branch we will find scores of insects hidden here and there; aphids and scale-insects upon the leaves or bark of the twigs, spiders still weaving their gossamer webs to capture stray flies or gnats; busy, hurrying ants ever seeking for some road that leads elsewhere than to water; perchance a

caterpillar or two hungrily munching at the partly withered leaves. Then, if we tear off some of the bark and expose the wood beneath, we will find little wood-engraver beetles, ghostly "shiners," small centipedes and millipedes, probably a few terrestrial crustaceans, the grubs or larvae of beetles and borers and very likely some cockroaches. Often, too, we will find slugs and land snails and, upon the under surface, where damp or submerged, we will discover fresh-water snails, perhaps some fresh-water crustaceans and, like as not, the larvae of aquatic insects.

If we approach the drifting log cautiously we will usually surprise turtles and perhaps frogs basking in the sun or we may even find a land salamander or a small snake resting in some cozy crevice. Sometimes, too, we may see a squirrel, a chipmunk or a wild mouse or rat upon the flotsam. All this little world of wild life being carried safely and rapidly on its way is but one of millions of similar little worlds which the great river transports each year. Perchance it may travel but a few miles and its inhabitants may find them-

selves in a district where there are many more of their kind and where everything is familiar, or again, they may travel far and find themselves at last in a strange land where, unable to secure the required food or habitat to keep them alive, or where new and unfamiliar enemies are met, they perish miserably. But the chances are, that if they reach a new district where their species have hitherto been unknown, that they will find fewer enemies than in their original homes and thus will increase and multiply even more rapidly than before.

If we should examine the bed of the river we would find it supported a vast amount of life; the water itself is the home of myriads of still different creatures and the banks are the homes of many more. Aside from fish and eels, turtles and frogs, newts and salamanders, the water is the home of countless aquatic insects. Long-legged, water-boatmen skip and slither across its surface in sheltered coves and bends, shiny black and green water beetles hurriedly dash off or dive to safe retreats at our approach,

great, ugly sharp-clawed water-bugs lurk in the water-weeds and slime close to the banks or in the shallows and, if it is a tropical or semi-tropical river we will find alligators, crocodiles or manatees making the waters their homes.

If the bottom is rocky we would find life on the river's bed rather scant, but even then we would be able to discover caddice-fly larvae in their quaint tube-like houses built of tiny pebbles, bits of twigs or other odds and ends; we would find dragon-fly larvae with their big, staring eyes dashing after any unfortunate little creature that came near; under the water-worn pebbles we would see the odd "dobsons" or "helgramites"; in crevices of the rocks or sheltered under boulders we would find spotted newts or salamanders and crawling slowly about, we would see many species of fresh-water snails with dull-brown or green fresh-water mussels resting on sandy patches.

If, on the other hand, the bottom of the river should be muddy or sandy we would find all these creatures and many more—

hellbenders or mud-puppies perhaps—mud turtles, annelids or aquatic worms, mud-loving snails, fresh water sponges and hydroids; crustaceans of many kinds and the larvae of many species of aquatic insects. Along the river's banks dwell frogs and turtles, we will find upon the stems of reeds and grasses the dried and empty skins of dragon-fly, May-fly and caddice-fly larvae where they have crawled forth from their watery home to split open and allow the winged insects to escape and fly about; we will find the holes of mink and muskrats, or, if fortune favors, we may even catch glimpses of the owners swimming in the nearby water and, if in a wild portion of the river's course, we may find the slide of an otter in the muddy bank.

If we travel down the stream towards the sea we will find that the animals of the river and its shores, and the plants as well, gradually change; that new species are constantly replacing the others and that by the time the sea is reached we have left true fresh-water forms behind. As we approach

the limit of tide-water and the stream becomes brackish, coarse marsh grasses, wild rice, mallows, stiff sedges and similar plants will take the place of the ferns, soft grasses, blue flags, dainty flowers and drooping vines which covered the shores far up the stream.

The insect larvae, with the exception of certain dragon-flies, will disappear; fresh-water snails and mussels will give way to salt water forms. Crabs and shrimp will become more abundant; terrapin will take the place of mud-turtles, our friends the salamanders and most of the frogs will be left behind and while the mink and musk-rat may still have their burrows along the banks we will find that the fish upon which they feed are very different. Far up the river, near its headwaters where it ran swiftly over stones and dashed in cataracts over ledges, were trout and dace; further down, in the calmer waters with their sandy bottom, we caught pickerel, perch, sun-fish and bass; still further downstream, as the river widened and deepened and the waters took on a muddy hue, we found garpike, cat-

fish and mullet and now, as we approach the sea and the river's mouth, we still find catfish and mullet and, in addition, blennies and chub, besides various species of true, salt-water fish.

But throughout the course of the river, if our investigations are conducted in the right season, we will find salmon or shad or sturgeon according to the locality of our river and we will learn that these fish, although denizens of the ocean, go up the rivers to lay their eggs or spawn and that they are equally at home in fresh or salt water. In fact, it is hard to say whether these fish are really ocean or river fish. For all we know, their ancestors may have been denizens of rivers and, having by chance found their way to the sea, adapted themselves to an ocean life, but with a dormant instinct leading them each spring to ascend the rivers to the cradle of their race. Occasionally we find spots where these fish have been cut off from salt water and have become thoroughly at home in lakes or ponds. But there are many species which cannot live

even in slightly brackish water while others cannot live where the water is fresh. As a result, the species which occur at or near the mouths of large rivers are limited, for a large river will so freshen the sea for a long distance that strictly ocean forms of life cannot exist in the vicinity.

It is the same way, to lesser extent perhaps, with the bottom and shore animals and plants. A great many fresh-water animals, such as many snails, turtles, crustaceans, etc., can and do exist in brackish or even salt water and there are also many salt-water forms which seem to get on and thrive just as well where the water is fairly fresh. But just as is the case with certain species of fish, many of the true marine animals cannot live in water which is the least freshened by rivers. We will not find many of the star-fishes on the shores near the mouth of a big river, or along its banks near its mouth, and neither will we find many sea-anemones, sea-cucumbers, jelly-fish or corals where the water is brackish. Certain plants and trees, such as willows, cypress, coconut and other

palms, mangroves, pines, cedars, cattails, many grasses and sedges, bamboos, wild roses, many shrubs and vines and cacti thrive equally well beside either fresh, brackish or salt water. Other forms of vegetation, such as our common deciduous trees, many tuberous and bulbous plants, ferns, alders, elders, lilies and other plants which are typical of river banks and the borders of lakes cannot withstand salt or brackish water and die almost immediately if their roots are flooded by salt water.

Of all the various forms of life which we find along rivers, perhaps the birds are the least typical, but even among the birds we will find, if we observe closely, that some are true river birds, others land birds which prefer to dwell near rivers and others are sea or shore birds, which follow the rivers' courses far inland, either in search of food or to rear their young. Perhaps the most noticeable birds which are ever present about rivers are the swallows and yet, with the exception of the bank-swallows or sand-martins which build their nests in burrows in the river

banks, swallows cannot be considered as river birds, for they seek the streams merely to secure the insects which abound upon or near the surface of the water. Ducks, geese and other swimming birds may be denizens of the rivers and yet they do not confine themselves to the streams but spend much of their lives on salt water. The same is true of waders or shore birds and of many land birds which we are wont to associate with rivers, merely because we are accustomed to seeing them along the streams.

But a species of bird may be a typical river bird in the north and yet never be seen near a river in the tropics, or vice versa. Thus, our red-winged blackbirds, our swamp sparrows and marsh wrens, several of our warblers and various other land birds are ever present inhabitants of the marshes, swamps, woods or brush along our streams and yet, in their winter homes in the tropics, some of these are never seen near rivers, but are found on open, dry, prairie lands. Even our lovely water-thrushes which are only

found in the north beside running water and whose nests are placed beside the streams they love, desert their usual haunts and frequent the seashores and brackish mangrove swamps of the West Indies during the winter. This is to be expected with the majority of birds, for these creatures are mobile, they inhabit the spots best suited to their needs for the time being and while water of some sort is essential to certain species, yet it makes but little difference whether it is fresh, salt or brackish. The red-wing is just as much at home in the salt meadows of the coast as in the alder swamp that fringes an interior lake or stream; the song sparrow trills as merrily upon some sea-girt islet as upon his swaying weed-stem beside the brook; the night heron finds crabs and clams just as good eating as baby turtles and fresh water mussels, and the various ducks and waders find food as abundant and as palatable in salt water as in fresh.

There are species of birds which appear to be true river birds and are never found elsewhere, while others seem to be confined to

fresh water and others to salt. The water-ouzels of our mountain streams of the west, and its cousins in tropical America, invariably haunt the rapid-flowing, tumbling brooks and streams. The short-billed marsh wren always builds its nest and lives its life in swamps or meadows near fresh water, while its cousin the long-billed marsh wren is just as firmly wedded to the salt marshes; the beautiful and graceful sun-bittern is never seen save beside flowing streams or rivers of the tropics; the odd, long-toed jacanas are strictly fresh-water birds and many species of todys, trogans, motmots and jacamars of tropical America are found only along the banks of the rivers. Last and perhaps most interesting of all, are the remarkable hoatzins of northern South America—strange, primitive birds which form a sort of connecting link with their reptilian ancestors and which are restricted to certain definite areas on certain rivers and are found nowhere else in the world. From all this it will be seen that rivers have a very great influence upon both animal and plant

life, but it is on the whole an influence of distribution and not of restriction. Just as islands tend to develop species of animals and plants peculiar to themselves, because they are cut off from other localities; so rivers tend to break down barriers and to distribute species far and near because they connect far distant places. Just as civilization, progress, manufactures, commerce, trade and industry have followed the courses of the great rivers, so too have animals and plants spread from the far interior to the ocean and from the ocean to the headwaters of the streams through the countless ages since the first river found its devious way across the new-made land to the sea.

CHAPTER V

HOW RIVERS SERVE MAN

I HAVE already mentioned that rivers have been of great importance to man in many ways, but it is very interesting to see just how rivers have served mankind and just how man has harnessed and controlled them and has made them serve him.

We will also find that while man has altered rivers and has forced them to his will, yet the rivers have also compelled man to adapt himself to them and have influenced him and his works just as they have influenced the land and the sea and animal and plant life.

As highways, the rivers first attracted man and, throughout the ages since the primitive savage first embarked on his floating log and crossed a river, the human race has found rivers of the utmost service for this purpose.

Even today, the great rivers of the world teem with shipping and are alive with commerce, despite railways, motor cars and other modern means of transportation. Vessels of every size, from tiny skiffs to great steamships, ply upon the various rivers of the world and yet, despite the differences in customs, in conditions, in races, in cargoes and in other matters, wherever we find much river traffic we find typical river craft, boats which have been developed and evolved to suit river conditions. And very often, even in widely separated parts of the world, we will find that river boats are much alike and are easily recognized. Upon the Mississippi and our western rivers are the big, flat-bottomed, stern-wheelers—steamers which can run on a "heavy dew" as the saying goes; but these are not peculiar to our own country and we will find very similar craft upon the Orinoco, the Magdalena, and the rivers in various parts of Asia, Europe and Africa. The palatial, swift, side-wheel steamboats of our Hudson have their counterparts on the Thames, the Seine, the Elbe and many an-

other great river. Canal boats, which might well have come down the Hudson, may be seen along the Loire, the Rhone, the Thames, the Elbe or the Seine. The roughly made, box-like flat-boat of our southern rivers, with its happy, singing darkey crew, is not peculiar to the rivers of Dixie Land, for if we travel to the great rivers of South America, or to certain African streams, we will find that similar conditions have developed similar craft and in almost exact duplicates of our southern flat-boats we will find bronze-skinned Indians or turbanned Arabs drifting down the rivers with the current.

On every great river we will find rafts. They may be the enormous lumber rafts of the Columbia, the log rafts of the Mississippi, the rafts of bamboo of the Orient, the rafts of hollow tree trunks of tropical rivers or the rafts of cork-like balsa wood, with heavy logs of mahogany, lignum vitæ or other rare woods slung to them, such as we see upon the rivers of South and Central America. But while in many cases there is a strong resemblance between the

river craft of various lands and races, yet there are certain types of river boats which are peculiar to certain countries and certain rivers. An Arab dhow with its high ends and its immense latteen sails, has no counterpart in any other portion of the world. The Chinese houseboats and sampans, in which countless thousands of Chinese dwell and pass their lives, are typical of the great rivers of their nation. Upon the Orinoco we find odd craft with high masts bearing huge sails far aloft in order to catch the wind above the river banks. England's rivers teem with punts and wherries which seem out of place amid any other surroundings. Guiana's coorials and batteaux are peculiar to the country and admirably adapted to the rapid-filled rivers within its borders. The dug-out cayucas of Panama, with their flattened ends on which the natives stand as they pole their craft over the shallow riffles and bars, are distinctive river boats. In the orient, especially on the rivers of the Holy Land, we find strange, circular, skin boats exactly like those used in Biblical days and

the Welshman still uses his plaited reed or willow coracle which he carries on his back as a turtle carries his shell.

Many of these craft seem very queer, very clumsy, very primitive or very badly designed, but just as the seaman thinks his particular type of boat is the staunchest, fastest, most seaworthy type of boat in the world, so the river man thinks his craft the only boat suited to his river and his needs. Moreover, he is no doubt perfectly right in his claims, for in nearly every case, where we find a distinctive or peculiar craft, we will find, if we investigate, that there are good and sufficient reasons for it. Such boats have been developed and evolved through the experience of countless thousands of men through many centuries and while, today, the reason for certain forms or peculiarities may not be so apparent, yet did we but know all the conditions of the country or the river where they exist we would readily see why they are as they are, and we would understand why a boat, which would be quite out of place and almost useless on one river,

might be the only type of boat which would serve its purpose on some other river. If a stream is shallow and with many bars a boat must be of very light draft in order to navigate it. If, as is the case with many of the big rivers of South America, the boatmen do not depend upon the wind, but upon the rising and falling tides, to travel up and down stream, their boats must be as broad and square as possible in order to present a better surface to the current which carries them along.

Where there are innumerable, rock-filled rapids to be run a boat with a keel or with a flat bottom would be constantly getting hard and fast on the rocks and hence the spoon-bottomed, keelless Guiana boats have been evolved. To stand in the rounded bottom of a dugout canoe and handle a long and heavy pole is a ticklish balancing feat and to give a better purchase to the men's feet and a flat surface on which to stand the Panamanians have hit upon the plan of constructing their cayucas with platforms at either end. Where narrow chan-

nels and shoal water must be navigated, frequent portages made and rapids run the light, strong, birch canoe has no equal, while the Indians of South America have devised an equally useful and handy craft for use on their rivers which form a maze of waterways through their country but which are separated by dense jungles or high mountains making portages impossible. These conditions have brought about the invention and universal use of the "woodskin," a buoyant, staunch form of canoe which can be built by two men inside of three hours. Cutting down a straight purple-heart or similar tree about two feet in diameter, the Indians strip off a section of bark from ten to twenty feet in length. A short space at each end of this bark roll is then thinned down and the ends drawn together by means of strong lianas or "bush ropes." Sticks or thwarts are then forced in between the sides and are lashed in position with lianas and the woodskin is complete. Very often the Indians will construct a score or more of these primitive canoes in making a single

Photo by Underwood & Underwood

A MODERN POWER DAM

The Elephant Butte Dam on the upper Rio Grande in New Mexico. This shows the transforma-

journey, using one on each stream they come to and abandoning it when they cut across to the next stream through the forest. Not only do the Indians use them for such short trips where an extemporized craft is required, but many tribes find them the most useful and handy of boats and use them exclusively. But where the woodskin is to be made for permanent use it is made more carefully and of much larger size. I have often seen a Carib woodskin laden with a dozen men, women and children and so low in the water that the Indians appeared to be seated on the surface of the river itself. The only drawback to the woodskin is the fact that it is open at the ends and in rapids the water often swashes in. But the naked Indians do not mind this and, moreover, what runs in at one end soon splashes out at the other.

But to continue. On a river several miles in width but with high banks cutting off the wind close to the water, ordinary sails would be useless and so the Venezuelans place the sails of their river boats near the summits

of their masts. A large craft which must at times be rowed, but which is used where there are light winds, must be easily propelled by oars or sail and must have huge sails to catch what little wind there may be and so the dhow came into existence. Along the backwaters of the Thames no small craft would serve so well as the punt or wherry, although they would be useless in many of our rivers. Among his native fens, ponds and small streams the Welshman's basket-like coracle is a most useful and handy craft and the Astrakhan-hatted Persian or Armenian finds, in his circular boat, a craft which takes up little space and is capable of carrying enormous loads from riverside to riverside. In John Chinaman's brightly painted picturesque sampan or house-boat we find a miniature junk adapted to use in shoal water and our familiar centerboard catboats, sloops and schooners were developed and invented to enable them to sail safely over sand bars and to enter the mouths of our rivers of the Atlantic coast.

We must not forget the manner in which rivers serve as highways for the lumbermen. Were it not for rivers, lumbering would be a difficult, and in fact, an impossible task in many places. From the far northern woods, from the deep swamps, from the vast forests of the tropics, the logs are floated down the streams to the mills or to shipping points and in many logging districts the spring drive is a marvelous sight. The rivers, swollen by melting snows and spring rains, are filled with the great logs and pitching, tossing, jumping and crashing they go tearing down the torrent, thrown about like matchsticks; whirled and upended and carried at express train speed. At times these thousands of logs jam and then the loggers must find the key log and dislodge it or else dynamite the jam to set it free, and at such times the men exhibit marvelous feats of skill and daring, balancing themselves on rolling, swaying logs; riding the tree trunks that jump and rear like bucking broncos and leaping from log to log as they swirl by. It is a sight never to be forgotten and to

these men the rivers mean everything, as without them, all their hard and dangerous toil would come to naught.

Just as it is impossible to tell when man first discovered that the rivers were easier highways for travel than the forest trails, so it is impossible to say when man first learned that the steadily flowing rivers could be harnessed and made to work for his own good. But undoubtedly it was many hundreds or thousands of years after true canoes and boats had come into use before the first water-wheel was made, for man was well along the road to civilization before he discovered the secret of the wheel in any form and this was probably the greatest single invention ever made by a human being. Perchance, the first water-wheel was a mere toy used by some prehistoric boy, or perhaps, some man, who had constructed a wheel with buckets at the end of its spokes to be used in lifting water from a stream, as is still done in many lands, noticed that it revolved by the current of the river and put his accidental discovery to use. But regardless of

the origin of the water-wheel, its use became world-wide and for many centuries it held its own as the cheapest form of power, just as the rivers held their own as the cheapest means of transportation. And just as river traffic still remains the most economical form of transportation in many parts of the world, so, in many places, water power is still the most economical source of energy. Indeed, were man to harness all the great rivers or cataracts of the world and thus create power which could be transmitted for long distances by wireless there would be no need of coal, oil, gasolene, wood or other fuel for generating power, for there is more than enough water power going to waste to operate every mill and factory, run every railway train, steamship and motor car, light every electric light and furnish all the energy required in the entire world.

We have harnessed a few of our large rivers, we have utilized the titanic power of Niagara, but all over the world there are rivers and cataracts capable of developing millions of times as much power as Niagara.

There are the enormous Nyanza and Zambesi falls in Africa, the stupendous Iguassu falls of the Brazilian border, Kaieteur in Guiana with its 820 foot drop and countless other mighty falls in Asia, Africa and South America all wasting their terrific power but which, some day, will be harnessed and controlled and made to do their part of the world's work.

Unquestionably the first water-wheel was a most simple affair, a crude wheel with flat paddles so placed that the current of the stream flowed against the paddles submerged in the water. Such a wheel, known technically as an "undershot" wheel, would work very well where the water flowed steadily and swiftly and it was an easy step for man to build a dam or barrier to divert a portion of the current to his wheel and thus increase the amount of water and its speed. Then, if he were an observant chap, he would notice that where the river flowed over a rocky barrier in the form of cataract or rapids the current was swifter and he would place a wheel where the falling water struck upon

its paddles. But as waterfalls were not always available it would dawn upon him that he could construct an artificial fall and having done this by means of a mill-dam, he would evolve the "back-pitch" and "overshot" type of wheels. Then, having once solved the principle of hydraulic power, the successive developments of the water-wheel, through the spatter-wheels, tub-wheels and other forms to the modern turbine would come as a matter of course.

But here, once more, we find that the rivers have influenced man's inventions and works quite as much as man has influenced the rivers. The modern, compact turbine has been evolved through the necessity of using water as power where there is comparatively little fall (although high-pressure turbines are also used), and through man's ceaseless ambition to produce results in the most economical manner; but where there is an abundance of water, plenty of fall and comparatively light work the old mill-wheels of the overshot, back-pitch or undershot types answer every purpose and are still in use.

But regardless of the type of wheel used, dams were essential in order to secure a steady supply of water and an even head or pressure and while, at first sight, the dams appear to influence and affect the rivers but slightly and very locally, yet their effects are really far-reaching and the bigger the dam and the river the greater are the effects produced.

Although the same amount of water must eventually find its way to the sea after a dam is built as before, yet the flow and current is interrupted and changed and this change affects, to some degree, the entire course of the river below the dam and even the mouth of the river where it reaches the sea. A single dam far up a stream may completely alter its bed, its course and its character, while above the dam, the effects may be even greater. The water, backing up to form the mill-pond, will allow its suspended silt to settle and thus less sand, mud and other material will be deposited below the dam. Drift, reaching the mill-pond will end its travels there and never reach the sea

or the lower parts of the river as before. The water, spreading out above the dam will flood country hitherto dry and numerous swamps, brooks and even other rivers may be formed where it overflows its boundaries and finds low places and hollows. Certain forms of plant and animal life will be killed by the rising water and other water-loving forms will take their places. Salt-water fish, coming up the river to spawn, will find their way barred and thus their kind will disappear from the upper reaches of the stream and in a hundred ways the life and character of the river and its surroundings may be altered.

I have said that dams are essential in order to operate any type of water mill, but there are exceptions. Occasionally one may still find an old-fashioned undershot water-wheel turned by the current flowing by and with no dam or mill-race while on the Danube we find the oddest of odd mills. Instead of being built on the shore and having their water wheels permanently fixed in one spot the mills of the Danube are built upon huge

floats and are anchored in mid-stream so that the passing current of the river turns their wheels.

Somewhat on the same principle are the fish traps used on the Columbia and other rivers. These, like the Danube mills, are anchored in the streams where their huge wheels revolve with the current and turn great wheel-like nets which scoop up the swarming fish and dump them into bins. Dams, however, are very useful things and whether man first learned to make them by watching the beavers, or whether he invented them independently, the discovery was a most important one and enabled him to utilize rivers in many ways which otherwise would have been impossible.

One of the most important and valuable of the uses to which man had put rivers is that of watering or irrigating his crops and fields. Primitive man no doubt carried the water from the rivers to his crops by means of pots and jars or even in skin sacks. Then, after many centuries, he learned to lift or pump the water by means of a rude wheel

with buckets attached to its spokes, a method still in use in many parts of the world. But these wheels were clumsy and turned by man power and it must have been a marvelous event when the water-wheel was discovered and the river's own power was utilized to lift or pump the water and distribute it over the fields by means of ditches. Nowadays, irrigation has become a science and stupendous dams are built and millions of gallons of water stored in vast lakes to be used in irrigating thousands of acres. In our great Southwest, irrigation has transformed vast deserts to rich and fertile lands bearing enormous crops; in California the fruit orchards and farms are dependent upon irrigation; along the Nile no crops could be raised if it were not for the river water which is led across the thirsty land and it has even been proposed to irrigate the Sahara and transform it to a stupendous garden.

Many rivers, too, carry vast wealth hidden beneath their waters. As they break down and wear away the rocks and earth tiny particles of gold and other heavy metals are

released and, being far heavier than the sand and rock, these settle to the bottom and accumulate. Gradually, through the ages, these deposits of precious metals increase until the gravels become so rich that they are worth mining and are known as placers. Gold, platinum, tin, and many precious stones occur in placers and in many localities they are the richest of mines and the chief sources of the metals or gems. All the Brazilian diamonds, the rubies and sapphires of the Orient, the platinum deposits of Russia and Columbia and gold mines in many parts of the world are placers. Moreover, even where the accumulations of precious stones or metals are not sufficiently rich to be mined, still they are of great value to the miner and prospector. By examining the gravel and rocks in a river or stream the prospector can determine if the stream cuts through a mineralized rock or a vein of ore or a deposit of gems. Then, if he finds bits of ore or precious stones or metal which are known as "float," he can follow up the stream and by constantly sampling the bot-

tom gravels and bits of broken rock he can determine the spot from which the float has come and thus locate the deposit.

In many places, especially in the tropics where there is dense jungle, this is the simplest and only sure way of locating mineral deposits, and, throughout the world, prospectors take advantage of streams for this purpose. You may wonder how the rich deposits of precious metals or gems which have accumulated as placers are recovered by the miners. There are several ways in which this is done. The simplest and most primitive method is to dig up the gravel and sand from the river bed and shores and "pan" it by twirling it back and forth with water in an iron or wooden basin or pan. This separates the heavy metals or gems from the lighter gravel and mud and the latter, by a peculiar twist of the pan, are thrown off over the edge, until at last, only the heavy metals or gems remain. Where placers are very rich or are far from civilization this method is often used, but more frequently the values are recovered by means of sluices

or rockers. Sluices are wooden troughs with cross pieces or "riffles" fastened along the bottom. The sluices are placed in or beside a stream so that water pours through them and the sand and gravel containing the metal or gems is shovelled into them. The lighter material is carried off by the water, but the heavy metals or gems sink to the bottom and lodge behind the riffles. Sometimes, the spaces back of the riffles are filled with quicksilver which dissolves and combines with or "amalgamates" the gold and silver. When this is done the precious metals are recovered by squeezing the quicksilver in a chamois skin, thus forcing out the bulk of the mercury, and the remaining amalgamate is then heated in a retort which drives off the quicksilver and leaves the gold and silver behind.

But the majority of placers are not rich enough to yield a profit by these methods and are worked by means of dredges or hydraulic power. Where the stream is large and conditions are favorable dredges are employed which dig up vast quantities of gravel

and sand from the river bed and banks and pass it over tables, sluices and other machinery where the precious metals or gems are separated from the sand. By handling an enormous amount of material at a very low cost many placers can be worked at a profit by dredges when it would be impossible to make them pay if worked by hand. In other localities, where the streams are too small for dredges or where the country is too rough or conditions are not right, the placers are worked by immense streams of water played upon the banks from giant hose-pipes and huge nozzles known as "monitors" or "giants." These streams cut and tear away the gravel and sand and wash it into huge, sluice-like arrangements with riffles made of railway rails. In this way, vast hillsides and mountains are rapidly cut and washed away and the wealth they hold is given up to man. Very often the water used in these hydraulic mines is brought many miles, for in order to obtain a strong enough stream to cut the gravel a dam must be built many feet above the level of the spot where the work is going

on. Thus you see, the rivers not only gather up the wealth of vast areas of land and hoard it ready for man to secure, but in addition, they supply man with the means of obtaining it and so, in still another way, they serve mankind and from their beds furnish incalculable fortunes to help the civilization, the progress and the industry of the world.

Chapter VI

SOME UNUSUAL RIVERS

We usually think of rivers as streams of water rising in some definite spot, flowing across a country and emptying at last into the sea. They may rise among the mountains or hills; their sources may be springs, lakes, swamps or melting snows; they may flow through wild and rocky country and through marvelous cañons, they may wind and curve in great bends and ox-bows or they may be sluggish, black streams flowing through dismal swamps and morasses. They may flow into the ocean as a single stream or they may possess deltas of many mouths; but still, in their most important features and characters they are all alike.

But there are many rivers of quite a different sort, rivers which have no apparent source or mouth, rivers which appear and disappear in most mysterious fashion, rivers which,

rising like any other river and flowing for many miles like any ordinary stream, suddenly sink into the earth or plunge into a cavern and never are seen again; rivers, which although long distances from the sea, rise and fall like the tides, rivers which instead of flowing upon the earth run underground and finally the unseen but very important rivers which flow under huge glaciers. Moreover, although we usually think of rivers as fresh, yet there are many rivers in the world which are salt. As a rule, however these are not true rivers but are merely long and narrow straits connecting bodies of salt water, either salt lakes or parts of the sea. They have no real source and no real mouth, both ends being source and mouth combined, for the only current or flow of such streams is the tide and hence for six hours a day they flow in one direction and for the next six hours in the other. But there are salt rivers in the world which are true streams of salt water with definite mouths, currents and sources. These are the streams which flow across alkali plains

that once, in long-past ages, were the beds of oceans which have now drained away through the uplifting of the land. In such spots the earth is impregnated with various salts and the rivers, flowing through these, dissolve them and carry them on their way towards the sea.

Similar salt rivers also occur in the great salt deposits in Europe and elsewhere, while in the vicinity of many volcanoes we may find rivers carrying not only chemical salts but also sulphur lime, iron and many other minerals. Very often these mineralized rivers are of hot water and as their waters become cool the chemicals they contain are deposited in crystals or masses upon their banks along their beds or upon any object which is immersed in the water. Sometimes the colors and forms of these deposits are most curious or are very beautiful while in other cases, the deposits have accumulated to such a depth during countless centuries that man has found them valuable and has mined them. Many of our most valuable ores, especially iron ores, were formed by water impregnated with

iron and in many parts of the world we find good-sized rivers whose beds and banks are thickly coated with iron deposited by the streams as they flow on their way. Where the waters carry copper we find the deposits wonderfully variegated in beautiful shades of green and blue, the material being known as malachite and azurite. If the water carries sulphur the deposits will be brilliant yellow, if it carries manganese the mineral coating left by the water will be black and it may be every color of the rainbow where iron is held in solution.

Many people wonder why the clay and sand banks of some rivers are so beautifully colored, but in every case it is due to minerals, either in the earth or in the stream. The rapidity with which the minerals are deposited depends upon the quantity held in solution, the speed of the current and many other factors, one of the most important being the temperature of the water where it absorbs or dissolves the minerals. A great many minerals are insoluble in cold water but are soluble in hot water while

others are only soluble in water containing certain acids or alkalis. For this reason rivers which rise or issue from volcanic craters or from hot springs usually carry a very high percentage of minerals, partly owing to their being boiling hot and partly to the fact that they absorb many chemicals which render the minerals soluble or partly so. So rapidly do some of these streams deposit minerals that people who live in the vicinity place various objects in the streams until they are transformed to mineral and then sell them as curios. Bird cages containing stuffed canaries when immersed in such rivers will, in a short time, become completely encrusted with a hard, stony or crystalline coating so that they appear to be made of solid rock. Such things are often sold to gullible tourists as "petrified" objects, but they are not true fossils, as the interior of the object remains unchanged and only the surface is coated with mineral. But if objects such as wood, cloth, bone, leather or any other porous material should be left in the waters for a sufficient length of time they would be-

come so thoroughly impregnated with the mineral matter that to all intents they would be fossils.

It was in this way that the hard and often beautiful silicified wood and the petrified forest of Arizona were formed.* Ages ago, some convulsion of nature lowered the land whereon grew great forests. Rivers, ever seeking the lowest levels, filled the basins thus formed and converted them into lakes with the dead trees rising, like skeletons, above the waters. Gradually, as the water, carrying a small amount of silica in solution, penetrated the pores of the wood, it transformed the dead forest giants to masses of many-colored agate. Then, countless

* This however is not the only way in which silicified forests are formed. Many forests were in past ages covered over and destroyed by volcanic ashes and dust. Then through the centuries, water percolating through this material dissolved and carried down mineral salts which impregnated the dead trees beneath and transformed them to agate. Gradually the accumulation of ashes was washed or worn away leaving the silicified forests as we find them today. In fact some scientists claim that the petrified forest of Arizona was formed in this manner. In the cases of others, however, there is nothing to prove that this occurred and all evidences point to silicification by mineral-impregnated water in rivers or lakes. The fossil forests of Panama are of this class, although it is not impossible or improbable that volcanic ashes or mud, falling upon them before they were submerged, or falling into the waters which flowed over them, aided in their petrification.

thousands of years later perhaps, the country rose slightly, the water drained away and the stone trees, perfect in every detail of bark, texture, knots, branches and even insect borings, were left scattered about to arouse the wonder and admiration of man. We invariably think of such things as having taken place in long past ages and while it is true that great alterations in the earth undoubtedly occurred more rapidly and more frequently when the world was young than at the present time, still the same things are going on today, although so slowly that we do not realize the fact. When our engineers built the wonderful Panama Canal they erected a stupendous dam across the Chagres River and thus formed the immense Gatun Lake covering over one hundred square miles. Buried fathoms deep beneath this great expanse of water are plains and valleys, hills and ridges, river beds, ponds and jungles. Hills that once rose above valleys now stand as wooded islands in the lake and everywhere rise the giant forest trees, gaunt, bare, pathetic skeletons above the water.

Many of them have decayed and broken off so that only their stumps remain as blackened, water-soaked snags; others have withstood wind, water and decay and are as firm and solid as ever and many have braved all and are sending forth leaves and buds in defiance of the overwhelming lake. But what will this spot be like a hundred thousand years or more hence? Who can say that by then the trees will not have been impregnated with the minerals and metal salts of the Chagres water, that when the ages have rolled by and the Canal is but an ancient ruin the waters of Gatun Lake may drain away and leave the drowned trees imperishably preserved as trunks and roots and branches of solid agate? Such things have happened in the past in Panama not many miles from Gatun Lake. Over vast areas of the country where once we know—from gravel bars and water worn rocks—that great rivers flowed and broad lakes were formed, we find countless silicified trees and in the dim future the forests of Gatun Lake may be the same.

A RIVER OF ICE

Perhaps you think that in such salt or mineral impregnated waters as I have mentioned there can be no life. But such is not the case and many of the salt rivers and even the hot water streams teem with life. Nature is a most adaptable thing and because one form of life cannot exist under certain conditions is no reason why other forms should not, while even species which are not normally found in one place may become so adapted to another that they are perfectly at home there. Just as some plants are killed by salt water while others thrive only where their roots are steeped in brine, so along the stinking, steaming water of mineralized volcanic streams we find delicate ferns, lovely flowers, strange orchids and many trees and shrubs whose leaves and stems are constantly exposed to deadly sulphurous fumes and whose roots are washed by water almost at the boiling point. We know that certain fish and water animals cannot live save where the stream flows swiftly and is almost icy cold and we know that others prefer the muddy, warmer waters of sluggish streams

and if we were to examine the rivers and brooks whose waters are fouled with chemicals or from whose surfaces steam rises in clouds, we would find that certain insects and even fishes dwell therein. I have seen tadpoles by thousands in water reeking with sulphur and uncomfortably hot to one's hand, I have caught fish in rivers so black with chemicals that the water looked like ink and in the bubbling, seething springs that fed a river rising among the steaming craters of a West Indian volcano, I have found the wiggling, semi-transparent larvae of flies and gnats perfectly contented and at home. And now let us turn to those strange rivers which have no outlet; to rivers that mysteriously appear and disappear, to the underground rivers, for all of these are closely related and all are very interesting and baffling until we know the reason for them.

In many parts of the world where limestone is the country rock we find rivers and streams issuing from apparently solid hills, flowing for long distances and then suddenly disappearing as though swallowed up by the

earth. In such localities, too, rivers will at times appear where no river has been before and after flowing for a variable length of time they will all at once dry up and disappear. But there is nothing mysterious about this for such rivers do not really flow from nowhere nor do they cease, but are merely underground rivers which flow above ground for a portion of their course or which, swollen by floods or other causes, find an outlet from their underground channels and flow across the land until the excess water has been drained off and they again resume their original course.

In the districts where such streams occur we will find numerous deep depressions known as "sink-holes," which often contained a pool of water and we will also find caves and caverns, some small and others often of gigantic dimensions. Such are the famous Luray and Mammoth caves of Kentucky, the Bellamar caves of Matanzas, Cuba, and many others. In such localities the water, soaking into the earth, finds it way to the grottoes and openings in the limestone

and forms underground lakes and streams. Very often these subterranean rivers may flow for miles far below the surface of the country and their presence may not even be suspected by the inhabitants unless, in digging or boring wells, the stream is reached. If, however, there is a deep hollow or valley whose bottom is below the level of the bed of the underground river the stream will issue from a fissure or cave and follow the depression until it reaches some other fissure or cavern at a lower level when it will at once leave the surface and vanish in the earth. At other times, an underground stream may flow through caverns and fissures throughout its course and under ordinary conditions may never appear above the surface of the ground. But if a portion of a cavern roof, a wall of rock or any other barrier should check its free flow or if unusually heavy rains or spring thaws should increase its volume to such an extent that its normal channels could not carry it off, then the underground river will rise and back up, exactly as the water of an ordin-

ary river rises above a dam. Then, when a fissure or opening leading to the surface of the earth is reached the river will pour out, flow across the land and appear as an ordinary stream, either flowing into some other river or a lake or finding a fissure through which to resume its underground journey.

If the barrier which has caused this is a mass of rock which remains as a permanent dam the river may continue on its new course forever, whereas, if it is merely a flood which has caused it to overflow its underground banks, the new stream will dwindle away and disappear as soon as the surplus water has been drained off and the subterranean river falls to its ordinary size. In many places streams of this character appear regularly every spring, for mysterious and strange as they may seem they are in reality no more remarkable or abnormal than the temporary waterways which are formed by ordinary rivers when the water overflows the banks during freshets.

In some places all of the streams are un-

derground, while in other districts there are both subterranean and surface rivers, for one stream may find a fissure through which to drop and form an underground river while another may not, or again, a river may be so large that the greater portion of its water remains above ground although much of it flows through underground channels. One of the most noteworthy spots where there are no surface streams is the little island of Barbados in the West Indies. This island which is of limestone formation built up of drifted sea sand and coral, is honeycombed with caves, grottoes and subterranean tunnels through which large streams of clear, cold, fresh water flow. You may travel over every inch of the island and never see a spring, brook or pond and yet there is an excellent water supply with stand-pipes along the roads and the visitor, who is not "in the know," wonders where the water comes from.

The Barbadians long ago solved the problem of their water supply by tapping one of the island's underground rivers. By descending into one of the caves or sink-holes

of the island—and sink-holes are merely caverns whose roofs have fallen in—it is possible to follow these underground streams for many miles. Some of them have been explored, but many others still remain practically unknown and it is a highly dangerous undertaking to attempt to follow them unless great care is taken that one may retrace one's steps to the starting-point, for the caves and fissures form a labyrinth of subterranean chambers with innumerable openings and with the streams dividing and branching in every direction. Many of the caves are very beautiful with their stalactite-hung roofs, great columnar stalagmites rising from the floor, white, transparent draperies, like delicate lace and grotesque folded, corrugated, nodular masses of the dripstone everywhere.

Here, as in many other limestone caves, the visitor may see the stalactites forming before his eyes. If we examine one of these tapering, pendant masses which is still in the process of growth we will find that a little drop of water gathers

upon the tip and as we watch we will see tiny, needle-like crystals forming about the end of the stalactite, just as ice crystals form in a drop of freezing water. Thus, drop at a time, the water trickles down the stalactite, each drop as it seeps through the earth and rock above gathering a solution of carbonate of lime and reaching the tip of the stalactite giving up its mineral contents and slowly but very steadily building the stalactites longer and larger. When we see how slowly these dripstone formations are built we realize how many countless thousands of years nature must have been at work producing the immense columns and pillars, the huge stalagmites and the thick masses which cover walls, ceilings and floors, for all of this was built in the same way by drops of water containing carbonate of lime.

This stone, formed by the dripping water, is much harder than the surrounding rock and thus the caverns and fissures where it has formed are protected from wearing away. Very often the surrounding rock may be worn, eroded and broken down leaving the

hard dripstone of the caves standing above the surrounding country in the forms of natural arches, bridges and hills. In many limestone countries every hillock marks a cavern whose dripstone coating has withstood the elements, while the limestone about it has slowly given way to wind, weather, frosts and rains. Strangely enough, too, the caverns and fissures which the water preserves and protects by coating them with dripstone, were carved and worn in the limestone by water in the first place and while they now mark harder areas of rock, in the beginning they were the softest spots. In places like the Bermudas or Barbados the limestone is formed by shell and coral sand blowing and drifting into dunes and then becoming cemented together by the rain water percolating through it and dissolving and redepositing the lime. Wherever this occurs there always are spots where, for one reason or another, the sand remains loose or is not so firmly cemented together and in time these softer spots wear away or are washed out to form hollows or fissures. And as they in-

crease in size the water, running through them, wears them larger and larger until big caves are formed. Then the water, percolating through the rock and sand above, commences its slow but sure process of forming stalactites, stalagmites and dripstone and the cavern becomes a fairy grotto filled with a crystal-clear pool or a rushing stream.

Very often, such caves extend in chains or series for many miles and may even be connected with the sea so that in those below tide level the ocean's tides rise and fall. Then, if a river flows across the country and into these caverns its waters may be backed up with every rising tide, to recede and flow swiftly as the tide goes down, thus presenting the phenomenon of a tidal river far from the sea coast.

Perhaps the strangest thing about underground rivers is the fact that they contain fish which are found nowhere else. Of course, many of the streams which flow partly underground and partly on the surface have the same forms of life as ordinary rivers, but the denizens of those streams which, through-

out their course, flow underground are very different. In these we find pale-colored fishes which are absolutely blind and even certain species of salamanders which are blind also. How and where, we may ask, did these blind denizens of the subterranean streams originate? They did not originate; they have been evolved through countless centuries, have been adapted by nature to life in waters where light never penetrates and their food consists of tiny creatures as perfectly adapted to a subterranean life as themselves. No doubt their ancestors lived in surface streams and by accident found themselves beneath the ground, and as in such places they had no need of sight or of color, their descendants, unable to regain the surface rivers, gradually lost their eyes and their bright hues until today we have the ghostly, blind inhabitants of these strange rivers that flow through fissures and caverns in the bowels of the earth, that dash in rapids down rock-filled underground cañons and that roar in cataracts over subterranean precipices.

Just as some rivers flow through crevices and caverns under the earth, so, where the vast moving masses of ice called glaciers occur, we find rivers flowing through the fissures and caverns in the ice, and many large and important rivers, such as the Columbia, the Rhine and the Rhone have, as their sources, these glacial streams. If you have ever watched the melting masses of snow and ice upon a hillside in spring you have no doubt noticed the innumerable, tiny rills which trickle from beneath them and you may have seen the miniature caves and cañons which these streamlets have formed in the frozen mass. These are in many ways exact counterparts of the rivers under glaciers, although of course infinitely smaller.

We are accustomed to think of glaciers as stupendous masses of solid ice moving slowly down their mountain valleys, but in reality these glaciers are built up of innumerable layers of ice and snow, like the strata of rocks which compose the mountains, each layer or strata representing a snowfall. Upon the surface we find the snow still soft

and white, but below this each layer becomes harder and darker and more compact, each successive layer more filled with stones and gravel, until, at the very bottom where the strata marks some ancient snowfall that drifted from the skies thousands of years ago, we find the ice so filled with sand and rocks as scarcely to be distinguished from the land about. Moreover, the surface of the glacier, and the layers of ice beneath, are not solid and unbroken, but are cracked and split and filled with huge crevices or crevasses where the mighty ice mass has been subjected to greater strains than it can withstand.

Just as the waters on the earth's surface follow the fissures in the rocks to underground caverns, so the water, formed by the melting of the surface of the glacier, pour down through the cracks in the ice. Then, reaching the layers filled with stones and sand and which are easily cut and eroded by the descending water, the stream carves caverns and grottoes and follows fissures and crevices until at last it gains the solid rock beneath the ice mass and can go no deeper. But the water is in-

tent on reaching the sea and between the bottom of the glacier and the rocky bed are many openings and irregularities and through these the water worms its way—ever melting and cutting the ice as it proceeds—until at last, it has formed a passageway beneath the monstrous mass of ice and gushes forth at the foot of the glacier. If the glacier is one of those of the far north which ends at the sea and breaking off forms mighty icebergs, our glacier river will lose itself in the ocean and no man may ever see it or realize that it exists. But should the glacier be a mountain glacier, such as those of the Alps or other great mountain ranges, the river, once free from the mass of ice, will wend its way through valleys and across plains to the distant sea and people, dwelling along its shores, will never stop to think that the flashing, sunlit river that turns their mills, waters their fields and carries them upon its bosom, had its beginning in the melting snows on the surface of a distant glacier.

Chapter VII

ARTIFICIAL RIVERS

STRANGE as it may seem, many of the most important waterways of the world have been made by man. Not content with making use of the rivers given him by nature, man has made streams to suit his own needs and to flow wherever he requires them. These artificial streams are known as canals and in many countries they are more numerous and more important than the natural rivers. Holland, as we all know, is a country of canals and the people, the traffic, the transportation, and the prosperity of the country are dependent upon its artificial waterways for not only do they serve as highways but in addition drain the land which is below sea level. France, too, is covered with a vast network of canals which are in many ways of more importance than the railways or highways for the purpose of transporting

freight. We also hear a great deal of the Canals of Venice, but in reality these are not true canals, but are natural waterways or estuaries of the sea which originally flowed between islands, but which have been so transformed by building up the shores with docks, houses and other structures as to give them the effect of canals.

True canals are dug by man to connect other bodies of water and very often a canal may be artificial for a part of its length and a natural stream for the rest of the distance. There are many reasons for making canals. Oftentimes, a large river may be only a short distance from another stream or lake and yet there may be no waterways connecting the two and the cities and their inhabitants upon one stream or lake may be prevented from using the cheap river highway. Or again, two rivers may be near together and yet they may flow into the sea at widely different points and the people on one may be in direct all-water communication with a port, while those upon the other may have to transport their goods hundreds of miles out of the way

to reach a port. Sometimes, too, a great river may flow near a rich, prosperous or thickly settled district and yet be too far from the farms and industries to afford a ready means of transportation, while in still other cases, a waterfall or rapids may interrupt the course of a river and thus prevent it from being used as a highway unless all goods are unloaded and carried around the falls on every trip. In all such cases man overcomes the difficulties by connecting the lakes and streams, or by going around the falls, by making the huge ditches which we call canals. Even today these man-made rivers are of great value and before the advent of railways they were absolutely necessary.

In addition to these canals I have mentioned are those which connect two bodies of salt water, such as seas or oceans. Very often two parts of the sea or two oceans may be separated by a narrow strip of land which compels ships to go thousands of miles out of their way and to waste weeks of time in order to go from a

port on one ocean to a nearby port on another. By digging a canal through the intervening land incalculable sums of money and an enormous amount of time are saved and freights and passengers can be carried more cheaply and more quickly. Such canals are the Cape Cod Canal, the Suez Canal and the Panama Canal. Finally, man often constructs artificial rivers to bring water from distant lakes or reservoirs to the cities and these, known as aqueducts, are among the most important of man-made streams. We would scarcely call our sewers rivers and yet one of the largest of man-made rivers and one of the most important of canals is the Chicago Drainage Canal. Indeed canals may be likened to rivers in many ways. Thus the true canals are like ordinary flowing rivers, the canals connecting bodies of the ocean are salt rivers or tidal rivers, the canals of a country like Holland may be compared to a huge delta, the aqueducts which bring fresh water to the great cities and our sewers and drainage canals are underground rivers, and the gutters of our city

streets and the farmer's ditches may be likened to brooks.

When a canal is cut through level land or connects two bodies of water of the same level the water flows through quietly and boats come and go as readily as upon an ordinary stream. But where the land is uneven or hilly or where the two bodies of water which the canal connects are of unequal level, some provision must be made to prevent the water from flowing too rapidly through the canal and thus rendering it impossible for boats to pass through. This is accomplished by means of locks and while the principle and operation of locks are very simple yet, to many people, they are a mystery.

A lock consists of two watertight dams or gates which are so arranged that they can be opened or shut and with smaller openings or valves in them. These are placed at the points where the surface of the ground changes its elevation and when a boat comes to such a spot the locks are used to raise or lower it from one level to the other. If the

boat is going up the canal the up-stream gate and valves are closed and the lower ones opened so that the boat enters the lock at the low level. Then the lower lock gate is closed behind the boat and the upper gates or valves opened, which allows the water from above to pour into the lock and raise the boat to the upper level of the canal when the upper gate is opened and the boat proceeds on its way. If the craft is coming down the canal the operation is reversed; that is, the lower gates are closed in front of the boat and the upper ones are shut behind it. Then the water in the lock is allowed to run out through the lower gate until the boat sinks to the lower level of the canal, the gates are then opened and the boat goes on its way. Very often, the elevation or hill where the canal passes is too great to be overcome with a single lock and several are used and as a usual thing a canal of any great length is provided with numerous locks and by means of these a boat may be raised for several hundred feet in a comparatively short distance. But at times the land where

a canal is dug rises so abruptly that locks would not be practical and in such places an inclined way is often provided and the canal boats are hauled out of the water at the lower level and up the ways to the upper level or vice versa by machinery.

For these reasons canals are much commoner and more important in level or flat countries than in hilly districts, for locks are expensive to install and to operate and in passing through them the traffic is greatly delayed. Thus Holland is so flat that comparatively few locks are required on its canals as most of them are at or below sea level and they do not cross any great elevations of land. It is the same way with the majority of the French canals and in these countries one may travel along a canal for many miles without seeing a single lock. Formerly canal boats were drawn through the canals by mules which were driven along a narrow pathway on the bank of the canal and which was known as a towpath, but nowadays, although mules and towpaths are still used to some extent, the more important can-

als are navigated by boats equipped with power and driven by propellers.

No one knows who first invented canals and no one can say what first put the idea of making artificial rivers into men's heads. It may have been a flood or freshet which overflowed a river's banks and formed waterways in gullys and valleys where no stream had flowed before, or it may have been an irrigation ditch or even a child sailing his toy boat in a tiny ditch he had dug; but whatever the origin it is very ancient, for canals were known and used in earliest historical times. The Greeks and Romans constructed enormous canals and aqueducts some of which still remain and are in daily use and even savage, primitive races dig miniature canals to permit their canoes to reach their villages at some distance from the rivers.

I have already spoken of the salt-water canals used to connect two portions of the sea or two oceans and these, as a rule, do not require locks as the sea is practically level. This is the case with the famous Suez Canal

—and much of this by the way was an ancient canal used long before the dawn of Christianity—but when man decided to connect the Atlantic and Pacific oceans by cutting a canal across the Isthmus of Panama he found that a sea level canal was an impossibility. Not only were there high mountains to be crossed which would mean cutting a huge ditch over six hundred feet deep, but the tide in the Pacific rises and falls for twenty feet, while in the Atlantic it only rises and falls a few inches. It was largely due to the fact that the French (who had dug the Suez Canal), thought that they could make a sea level canal across the Isthmus that they failed in their attempt for they wasted vast sums of money before they realized their error and changed their plans, while it was owing to the fact that our engineers profited by the experience of the French and constructed a lock canal that we were successful. Many people think that the idea of a canal connecting the Atlantic and Pacific Oceans originated with the French; but in reality, the Spaniards had considered

the matter and had even had a survey and report made over three hundred years before the French took up the idea. Although the old Spanish engineers reported that a canal could be made they advised the Spanish King not to undertake it for three reasons: first, on account of the cost; second, as it would enable pirates and other enemies to attack Spanish settlements on the Pacific and, third, because the Church declared that it would be sacreligious to connect two oceans which God had separated by land.

Although the Panama Canal is the largest and most famous of man-made rivers in the world, yet few realize what a stupendous undertaking it was or the tremendous amount of labor, materials and supplies used in its construction or the immense size of the locks. At Gatun dam, where ships are raised for eighty-five feet to the level of Gatun Lake, there are three sets of locks, while at the other end of the lake where ships are raised from the Pacific level or lowered to it, there are also three sets, two at Miraflores and one at Pedro Miguel. When we watch a boat

being locked through an ordinary canal the massive wooden gates look very large and cumbersome, but try to imagine great, steel, lock-gates, sixty-five feet long, eighty-two feet high, seven feet thick and weighing 730 tons each! And instead of the bluff-bowed canal boat in its lock chamber a hundred feet in length, try to think what it would be like to see a huge battleship or ocean liner in a lock-chamber one thousand feet long and over one hundred feet in width! Slowly, very slowly, the water rises in our old-fashioned canal locks until the barge reaches the upper level, and yet, in the gigantic locks of the Panama Canal the chamber can be filled and the ship raised in fifteen minutes! But even such comparisons give no adequate idea of this stupendous man-made river. Everything is on such a colossal scale that the mind can scarcely grasp it. Thus, who can conceive the amount of material excavated—a total of over twelve million cubic yards or enough to have dug a tunnel thirteen feet in diameter through the center of the earth? In hauling and dumping this mountain of ma-

terial over one hundred locomotives and two thousand cars were required, while, to blast the rock in making the huge ditch, over six million pounds of dynamite were used each year. Still, with all our resources, all our vast expenditure, all our herculean labors and all our engineers, this gigantic canal would not have been possible had it not been for a river, for in order to secure a water supply to enable the locks to be operated a stupendous lake covering over one hundred and sixty square miles was formed by blocking the Chagres River with the largest dam in the world. Thus, this comparatively small stream which was hardly known to the outside world, became one of the most important rivers on earth, for it enabled man to perform the greatest engineering feat ever known when the Atlantic and Pacific Oceans were linked by the Panama Canal.

CHAPTER VIII

A JOURNEY DOWN A NORTHERN RIVER

WANDERING through the northern woodland we come upon a brawling, tumbling brook; a merry, flashing rill of crystal water, cold as ice and dashing, rushing onward over its bed of granite boulders and smooth, worn ledges as though its speed were the most important thing in the world. If we are ardent anglers we will recognize the stream as an ideal spot for trout and skirting the shores under their fringe of sweet-scented balsam fir and gleaming, silver-white birches we cast our lines into still dark pools or into the bubbling water at the foot of miniature cataracts and are rewarded by many a flashing, speckled beauty. But if we are not too intent on luring the handsome fish from their cool homes in the mountain brook and will devote a bit of our attention to our surround-

ings we will find many things to interest us and to arouse our curiosity. We will note how the rocks and ledges are deeply scored or grooved in many spots, we will see that where the stream dashes over a smooth ledge in a little waterfall that there is a well-marked gutter or channel cut in the hard granite and we will begin to wonder how the water could have worn the rock to such an extent, how long it has been in doing it and why some of the smooth, worn ledges are far above the present level of the brook. Then we may notice that all the pebbles and boulders in the bed of the stream are worn smooth and round and that many of them are of a different material from the ledges. As we carelessly toss back those we have been examining we see them go rolling and jumping and grinding along in the current of the stream. Here we at once have a solution, a key, to the puzzle of the water grooving the rock, for instantly we realize that in times of freshet or flood our merry brook is capable of moving good-sized boulders with its current and that these, grating and grinding and

sliding across the ledges, have cut the grooves and that once they have been started the stones will naturally follow the grooves and will cut them ever deeper and deeper.

In examining these deeply-scored marks we will find that, in spots, harder rock—narrow veins of quartz or finer-grained areas, are scattered through the granite and that where these occur they project slightly from the surrounding rock. In other spots we will find masses of rock softer than the granite, veins of mica, feldspar and other minerals known as pegmatite, and that where these occur the water and its cobbles have worn and cut deep holes and crevices and that in many places the stream follows a bed which represents the spot from which this softer rock has been worn. Perchance, too, we may find a curious, circular hole, or several of them, cut as smoothly and evenly as though bored by man. These holes may be above the present level of the brook or they may be under water and in them we will find one or more rounded smoothed masses of hard rock.

If the hole is under water we will find that the current swirls and eddies about within it, like a miniature whirlpool, and we surmise, and rightly, that it is the swirling water and the stones which have cut these pot-holes in the granite. Just below here the water tumbles into a shallow, quiet pool floored with fine sand and as we gaze through the crystal-clear water we are surprised to see something moving upon the bottom. We look closer and discover that the object is a little bunch of twigs, and anxious to learn why it should move about, we reach down and secure it. Within our hand the little bundle of tiny sticks is motionless and seems devoid of life, but if we place it in a little pool of water we will presently see a small head appear from one end of the object and a moment later it will commence to move slowly along, for this is the home of a caddice worm, the larvae of a pretty lace-winged insect. Our interest now aroused, we search our pool for more specimens and find them aplenty; caddice worms in houses of twigs, in houses of sand, in houses built of

RAPIDS ON A NORTHERN RIVER

These rapids were caused by dykes of hard rock in the bed of the stream.

tiny snail shells and, in one corner between two little pebbles, we see what we mistake for a spider web and we wonder why a spider should place its silken trap under water. But here again we are mistaken for the web does not belong to our old friend the spider, but to one of our caddice worms, a tiny insect-fisherman who spreads his net wherever the water runs swiftly among the pebbles and in it captures many a tiny insect and crustacean for his dinner.

Here, too, if we turn over some of the larger stones, we may find a strange dark-colored, savage looking creature which the country boys will tell us is a helgramite or dobson and which, if we are bass fishermen, we will recognize as one of the most highly prized baits for those gamey fish. Perhaps, too, we may find a dainty orange newt aglow with scarlet spots, or a swift-swimming, big-headed, powerful dragon-fly larvae and we will most assuredly find many small snails, and, on the surface of the pool, a number of the long-legged water-boatmen and the glossy-black whirligig beetles. But all of

these are more or less familiar to us and are of little interest and anxious to see whither this roaring brook goes we pick our way down stream.

Presently the hard, gray granite gives way to a softer reddish rock and instantly the character of the brook and of its bed and banks are changed. Here there are no smoothly-worn, abrupt ledges and rounded boulders, no noisy cataracts and rock-filled falls. Instead the brook flows between steep, sharply-cut banks of red stone curiously piled in thin horizontal layers; its bed is broad and smooth, dropping in a series of slopes down the ravine-like cut through the hills. We find few boulders or pebbles in the stream and these we recognize as having been brought down from the area of granite above. Far over our heads the summits of the banks are fringed with firs and spruces and glancing up we see plainly that the sides of the ravine are water worn and we realize that the stream has cut its way through the sandstone for scores of feet. It is a dark, damp, quiet, spot with the brook

purling in subdued tones through its sloping bed and as we reach the lower end of the ravine we come to a bright, sunny clearing where the brook flows under drooping alders and hazel bushes through a bed of rich, black earth.

Close at hand runs a country road and forsaking the tangle of brush beside the brook we take to the highway, and keeping our stream in sight, walk along in the shade of the big maples. Presently the road turns to one side and we find ourselves upon a rustic plank bridge spanning the brook which, just below, widens out into a little pond with the roofs of buildings peeping through the foliage of trees at the farther end. Following a narrow path that skirts one side of the pond, and startling many a frog that plumps with a splash into the water, we approach the buildings. We find them old, weather-beaten and deserted, but beside one we see an ancient, massive water-wheel while the piles of rotting, half-overgrown sawdust tells the tale of the old sawmill which, years before, sawed the trees from the clearing into

boards and timbers for the farmers in the neighborhood. Before us, too, is the old dam, built of logs and stones, broken in places and out of repair, but still strong and tight enough to hold the bulk of the water of our brook. In a pretty cataract the stream pours over the rotting dam and gurgles through the half-choked millrace, to hurry on down the valley.

A mile or two further on our stream is joined by another brook and, spreading out sweeps in broad curves through a meadow. Just where the two streams join is a little house and, pulled upon the bank of the stream, are two canoes. Here then is an easier means of following our brook and from the swarthy French-Canadian who appears at our approach we hire a canoe and embarking, slip swiftly downstream with the current. As our craft swings around the bends we wonder why the brook did not run straight, for there seems no reason for its not following a direct line down the centre of the valley. We see that the banks of the stream are of sand and clay and then

we notice that each time the current carries us around a bend it swings us far over to the outer side of the curve. On this side, too, we note that the water not only runs more swiftly, but is deeper than the opposite side which is shallow and has an accumulation of dead trees, leaves and other drift piled upon the sand and gravel which extends from the bank into the stream. On another bend we see where the current has recently cut away a slice of the bank, exposing fresh earth, and wondering why this should happen we glance about and see a log stranded in midstream and which has forced the entire current against the bank. Then the reason dawns upon us and we know why the stream flows in curves instead of straight; we grasp the fact that a log, stump or stone in the channel will turn the current and compel it to cut away the bank and that as fast as it cuts in one side it fills in the other.

If we land and examine the meadow near these curves we may be able to trace the bend for a long distance by the

hollows they have left as they have been gradually filled in, and, in places, we may still find the shallow, grass-grown remains of an ancient channel which ran nearly straight across the meadow. If there should be any question that this is so we could readily prove it by digging into the earth. If we found only ordinary soil with scattered pebbles and stones we would know that the stream had not flowed there, but if we should find gravel, sand and stones evenly assorted or "classified" we would be sure it was the old bed of the stream, for the sands and gravels of river beds are always deposited in regular order with the heavier stones and pebbles below and the lighter above. Thus geologists can always distinguish gravel beds or sand banks made by streams from those formed by glaciers, wind or other causes.

There are many other interesting facts which we could learn about our stream also. If we are hungry and cast our lines into the water we will not catch speckled trout, but perch, dace, pum'kin-seeds, roach or other fish; we would find more snails and many

fresh water mussels on the bottom and while we would still find caddice worms, dragon-fly larvae and various water insects we would miss our insect-fisherman; we would find a different kind of salamander and we would have to search for a long time to locate a dobson.

We would also discover that the plants along the banks were different and that the birds had changed. Back in the granite hills, balsams, birches, larch and spruce were the prevailing trees. Maiden's hair and other ferns grew in the shady spots and columbines, hair-bells and saxifrage brightened the crevices of the rocks. Chickadees sought for their food upon the tree trunks, hermit thrushes trilled from dense thickets of spruce; a kingfisher rattled his challenge as he plunged into a pool after an unwary trout and a dainty wagtail teetered curiously as he walked mincingly beside the falls. But here by the broader stream in the meadow we find willows and elms with an occasional oak or hickory. A vivid cardinal flower gleams among the coarse grass on the bank, blue gen-

tians dot the grass in the old, dry channels and in the quieter stretches pickerel-weed, arrow-head and flag are seen. From the waterside an occasional green heron flaps to safety at our approach, song sparrows sing gaily from nodding mullein stalks, and the clear, piping whistle of the red-wings is borne to us on the breeze.

All this we note as our canoe slips swiftly down the stream, while from time to time, we pass the mouths of other brooks, until, without realizing it, our brook has been transformed into a river. Then, swinging around the base of a wooded hill, purling musically over a stretch of gravelly rapids, hurrying through a dark, hackmatack swamp, the river carries us through an ever changing panorama to leave us floating upon the tranquil waters of a broad lake. On all sides rise the forested hills, dark with pines, and skirting the shores we search for an outlet. At last we find it, but it is a brawling, rapid-filled stream with jagged, upjutting rocks, and before trusting our frail canoe upon it we decide to investigate. Close at

hand is a pathway through the woods and landing here we follow the stream as it roars over its rocky bed. The trail descends steeply and a few moments later we come out upon a second and smaller lake with the stream falling in a cataract into its waters. We now know that the trail is a portage, that in order to reach the second lake and thus continue down the river we must carry our canoe overland, and we are thankful that it is such a light and easily-handled craft.

Once more seated in our canoe upon the second lake we paddle rapidly along the shore and find a large, smoothly-flowing river leading from it through a cleft in the hills. And here we find the rocky banks very different from anything we have seen before. They are carved and cut and worn in queer grotesque forms. In several places we see big caverns extending into the cliffs. In other spots the rock seems to be painted or whitewashed and when we pick up a fragment of the rock to examine it we find to our surprise that it is made up of countless shells, some perfect, others mere frag-

ments, but all cemented together and as hard as the surrounding gray rock. How, we wonder, did these shells come here to this hill miles from the sea? But a geologist would solve the riddle for us in an instant. He would tell us that long ages ago no river flowed here; that in those far-distant times these rocky cliffs were covered by many feet of water, that the country was once the bottom of a vast inland sea or lake and the hard limestone rock was then soft mud or ooze in which the dead shells sunk and that, through some movement of the earth's crust, the land rose, the water of the great lake drained off and the mud, with its contained shells, gradually was transformed to rock. The geologist, also, would go farther; he would explain that the red sandstone, through which the brook cut its way, had once been the sandy shores or bed of a prehistoric stream or bay; that it had once overlaid the granite and that, through the ages, the softer sandstone had been worn away by the elements until only fragments here and there remained. He would also

tell us many other interesting facts about our river and the fascinating history of the country through which it passes, for, to the geologist, the banks of a river are an open book telling, to those who can read them, much of the past history of our old earth.

Soon after leaving the limestone cliffs with their fossil shells behind, the river flows beneath an iron bridge and we come to a small town beside the stream. Here we find busy mills and factories; buzzing saw-mills, rumbling grist-mills, noisy machine-shops and a tannery, all running by the power of our river whose waters, confined by a broad, low dam and led into sluice-ways, turns the big turbine wheels in their pits beneath the mills. Here, too, we will find straight-sided, bluff-bowed canal boats, a few power boats and perhaps a small steamer, for our tiny trout brook has now developed into a large river which constantly widens and deepens as we resume our journey. Stream after stream flows into it, town after town and village after village is passed. Each mile, as we go downstream we find the houses and set-

tlements along the banks increasing. Each day we see more and more river craft. We pass great rafts of logs drifting slowly close to shore; we meet big, smoke-belching, stern-wheel steamers breasting their way upstream; motor boats speed by and long strings of barges and canal boats move slowly along to the pull of powerful tugs. The river is a busy thoroughfare and beyond the banks, now a mile and more apart, stretch wide, well-tilled fields of grain, corn and vegetables. Here and there monstrous iron bridges span the waters and far above our heads railway trains roar, trolley cars and trucks rumble, motor cars glide and pedestrians gaze down upon the passing craft beneath. Far, far away, is the tumbling brook and its speckled trout; for distant are the firs and birches. The trilling thrush and friendly chickadees are things of another world, but still our river supports a teeming, living world of its own. Song sparrows still sing their rollicking melodies on the outskirts of the towns. In marshy spots the red-wings still whistle as sweetly as back in the country

meadow. Elms, willows and maples rise above the banks and in little backwaters and side creeks we might still find frogs and turtles and even caddice-worms and dragon-fly larvae; in the muddy, dirty water we can still catch fish—great, ugly catfish mainly, with a few mullet or other fish, while, in the spring, shad and sturgeon, with now and then a lordly salmon, still make their way up the busy river to lay their eggs in the upper reaches of the stream in the same spots in which their ancestors laid theirs centuries before the first man ventured on the waters of the river.

Then one day, we discover that we are no longer drifting down with the current; to our wonder we find ourselves being carried upstream—the river seems to be flowing backwards. We have struck tidewater and while we find the water still fresh yet the tides of the sea, flowing into the river's mouth, forces the fresh water of the stream backwards. Slowly we paddle on against the tide; we reach an area of vast, grassy meadows stretching for miles on either

hand. Along the ill-smelling black mud at the roots of the coarse reeds and stiff grass, odd fiddler-crabs scuttle into their holes or stare impudently at us with their single, huge claws held menacingly forward. As the tide recedes and leaves vast areas of the mud bare, we see clusters of mussels and the bleached shells of oysters scattered about, and we feel the salt tang of sea air. Far ahead we see the smoking chimneys, the lofty buildings and the slender spires of a great city. Docks and wharves come into view, big steamships and sailing vessels throng the river or lie moored at the piers; ferryboats spatter hurriedly from shore to shore like gigantic whirligig beetles, while the river, which began so cleanly and purely in that distant mountain gorge, is filthy with sewerage, floating rubbish and patches of oil and coal dust. Then the last, outlying dock is passed, the last squalid hut of the city is left behind; our league-wide river opens out between sandy beaches; before us stretches the limitless horizon of the ocean and our craft bobs and courtesies to the long swell.

We have reached the river's mouth; we have followed our tiny trout stream to its end, we have seen how, throughout its long journey, it has served our fellow men. For long it has been a slave, for many scores of miles it has done man's bidding; it has turned his mill wheels, has watered his crops, has provided him with food, has carried him safely on its bosom. But now once more it is free and unfettered and like a giant unleashed it joins hands with the mighty ocean and leaps and dances and roars in white-crested rollers upon the clean sea beach.

CHAPTER IX

A JOURNEY UP A TROPICAL RIVER

FOR many days we have been steaming southward across a sea of deepest ultramarine, but now, as we gaze ahead searching for the first sight of the distant land, we find that the marvellously colored sea is beginning to lose its brilliant azure tint and is becoming dull greenish. Rapidly the color deepens and presently our ship is ploughing through water of a dirty brown and to our enquiries the captain replies that it is due to the mud carried down by the great river whose mouth we are approaching. Far ahead, and stretching to east and west, we catch a glimpse of the coast and we note the strange effect of clumps and masses of trees rising from the rim of the sea, for so low are the shores that long before the land is visible the higher trees are seen. Then, rising

among the masses of bluish green, we see the lofty chimneys of sugar mills, the slender wireless towers and the higher buildings of a town and still there seems to be no solid ground for them to rest upon. But as the ship slows down to take on the dusky pilot and then threads her way from buoy to buoy towards the port, the real shores appear with the trees and buildings rising from them and in one spot a broad opening which marks the river whose mouth we are now entering. But such a mouth! Had the genial captain not told us we should have thought we were still upon the sea, for no land is in sight on either side and we learn that the river is nearly forty miles in width at this spot!

As we proceed we find that much of the land which we took for the coast of the great southern continent is but the shores of islands, some of them a score or more of miles in length, which are scattered about in these lower reaches of the river. But all about us are interesting things to be seen. Flocks of black-headed gulls flutter and cry in our wake, a string of great, clumsy peli-

cans come winging across the dark brown river so close to the surface that their wing tips seem to touch the water. Overhead, frigate birds wheel in great circles on motionless wings and a school of river dolphins leap and play a short distance ahead. Now too, the banks of the river are distinguishable, the docks and piers of the city are in view and above them rise the masts and funnels of many ships. Then, above the roofs, we see the nodding palm trees; buildings detach themselves from the greenery and soon we are alongside the dock and our overseas journey is at an end. It is an interesting, foreign spot, but we are here to take a trip up the great river that flows for hundreds of miles from the far-distant, unexplored mountain fastnesses through marvellous, untamed jungles and the city and its attractions must not detain us. Boarding a little river steamer we set forth on our journey and head up the great river. Everywhere are the black and muddy shores covered with a low growth of dense mangrove trees and as our steamer swings to one side

and follows the channel close to the bank, great flocks of herons rise from their feeding places and flap on white or blue wings into the branches of the trees. In one spot, as we round a bend, we see a strange patch of vivid scarlet upon the black mud and while we are wondering what it may be it suddenly springs into life and is transformed into a scarlet cloud and as it settles upon the trees, giving them the appearance of having blood-red leaves, we realize that we are gazing at a flock of the rare and beautiful scarlet ibis. Rare I say; but not rare here; in fact, so common, such an everyday sight that the natives pay no more heed to them than if they were so many insignificant sparrows. But already our attention has been diverted from the wonderful birds as we see a gigantic crocodile basking upon the mud, and then, having learned to distinguish the scaly reptiles from the stranded logs, we discover that there is not one but scores upon the banks.

For hour after hour we travel, constantly seeing new and interesting birds and beasts;

constantly passing along the interminable mangrove swamps that border the river. Now and then we meet a huge, square, box-like boat or lighter drifting slowly with the stream, its load of firewood piled high, a ragged negro steering lazily with a huge oar and a ridiculously small sail made of old gunny-sacks spread to yards and masts of giant bamboos. So slowly does the lighter move that we wonder if it ever will reach its destination, but time is of no object and if it takes two or three tides for the lighter-man to make his down journey of a dozen miles and as many more to return he will be quite satisfied. Then, when we have begun to think the mangroves will never end, we see larger trees ahead, the banks seem higher and drier, a few palm trees show above the brush, the roof of a building peeps from among the foliage and as the little steamer slows down a boat pulls out from shore. Manned by half-naked negroes, the craft paddles alongside and we almost feel as though we were on one of our own southern rivers, for the boat is an almost perfect coun-

A GORGE CUT THROUGH THE HILLS BY A TROPICAL RIVER

The valley of the Kaieteur River in British Guiana. This photograph was taken from below

terpart of the familiar, darkey flat-boat. Onward up the stream we go once more and ever as we proceed the banks grow higher and drier, the mangroves decrease and are replaced by hardwoods and thickets of palm; along the water's edge we see masses of giant, lily-like plants ten feet or more in height with immense arrow-shaped leaves like our own arrow-head magnified a thousandfold.

In little coves and backwaters the stream is covered with thousands of the immense six-foot leaves of the giant Victoria Regia lily with the great wax-white flowers everywhere among them. Over the huge, saucer-shaped leaves, odd, long-toed, brown jacanas run nimbly and appear like some sort of enormous butterflies as they spread their sulphur-yellow wings in fluttering, erratic flights.

Here and there, on little sandy knolls or in small clearings, we catch glimpses of tiny, thatched cottages. From the landing-place before one of these a huge dugout canoe darts out and as our ship slows down and the craft bobs along beside us to receive a few

packages and mail, we see that its crew is composed of bronze-skinned, stocky, pleasant-faced Arowak Indians. Then once more we resume our journey; a low, rocky islet is passed in mid-stream, ahead we see good-sized hills covered with forest, the shores show areas of gray granite and far away appears a little town. Here we draw into a tiny wharf and are surprised to see that it towers far above our decks and then, as we notice the water-soaked, muddy spiles it dawns upon us that we are still where the tide rises and falls for a dozen feet, although over fifty miles from the sea.

At this little settlement at the limit of steamer navigation we step ashore and a few hours later are seated in a large river boat or coorial. The boat is very different from anything we have seen, a heavily built craft of native wood with no stem or stern posts, but with a rounded, spoon-shaped bottom. But we will soon learn why the boat is thus made and now turn our attention to the crew. Six of them are bronze-skinned Indians; short, stocky and with enormous chest and

shoulder muscles from constant paddling. In the bow stands a colored man whose features and skin show a strain of Indian blood and at the stern stands the captain, a gaunt, elderly mulatto. Each of the crew grasps a strong, hardwood paddle, the bowman holds a huge paddle, five or six feet in length, and at the stern a still larger paddle is slung in a bight of rope to serve as the captain's rudder. At last all is ready, the provisions, supplies and luggage are stowed, we are seated comfortably under the rounded awning or "tent" of palm leaves in the stern and with a shout from the captain the six paddles dig into the water as one and our boat surges forward up the river.

Steadily and in perfect unison the men paddle, singing a weird, Indian chant as they make the heavy boat fairly fly and ever and anon changing the song suddenly and altering their stroke at the same time. Quickly the shores slip past, soon the little town is left behind and on either hand, stretching ahead as far as we can see, rise the huge trees of the unbroken forest. Close

to the shore we sweep along, the further banks hazy and indistinct over three miles away. Winging rapidly in pairs and flocks screaming parrots fly overhead, great macaws in scarlet, yellow and blue screech at us from the lofty trees, toucans with grotesque bills clatter among the foliage and everywhere we hear the cries and songs of strange birds. From time to time enormous, sky-blue, morpho butterflies flit above the water; we see innumerable new and interesting forms of vegetation and we long to step ashore and penetrate the mysterious jungle. But we have many miles to travel and our men are anxious to make the first rapids ere nightfall and we hurry on. At noon the boat is swung inshore and run upon a stretch of sandy beach and as the men prepare the noonday meal we stroll along the banks and even push for a short distance into the jungle, but we cannot go far, for the clinging and trailing vines, the spiny palms, the creepers, the saw-grass and the trees form a dense, impenetrable barrier through which one must hew a way in order to travel a hundred feet.

Even our brief excursion into the edge of this forest shows us many things of interest, however. We note that the large trees widen out into strange, flattened buttresses at their bases, that the roots of many of them sprawl and twist for long distances upon the surface of the ground and our curiosity is aroused by several trees, among them lofty palms, whose trunks end several feet above the earth and are supported by innumerable, slender roots like wire cables. We wonder why these things should be, but if we should visit the spot during the rainy season when the river, swollen by torrential, tropic downpours, rises above its banks and floods the jungle for miles inland, we would understand. Then, with the forest floor a vast lake and with the turbid waters swirling about the trees we would find that the broad roots grasping and clinging to a vast area of earth prove a far safer anchorage for the large trees than ordinary roots, while the slender cables holding up the palms present little resistance to the swift-flowing water and support the trunk above the level of the flood. Moreover, if we

should dig into the earth beneath our feet we would find that it is composed entirely of dead and decaying leaves and vegetation, that there is little or no true soil and that a few feet under the surface there is solid rock. Often, in times of floods, great areas of this forest floor break loose, and still bearing the mighty trees, which bind the ground together with their roots, float free and are carried downstream in the form of wooded islands. Sometimes these floating islands are broken up and washed to pieces, at other times they become stranded at the edge of the river and soon become a part of the forest once more, while, very often, they ground on bars or rocks and form wooded islands in midstream which no one would dream had once been bits of the distant jungle torn free by the swollen river current.

Our noonday meal over, we again take our places in the coorial and for several hours paddle up the river. Often we pass the mouths of little streams or creeks—dark, mysterious, inviting spots with their tangle of strange tropic plants, their slender, grace-

ful palms, their weird air-plants and blazing orchids. Then the current becomes swifter, the banks become rocky and presently we are paddling between charming little islands, some covered with trees and shrubs, others like emerald mounds of grass and others bare rocks carved into grotesque forms like strange monsters. And as we pass close to them we can see the high water mark of the river, the limit of the rainy season floods, clearly defined upon the rocks a score of feet above our heads and we realize the terrific power and irresistible force of the river when in flood as we notice huge tree trunks, forty or fifty feet in length, cast high and dry upon the summits of these rocky islands.

Between them the river swirls and eddies, great flocks of twittering, blue-green swallows wheel and dip and skim all about, an otter slips from a ledge and swims across the channel ahead and flocks of cormorants perch upon the branches of the waterside trees. Then, far ahead, we see a line of white crossing the river, and the faint roar of the falls is borne to our ears and half an

hour later our coorial is run upon a tiny sand beach on an islet just below the first falls. Here camp is made and as our Indians stretch the canvas for our shelter and light their camp fires we stroll about the island and study its many interesting features. Upon the damp sand we see the tracks of some animal, and curiously following them, come suddenly upon a little herd of capybara, odd creatures like gigantic guinea pigs, which take to the water like ducks and swim to the opposite shore at our approach. A bit further on we surprise a dainty, slender-necked sun-bittern whose wings, as he flits in soft, short flights before us, look like the rays from an orange sun, while all about us the pretty, gray, red-headed finches twitter and flutter about along the water's edge.

Returning to the camp we think what a lovely spot it is for a swim and are about to disrobe when our boat captain shouts a warning and explains that to enter the river would be to invite sure and terrible death. The water, he says, teems with the dreaded Perai or cannibal fish which would tear us

to pieces in a moment. We can scarcely credit the tale, but to prove it is so, the negro tosses a bit of meat into the river and instantly a score of great silvery fish leap at it, churning the water into foam, snapping and tearing with savage jaws and madly attacking one another in their struggles. Then, to show us what manner of fish these creatures are, the captain baits a line and a moment later yanks a Perai onto the sand. As it flaps about, snapping its jaws like steel traps and uttering low, savage grunts, the men give it a wide berth. But at last its struggles cease and after killing it with a blow on the head the old man picks it up and we examine its teeth and jaws. Then we realize how such a small fish can prove so dangerous, for the enormous, powerful jaws are equipped with razor-edge teeth, all joined to form a solid continuous row of saw-like points, so arranged that the upper and lower teeth fit tightly and perfectly together, and when the captain informs us that an eighteen-inch Perai can bite a piece from an inch-plank we

can readily believe him and we thank our stars that we did not take our bath.

As we eat our evening meal and darkness falls over the river innumerable night-jars flit softly about uttering their querulous calls, we hear the low grunting of a herd of peccaries from the bush on the nearby river bank, fish splash in the quiet water near the beach and from far off in the jungle a jaguar screams.

At daybreak the next morning we are up, and ere the sun has risen above the banks of mist above the forest, our coorial is headed towards the falls. We wonder how the men expect to get the heavy boat and its cargo up the roaring, tumbling water, but we are not long left in doubt. Running the boat alongside a rocky ledge the captain requests us to step ashore and as we obey, the men uncoil long ropes and prepare for their battle with the cataract. One rope is attached to the bow, another to the stern and while two of the men hold the boat in place against the rock, the others work their way upstream above the falls. Here, with some

standing waist deep in the rushing current, others standing upon slippery, water-washed rocks, and all grasping the stout rope they await the captain's orders. Meanwhile, the stern line is carried ashore, two men brace themselves as they hold it and, at the captain's word, the men on the bow rope tug and strain, the captain pulls with his huge paddle, the men on the stern line swing the boat free from fang-like, jagged rocks and aid their fellows and slowly the boat moves up the foaming rapids and into the comparatively smooth water beyond. It is all done so skillfully, so orderly and so quickly that we scarcely realize the difficulties and the strength required or the dangers that threaten both men and boat. But although the worst parts of the falls are passed there is still a long stretch of racing, foaming rapids ahead and as the men work and haul the boat through these we pick our way over the rocks. We note that most of the rocks are dull, reddish granite curiously carved and worn and with innumerable pot-holes and when we examine them more

closely we discover that they are filled with irregular veins and masses of a darker, finer grained rock and that the erosion or wearing of the granite has left these harder masses exposed and has thus produced the oddly carved and irregular masses. We find, too, that instead of being bare and lacking in vegetation the rocky ledges are everywhere covered with a low, strange growth of a pinkish color—tiny, wiry stems bearing odd little blossoms whose roots are cemented firmly to the bare stone and which at a distance give the rocks a peculiar, fuzzy appearance as though they bore a stubble of beard. Had we been here a few weeks earlier we would have found that all these rocks were covered with a dense, lush green, weed-like growth like gigantic lettuce leaves and that the stems and flowers, which we now see, are all that remain of these remarkable plants.

As we walk along noting these things great clouds of sulphur-yellow butterflies rise and settle and flutter about, saucy yellow and white headed kiskadee flycatchers challenge us with sharp, harsh cries from the

stunted guava bushes growing in the crevices of the rocks; big, green lizards scuttle from our pathway and charming humming birds hover before gay-hued blooms of orchids and flowering shrubs, and yet, where we are now standing, a raging torrent flowed and roared less than a month before. By now the boat has been hauled above the rapids, and once more we take our seats and are paddled up-stream. It is a constant battle, a never-ceasing struggle for the men, for the current runs like a mill-race; wicked, sharp-edged rocks project above the surface of the stream and the bowman is kept ever busy swinging the craft into the narrow channels while the men paddle with all their strength and the captain deftly guides the boat between the rocks. Presently, however, a stretch of smooth tranquil water is reached, the men paddle easily and rest their tired muscles and we exclaim in delight at the beauty of the scene. In twin walls of green the jungle-clad shores tower above the river, the trees so interlaced and woven together with vines and creepers that they appear as though draped with green

velvet, while here and there, some towering tree is ablaze with mauve, yellow, scarlet or white flowers which, dropping to the water below, cover the river's surface with a multicolored carpet. Everywhere the swallows flit; from resting places on tree trunks flocks of vampire bats flutter off at our approach to alight and become, apparently, transformed to bits of bark upon another tree; from the forests come the cries of macaws, parrots and toucans; we catch a glimpse of a troop of white-faced monkeys romping through the tree tops, dainty terns and long-winged skimmers preen themselves on sand bars in the stream and far overhead a great king vulture sails. But the greatest beauty is in the river itself—the water, dark brown from the stain of decaying vegetation is as smooth as glass and on it the sky, the forest, each tree and twig and drooping palm —even the great azure butterflies and sweeping swallows—are reflected by the oil-like surface to such perfection that we cannot say which is water and which land and we have the strange sensation of floating on air be-

tween two forests, one right side up, the other upside down.

A mile or two of this and then once more the foaming rapids ahead. Again the tedious labor of hauling through and then, as we once more embark, the captain cautions us to sit tight and hold fast as just ahead is an enormous whirlpool which our craft must cross. Gathering all their strength our Indians grip their paddles firmly, the bowman braces himself for the supreme effort and at the captain's shout the boat darts forward. All about the water swirls and eddies, we can feel the boat tremble and shake as the men paddle furiously to overcome the drag of the current. Then the centre of the maelstrom is reached, our boat hangs motionless, the bow rises and the stern sinks down, we hold our breaths and thrill with excitement as we watch this battle between the men and the river and we almost forget the peril which hovers over us. Should a paddle break, should a man miss a stroke, our craft would instantly be helpless in the whirlpool and in a moment we would be capsized and

drawn down to our deaths; but the paddles are stout and strong, the Indians are skilled and experienced in navigating these danger spots and presently, inch at a time, our boat forges ahead, the worst of the whirlpool is passed and a minute later we are in the calm water beyond.

Then, just as we feel safe once more, our boat grounds with a sickening, grating thud upon a submerged rock. Quick as a flash the men leap over the side and in the water to their armpits lift and shove the boat free. And now we realize why these river boats are built with spoon-shaped bottoms. A flat-bottomed boat, or one with a keel, would be jammed hard and fast upon the rocks and all its cargo would have to be discharged ere it could be freed, but the native craft, with a bottom rounded and curved in every direction, is easily pushed off without danger of injury or capsizing. A short distance further on we come to a roaring waterfall a score of feet in height and here our captain tells us a portage must be made and all the

cargo discharged, carried around the falls and reloaded on the other side.

As the men busy themselves unloading the boat and carrying the boxes, bags and packages around the falls, we wander about, examining the trees and plants, the shores and the rocks. We find that here the coarse-grained rock is cut by a great dyke or seam of black, fine-grained diorite and tracing this along we find that it is this dyke which has caused the waterfall. Above it the river has cut and worn the country rock into a deep bed and below it the tumbling waters have hollowed a vast basin, but the flint-like diorite has resisted the water and the grinding sand and pebbles and still stands, like a solid dam, barring the river. At one side, however, there is a break or crack and here the water has forced a way and flows in a narrow, gurgling, noisy brook around the dam to where it joins the river below. It is a pretty spot, shaded with great trees, bordered with giant ferns and bright flowering plants and as we stand admiring it our attention is attracted to one of our Indians who is stealth-

ily hurrying over the rocks with an enormous bow and arrow in his hands. Presently he stands reect, peers intently into the foaming water, draws his bow to his ear and sends the long arrow like a streak of light into the rapids. Casting aside his bow, he darts forward, grasps the floating arrow and to our surprise, drags forth a huge, flapping fish. It is the first time we have seen the Indians shoot fish in the rapids and we marvel that the redman can see his finny prey in the foaming torrent and are amazed at his almost incredible marksmanship, but as we dine on the delicious "pacu" fish later we are thankful that our men are native Indians with the knowledge and skill to keep us supplied with fish in this remarkable manner.

Then, for a time, we watch the men, as toiling and sweating, but doggedly persevering, they lift and haul the heavy boat through the roaring, foaming water at one end of the falls and at last, by dint of almost superhuman strength, raise it to the verge of the cataract. Half filled with water, but unscathed, the coorial now rests in the water

above the falls and the men busy themselves bailing it out and stowing the cargo. Meanwhile, we have been attracted by the glistening black sand lying in little beds between the rocks and scooping some up in our hands we examine it closely to see why it is so black and brilliant. Noticing what we are doing our bowman approaches and asks if we are looking for gold. Thinking he is joking we laugh at the question, but he assures us that the river carries gold in its sands and rummaging in his dunnage bag he brings out a conical-bottomed, iron basin or pan. Scooping up a quantity of the black sand in this he squats by the river side, and half filling his pan with water, twirls it rapidly back and forth. At each movement a small quantity of water and sand slops over the edge of the pan and we watch him curiously and with a sort of fascination as he deftly washes out the sand and gravel until, at last, only a little ridge of fine black sand remains. Then, with a quick flirt of his pan, he throws off the last of the water and holds the pan toward us with a grin on his dusky face.

Spread upon the bottom of the pan is a little crescent of fine black sand and along its edge gleam several tiny flakes of yellow gold. Instantly the fever of gold hunting grips us and for an hour or more our trip is delayed as we try our hands at panning out the sand. But we find it is a trick we cannot learn in an hour or even a day and although we succeed in a way and are rewarded by several more "colors" we decide that riches would be too dearly earned in this way and at last give up. Then, as we paddle up stream, our captain tells us that only in the side creeks is gold to be found in paying quantities and that in some of these are sluices and long-toms where gold is being recovered from the gravels and that diamonds also are obtained in several of the creeks.

We now notice that the character of the river has greatly altered. The shores, though still two miles or more apart, are hidden by numerous islands between which the river runs in swift, erratic, winding channels; the rock is no longer the dull-gray granite or the black diorite, but a coarse red rock which

we find upon examination is a sandstone filled with rounded pebbles and which at a short distance appears like soft sand and gravel.

We land for our midday meal upon a little islet and here we find a number of interesting things and learn a great deal about the river from the story it has written in the rocks. All along the shores we find the conglomerate sandstone deeply grooved and cut, just as we found the rocks grooved in our northern river, and searching further, we find innumerable pot-holes, some below the water, others high and dry, some sharply defined while others have been worn and enlarged until the walls between them have broken away and huge oval or oblong depressions have been formed. We are not surprised at this, for the conglomerate is soft, and the pebbles and rocks in the bottoms of the pot-holes are hard as flint and the eddies and currents of the stream flow swiftly; but when, on the very summit of our island, we find similar grooves and holes, we realize that at some long past time the mighty river

swirled and flowed many feet above its present level; and that what is now the top of the island was then the bottom of the river bed; that through the centuries the stream has cut its way deeper and deeper into the conglomerate until it has worn down the stone to its present level. But there are still facts which puzzle us and which we must solve by observation and reasoning. Perhaps our knowledge of geology may tell us that the conglomerate was once the pebble-filled sand of a vast prehistoric river and which has gradually been hardened into stone; but this does not explain why the little masses of rock which form the islands should have been spared as the water cut and wore its way. And this is a hard question for us to answer. Perchance these particular spots may have been slightly harder than the surrounding material and therefore resisted the ruthless grinding of the water-borne stones and pebbles until the rock about was cut so deeply that their summits projected above the water and the river was obliged to recede and abandon its efforts to level the islands. Or, per-

haps, as a river follows the path of least resistance and the lowest levels, the islands were spared because they were higher than the rest of the prehistoric river bed and thus retained their elevation above the valley which forms the present river bed. But if this were the solution why, we may ask, should these present islands have been higher than the surrounding rocks in the first place if all the conglomerate formed the bed of a gigantic stream? But we must remember that the bed of a river is not level or smooth, any more than the bed of the ocean, that the sand or mud upon the bottom is uneven and irregular, that where there are narrow, swift currents there are deep channels, that where the current is interrupted or retarded there are bars and shoals, that a slight obstruction may produce an island and that where the water pours over a ledge or rock a deep basin may be formed. So, just as we find such conditions in the soft bed of a river today, they must have existed in those ancient times when the conglomerate was gravel and sand at the bottom of a stupendous stream. Then,

through some alteration in the surface of the country, the land was slightly raised, the vast prehistoric river drained away and disappeared, its empty bed was transformed to conglomerate with its channels, bars, pools and depressions intact and ages later, when a new river sought a way to the sea, it followed the ancient channels and wore them deeper and deeper until what were once sand bars rose above the flowing water in the form of islands.

But there are also many other interesting things upon the shores of our river island, things which teach us much about the river's life. Upon a tiny patch of sand we find the tracks of a big turtle and after a brief search we discover its nest filled with round, soft-shelled eggs. We frighten a huge, seven foot iguana from its basking place and watch with interest as the great lizard leaps far out into the stream and swims to a neighboring islet; we find giant fresh-water snails washed upon the shores and in the little winrows of drift among the rocks we find strange seeds, odd nuts and innumerable giant beet-

les. Perhaps we may even come unexpectedly upon a great anaconda, fifteen to twenty feet in length, coiled upon some sunny rock. He is a monstrous creature, terrifying at first, but harmless and takes to the water as readily as the iguana, for many of the reptiles, mammals and birds that inhabit the banks, or the vicinity, of a tropical river are amphibious, a wise foresight on nature's part to prevent them from being drowned when the rivers rise and overflow the surrounding forests.

Soon after leaving the island, we pass a quiet, shaded expanse and across the water before our bows a number of fresh-water flying-fish skitter away and a moment later we see the odd, goggly, protruding eyes of curious "four-eyed fishes" as they swim rapidly from the path of our boat. So, for day after day, we paddle up the river, each day finding more and more rapids, occasionally making portages around falls, stopping now and then to visit the simple, friendly Indians who dwell in thatched open huts up the side creeks; once or twice leaving the river to

paddle up some shady creek to a gold or diamond placer and ever penetrating deeper and deeper into the wilderness.

Gradually the country becomes higher and more rugged; above the forest tops we catch glimpses of far-off blue peaks, the hills increase in height and the river flows beneath frowning precipices and cloud-draped, wooded mountains. Then we enter a deep and narrow gorge — a stupendous cleft through the solid rock—a vast cañon whose seamed and scarred sides are worn into weird shapes and terraces and we know that once our river flowed in a bed hundreds of feet about our heads, that slowly but irresistibly the stream has hewn its way down through the solid rock, leaving behind it the carved pinnacles and castellated strata to mark its handiwork. And now, before us, at the end of this gorge, we see a marvellous sight—an immense column of water, an awe-inspiring cataract plunging down for hundreds of feet. Here is the end of our boat journey, if we are to trace the river further we must go afoot, and shouldering our packs and

with the Indians, laden like packhorses, leading the way, we clamber up the rough, steep mountain side until we gain the summit and come forth upon another world. Gone are the vast forests and the jungles and in their place we see giant, lily-like plants a dozen feet in height, great masses of coarse ferns, bunches of nodding bluebells and clumps of odd, grotesque-flowered orchids. Underfoot is smooth, hard rock almost as level as a floor and crossing this we approach the verge of the falls. At first we are disappointed, for the cataract appears far smaller than we imagined from the glimpse we had caught from the river; but gradually, as our eyes and senses become accustomed to the surroundings, the majesty and size of the falls dawn upon us. We discover that the soft, green carpet at the bottom of the gorge which we mistook for moss and grass is really the top of a forest, that the objects we thought were pebbles are enormous masses of rocks, which have fallen from the precipices which hem in the gorge and we note that so tremendous is the height of the cataract that the

water is transformed to spray ere it reaches the bottom and that a passing breeze blows it like smoke to one side and reveals a vast cavern carved into the rock below the falls by the ceaseless action of the water. Then we see where immense masses of the rock have broken from the verge of the cataract in times past and by carefully examining the sides of the cañon through our glasses we can trace the course of the ever receding falls and we realize that the entire gorge has been formed by the cataract slowly eating its way backward; that ages and ages ago, it roared over a brink where now is the far distant entrance to the gorge and that in time it will be many miles up stream from its present position.

Moreover just as we found the small falls down the river were formed by a dyke of hard rock which resisted the action of the water, so, when we examine the verge of this titanic cataract, we find that the falls are produced by a layer or strata of hard rock overlying the softer rock below, that had it not been for this there would be no great

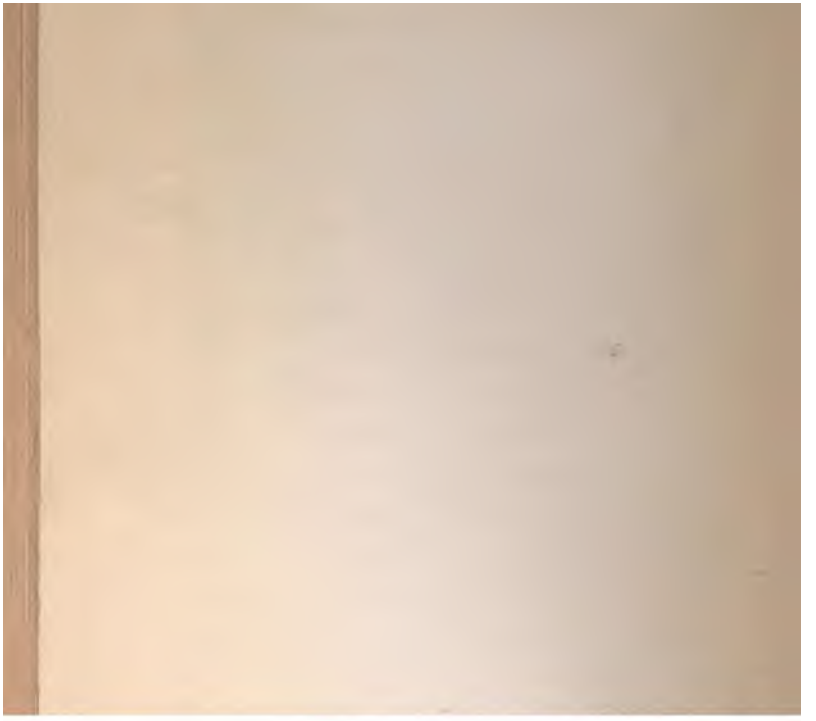
falls but in its place a deep ravine with the river roaring over rapids in its bottom. Having discovered all this we know also why there is such a huge cavern beneath the falls and why the verge of the cataract projects far over it and breaks off in great masses instead of wearing away evenly and gradually. The hard upper layer resists the water longer than the softer rock below and remains in place until the water has eaten away the underlying strata so far that the weight of the overhanging ledge is too great to be sustained and with a deafening roar it falls crashing down and shifts the verge of the falls backward for a score of feet.

We have many miles to travel if we are to follow the river to its source, and leaving the cataract with regret we follow a trail that leads along the river bank. A few miles from the falls we find a frail bark canoe drawn upon the shore and thankful for an opportunity to travel by water we pile our dunnage in it and are soon speeding up stream. Here the banks are low and flat, sometimes rocky, but more often of bril-

liant clays or hard-packed sand, and stretching away on every hand, are broad, rolling grassy plains or savannas, for we are now on the high interior plateau or tableland of the country. In places the river flows majestically in great sweeping curves, in others it has cut a straight path through the land and often it widens out into broad, lake-like expanses. As we cross one of these we see an isolated steep-sided mountain rising sheer from the plains and soon after, our further progress is barred by a small waterfall with the stream above it so shallow and filled with stones that even our light canoe cannot float upon it. Now, close at hand, the odd, lone mountain rises to the clouds, its precipitous sides almost perpendicular and seamed with deep gulleys and its summit, as seen through our glasses, carved into odd upjutting pillars, huge columnar structures, slender pinnacles bearing broad table-like masses of stone at their summits and other strange forms, the whole appearing like the ruins of some ancient city on the mountain top. Picking our way over the rough boulders

A WATERFALL IN THE TROPICS

This shows the stream above and below the Kaieteur Falls in British Guiana (Height, 822 feet).



that fill the river bed we draw ever nearer to the base of this strange peak and as we proceed we find the stream splitting and dividing into innumerable little brooks and rills spreading in every direction among the immense masses of rocks which have tumbled down from the mountain side. Then, at last, we can go no farther; stupendous blocks of rock bar our pathway, dense brush, razor-edged saw-grass and thorny scrub form an impenetrable barrier and from between the masses of rock the water issues in gurgling springs and rills. Then we notice that some of these rocks are of hard, close-grained material, while others are of soft, reddish sandstone, and remembering the lesson we learned upon our northern river the riddle of this isolated, lonely mountain and its oddly worn cap is solved. We know now that once, when the world was young, this whole vast plain was buried hundreds of feet beneath the sand which formed the bed of a mighty lake or a prehistoric sea, that some titanic force raised the continent until the water drained away and left the sandy bed to so-

lidify and become sandstone. That through it, molten, white-hot lava was forced upward in great masses or dykes, that slowly, through countless millions of years, the rain and wind and water wore the softer rock away and left the hardened lava standing solid and unscathed above the plain and that the layer of sandstone upon its summit, having been hardened and molten by the heat, has remained, cut, carved and worn by the elements to be sure, but still existing as a cap upon the titanic monolith ages after all other sandstone has disappeared.

But while all this is very interesting and remarkable and our minds cannot grasp or conceive of the vast space of time which has passed since the plain was the bed of a sea, yet it does not explain where the water comes from to form the rivulets issuing from among the rocks. And then, even as we are cudgelling our brains for an answer to the riddle a heavy cloud darkens the sky and sweeps low across the mountain top and instantly the puzzle is solved. Although the spot whereon we stand is still bathed in sunshine,

torrents of rain are falling on the mountain top and from every side, from scores of depressions on the summit, the water pours and plunges in innumerable cataracts. It is a unique, a wonderful, an amazing sight to thus see the lofty peak veiled in waterfalls that thunder down for hundreds of feet while the spray drifts like a cloud about the precipices and gleams with rainbows in the sun. And as we gaze spellbound at the marvellous scene and the cloud, having given up its moisture drifts away and the cataracts dwindle to mere threads, we realize that we have trailed the mighty river to its source and that its source is a mountain top—a stupendous, natural reservoir a thousand feet in air.

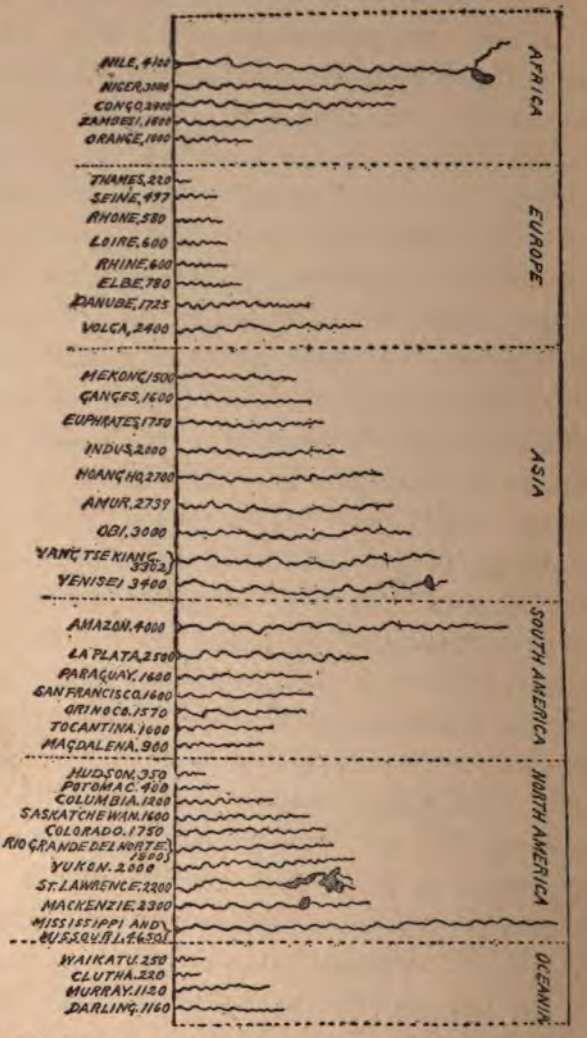
CHAPTER X

IMPORTANT AND FAMOUS RIVERS

WE usually think of famous or important rivers as large rivers, but famous rivers, like famous men, are not always of large size and many of the most important and famous rivers in the world are comparatively small, while names of others many times as large are seldom heard.

Thus the Seine, which has been famous for centuries and which is historically a most important river, is but 497 miles in length; the Rhone, which is another most famous and important stream is only 83 miles longer; the Rhine, which is Germany's most famed river is only 600 miles long,—or the same length as the Loire which is much less famous; the Elbe is 780 miles from mouth to source and the Thames, which is one of the most famed and important rivers in the world, is only 220 miles long.

In our own country there are many enormous rivers, but many of these are far less familiar to most people than smaller rivers. Our Hudson is but a scant 350 miles long and the Potomac is only fifty miles longer, while the Rio Grande del Norte, which to most of us is merely a name, is 1600 miles long or nearly the same length as the Danube whose fame and importance is world wide. In fact, although Europe's rivers are probably more widely known, more famous and more important in many ways than the rivers of any other part of the world, yet Europe has fewer large rivers than Asia, Africa, North America or South America. The longest river in Europe is the Volga, 2400 miles long and this and the Danube are its only rivers which are over 1000 miles in length, whereas North America possesses eight rivers over 1000 miles long, South America has six, Africa has five and Asia leads all other countries with nine. Indeed, every one of Asia's famous rivers measures over 1000 miles in length, the longest being the Yenisei 3400 miles, followed by the Yang-tse Kiang 3302



COMPARATIVE LENGTHS OF THE WORLD'S GREATEST RIVERS

miles, the Obi 3000 miles, the Amur 2739 miles, the Hoang Ho 2700 miles, the Indus 2000 miles, the Euphrates 1750 miles, the Ganges 1600 miles and the Mekong 1500 miles.

Africa's important rivers also are large streams, the longest of all and the second longest river in the world being the Nile 4100 miles long with the next largest, the Niger, 3000 miles, followed by the Congo 2900 miles, the Zambesi 1800 miles and the Orange 1000 miles. So too, South America has few really well-known rivers which are not long, for the fame of a river in a comparatively new or little known country depends very largely upon its length whereas in an old and thickly populated land, the fame of a stream depends upon its historical associations, its importance to commerce and the size of the cities along its banks. Thus, in South America, we have the mighty Amazon over 4000 miles in length, the Rio de la Plata 2500 miles, the Paraguay 1600 miles, the San Francisco 1600 miles, the Orinoco 1570 miles, the Tocantins 1000 miles and

the Magdalena 900 miles; but who ever hears of the Essequibo which is many miles longer than the Seine, the Potomac or the Rhone, how many of us know that the Demerara is longer than our Hudson or the Thames, did we ever learn at school that the Berbice is a larger river than the Rhine or that the Courantyne would put many of the most famous rivers of Europe and the United States to shame?

All over South America we find scores of rivers larger than the best known streams of North America and Europe and even in tiny little Panama there are rivers much longer than the Potomac, the Hudson or the Connecticut. But if we cannot lay claim to having more large rivers or more famous rivers than other countries, still we can boast that we have the longest river in the world, for the Mississippi, with the Missouri, flows for 4650 miles, which is over 500 miles longer than the Nile and 650 miles longer than the Amazon. We have many other very large rivers also, such as the Mackenzie 2300 miles long, the St. Lawrence 2200 miles,

the Yukon 2000 miles, the Rio Grande 1800 miles, the Colorado 1759 miles, the Saskatchewan 1600 miles and the Columbia 1200 miles.

But how about Australia, you may ask? Somehow, we never think of Australia as having large rivers and it comes as a distinct surprise to many to learn that Australia possesses two rivers each over 1000 miles in length; the Darling being 1160 miles long and the Murray 1120 miles, while the Waikatu in New Zealand is 250 miles in length.

But mere figures are very uninteresting and unsatisfactory things and we can obtain but a very imperfect idea of the size, character or appearance of a river by knowing that it is so many hundreds or thousands of miles in length.

Does the European or South American who learns from his geographies that the Hudson is 350 miles long and flows into New York Bay have any conception of the Palisades, of the majesty of the river, of the dream-like sky line of the vast city half-

veiled in the haze of a summer afternoon, or of the teeming commerce that plies up and down and back and forth across the river? Do our own people, who have never been to Europe, picture the Seine at Paris as a canal-like stream whose dirty waters are scarcely as wide as the Harlem River? We read much about the Thames, but until we have stood upon the Embankment and under the graceful arches of its bridges, have seen Westminster against the moonlit sky; until we have poled a punt along the terraced gardens and under the drooping willows of Marlowe and Richmond we can have no true idea of this famous river. A trip up or down the Mississippi is a revelation to anyone whose ideas of the world's longest river have been obtained through descriptions alone and the traveler to South America, who finds great, ocean-going steamers and full-rigged ships moored in some unheard of river over one hundred miles from the sea or finds such a river as the Essequibo has a mouth thirty-five miles wide, wonders why he never saw even a mention of the

streams in his school geography. How many of us really know anything about the Amazon? How many people have any conception of the character, the size, the life or the wonders of this mighty stream? We may by chance read a steamship advertisement which mentions ships sailing from New York for Para and Iquitos, but do we realize that, should we take one of these ships and travel for ten days across the ocean until we entered the mouth of the Amazon and reached Para, we would then be but half way on our journey?. Even after we had sailed for several days through the muddy, discolored sea which told us we were approaching the mouth of the vast river we would never know when we entered the stream, for, were we in the center, we would still be out of sight of land with the exception of islands. Indeed, we could sail for several days up the Amazon before we realized that we were upon a river and not upon the ocean. Then, when at last the banks became visible, and remembering the pictures in our geographies, we searched the foliage for monkeys,

boa constrictors, tapirs and jaguars we would be sadly disappointed and would probably see no forms of animal life save the herons, flocks of parrots, pelicans and other water fowl.

We would also find that all our preconceived ideas of the shores of a tropical river were entirely wrong and in place of brilliantly-flowered plants, groves of palms and masses of bamboo we would see mile after mile of dark green, monotonous mangrove trees topped by an occasional palm. Not until our ship had traveled for many days up the river would we find the tropic jungles and even then they would appear as a solid wall of greenery, a mass of trees bound together by vines and creepers and with no hints of the teeming life and strange things which lay hidden beyond our view, for the Amazon is a great water highway and the wild things of the jungle give the passing boats, the smoke-belching steamships and mankind a wide berth. Perchance we might take a ship for Manaos, on the Rio Negro, and here we would find a tributary of the

Amazon as large, or even larger, than we had imagined the Amazon itself, and yet, this is but one of many branches each of which is many hundreds of miles in length and which, in any other country, would be considered immense rivers. In fact, it is not so much the enormous length of the Amazon, or the stupendous volume of water it carries, which makes it remarkable, as the vast system of waterways which it forms with its innumerable tributaries and the tremendous area of country which this system drains—an area of over 800,000 square miles or a territory over three times the size of Texas, one and one-half times the size of Alaska; larger than the whole of Mexico, over twice the size of Venezuela, sixteen times the size of England, four times the size of France, nearly four times the size of Germany or nearly as great as the whole of Europe without Russia. Only by such comparisons can we obtain any adequate idea of these enormous rivers and even then our imaginations cannot picture them as they really are. Although our Mississippi is the longest of

rivers, still, in comparison with the volume of the Amazon, it is only a medium-sized stream and yet its importance from a commercial and industrial point of view is incalculably greater than the Amazon. So, too, the Hudson, the Potomac, and many other rivers in the United States, while smaller than some of the so-called creeks which feed the smaller tributaries of the Amazon, are of more value and importance to the world at large than the mighty South American river. On the other hand, the Nile, which is one of the largest rivers of the world, is of greater importance to Egypt than the Amazon to Brazil, for while the Brazilians find their Amazon a very useful highway, an outlet for a vast territory, and a most important factor of their climate and their products, the inhabitants of the Nile district are absolutely dependent upon the river for their very existence.

But it is in Asia, and especially in China, that we find more people really dependent upon rivers than in any other lands. Upon the Yang-tse Kiang and other Chinese rivers

countless thousands of people have their homes. For generations these people have dwelt upon the river in their quaint house boats; they are born, live and die upon the bosoms of the rivers; mooring their floating dwellings to the banks, congregating in vast floating cities, moving from place to place at will and forming a teeming population with no counterpart in all the world. Unfortunate would be the lot of these river dwellers if the streams should disappear, for they have never known homes or life upon the land and overcrowded China would have no place for them. We may think it very strange for whole families of Chinese to thus pass their lifetime on their rivers, but right on our own rivers we will find many families doing the same, not for a few weeks in midsummer for pleasure on luxuriously appointed houseboats, but throughout the year and from necessity. These people are the families of owners and captains of canal boats and barges and if we visit the docks or the basins about New York City or other ports where these straight-sided, bluff-bowed

boats are moored we will find them by scores. Near the sterns of the craft are the little cabins, houses in miniature with neatly curtained windows in which are boxes and pots of growing plants; with the family washing drying in the breeze and with the smoke from the kitchen fire drifting from the stovepipes in the roofs and giving them a most homey appearance. In coops or enclosures, fowls and chickens cluck contentedly, sleek cats doze in the sun beside the cabin doorway, sharp-eyed dogs keep vigilant watch and the kiddies romp and play upon the decks while their tanned and grizzled father smokes and reads the paper in a shady spot and their sunbonneted mother busies herself with the household duties of her floating home. To these people life ashore has few attractions; they have neither rent nor landlord to worry them, they travel far and wide in their slow-moving but safe craft, and when in port and moored among scores of similar boats they form a neighborly little community. Indeed, they even have schools which the youngsters attend,

with teachers who visit the boats and instruct the children who are born and raised upon the water and know no other homes.

You may think that these people lead a humdrum, monotonous life, but there are adventure, thrills and danger to spare with tragedy as well. The canal boats, to be sure, seldom meet with peril or mishap, but on the big barges which are towed long distances at sea it is a different matter. Often in stormy weather, barges will break their hawsers and drift away and while the captain of the tugboat may use every effort to recover and save them it is often an impossibility, while in other cases, to save the barge that breaks loose would mean sacrificing the others. Tossed on the waves, drifting at the will of wind and sea, the helpless barge and its little family are in imminent peril of their lives, and every winter we will find terse newspaper paragraphs telling of the loss of barges with all on board. Few who read ever stop to think of the anguish and suffering of the little families who go to their deaths with their floating homes; of the

father battling with superhuman strength and heroic courage to save his tossing, storm-lashed craft and dear ones; of the mother, clasping her children to her breast and praying that by some miracle they may yet be saved; of the kiddies, wild-eyed and terrified as they see the comforting lights of the other barges and the towboat disappearing in the black night, and, childlike, trusting to their parents to guard them until, half-filled with water, strained and battered by the waves, pitching and reeling in the trough of the great seas, the stout, heavily-laden barge sinks lower and lower and with a final, gurgling plunge disappears forever, leaving the stricken family to struggle hopelessly in the icy water until death mercifully ends their sufferings.

But we have drifted far from the Chinese rivers and their teeming human life, where there are no storms to wreck and destroy and the greatest danger to the slant-eyed kiddies lies in tumbling overboard into the yellow waters of the rivers, from which they are usually quickly fished out no worse and per-

haps a little better off, from a sanitary viewpoint, than before their unexpected bath.

Then, if we journey to India we will find the people regarding their rivers of paramount importance for quite another reason. Here countless thousands of people regard the rivers as sacred and would suffer death or worse rather than be deprived of the religious rite of bathing in the waters. From far and near they flock to the Ganges, often making pilgrimages of hundreds of miles to bathe in the sacred stream and there are few stranger sights in all the world than the bathing ghats at Benares and other Indian towns. Here men and women by hundreds descend the stairs to wash themselves and to drink the water, the condition of which can better be imagined than described when we think of the teeming hordes, immersing their bodies in the slow-flowing stream. Moreover, upon the burning ghats on the banks, the bodies of scores of dead are being cremated and the ashes of these add to the pollution of the water. One would think that plague and pestilence would result from the custom

and that half of the population of India would be destroyed through these acts of devotion, but there is no data to show that those who bathe and drink of the Ganges are any the worse for their acts and to prohibit the ceremonies for sanitary reasons would only result in a bloody revolution and the most terrible of holy wars.

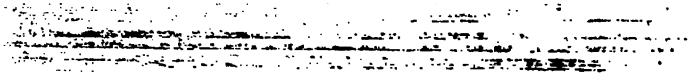
We may think that river worship is a heathenish sort of religion, but we must remember that it is, or was, almost universal among all races. The Romans worshipped their Tiber; primitive races everywhere look upon the rivers as deities or the abodes of spirits, and our own ancestors worshipped streams and imagined they were the abiding places of fairies, water spirits and other supernatural beings who had tremendous powers over man. For this reason many races are in the habit of making periodical offerings to the river gods and with impressive ceremonies cast valuables, food and other articles into the streams, while some even made human sacrifices to propitiate the spirits or gods of the waters.

In many parts of the world treasures in gold and silver ornaments, statues, jewels and objects of art have been taken from rivers and lakes wherein they were cast as offerings. In various portions of South and Central America the Indians for centuries threw golden images and ornaments into the rivers and lakes they worshipped and fortunes still lie hidden beneath the surface of these sacred waters, although hundreds of thousands of dollars' worth of the golden offerings have been recovered. Even today many of the South American Indians hold elaborate religious ceremonies and after weird and sacred dances hang their fantastic dancing costumes upon snags and stumps in the streams in order to appease the spirits of the river and to induce them to remain calm and quiet so that the Indians may travel with safety upon their waters.

To us, with our knowledge of science and our understanding of the forces of nature, all this seems very silly and childish, but to the simple savage or to semi-civilized man, a river is a most mysterious and inexplicable

thing with almost human attributes. It murmurs and mutters and whispers, at times it is peaceful, calm and quiet, at other times it roars and growls with anger and destroys all in its path; it can work tremendous harm or can be most beneficial and as primitive religion consists of adoring good spirits and propitiating evil ones the savage, not quite sure whether his river gods are good or evil, places himself on the safe side by both worshipping the rivers and bestowing gifts upon them. Of course, we scoff at this as superstition, but is it any more foolish or ridiculous than our own superstititions; is it not just as sensible to think that a golden armlet cast into a river will insure a calm and safe journey on the stream as to imagine that printed playing cards can foresee and divulge one's future, that misfortune lurks in number thirteen or that breaking a bit of silvered glass will result in the death of some one? Personally, I think not. There is nothing remarkable, mysterious nor inexplicable about cards or mirrors, but even civilized man is impressed by the power, the majesty

and the mystery of rivers. Cards and mirrors are our own handiwork; their origin, their purposes and their ultimate ends are familiar to us all and they have no great influence upon our lives, our livelihood or our happiness; but the river is a power beyond our control, it possesses the power of life and death, it is irresistible, mysterious, romantic. It is the handiwork of a Supreme Being of whom we know nothing and while science has taught us many things, and has explained more, about the rivers, yet, behind all, are the unsolved, awe-inspiring mysteries of the Creator.



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