SCIENCE SKETCHES

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BY

DAVID STARR JORDAN

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PREFACE.

THIS volume is made up of a number of unconnected sketches and addresses, coming more or less distinctly under the head of Popular Science. Three of them — the paper on "The Dispersion of Fresh-Water Fishes," the address on "Darwin," and the paper on "The Evolution of the College Curriculum" — are here published for the first time. The others have appeared in various periodicals. All the articles have been freely retouched, and some of them entirely rewritten. The author wishes to express his obligations to Messrs. D. Appleton & Co., to S. E. Cassino & Co., and to the Century Company for permission to reprint articles which have appeared in the "Popular Science Monthly," in the "Standard Natural History," and in "St. Nicholas."

D. S. J.

University of Indiana,

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APPENDIX.

SCIENCE SKETCHES.

THE STORY OF A SALMON.

IN the realm of the Northwest Wind, on the boundary-line between the dark fir-forests and the sunny plains, there stands a mountain, — a great white cone two miles and a half in perpendicular height. On its lower mile the dense fir-woods cover it with never-changing green; on its next half-mile a lighter green of grass and bushes gives place in winter to white; and on its uppermost mile the snows of the great ice age still linger in unspotted purity. The people of Washington Territory say that their mountain is the great "King-pin of the Universe," which shows that even in its own country Mount Tacoma is not without honor.

Flowing down from the southwest slope of Mount Tacoma is a cold, clear river, fed by the melting snows of the mountain. Madly it hastens down over white cascades and beds of shining sands, through birch-woods and belts of dark firs, to mingle its waters at last with those of the great Columbia. This river is the Cowlitz; and on its bottom, not many years ago, there lay half buried

in the sand a number of little orange-colored globules, each about as large as a pea. These were not much in themselves, but great in their possibilities. In the waters above them little suckers and chubs and prickly sculpins strained their mouths to draw these globules from the sand, and vicious-looking crawfishes picked them up with their blundering hands and examined them with their telescopic eyes. But one, at least, of the globules escaped their curiosity, else this story would not be worth telling. The sun shone down on it through the clear water, and the ripples of the Cowlitz said over it their incantations, and in it at last awoke a living being. It was a fish, — a curious little fellow, not half an inch long, with great, staring eyes, which made almost half his length, and with a body so transparent that he could not cast a shadow. He was a little salmon, a very little salmon; but the water was good, and there were flies and worms and little living creatures in abundance for him to eat, and he soon became a larger salmon. Then there were many more little salmon with him, some larger and some smaller, and they all had a merry time. Those who had been born soonest and had grown largest used to chase the others around and bite off their tails, or, still better, take them by the heads and swallow them whole; for, said they, "even young salmon are good eating." "Heads I win, tails you lose," was their motto. Thus, what was once two small salmon became united into a single larger one, and the process of "addition, division, and silence" still went on.

By-and-by, when all the salmon were too large to be swallowed, they began to grow restless. They saw that the water rushing by seemed to be in a great hurry to get somewhere, and it was somehow suggested that its hurry was caused by something good to eat at the other end of its course. Then they all started down the stream, salmon-fashion, — which fashion is to get into the current, head up-stream, and thus to drift backward as the river sweeps along.

Down the Cowlitz River the salmon went for a day and a night, finding much to interest them which we need not know. At last they began to grow hungry; and coming near the shore, they saw an angle-worm of rare size and beauty floating in an eddy of the stream. Quick as thought one of them opened his mouth, which was well filled with teeth of different sizes, and put it around the angle-worm. Quicker still he felt a sharp pain in his gills, followed by a smothering sensation, and in an instant his comrades saw him rise straight into the air. This was nothing new to them; for they often leaped out of the water in their games of hide-and-seek, but only to come down again with a loud splash not far from where they went out. But this one never came back, and the others went on their course wondering.

At last they came to where the Cowlitz and the Columbia join, and they were almost lost for a time; for they could find no shores, and the bottom and the top of the water were so far apart. Here they saw other and far larger salmon in the deepest part of the current, turning neither to the right nor

to the left, but swimming right on up-stream just as rapidly as they could. And these great salmon would not stop for them, and would not lie and float with the current. They had no time to talk, even in the simple sign-language by which fishes express their ideas, and no time to eat. They had important work before them, and the time was short. So they went on up the river, keeping their great purposes to themselves; and our little salmon and his friends from the Cowlitz drifted down the stream.

By-and-by the water began to change. It grew denser, and no longer flowed rapidly along; and twice a day it used to turn about and flow the other way. Then the shores disappeared, and the water began to have a different and peculiar flavor, — a flavor which seemed to the salmon much richer and more inspiring than the glacier-water of their native Cowlitz. There were many curious things to see, — crabs with hard shells and savage faces, but so good when crushed and swallowed! Then there were luscious squid swimming about; and, to a salmon, squid are like ripe peaches and cream. There were great companies of delicate sardines and herring, green and silvery, and it was such fun to chase and capture them! Those who eat sardines packed in oil by greasy fingers, and herrings dried in the smoke, can have little idea how satisfying it is to have a meal of them, plump and sleek and silvery, fresh from the sea.

Thus the salmon chased the herrings about, and had a merry time. Then they were chased about in turn by great sea-lions, — swimming monsters

with huge half-human faces, long thin whiskers, and blundering ways. The sea-lions liked to bite out the throat of a salmon, with its precious stomach full of luscious sardines, and then to leave the rest of the fish to shift for itself. And the seals and the herrings scattered the salmon about, till at last the hero of our story found himself quite alone, with none of his own kind near him. But that did not trouble him much, and he went on his own way, getting his dinner when he was hungry, which was all the time, and then eating a little between meals for his stomach's sake.

So it went on for three long years; and at the end of this time our little fish had grown to be a great, fine salmon of twenty-two pounds' weight, shining like a new tin pan, and with rows of the loveliest round black spots on his head and back and tail. One day, as he was swimming about, idly chasing a big sculpin with a head so thorny that he never was swallowed by anybody, all of a sudden the salmon noticed a change in the water around him.

Spring had come again, and the south-lying snow-drifts on the Cascade Mountains once more felt that the "earth was wheeling sunwards." The cold snow waters ran down from the mountains and into the Columbia River, and made a freshet on the river. The high water went far out into the sea, and out in the sea our salmon felt it on his gills. He remembered how the cold water used to feel in the Cowlitz when he was a little fish. In a blundering, fishy fashion he thought about it; he wondered whether the little eddy looked as it used

to look, and whether caddis-worms and young mosquitoes were really as sweet and tender as he used to think they were. Then he thought some other things; but as the salmon's mind is located in the optic lobes of his brain, and ours is in a different place, we cannot be quite certain what his thoughts really were.

What our salmon did, we know. He did what every grown salmon in the ocean does when he feels the glacier-water once more upon his gills. He became a changed being. He spurned the blandishment of soft-shelled crabs. The pleasures of the table and of the chase, heretofore his only delights, lost their charms for him. He turned his course straight toward the direction whence the cold water came, and for the rest of his life never tasted a mouthful of food. He moved on toward the river-mouth, at first playfully, as though he were not really certain whether he meant anything after all. Afterward, when he struck the full current of the Columbia, he plunged straightforward with an unflinching determination that had in it something of the heroic. When he had passed the rough water at the bar, he was not alone. His old neighbors of the Cowlitz, and many more from the Clackamas and the Spokan and Des Chûtes and Kootanie, — a great army of salmon, — were with him. In front were thousands pressing on, and behind them were thousands more, all moved by a common impulse which urged them up the Columbia.

They were all swimming bravely along where the current was deepest, when suddenly the foremost

felt something tickling like a cobweb about their noses and under their chins. They changed their course a little to brush it off, and it touched their fins as well. Then they tried to slip down with the current, and thus leave it behind. But, no! the thing, whatever it was, although its touch was soft, refused to let go, and held them like a fetter. The more they struggled, the tighter became its grasp, and the whole foremost rank of the salmon felt it together; for it was a great gill-net, a quarter of a mile long, stretched squarely across the mouth of the river.

By-and-by men came in boats, and hauled up the gill-net and the helpless salmon that had become entangled in it. They threw the fishes into a pile in the bottom of the boat, and the others saw them no more. We that live outside the water know better what befalls them, and we can tell the story which the salmon could not.

All along the banks of the Columbia River, from its mouth to nearly thirty miles away, there is a succession of large buildings, looking like great barns or warehouses, built on piles in the river, high enough to be out of the reach of floods. There are thirty of these buildings, and they are called canneries. Each cannery has about forty boats, and with each boat are two men and a long gill-net. These nets fill the whole river as with a nest of cobwebs from April to July, and to each cannery nearly a thousand great salmon are brought every day. These salmon are thrown in a pile on the floor; and Wing Hop, the big Chinaman, takes them one after another on the table, and with

a great knife dexterously cuts off the head, the tail, and the fins; then with a sudden thrust he removes the intestines and the eggs. The body goes into a tank of water; and the head is dropped into a box on a flat-boat, and goes down the river to be made into salmon oil. Next, the body is brought to another table; and Quong Sang, with a machine like a feed-cutter, cuts it into pieces each just as long as a one-pound can. Then Ah Sam, with a butcher-knife, cuts these pieces into strips just as wide as the can. Next Wan Lee, the "China boy," brings down a hundred cans from the loft where the tinners are making them, and into each can puts a spoonful of salt. It takes just six salmon to fill a hundred cans. Then twenty Chinamen put the pieces of meat into the cans, fitting in little strips to make them exactly full. Ten more solder up the cans, and ten more put the cans into boiling water till the meat is thoroughly cooked, and five more punch a little hole in the head of each can to let out the air. Then they solder them up again, and little girls paste on them bright-colored labels showing merry little cupids riding the happy salmon up to the cannery door, with Mount Tacoma and Cape Disappointment in the background; and a legend underneath says that this is "Booth's," or "Badollet's Best," or "Hume's," or "Clark's," or "Kinney's Superfine Salt Water Salmon." Then the cans are placed in cases, forty-eight in a case, and five hundred thousand cases are put up every year. Great ships come to Astoria, and are loaded with them; and they carry them away to London and San Francisco and Liverpool and New York

and Sidney and Valparaiso; and the man at the corner grocery sells them at twenty cents a can.

All this time our salmon is going up the river, eluding one net as by a miracle, and soon having need of more miracles to escape the rest; passing by Astoria on a fortunate day, — which was Sunday, the day on which no man may fish if he expects to sell what he catches, — till finally he came to where nets were few, and, at last, to where they ceased altogether. But there he found that scarcely any of his many companions were with him; for the nets cease when there are no more salmon to be caught in them. So he went on, day and night, where the water was deepest, stopping not to feed or loiter on the way, till at last he came to a wild gorge, where the great river became an angry torrent, rushing wildly over a huge staircase of rocks. But our hero did not falter; and summoning all his forces, he plunged into the Cascades. The current caught him and dashed him against the rocks. A whole row of silvery scales came off and glistened in the water like sparks of fire, and a place on his side became black-and-red, which, for a salmon, is the same as being black-and-blue for other people. His comrades tried to go up with him; and one lost his eye, one his tail, and one had his lower jaw pushed back into his head like the joint of a telescope. Again he tried to surmount the Cascades; and at last he succeeded, and an Indian on the rocks above was waiting to receive him. But the Indian with his spear was less skilful than he was wont to be, and our hero escaped, losing only a part of one of his fins; and with him came one

other, and henceforth these two pursued their journey together.

Now a gradual change took place in the looks of our salmon. In the sea he was plump and round and silvery, with delicate teeth in a symmetrical mouth. Now his silvery color disappeared, his skin grew slimy, and the scales sank into it; his back grew black, and his sides turned red, — not a healthy red, but a sort of hectic flush. He grew poor; and his back, formerly as straight as need be, now developed an unpleasant hump at the shoulders. His eyes — like those of all enthusiasts who forsake eating and sleeping for some loftier aim — became dark and sunken. His symmetrical jaws grew longer and longer, and meeting each other, as the nose of an old man meets his chin, each had to turn aside to let the other pass. His beautiful teeth grew longer and longer, and projected from his mouth, giving him a savage and wolfish appearance, quite at variance with his real disposition. For all the desires and ambitions of his nature had become centred into one. We may not know what this one was, but we know that it was a strong one; for it had led him on and on, — past the nets and horrors of Astoria; past the dangerous Cascades; past the spears of Indians; through the terrible flume of the Dalles, where the mighty river is compressed between huge rocks into a channel narrower than a village street; on past the meadows of Umatilla and the wheat-fields of Walla Walla; on to where the great Snake River and the Columbia join; on up the Snake River and its eastern branch, till at last

he reached the foot of the Bitter Root Mountains in the Territory of Idaho, nearly a thousand miles from the ocean which he had left in April. With him still was the other salmon which had come with him through the Cascades, handsomer and smaller than he, and, like him, growing poor and ragged and tired.

At last, one October afternoon, our finny travellers came together to a little clear brook, with a bottom of fine gravel, over which the water was but a few inches deep. Our fish painfully worked his way to it; for his tail was all frayed out, his muscles were sore, and his skin covered with unsightly blotches. But his sunken eyes saw a ripple in the stream, and under it a bed of little pebbles and sand. So there in the sand he scooped out with his tail a smooth round place, and his companion came and filled it with orange-colored eggs. Then our salmon came back again; and softly covering the eggs, the work of their lives was done, and, in the old salmon fashion, they drifted tail foremost down the stream.

Next morning, a settler in the Bitter Root region, passing by the brook near his house, noticed that a "dog-salmon" had run in there, and seemed "mighty nigh tuckered out." So he took a hoe, and wading into the brook rapped the fish on the head with it, and carrying it ashore threw it to the hogs. But the hogs had a surfeit of salmon-meat; so they ate only the soft parts, leaving the head untouched. And a wandering naturalist found it there, and sent it to the United States Fish Commission to be identified. Thus it came to me.

JOHNNY DARTERS.[1]

ANY one who has ever been a boy and can remember back to the days of tag-alders, yellow cowslips, and an angle-worm on a pin-hook, will recall an experience like this: You tried some time to put your finger on a little fish that was lying, apparently asleep, on the bottom of the stream, half hidden under a stone or a leaf, his tail bent around the stone as if for support against the force of the current. You will remember that when your finger came near the spot where he was lying, the bent tail was straightened, and you saw the fish again resting, head up-stream, a few feet away, leaving you puzzled to know whether you had seen the movement or not. You were trying to catch a Johnny Darter. Nothing seems easier, but you did not do it.

Having by well-understood stratagem succeeded where you failed, allow us to give you that acquaintance which he so deftly declined.

In all clear streams from Maine to Mexico the Johnny Darters are found; and the boy who does not know them has missed one of the real pleasures of a boy's life. All of them are very little fishes, — some not more than two inches long, and

[1] The original version of this paper was the joint work of the late Professor Herbert Edson Copeland and the writer. — D. S. J.

the very largest but six or eight. But small though they are, they are the most interesting in habits, the most graceful in form, and many of them the most brilliant in color of all fresh-water fishes. The books call them "Darters;" for one of the first species known was named *Boleosoma*, and that in Greek means "dart-body," — a name most appropriate to them all. The realistic dwellers in the Ohio Valley call some of them "Hog-fish," and the boys call them "Johnnies." Certainly the boys ought to know, — and Johnnies they are, and Darters they are; so Johnny Darters they shall be. Their first introduction to science was in 1819, when Rafinesque gave to them their scientific name of *Etheostoma*. This name seems to mean "strainer-mouth;" but the "eccentric naturalist," whose peculiar use of the Greek language was not the least of his eccentricities, says that it means "various-mouth," because no two of those he knew[1] have the mouth alike. But whatever it may mean, *Etheostoma* is their name, and Rafinesque their godfather; and we may call them Johnnies for short.

Rafinesque said of the Johnnies that he knew "they are good to eat fried." I suppose that he had tried them; but we have not. We should as soon think of filling our pan with wood-warblers as to make a meal of them. The good man goes a-fishing not for "pot-luck," but to let escape "the Indian within him."

The Johnny Darter deserves our especial atten-

[1] These were *Etheostoma flabellare*, *Percina caprodes*, and *Diplesion blennioides*.

tion in this Centennial year, for he is altogether an American product. He has all that ardent desire for perfect freedom that is supposed to be native to this continent. Unless all appearance of captivity be concealed in a well-kept aquarium, he will quickly lie on the bottom, dead. Here, at the beginning (for much as we may regret the fact, the death of some individual must precede our acquaintance with the group, and even to some extent with the individual himself), we observe two noteworthy facts: the fish in dying does not turn over, and does not rise to the surface. On dissection, we find that the air-bladder is only rudimentary, being structurally, but not functionally, present, — a distinction not without meaning in these days of evolutionary hypotheses. If our tank be so arranged that the conditions are nearly natural, there being an abundance of stones and weeds on the bottom, our Johnnies will cheerfully live with us, and we shall be ready to study their individual peculiarities, or, as Boyesen's "Scientific Vagabond" would have said, their "psychology."

For it must be known that while all fish are fish, they are so only as all men are men. The children of one family are not more unlike one another than the fishes of one brood might be if the sickly ones and the lazy ones were as carefully guarded as are ours. As it is, they have their individuality. One is constantly darting over and among the stones, never resting, moving his head from side to side when his body is for a moment still. Another will lie for hours motionless under a stone, moving only for a few inches when pushed out

with a stick. These peculiarities of temperament are important factors in the problem of life; and from such differences under varying conditions, may have resulted forms which we now designate as different species.

But we must leave these general questions for the present, and tell the story of the Johnny Darters that live in our aquarium.[1]

First of these in size and therefore in dignity comes the Log Perch or Hog-fish (*Percina caprodes* Rafinesque). This is the giant of the family, — the most of a fish, and therefore the least of a darter. It may be readily known by its zebra-like colors. Its hue is pale olive, — silvery below, darker above. On this ground-color are about fifteen black vertical bars or incomplete rings, alternating with as many shorter bars which reach only half-way down the side. The hindmost bar forms a mere spot on the base of the tail, and there are many dots and speckles on the fins. The body is long and slender, spindle-shaped, and firm and wiry to the touch. The head is flat on top, and tapers into a flat-pointed snout which is squared off at the end like the snout of a pig; and this resemblance is heightened by the form of the small mouth underneath it. From this pig-like snout has come the scientific name *caprodes*. This is a translation of the older name of "hog-fish," which Rafinesque heard applied to it in his time, and which is still used in the same regions.

Percina reaches a length of six or eight inches,

[1] At Indianapolis, Indiana. All the species here mentioned, and some others, are found in the White River, near Indianapolis.

and it may readily be caught on a small hook baited with a worm. We often meet an urchin with two or three of them strung through the gills on a forked stick, along with "red-eyes," "stone-toters," "horny-heads," and other "boys' fish." At such times we generally buy the hog-fish for a cent, cut it open to look at the air-bladder, which the books say it does not have, and then lay it away with the rest of our treasures in the bottle of alcohol. We find *Percina* usually in rapid and rather deep water, — as deep as we can wade in when seining in hip-boots. We rarely find them small enough for ordinary aquarium purposes; and the living specimen before us, though wonderfully quick and graceful in its movements, has shown little that is noteworthy, save his courage, his fondness for angle-worms, and a possible disposition to bury himself in the sand. There is something in the expression of his face, as he rests on his "hands and feet" on a stone, that is remarkably lizard-like, suggesting the Blue-tailed Skink (*Eumeces fasciatus*).

We next come to the fine gentleman of the family, the Black-sided Darter (*Hadropterus aspro* Cope and Jordan). This one we may know by its colors. The ground hue is a salmon yellow; the back is regularly and beautifully marbled with black in a peculiar and handsome pattern. On the sides, from the head to the tail, runs a jet-black band, which is widened at intervals into rounded spots which contrast sharply with the silvery color of the belly; or we may say that on each side is a chain of confluent round black blotches. Sometimes

the fishes seem to fade out; these blotches grow pale, and no longer meet; but in an instant they may regain their original form and shade. This latter change can be induced by the offer of food, and it is of course due to muscular action on the scales which cover the darker pigment. A male in our aquarium underwent almost instantly an entire change of coloration upon the introduction of a female fish of the same species recognized by him as his affinity. Although the two have been together for some weeks, the novelty has not yet worn off; and although his colors vary much from one hour to another, he has never yet quite reverted to his original hues. The form of the black-sided darter is more graceful than that of any other, and his movements have little of that angular jerkiness which characterizes his relatives.

The fins of *Hadropterus*, like those of *Percina*, are long and large, the number of dorsal spines being about fourteen. A notable peculiarity in both species is the presence of a row of shields, or enlarged scales, along the middle line of the abdomen. These may help to protect that part from the friction of the stony bottom. They seem to be shed sometimes; but when or why this happens we do not know. *Hadropterus* delights in clear running water, and may be found in most streams south and west of New York. It is especially desirable for aquaria, being hardier than any other fish as pretty, and prettier than any other fish as hardy, and withal with "a way of his own," as an Irish laborer, Barney Mullins, once said to us of Thoreau.

One of the most simply beautiful of all fishes is the Green-sided Darter (*Diplesion blennioides* Rafinesque). He is not, like the *Pœcilichthys*, an animated rainbow; but he has the beauty of green grass, wild violets, and mossy logs. As we watch him in the water, with his bright blended colors and gentle ways, once more, with Old Izaak, "we sit on cowslip banks, hear the birds sing, and possess ourselves in as much quietness as the silent silver streams which we see glide so quietly by us." During the ordinary business of the year *Diplesion*, like most sensible fishes and men, dresses plainly. It is not easy to get time for contemplation when the streams are low and food is scarce. Besides, a plain coat may ward off danger as well as facilitate attack. At all times, however, he may be known by these marks: the fins are all large; the back is covered with zigzag markings, while on the lower part of the sides are eight or nine *w*-shaped olive spots. These are more or less connected above, and sometimes form a wavy line. The eyes are prominent; the snout is very short and rounded; while the little inferior mouth is puckered up as if for saying "prunes and prisms, prunes and prisms." But when the first bluebirds give warning by their shivering and bodiless notes that spring is coming, then *Diplesion* puts on his wedding-clothes, and becomes in fact the green-sided darter. The dorsal fins become of a bright grass-green, with a scarlet band at the base of each; the broad anal has a tinge of the deepest emerald; while every spot and line upon the side has turned from an undefined olive to a deep rich green, such

as is scarcely found elsewhere in the animal world excepting on the heads of frogs. The same tint shines out on the branching rays of the caudal fin, and may be seen struggling through the white of the belly. The blotches nearest the middle of the back become black, and thickly sprinkled everywhere are little shiny specks of a clear bronze-orange. In the aquarium *Diplesion* is shy and retiring, — too much of a fine lady to scramble for angle-worms or to snap at the "bass-feed." She is usually hidden among the plants, or curled up under an arch of stones or in a geode.

We never tired of watching the little Johnny, or Tessellated Darter (*Boleosoma nigrum* Rafinesque). Although our earliest aquarium friend, — and the very first specimen showed us by a rapid ascent of the river-weed how "a Johnny could climb trees," — he has still many resources which we have never learned. Whenever we try to catch him with the hand, we begin with all the uncertainty that characterized our first attempts, even if we have him in a two-quart pail. We may know him by his short fins, his first dorsal having but nine spines, and by the absence of all color save a soft yellowish brown, which is freckled with darker markings. The dark brown on the sides is arranged in seven or eight *w*-shaped marks, below which are a few flecks of the same color. Covering the sides of the back are the wavy markings and dark specks which have given the name of the "Tessellated Darter;" but *Boleosoma* is a braver name, and we even prefer "Boly" for short. In the spring the males have the head jet-black; and

this dark color often extends on the back part of the body, so that the fish looks as if he had been taken by the tail and dipped into a bottle of ink. But with the end of the nuptial season, this color disappears, and the fish regains his normal strawy hue.

The head in *Boleosoma* resembles that of *Diplesion;* but the habit of leaning forward over a stone, resting on the front fins, gives a physiognomy even more frog-like. His actions are, however, rather bird-like; for he will strike attitudes like a tufted titmouse, and he flies rather than swims through the water. He will, with much perseverance, push his body between a plant and the side of the aquarium, and balance himself on the slender stem. Crouching cat-like before a snail-shell, he will snap off the horns which the unlucky owner pushes timidly out. But he is often less dainty, and seizing the animal by the head, he dashes the shell against the glass or a stone until he pulls the body out or breaks the shell. Boly, alas! is the "Quaker of our aquarium" only in appearance.

Gayest of all the darters, and indeed the gaudiest of all fresh-water fishes, is the Rainbow Darter (*Pœcilichthys cœruleus* Storer). This is a little fish, never more than three inches long, and usually about two. Everywhere, throughout the northern parts of the Mississippi Valley, it makes its home in the ripples and shallows of the rivers and in the shady retreats of all the little brooks. The male fish is greenish above, with darker blotches, and its sides are variegated with oblique bands alternately of indigo-blue and deep orange, the orange

often edged with patches of white. The cheeks are deep blue, the breast deep orange; while the expanded fins are gorgeous in scarlet, indigo, and crimson. The female, as is usually the case when the male of the species is resplendent, is plainly colored, — a speckly green, with no trace of blue or orange.

When the War of the Rebellion broke out, there were some good people who were anxiously looking for some sign or omen, that they might know on which side the "stars in their courses" were fighting. It so happened that in a little brook in Indiana, called Clear Creek, some one caught a rainbow darter. This fish was clothed in a new suit of the red, white, and blue of his native land, in the most unmistakably patriotic fashion. There were some people who had never seen a darter before, and who knew no more of the fishes in their streams than these fishes knew of them, by whom the coming of this little "soldier-fish" into their brooks was hailed as an omen of victory. Of course, these little fishes had really "always been there." They were there when America was discovered and for a long time before, but the people had not seen them. The warblers lived, you remember, in Spalding's woods at Concord; but Spalding did not know that they were there, and they had no knowledge of Spalding. So with the darters in Spalding's brooks. Still, when the day comes when history shall finally recount all the influences which held Indiana to her place in the Union, shall not, among greater things, this least of little fishes receive its little meed of praise?

Pœcilichthys is a chubby little fish, as compared with the other darters. In its movements it is awkward and ungraceful, though swift and savage as a pike. One of the mildest of its tricks which we have noticed, is this. It would gently put its head over a stone and catch a water-boatman by one of its swimming legs, release it, catch it again and again release it, until at last the boatman, evidently much annoyed, swam away out of its reach. It will follow to the surface of the water a piece of meat suspended by a string. It is more alert in discovering this than a hungry sunfish or rock-bass, and it can be led around like a pet lamb by a thread to which is fastened a section of a worm.

A more beautiful fish than this — beyond question the handsomest of them all — is the Blue-breasted Darter (*Nothonotus camurus* Cope). It is a deep olive-green little fish, sprinkled over with dots of carmine like a brook trout. Its breast is of a deep ultramarine blue, and its fins gayly variegated with blue, yellow, and crimson. But we hardly learned to know it as an aquarium acquaintance; for we found it but twice, both times in the clearest of water, and our specimens never survived confinement more than two or three hours. We can only say of their habits that they died where other darters lived, and that before they died all other fishes seemed cheap and common beside them.

The darter of darters is the Fan-tail (*Etheostoma flabellare* Rafinesque). Hardiest, wiriest, wariest of them all, it is the one which is most expert in catching other creatures, and the one which most

surely evades your clutch. You can catch a weasel asleep when you can put your finger on one of these. It is a slim, narrow, black, pirate-rigged little fish, with a long pointed head, and a projecting, prow-like lower jaw. It carries no flag, but is colored like the rocks, among which it lives. It is dark brown in hue, with a dusky spot on each scale, so that the whole body seems covered with lengthwise stripes; and these are further relieved by cross-bands of the same color. Its fins, especially the broad fan-shaped caudal, are likewise much checkered with spots of black. The spines of the dorsal fin are very low; and each of these in the male ends in a little fleshy pad of a rusty-red color, the fish's only attempt at ornamentation.

The fan-tail darter chooses the coldest and swiftest waters; and in these, as befits his form, he leads an active, predatory life. He is the terror of water-snails and caddis-worms, and the larvæ of mosquitoes. In the aquarium this darter is one of the most interesting of fishes; for though plainly colored it is very handsome, and in its movements is the most graceful of all the darters. Its mouth opens wider than that of any of the others, and it is fuller of bristling teeth. Its large, yellow-rimmed black eyes are ever on the watch. The least of a "fish" and the most of a darter, the fan-tail is worthily left as the type of the genus *Etheostoma*, in which it was first placed by its discoverer, Rafinesque.

We often brought home with us a "Johnny," "Speck," or "Crawl-a-bottom," of a different type from any of those whose habits we already knew. It had a very sharp nose which projected over its

mouth; its body was exceedingly slim and round, as transparent as jelly, but hard and firm to the touch. Its belly and much of its back were quite bare of scales, and those along its sides were small and inconspicuous. After much searching through the scattered descriptions which Eastern naturalists have given us of the darters found in their bottles of alcohol, we decided that our little friend was the Pellucid Darter (*Ammocrypta pellucida* Baird), better called the "Sand Darter" for reasons soon to be given.

Our aquarium had been arranged for the convenience of our other Etheostomine friends, and the bottom was thickly covered with stones among which a small fish might easily hide. Several days passed after the introduction of the first *Ammocrypta*[1] which survived the change of water, when we noticed that it had disappeared. Careful search among the stones and around the geode only made it the more certain that it had gone, and increased our wonder as to the way; for surely it had not been eaten, nor had it jumped out, unless, like Ariel, it could assume a "shape invisible." Finally, after going over every inch of the ground, there was discovered, under the nose of *Boleosoma*, which was standing as usual on its hands and tail, the upper edge of a caudal fin, and on each side of Boly's tail appeared a little black eye set in a yellow frame. *Pleurolepis* was buried! Was he dead? Slowly one eye was closed in a darter's inimitable way, — for they can outwink all animals

[1] Or, as we then called it, *Pleurolepis;* this name being earlier, but already preoccupied by a genus of extinct ganoid fishes.

in creation except owls, — and a touch of a finger on its tail showed that it had lost none of its activity. It was quite improbable that it had been buried so completely by accident. We therefore cleared of stones a small spot, leaving the hard white sand exposed, and awaited developments. Then for days we watched it closely, only to learn that it could bury itself with great celerity, for it was not caught in the act. But our patience was at last rewarded; for one morning, as we came out to breakfast, it put its nose, that we now know has a tip nearly as hard as horn, against the bottom, stood up nearly straight on its head, and with a swift beating of the tail to right and left was in less than five seconds completely buried. The sand had been violently stirred, of course; and just as it had nearly settled, probably in less than half a minute, its nose was put quietly out, and settling back left the twinkling eyes and narrow forehead alone visible.

Since then we have kept scores of them in an aquarium arranged especially for their convenience, and have often seen them burrow into the sand. They will remain buried so long as the water is pure and cool. Indeed, we now rely almost entirely on them to warn us when the water needs changing. When this need is felt, they come out of the sand and lie on the bottom panting violently. We have been unable to discover any immediate incentive for the act. It seems to be entirely unpremeditated. A number of them in confinement lie helplessly on the bottom, motionless and slowly breathing, when one suddenly

starts and buries his head and neck in the now whirling sand, by a motion as quick as thought; his tail beats frantically about, and when again the clean sand lies smooth on the bottom, the little eyes are looking at you like two glistening beads, as if to witness your applause at so clever a trick.

We have never seen *Ammocrypta* taste of food, nor do we ever expect to do so; for although its mouth bristles with teeth, its small size forbids an attack on any game which we can offer. Its quiescent habits and the character of the bottoms to which it confines itself seem to indicate that its prey is minute if not microscopic. But speculation about what we do not know as to its food might lead us to speculation as to the origin of its characteristic features, — how, for instance, the hard snout, the transparent muscles, and the burrowing habits are consequent on its loss of scales, or how the loss of unnecessary scales and of pigment cells is consequent on its burrowing habits. Then, when we have finished these matters, we might inquire how it came about that there are "Johnny Darters" at all, and why no other continent has them. And we might go on with endless queries like these, which would take us far beyond the purpose of this article. We have wished only to introduce our aquarium friends, and to commend them to all lovers of beautiful things in Nature.

THE SALMON FAMILY.

OF all the families of fishes, the one most interesting from almost every point of view is that of the *Salmonidæ*, the Salmon family. As now restricted, it is not one of the largest families, as it comprises less than a hundred species; but in beauty, activity, gaminess, quality as food, and even in size of individuals, different members of the group stand easily with the first among fishes. The following are the chief external characteristics which are common to the members of the family as here understood; the *Argentinidæ* and the *Salangidæ*, usually included with them, being here placed in separate groups: —

Body oblong or moderately elongate, covered with cycloid scales of varying size. Head naked. Mouth terminal or somewhat inferior, varying considerably among the different species, those having the mouth largest usually having also the strongest teeth. Maxillary provided with a supplemental bone, and forming the lateral margin of the upper jaw. Pseudobranchiæ present. Gill-rakers varying with the species. Opercula complete. No barbels. Dorsal fin of moderate length, placed near the middle of the length of the body. Adipose fin well developed. Caudal fin forked. Anal fin moderate or rather long. Ventral fins nearly

median in position. Pectoral fins inserted low. Lateral line present. Outline of belly rounded. Vertebræ in large number, usually about sixty.

The stomach in all the *Salmonidæ* is siphonal, and at the pylorus are many (15 to 200) comparatively large pyloric cœca. The air-bladder is large. The eggs are usually much larger than in fishes generally, and the ovaries are without special duct, the ova falling into the cavity of the abdomen before exclusion. The large size of the eggs, their lack of adhesiveness, and the readiness with which they may be impregnated, render the *Salmonidæ* peculiarly adapted for artificial culture.

The *Salmonidæ* are peculiar to the North Temperate and Arctic regions, and within this range they are almost equally abundant wherever suitable waters occur. Some of the species, especially the larger ones, are marine and anadromous, living and growing in the sea, and ascending fresh waters to spawn. Still others live in running brooks, entering lakes or the sea when occasion serves, but not habitually doing so. Still others are lake fishes, approaching the shore or entering brooks in the spawning season, at other times retiring to waters of considerable depth. Some of them are active, voracious, and gamy; while others are comparatively defenceless, and will not take the hook. They are divisible into eight easily recognized genera, — *Coregonus*, *Plecoglossus*, *Brachymystax*, *Stenodus*, *Thymallus*, *Oncorhynchus*, *Salmo*, and *Salvelinus*. These groups may be discussed in order.

The genus *Coregonus*, which includes the various species known in America as lake white-fish, is distinguishable in general by the small size of its mouth, the weakness of its teeth, and the large size of its scales. The teeth, especially, are either reduced to very slight asperities, or else are altogether wanting. The species reach a length of one to two feet or more. With scarcely an exception they inhabit clear lakes, and rarely enter streams except to spawn. In far northern regions they often descend to the sea; but in the latitude of the United States this is rarely possible for them, as they are unable to endure impurities in the water. They seldom take the hook, and rarely feed on other fishes. From their restriction to the waters of the different lake systems in which they live, numerous local varieties have been developed both in Europe and America, distinguished by characters less constant and less important than those which separate the different species. European writers have somewhat inconsistently regarded these varying and intangibly different forms as distinct species, and many of them have come to the conclusion that almost every lake system of Scandinavia, Scotland, and Russia has several species which are peculiar to it. Dr. Günther observes that "the species of this genus are not less numerous than those of *Salmo*, some having a very extended geographical range, whilst others are confined to very limited localities. They are less subject to variation than the trout, and therefore more easily characterized and distinguished. Hence we find that naturalists who

look with distrust on the different species of *Salmo* are quite ready to admit those of *Coregonus*."

It seems to me, however, that the variableness in *Coregonus* has been underestimated. The American species at least are all fishes of wide range, varying considerably with their surroundings.

None of the other species reach the size, or have the value as food, of our common white-fish. The species of *Coregonus* differ from each other in the form and size of the mouth, in the form of the body, and in the development of the gill-rakers. These differences have led to the establishment of about five sections, or subgenera, the extremes of which differ remarkably, but which gradually pass from one into another. Of the species, the following are among the most noteworthy: —

Coregonus oxyrhynchus — the *Schnäbel* of Holland, Germany, and Scandinavia — has the mouth very small, the sharp snout projecting far beyond it. No species similar to this is found in America.

The Rocky Mountain White-fish (*Coregonus williamsoni*) has also a small mouth and projecting snout, but the latter is blunter and much shorter than in *C. oxyrhynchus*. This is a small species abounding everywhere in the clear lakes of the Rocky Mountains and the Sierra Nevada, from Colorado to Vancouver Island. It is a handsome fish, and excellent as food.

Closely allied to *Coregonus williamsoni* is the Pilot-fish, Shad-waiter, Round-fish, or Menomonee White-fish (*Coregonus quadrilateralis*). This species is found in the Great Lakes, the Adirondack

region, the lakes of New Hampshire, and thence northwestward to Alaska, abounding in cold deep waters, its range apparently nowhere coinciding with that of *Coregonus williamsoni*.

The common White-fish (*Coregonus clupeiformis*) is the largest in size of the species of *Coregonus*, and is unquestionably the finest as an article of food. It varies considerably in appearance with age and condition, but in general it is proportionately much deeper than any of the other small-mouthed *Coregoni*. The adult fishes develop a considerable fleshy hump at the shoulders, which causes the head, which is very small, to appear disproportionately so. The white-fish spawns in November and December, on rocky shoals in the great lakes. Its food, which was for a long time unknown, was ascertained by Dr. P. R. Hoy to consist chiefly of deep-water crustaceans, with a few mollusks, and larvæ of water insects. "The white-fish," writes Mr. James W. Milner, "has been known since the time of the earliest explorers as pre-eminently a fine-flavored fish. In fact, there are few table-fishes its equal. To be appreciated in its fullest excellence, it should be taken fresh from the lake and broiled. Father Marquette, Charlevoix, Sir John Richardson, — explorers who for months at a time had to depend on the white-fish for their staple article of food — bore testimony to the fact that they never lost their relish for it, and deemed it a special excellence that the appetite never became cloyed with it." The range of the white-fish extends from the lakes of New York and New England northward to the Arctic Circle.

The "Otsego bass" of Otsego Lake in New York, celebrated by De Witt Clinton, is the ordinary white-fish.

Allied to the American white-fish, but smaller in size, is the Lavaret, Weissfisch, Adelfisch, or Weissfelchen (*Coregonus lavaretus*), of the mountain lakes of Switzerland, Germany, and Sweden. Several other related species occur in northern Europe and Siberia.

Another American species is the Sault White-fish, Lake Whiting, or Musquaw River White-fish (*Coregonus labradoricus*). Its teeth are stronger, especially on the tongue, than in any of our other species, and its body is slenderer than that of the white-fish. It is found in the upper Great Lakes, in the Adirondack region, in Lake Winnepesaukee, and in the lakes of Maine and New Brunswick. It is said to rise to the fly in the Canadian lakes. This species runs up the St. Mary's River, from Lake Huron to Lake Superior, in July and August. Great numbers are snared or speared by the Indians at this season at the Sault Ste. Marie.

The smallest and handsomest of the American white-fish is the Cisco of Lake Michigan (*Coregonus hoyi*). It is a slender fish, rarely exceeding ten inches in length, and its scales have the brilliant silvery lustre of the Moon-eye and the Lady-fish.

The Lake Herring, or Cisco (*Coregonus artedi*), is, next to the white-fish, the most important of the American species. It is more elongate than the others, and has a comparatively large mouth, with projecting under jaw. It is correspondingly more voracious, and often takes the hook. During the

spawning season of the white-fish the lake herring feeds on the ova of the latter, thereby doing a great amount of mischief. As food, this species is fair, but much inferior to the white-fish. Its geographical distribution is essentially the same, but to a greater degree it frequents shoal waters. In the small lakes around Lake Michigan, in Indiana and Wisconsin (Tippecanoe, Geneva, Oconomowoc, etc.), the cisco has long been established; and in these waters its habits have undergone some change, as has also its external appearance. These lake ciscoes remain for most of the year in the depths of the lake, coming to the surface only in search of certain insects, and to shallow water only in the spawning season. This periodical disappearance of the cisco has led to much foolish discussion as to the probability of their returning by an underground passage to Lake Michigan during the periods of their absence. One author, confounding "cisco" with "siscowet," has assumed that this underground passage leads to Lake Superior, and that the cisco is identical with the fat lake trout which bears the latter name. The name "lake herring" alludes to the superficial resemblance which this species possesses to the marine herring, a fish of quite a different family.

Closely allied to the lake herring is the Blue-fin of Lake Michigan and of certain lakes in New York (*Coregonus nigripinnis*), a fine large species inhabiting deep waters, and recognizable by the blue-black color of its lower fins. In Alaska and Siberia are still other species of the cisco type (*Coregonus laurettæ, C. merki, C. nelsoni*); and in

Europe very similar species are the Scotch Vendace (*Coregonus vandesius*) and the Scandinavian Lok-Sild (lake herring), as well as others less perfectly known.

The Tullibee, or "Mongrel White-fish" (*Coregonus tullibee*), has a deep body, like the shad, with the large mouth of the ciscoes. Fishermen think it a hybrid between *Coregonus clupeiformis* and *C. artedi*. It is found in the Great Lake region and northward, and very little is known of its habits. A similar species (*Coregonus cyprinoides*) is recorded from Siberia, — a region which is peculiarly suited for the growth of the *Coregoni*, but in which the species have never received much study.

Allied to the *Coregoni* is *Plecoglossus altivelis*, a small fish of the waters of Japan and Formosa. It has small, compressed, serrated, movable teeth in the jaws. This is said to be an annual fish, the life of each individual ceasing at the end of the season of reproduction.

Another little-known form, intermediate between the white-fish and the salmon, is *Brachymystax lenock*, a large fish of the mountain streams of Siberia. Only the skins brought home by Pallas about a century ago seem to be known as yet. According to Pallas, it sometimes reaches a weight of eighty pounds.

Still another genus, intermediate between the white-fish and the salmon, is *Stenodus*, distinguished by its elongate body, feeble teeth, and projecting lower jaw. The Inconnu, or Mackenzie River Salmon (*Stenodus mackenzii*) belongs to this genus. It reaches a weight of twenty pounds or

more, and in the far north is a food fish of good quality. Little is recorded of its habits, and few specimens exist in museums. Species of *Stenodus* are said to inhabit the Volga, Obi, Lena, and other northern rivers; but as yet little is definitely known of them.

The Grayling (*Thymallus*), termed by Saint Ambrose "the flower of fishes," is likewise intermediate between the white-fish and the trout, having larger scales and feebler teeth than the latter. The teeth on the tongue, found in all the trout and salmon, are obsolete in grayling. The chief distinctive peculiarity of the genus *Thymallus* is the great development of the dorsal fin, which has more rays (20 to 24) than are found in any other of the *Salmonidæ*, and the fin is also higher. All the species are gayly colored, the dorsal fin especially being marked with purplish or greenish bands and bright rose-colored spots; while the body is mostly purplish-gray, often with spots of black. Most of the species rarely exceed a foot in length, but northward they grow larger. Grayling weighing five pounds have been taken in England; and according to Dr. Day, they are said in Lapland to reach a weight of eight or nine pounds. The grayling in all countries frequent clear, cold brooks, and rarely, if ever, enter the sea, or even the larger lakes. They are said to congregate in small shoals in the streams, and to prefer those which have a succession of pools and shallows, with a sandy or gravelly rather than rocky bottom. The grayling spawns on the shallows in April or May (in England). It is said to be non-migratory

in its habits, depositing its ova in the neighborhood of its usual haunts. The ova are said to be far more delicate and easily killed than those of the trout or charr. The grayling and the trout often inhabit the same waters, but not altogether in harmony. It is said that the grayling devour the eggs of the trout. It is certain that the trout feed on the young grayling. As a food-fish, the grayling, of course, ranks high; but the true sportsman will hardly seek such fish as these to fill his frying-pan. They are considered gamy fishes, although less strong than the brook-trout, and perhaps less wary. The five or six known species of grayling are very closely related, and are doubtless comparatively recent offshoots from a common stock, which has now spread itself widely through the northern regions.

The common Grayling of Europe (*Thymallus thymallus*) is found throughout northern Europe, and as far south as the mountains of Hungary and northern Italy. The name *Thymallus* was given by the ancients, because the fish, when fresh, had the odor of water thyme, — an odor which the duller sense of the moderns now fails to detect. Grayling belonging to this or other species are found in the waters of Russia and Siberia.

The American Grayling (*Thymallus signifer*) is widely distributed in British America and Alaska. In several streams in northern Michigan and in Montana occurs a dwarfish variety of this species, known to anglers as the Michigan Grayling (*Thymallus signifer ontariensis*).[1] This form has a

[1] *Thymallus tricolor* Cope = *Thymallus montanus* Milner.

longer head, rather smaller scales, and the dorsal fin rather lower than in the northern form (*signifer*); but the constancy of these characters in specimens from intermediate localities is yet to be proved. It is probable that the grayling once had a wider range to the southward than now, and that so far as the waters of the United States are concerned, it is tending towards extinction. This tendency is, of course, being accelerated in Michigan by lumbermen and anglers. The colonies of grayling in Michigan and Montana are probably remains of a post-glacial fauna.

The genus *Oncorhynchus* contains those species of *Salmonidæ* which have the greatest size and value. They are in fact, as well as in name, the king salmon. The genus is closely related to *Salmo*, with which it agrees in general as to the structure of its vomer, and from which it differs in the increased number of anal rays, branchiostegals, pyloric cœca, and gill-rakers. The character most convenient for distinguishing *Oncorhynchus*, young or old, from all the species of *Salmo*, is the number of developed rays in the anal fin. These in *Oncorhynchus* are thirteen to twenty, in *Salmo* nine or ten.

The species of *Oncorhynchus* have long been known as anadromous salmon, confined to the North Pacific. The species were first made known one hundred and thirty years ago, by that most exact of early observers, Steller, who described and distinguished them with perfect accuracy, under their Russian vernacular names. These Russian names were, in 1792, adopted by Walbaum as

specific names, in giving to these animals a scientific nomenclature. Since Steller's time, writers of all degrees of incompetence, and writers with scanty material or with no material at all, have done their worst to confuse our knowledge of these salmon, until it became evident that no exact knowledge of any of the species remained. In the current system of a few years ago, the breeding males of the five species known to Steller constituted a separate genus of many species (*Oncorhynchus* Suckley); the females were placed in the genus *Salmo*, and the young formed still other species of a third genus, called *Fario*, supposed to be a genus of trout. The young breeding males (*grilse*) of one of the species (*Oncorhynchus nerka*) made still a fourth genus designated as *Hypsifario*. Not one of the writers on these fishes of twenty-five years ago knew a single species definitely, at sight, or used knowingly in their descriptions a single character by which species are really distinguished. Not less than thirty-five nominal species of *Oncorhynchus* have already been described from the North Pacific, although, so far as is now known, only the five originally noticed by Steller really exist. The descriptive literature of the Pacific salmon is among the very worst extant in science. This is not, however, altogether the fault of the authors, but it is in great part due to the extraordinary variability in appearance of the different species of salmon. These variations are, as will be seen, due to several different causes, notably to differences in surroundings, in sex, and in age, and in conditions connected with the process of reproduction.

The writer and his associate, Professor Charles H. Gilbert, have had, under the auspices of the United States Fish Commission, better opportunities to study the different species of *Oncorhynchus* than have fallen to the lot of any other ichthyologists. The following discussion of the different species is condensed from our report to the United States Census Bureau, portions of which were published in the "American Naturalist" for March, 1881. Entirely similar conclusions have been independently reached by Dr. Tarleton H. Bean, who visited Alaska in 1880, and whose means of studying the species have been scarcely less extensive.

There are five species of salmon (*Oncorhynchus*) in the waters of the North Pacific. We have at present no evidence of the existence of any more on either the American or the Asiatic side. These species may be called: (1) the Quinnat, or King Salmon, (2) the Blue-back Salmon, or Red-fish, (3) the Silver Salmon, (4) the Dog Salmon, and (5) the Humpback Salmon; or (1) *Oncorhynchus tschawytscha*, (2) *Oncorhynchus nerka*, (3) *Oncorhynchus kisutch*, (4) *Oncorhynchus keta*, and (5) *Oncorhynchus gorbuscha*. All these species are now known to occur in the waters of Kamtschatka as well as in those of Alaska and Oregon. These species, in all their varied conditions, may usually be distinguished by the characters given below. Other differences of form, color, and appearance are absolutely valueless for distinction, unless specimens of the same age, sex, and condition are compared.

The Quinnat Salmon (*Oncorhynchus tschawytscha*)

has an average weight of 22 pounds, but individuals weighing 70 to 100 pounds are occasionally taken. It has about 16 anal rays, 15 to 19 branchiostegals, 23 (9 + 14) gill-rakers on the anterior gill arch, and 140 to 185 pyloric cœca. The scales are comparatively large, there being from 130 to 155 in a longitudinal series. In the spring the body is silvery, the back, dorsal fin, and caudal fin having more or less of round black spots, and the sides of the head having a peculiar tin-colored metallic lustre. In the fall the color is often black or dirty-red, and the species can then only be distinguished from the dog-salmon by its technical characters.

The Blue-back Salmon (*Oncorhynchus nerka*) usually weighs from 5 to 8 pounds. It has about 14 developed anal rays, 14 branchiostegals, and 75 to 95 pyloric cœca. The gill-rakers are more numerous than in any other salmon, the number being usually about 39 (16 + 23). The scales are larger, there being 130 to 140 in the lateral line. In the spring the form is plumply rounded, and the color is a clear bright blue above, silvery below, and everywhere immaculate. Young fishes often show a few round black spots, which disappear when they enter the sea. Fall specimens in the lakes are bright red in color, hook-nosed and slab-sided, and bear little resemblance to the spring run. Young spawning male grilse are also peculiar in appearance, and were for a time considered as forming a distinct genus, under the name of "*Hypsifario Kennerlyi*." This species appears to be sometimes landlocked in mountain lakes, in

which case it reaches but a small size. Such specimens, called "Kokos" by the Indians, have been sent us from Lake Whatcom, Washington Territory, by Mr. T. J. Smith of Whatcom.

The Silver Salmon (*Oncorhynchus kisutch*) reaches a weight of 3 to 8 pounds. It has 13 developed rays in the anal, 13 branchiostegals, 23 (10 + 13) gill-rakers, and 45 to 80 pyloric cœca. There are about 127 scales in the lateral line. In color, it is silvery in spring, greenish above, and with a few faint black spots on the upper parts only. In the fall the males are mostly of a dirty red.

The Dog Salmon (*Oncorhynchus keta*) reaches an average weight of about 12 pounds. It has about 14 anal rays, 14 branchiostegals, 24 (9 + 15) gill-rakers, and 140 to 185 pyloric cœca. There are about 150 scales in the lateral line. In spring it is dirty silvery, immaculate, or sprinkled with small black specks, the fins dusky. In the fall the male is brick-red or blackish, and its jaws are greatly distorted.

The Humpback Salmon (*Oncorhynchus gorbuscha*) is the smallest of the species, weighing from 3 to 6 pounds. It has usually 15 anal rays, 12 branchiostegals, 28 (13 + 15) gill-rakers, and about 180 pyloric cœca. Its scales are much smaller than in any other salmon, there being 180 to 240 in the lateral line. In color it is bluish above, silvery below, the posterior and upper parts with many round black spots. The males in fall are red, and are more extravagantly distorted than in any other of the *Salmonidæ*.

Of these species the blue-back predominates in

Frazer River, the silver salmon in Puget Sound, the quinnat in the Columbia and the Sacramento, and the silver salmon in most of the streams along the coast. All the species have been seen by us in the Columbia and in Frazer River; all but the blue-back in the Sacramento and in waters tributary to Puget Sound. Only the quinnat has been noticed south of San Francisco. Its range has been traced as far as Ventura River. Of these species, the quinnat and blue-back salmon habitually "run" in the spring; the others in the fall. The usual order of running in the rivers is as follows: *nerka*, *tschawytscha*, *kisutch*, *gorbuscha*, *keta*.

The economic value of the spring-running salmon is far greater than that of the other species, because they can be captured in numbers when at their best, while the others are usually taken only after deterioration. To this fact the worthlessness of *Oncorhynchus keta* as compared with the other species is probably wholly due.

The habits of the salmon in the ocean are not easily studied. Quinnat and silver salmon of all sizes are taken with the seine at almost any season in Puget Sound. This would indicate that these species do not go far from the shore. The quinnat takes the hook freely in Monterey Bay, both near the shore and at a distance of six to eight miles out. We have reason to believe that these two species do not necessarily seek great depths, but probably remain not very far from the mouth of the rivers in which they were spawned. The blue-back and the dog salmon probably seek deeper water, as the former is seldom or never taken with the

seine in the ocean, and the latter is known to enter the Strait of Fuca at the spawning season, therefore coming in from the open sea. The great majority of the quinnat salmon, and nearly all the blue-back salmon enter the rivers in the spring. The run of both begins generally at the last of March; it lasts, with various modifications and interruptions, until the actual spawning season in November; the time of running and the proportionate amount in each of the subordinate runs varying with each different river. In general, the runs are slack in the summer and increase with the first high water of autumn. By the last of August only straggling blue-backs can be found in the lower course of any stream; but both in the Columbia and in the Sacramento the quinnat runs in considerable numbers at least till October. In the Sacramento the run is greatest in the fall, and more run in the summer than in spring. In the Sacramento and the smaller rivers southward, there is a winter run, beginning in December. The spring salmon ascends only those rivers which are fed by the melting snows from the mountains, and which have sufficient volume to send their waters well out to sea. Those salmon which run in the spring are chiefly adults (supposed to be at least three years old). Their milt and spawn are no more developed than at the same time in others of the same species which are not to enter the rivers until fall. It would appear that the contact with cold fresh water, when in the ocean, in some way causes them to run towards it, and to run before there is any special influence to that end exerted by the

development of the organs of generation. High water on any of these rivers in the spring is always followed by an increased run of salmon. The salmon-canners think — and this is probably true — that salmon which would not have run till later are brought up by the contact with the cold water. The cause of this effect of cold fresh water is not understood. We may call it an instinct of the salmon, which is another way of expressing our ignorance. In general, it seems to be true that in those rivers and during those years when the spring run is greatest, the fall run is least to be depended on.

As the season advances, smaller and younger salmon of these species (quinnat and blue-back) enter the rivers to spawn, and in the fall these young specimens are very numerous. We have thus far failed to notice any gradations in size or appearance of these young fish by which their ages could be ascertained. It is, however, probable that some of both sexes reproduce at the age of one year. In Frazer River, in the fall, quinnat male grilse of every size, from eight inches upwards, were running, the milt fully developed, but usually not showing the hooked jaws and dark colors of the older males. Females less than eighteen inches in length were rare. All of either sex, large and small, then in the river, had the ovaries or milt developed. Little blue-backs of every size, down to six inches, are also found in the upper Columbia in the fall, with their organs of generation fully developed. Nineteen twentieths of these young fish are males, and some of them

have the hooked jaws and red color of the old males.

The average weight of the quinnat in the Columbia, in the spring, is twenty-two pounds; in the Sacramento, about sixteen. Individuals weighing from forty to sixty pounds are frequently found in both rivers, and some as high as eighty or even one hundred pounds are recorded. It is questioned whether these large fishes are those which, of the same age, have grown more rapidly; those which are older, but have for some reason failed to spawn; or those which have survived one or more spawning seasons. All these origins may be possible in individual cases; we are, however, of the opinion that the majority of these large fishes are those which have hitherto run in the fall, and thus having spawned not far from the sea, have survived the spawning season of the previous year.

Those fish which enter the rivers in the spring continue their ascent till death or the spawning season overtakes them. Probably none of them ever return to the ocean, and a large proportion fail to spawn. They are known to ascend the Sacramento to its extreme head-waters, about four hundred miles. In the Columbia they ascend as far as the Bitter Root Mountains and at least to the Spokane Falls, and their extreme limit is not known. This is a distance of six to eight hundred miles. At these great distances, when the fish have reached the spawning grounds, besides the usual changes of the breeding season, their bodies are covered with bruises, on which patches of white fungus develop. The fins become

mutilated, their eyes are often injured or destroyed, parasitic worms gather in their gills, they become extremely emaciated, their flesh becomes white from the loss of oil; and as soon as the spawning act is accomplished, and sometimes before, *all* of them die. The ascent of the Cascades and the Dalles probably causes the injury or death of a great many salmon.

When the salmon enter the river they refuse to take bait, and their stomachs are always found empty and contracted. In the rivers they do not feed; and when they reach the spawning grounds, their stomachs, pyloric cœca and all, are said to be no larger than one's finger. They will sometimes take the fly, or a hook baited with salmon roe, in the clear waters of the upper tributaries, but there is no other evidence known to us that they feed when there. Only the quinnat and blue-back (there called red-fish) have been found at any great distance from the sea, and these (as adult fishes) only in late summer and fall.

The spawning season is probably about the same for all the species. It varies for each of the different rivers, and for different parts of the same river. It doubtless extends from July to December. The manner of spawning is probably similar for all the species, but we have no data for any except the quinnat. In this species the fishes pair off; the male, with tail and snout, excavates a broad, shallow "nest" in the gravelly bed of the stream, in rapid water, at a depth of one to four feet; the female deposits her eggs in it, and after the exclusion of the milt, they cover them with stones and

gravel. They then float down the stream tail foremost. As already stated, a great majority of them die. In the head-waters of the large streams, unquestionably, all die; in the small streams, and near the sea, an unknown percentage probably survive. The young hatch in about sixty days, and most of them return to the ocean during the high water of the spring.

The salmon of all kinds in the spring are silvery, spotted or not according to the species, and with the mouth about equally symmetrical in both sexes. As the spawning season approaches, the female loses her silvery color, becomes more slimy, the scales on the back partly sink into the skin, and the flesh changes from salmon red and becomes variously paler, from the loss of oil; the degree of paleness varying much with individuals and with inhabitants of different rivers. In the Sacramento the flesh of the quinnat, in either spring or fall, is rarely pale. In the Columbia a few with pale flesh are sometimes taken in spring, and a good many in the fall. In Frazer River the fall run of the quinnat is nearly worthless for canning purposes, because so many are "white-meated." In the spring very few are "white-meated;" but the number increases towards fall, when there is every variation, some having red streaks running through them, others being red toward the head and pale toward the tail. The red and pale ones cannot be distinguished externally, and the color is dependent on neither age nor sex. There is said to be no difference in the taste, but there is no market for canned salmon not of the conventional orange-color.

As the season advances, the difference between the males and females becomes more and more marked, and keeps pace with the development of the milt, as is shown by dissection. The males have (1) the premaxillaries and the tip of the lower jaw more and more prolonged, both of the jaws becoming finally strongly and often extravagantly hooked, so that either they shut by the side of each other like shears, or else the mouth cannot be closed. (2) The front teeth become very long and canine-like, their growth proceeding very rapidly, until they are often half an inch long. (3) The teeth on the vomer and tongue often disappear. (4) The body grows more compressed and deeper at the shoulders, so that a very distinct hump is formed; this is more developed in *Oncorhynchus gorbuscha*, but is found in all. (5) The scales disappear, especially on the back, by the growth of spongy skin. (6) The color changes from silvery to various shades of black and red, or blotchy, according to the species. The blue-back turns rosy red, the dog salmon a dull blotchy red, and the quinnat generally blackish. The distorted males are commonly considered worthless, rejected by the canners and salmon-salters, but preserved by the Indians. These changes are due solely to influences connected with the growth of the reproductive organs. They are not in any way due to the action of fresh water. They take place at about the same time in the adult males of all species, whether in the ocean or in the rivers. At the time of the spring runs all are symmetrical. In the fall all males, of whatever species, are more or less distorted.

Among the dog salmon, which run only in the fall, the males are hook-jawed and red-blotched when they first enter the Strait of Fuca from the outside. The humpback, taken in salt water about Seattle, have the same peculiarities. The male is slab-sided, hook-billed, and distorted, and is rejected by the canners. No hook-jawed females of any species have been seen. It is not positively known that any fully hook-jawed male survives the reproductive act. If any do, the jaws must resume the normal form.

On first entering a stream the salmon swim about as if playing. They always head towards the current, and this appearance of playing may be simply due to facing the moving tide. Afterwards they enter the deepest parts of the stream and swim straight up, with few interruptions. Their rate of travel at Sacramento is estimated by Stone at about two miles per day; on the Columbia at about three miles per day. Those who enter the Columbia in the spring and ascend to the mountain rivers of Idaho, must go at a more rapid rate than this, as they must make an average of nearly four miles per day.

As already stated, the economic value of any species depends in great part on its being a "spring salmon." It is not generally possible to capture salmon of any species in large numbers until they have entered the rivers, and the spring salmon enter the rivers long before the growth of the organs of reproduction has reduced the richness of the flesh. The fall salmon cannot be taken in quantity until their flesh has deteriorated; hence

the dog salmon is practically almost worthless, except to the Indians, and the humpback salmon is little better. The silver salmon, with the same breeding habits as the dog salmon, is more valuable, as it is found in the inland waters of Puget Sound for a considerable time before the fall rains cause the fall runs, and it may be taken in large numbers with seines before the season for entering the rivers. The quinnat salmon, from its great size and abundance, is more valuable than all the other fishes on our Pacific coast taken together. The blueback, similar in flesh, but much smaller and less abundant, is worth much more than the combined value of the three remaining species of salmon.

The fall salmon of all species, but especially of the dog salmon, ascend streams but a short distance before spawning. They seem to be in great anxiety to find fresh water, and many of them work their way up little brooks only a few inches deep, where they perish miserably, floundering about on the stones. Every stream, of whatever kind, has more or less of these fall salmon.

It is the prevailing impression that the salmon have some special instinct which leads them to return to spawn in the same spawning grounds where they were originally hatched. We fail to find any evidence of this in the case of the Pacific coast salmon, and we do not believe it to be true. It seems more probable that the young salmon hatched in any river mostly remain in the ocean within a radius of twenty, thirty, or forty miles of its mouth. These, in their movements about in the ocean, may come into contact with the cold

waters of their parent rivers, or perhaps of any other river, at a considerable distance from the shore. In the case of the quinnat and the blueback, their "instinct" seems to lead them to ascend these fresh waters, and in a majority of cases these waters will be those in which the fishes in question were originally spawned. Later in the season the growth of the reproductive organs leads them to approach the shore and search for fresh waters, and still the chances are that they may find the original stream. But undoubtedly many fall salmon ascend, or try to ascend, streams in which no salmon was ever hatched. In little brooks about Puget Sound, where the water is not three inches deep, are often found dead or dying salmon, which have entered them for the purpose of spawning. It is said of the Russian River and other California rivers, that their mouths, in the time of low water in summer, generally become entirely closed by sand-bars, and that the salmon, in their eagerness to ascend them, frequently fling themselves entirely out of water on the beach. But this does not prove that the salmon are guided by a marvellous geographical instinct which leads them to their parent river in spite of the fact that the river cannot be found. The waters of Russian River soak through these sand-bars, and the salmon instinct, we think, leads them merely to search for fresh waters. This matter is much in need of further investigation; at present, however, we find no reason to believe that the salmon enter the Rogue River simply because they were spawned there, or that a salmon hatched in the Clackamas

River is more likely, on that account, to return to the Clackamas than to go up the Cowlitz or the Des Chûtes. "At the hatchery on Rogue River, the fish are stripped, marked, and set free, and every year since the hatchery has been in operation some of the marked fish have been re-caught. The young fry are also marked, but none of them have been re-caught." The shad is another species of fish supposed to possess this remarkable homing instinct. Shad have been planted in the Sacramento River, and considerable numbers descended from this plant have been already taken in the Columbia River and in Monterey Bay, but not a single one, so far as known to me, in the original stream, the Sacramento.

In regard to the diminution of the number of salmon on the coast we may make these observations. In Puget Sound, Frazer River, and the small streams, there appears to be little or no evidence of diminution. In the Columbia River the evidence appears somewhat conflicting. The catch in 1880 was considerably greater than ever before (nearly 540,000 cases of 48 pounds each having been packed), although the fishing for three or four years has been very extensive. On the other hand, the high water of that year undoubtedly caused many fish to become spring salmon which would otherwise have run in the fall. Moreover, it is urged that a few years ago, when the number caught was about half as great as in 1880, the amount of netting used was perhaps one eighth as much. With a comparatively small outfit the canners caught half the fish; now, with nets much

larger and more numerous, they catch them nearly all, scarcely any escaping during the fishing season (April 1 to August 1). Whether an actual reduction in the number of fish running can be proved or not, there can be no question that the present rate of destruction of the salmon will deplete the river before many years. A considerable number of quinnat salmon run in August and September, and some stragglers even later; these are all which now keep up the supply of fish in the river. The non-molestation of this fall run, therefore, does something to atone for the almost total destruction of the spring run. This, however, is insufficient. A well-ordered salmon hatchery is the only means by which the destruction of the salmon fisheries of the Columbia River can be prevented.

The fact that the humpback salmon runs only on alternate years in Puget Sound (1875, 1877, 1879, etc.) is well attested and at present unexplained. Stray individuals only are taken in other years. This species has a distinct run in the United States in Puget Sound only, although individuals (called "lost salmon") are occasionally taken in the Columbia and in the Sacramento.

Numerous attempts have been made to introduce the quinnat salmon into the waters of the Eastern States and of Europe. Individuals thus planted have been taken in several different localities, but as yet not in any considerable number.

The genus *Salmo* comprises those forms of salmon and trout which have been longest known. As in related genera, the mouth is large, and the jaws, palatines, and tongue are armed with strong

teeth. The vomer is flat, its shaft not depressed below the level of the head or chevron (the anterior end). There are a few teeth on the chevron; and behind it, on the shaft, there is either a double series of teeth or an irregular single series. These teeth in the true salmon disappear with age, but in the others (the black-spotted trout) they are persistent. The scales are silvery, and moderate or small in size. There are 9 to 11 developed rays in the anal fin. The caudal fin is truncate, or variously concave or forked. There are usually 40 to 70 pyloric cœca, 11 or 12 branchiostegals, and about 20 (8 + 12) gill-rakers. The sexual peculiarities are in general less marked than in *Oncorhynchus;* they are also greater in the anadromous species than in those which inhabit fresh waters. In general, the male in the breeding season is redder, its jaws are prolonged, the front teeth enlarged, the lower jaw turned upwards at the end, and the upper jaw notched, or sometimes even perforated, by the tip of the lower. All the species of *Salmo* (like those of *Oncorhynchus*) are more or less spotted with black.

Two species (salmon) are marine and anadromous, taking the place in the North Atlantic occupied in the North Pacific by the King Salmon or species of *Oncorhynchus*. The others (trout), forming the sub-genus *Salar*, are non-migratory, or at least irregularly or imperfectly anadromous. They abound in all streams of northern Europe, northern Asia, and in that part of North America which lies *west* of the Mississippi Valley. The black-spotted trout are entirely wanting in eastern

America, — a remarkable fact in geographical distribution, perhaps explained only on the hypothesis of the comparatively recent and Eurasiatic origin of the group, which, we may suppose, has not yet had opportunity to extend its range across the plains, unsuitable for salmon life, which separate the upper Missouri from the Great Lakes.

The Salmon (*Salmo salar*) is the only black-spotted salmonoid found in American waters tributary to the Atlantic. In Europe, where other species similarly colored occur, the species may be best distinguished by the fact that the teeth on the shaft of the vomer mostly disappear with age. From the only other species positively known (*Salmo trutta*) which shares this character, the true salmon may be distinguished by the presence of but eleven scales between the adipose fin and the lateral line, while *Salmo trutta* has about fourteen. The scales are comparatively large in the salmon, there being about one hundred and twenty-five in the lateral line. The caudal fin, which is forked in the young, becomes, as in other species of salmon, more or less truncate with age. The pyloric cœca are fifty to sixty in number.

The following account of the coloration of the salmon is from Dr. Day's "Fishes of Great Britain: " —

"Color in adults superiorly of a steel blue, becoming lighter on the sides and beneath. Mostly a few rounded or *x*-shaped spots scattered above the lateral line and upper half of the head, being more numerous in the female than in the male. Dorsal, caudal, and pectoral fins dusky; ventrals and anal white, the former grayish

internally. Prior to entering fresh waters these fish are of a brilliant steel blue along the back, which becomes changed to a muddy tinge when they enter rivers. After these fish have passed into the fresh waters for the purpose of breeding, numerous orange streaks appear in the cheeks of the male, and also spots or even marks of the same, and likewise of a red color, on the body. It is now termed a 'red-fish.' The female, however, is dark in color, and known as 'black-fish.' 'Smolts' (young river fish) are bluish along the upper half of the body, silvery along the sides, due to a layer of silvery scales being formed over the trout-like colors, while they have darker fins than the yearling 'pink;' but similar bands and spots, which can be seen (as in the parr) if the example be held in certain positions of light. 'Parr' (fishes of the year) have two or three black spots only on the opercle, and black spots and also orange ones along the upper half of the body, and no dark ones below the lateral line, although there may be orange ones which can be seen in its course. Along the side of the body are a series (12 to 15) of transverse bluish bands, wider than the ground color and crossing the lateral line, while in the upper half of the body the darker color of the back forms an arch over each of these bands, a row of spots along the middle of the rayed dorsal fin and the adipose orange-tipped."

The dusky cross-shades found in the young salmon or parr are characteristic of the young of nearly all the *Salmonidæ*.

The salmon of the Atlantic is, as already stated, an anadromous fish, spending most of its life in the sea, and entering the streams in the fall for the purpose of reproduction. The time of running varies much in different streams and also in different countries. As with the Pacific species, these

salmon are not easily discouraged in their progress, leaping cascades and other obstructions, or, if these prove impassable, dying after repeated fruitless attempts.

The young salmon, known as the "parr," is hatched in the spring. It usually remains about two years in the rivers, descending at about the third spring to the sea, when it is known as "smolt." In the sea it grows much more rapidly, and becomes more silvery in color, and is known as "grilse." The grilse rapidly develop into the adult salmon; and some of them, as is the case with the grilse of the Pacific salmon, are capable of reproduction.

After spawning the salmon are very lean and unwholesome in appearance, as in fact. They are then known as "kelts." The Atlantic salmon does not ascend rivers to any such distances as those traversed by the quinnat and the blue-back. Its kelts, therefore, for the most part survive the act of spawning. Dr. Day thinks that they feed upon the young salmon in the rivers, and that, therefore, the destruction of the kelts might increase the supply of salmon.

As a food-fish, the Atlantic salmon is very similar to the Pacific species, neither better nor worse, so far as I can see, when equally fresh. In both the flesh is rich and finely flavored; but the appetite of man becomes cloyed with salmon-flesh sooner than with that of whitefish, smelt, or charr. In size, the Atlantic salmon does not fall far short of the quinnat. The average weight of the adult is probably less than

fifteen pounds. The largest one of which I find a record was taken on the coast of Ireland in 1881, and weighed eighty-four and three-fourths pounds.

The salmon is found in Europe between the latitude of 45° and 75°. In the United States it is now rarely seen south of Cape Cod, although formerly the Hudson and numerous other rivers were salmon streams. Over-fishing, obstructions in the rivers, and pollution of the water by manufactories and by city sewage are agencies against which the salmon cannot cope.

Seven species of salmon (as distinguished from trout) are recognized by Dr. Günther in Europe, and three in America. The landlocked forms, abundant in Norway, Sweden, and Maine, which cannot, or at least do not, descend to the sea, are regarded by him as distinct species. "The question," observes Dr. Günther, "whether any of the migratory species can be retained by artificial means in fresh water, and finally accommodate themselves to a permanent sojourn therein, must be negatived for the present." On this point I am compelled to disagree with Dr. Günther. I have compared numerous specimens of the common landlocked salmon (*Salmo salar sebago*) of the lakes of Maine and New Brunswick with landlocked salmon (*Salmo salar hardini*) from the lakes of Sweden, and with numerous migratory salmon, both from America and Europe. I can have no hesitation in regarding them all as specifically identical. The differences are very trivial in kind, and not greater than would be expected on

the hypothesis of recent adaptation of the salmon to lake-life. We have, therefore, on our Atlantic coast but one species of salmon, *Salmo salar*. Dr. Francis Day, who has very thoroughly studied these fishes, takes, in his memoir on "The Fishes of Great Britain and Ireland," and in other papers, a similar view in regard to the European species. Omitting the species with permanent teeth on the shaft of the vomer (sub-genus *Salar*), he finds among the salmon proper only two species, *Salmo salar* and *Salmo trutta*. The latter species, the sea-trout or salmon-trout of England, is similar to the salmon in many respects, but has rather smaller scales, there being fourteen in an oblique series between the adipose fin and the lateral line. It is not so strong a fish as the salmon, nor does it reach so large a size. Although naturally anadromous, like the true salmon, land-locked forms of the salmon-trout are not uncommon. These have been usually regarded as different species, while aberrant or intermediate individuals are usually regarded as hybrids.

The present writer has examined many thousands of American *Salmonidæ*, both of *Oncorhynchus* and *Salmo*. While many variations have come to his attention, and he has been compelled more than once to modify his views as to specific distinctions, he has never yet seen an individual which he had the slightest reason to regard as a "hybrid." It is evident that in America but few species of salmonoids exist, and that these are subject to many variations. It is certainly illogical to conclude that every specimen which does not

correspond to our closet-formed definition of its species must therefore be a "hybrid" with some other. There is no evidence worth mentioning, known to me, of extensive hybridization in a state of nature in any group of fishes. This matter is much in need of further study; for what is true of the species in one region, in this regard, may not be true of others. The species of trout, also, may perhaps hybridize, while *Salmo salar* and the species of *Oncorhynchus* certainly do not. Dr. Günther observes: —

"Johnson, a correspondent of Willughby, had already expressed his belief that the different salmonoids interbreed; and this view has since been shared by many who have observed these fishes in Nature. Hybrids between the sewin (*Salmo trutta cambricus*) and the river-trout (*Salmo fario*) were numerous in the Rhymney and other rivers of South Wales before salmonoids were almost exterminated by the pollutions allowed to pass into these streams, and so variable in their characters that the passage from one species to the other could be demonstrated in an almost unbroken series, which might induce some naturalists to regard both species as identical. Abundant evidence of a similar character has accumulated, showing the frequent occurrence of hybrids between *Salmo fario* and *S. trutta*. . . . In some rivers the conditions appear to be more favorable to hybridism than in others, in which hybrids are of comparatively rare occurrence. Hybrids between the salmon and other species are very scarce everywhere."

The black-spotted trout, forming the sub-genus *Salar*, differ from *Salmo salar* and *Salmo trutta* in the greater development of the vomerine teeth,

which are persistent throughout life, in a long double series on the shaft of the vomer. About seven species are laboriously distinguished by Dr. Günther, in the waters of western Europe. Most of these are regarded by Dr. Day as varieties of *Salmo fario*. The latter species, the common river-trout or lake-trout of Europe, is found throughout northern and central Europe, wherever suitable waters occur. It is abundant, gamy, takes the hook readily, and is excellent as food. It is more hardy than the different species of charr, although from an æsthetic point of view it must be regarded as inferior to all of the *Salvelini*. The largest river-trout recorded by Dr. Day weighed twenty-one pounds. Such large individuals are usually found in lakes in the north, well stocked with smaller fishes on which trout may feed. Farther south, where the surroundings are less favorable to trout-life, they become mature at a length of less than a foot, and a weight of a few ounces. These excessive variations in the size of individuals have received too little notice from students of *Salmonidæ*. Similar variations occur in all the non-migratory species of *Salmo* and of *Salvelinus*. Numerous river-trout have been recorded from northern Asia, but as yet nothing can be definitely stated as to the number of species actually existing.

In North America, only the region west of the Mississippi Valley, and the valley of Mackenzie River, have species of black-spotted trout. If we are to follow the usage of the names "salmon" and "trout," which prevails in England, we should

say that it is only these Western regions which have any trout at all. Of the number of species (about twenty in all) which have been indicated by authors, certainly not more than four can possibly be regarded as distinct species; and of these four, two are, as will be seen, still extremely doubtful. The other names are either useless synonymes, or else they have been applied to local varieties which pass by degrees into the ordinary types.

Of the American species the Rainbow Trout (*Salmo irideus*) most nearly approaches the European *Salmo fario*. It has the scales comparatively large, although rather smaller than in *Salmo fario*, the usual number in a longitudinal series being about 135. The mouth is smaller than in other American trout; the maxillary, except in old males, rarely extending beyond the eye. The caudal fin is well forked, becoming in very old fishes more nearly truncate. The color, as in all the other species, is bluish, the sides silvery in the males, with a red lateral band, and reddish and dusky blotches. The head, back, and upper fins are sprinkled with round black spots, which are very variable in number. In specimens taken in the sea, this species, like most other trout in similar conditions, is bright silvery, and sometimes immaculate. This species is especially characteristic of the waters of California. It abounds in every clear brook, from the Mexican line northward to Mount Shasta, and occasionally in coastwise streams to Alaska. No specimens have been anywhere obtained to the eastward of the Cascade

Range or of the Sierra Nevada. It varies much in size; specimens from northern California often reach a weight of six pounds, while in the Rio San Luis Rey, the southernmost locality from which I have obtained trout, they seldom exceed a length of six inches. Although not an anadromous species, the rainbow trout frequently moves about in the rivers, and it often enters the sea. Several attempts have been made to introduce it in Eastern streams. It is apparently more hardy and less greedy than the American Charr, or Brook Trout (*Salvelinus fontinalis*). On the other hand, it is distinctly inferior to the latter in beauty and in gaminess.

The Steel-head (*Salmo gairdneri*) is a large trout, of twelve to twenty pounds in weight, found very abundantly in the mouth of the Columbia and other rivers, in the spring, at the time of the early salmon run. These are evidently spent fishes. This fact would indicate a spawning time later (probably midwinter) than that of the salmon, and their occurrence in the river at the salmon run is evidently due to a return toward the sea. Steel-heads are occasionally taken in the Sacramento, but in the Columbia they are abundant. They are rejected by the salmon fishermen, as their flesh is pale, and the bones are much more firmly ossified than in the species of *Oncorhynchus*. The soft characters of the bones in the latter group, as compared with those of the larger trout, is one feature of their excellence as food, especially in the canned condition.

Comparing the steel-heads with the rainbow

trout, we find no differences, other than that the former is of much larger size, and has a larger mouth, and its caudal fin is truncate instead of forked. But the tail becomes more truncate, and the mouth larger with age in all species of salmon and trout. If a rainbow trout were to reach the size of the steel-head, it ought to acquire characters similar to those of the latter species. Conversely, unless the rainbow trout are young of the steel-head, the young of the latter are unknown. It is my belief that the steel-head is simply the large rainbow trout which has lived in the sea, and ascends the river to spawn. If this be true, *Salmo irideus* must be omitted from our lists, as identical with *Salmo gairdneri*, the latter name being the earlier one.

The most widely distributed, and decidedly the most important, of the American black-spotted trout is the *Salmo mykiss* (= *Salmo purpuratus* and *clarki* of authors), or, as we call it, the Red-throated Trout. This species has much smaller scales than the rainbow trout or steel-head, the usual number in a longitudinal series being 150 to 170. Its mouth is proportionately larger, and there is usually a narrow band of small teeth on the hyoid bone at the base of the tongue. These teeth are always wanting in *Salmo irideus* and *gairdneri*. The color in *Salmo mykiss* is, as in other species, excessively variable. In almost all specimens there is a deep-red blotch on the throat, between the branches of the lower jaw and the membrane connecting them. This I have not found in other species; and as it seems to be

constant in all varieties of *Salmo mykiss*, at all ages, it will furnish a good distinctive character. The red-throated trout is found in every suitable river and lake in the great basin of Utah, in the streams of Colorado, Wyoming, and Montana, on both sides of the Rocky Mountains. It is also found throughout Oregon, Washington, Idaho, British Columbia, and Alaska, probably no stream or lake suitable for salmonoid life being without it. In California the species seems to be comparatively rare, and its range has not been well made out. Large sea-run individuals apparently analogous to the steel-heads are sometimes found in the mouth of the Sacramento. In Washington Territory and Alaska this species regularly enters the sea. In Puget Sound it is a common fish. These sea-run individuals are more silvery and less spotted than those found in the mountain streams and lakes. Numerous more or less tangible varieties of *Salmo mykiss* occur, one of the most marked of which is the beautiful trout (*Salmo mykiss henshawi*) found in Lake Tahoe, the finest of all the mountain lakes of the Sierra Nevada. The size of *Salmo mykiss* is subject to much variation. Ordinarily, four to six pounds is a large size; but in certain favored waters, as Lake Tahoe, and the fjord bays of the Northwest, specimens from twenty to thirty pounds are occasionally taken. No attempt has been made (1880) to transport this, the finest known species of black-spotted trout, to Eastern waters. The writer thinks it much worthier of experiment, in this regard, than the rainbow trout. The great variety of the waters in which it occurs

seems to promise a ready adaptation to other surroundings.

The Rio Grande Trout (*Salmo mykiss spilurus*) is a large and profusely spotted trout, found in the head-waters of the Rio Grande, the mountain streams of the great basin of Utah, and as far south as the northern part of Chihuahua. Its scales are still smaller than those of the red-throated trout, to which it bears much resemblance, and of which it is probably simply a local variety.

The genus *Hucho* has been framed for the Huchen or Rothfisch (*Hucho hucho*) of the Danube, — a large salmon, differing from the genus *Salmo* in having no teeth on the shaft of the vomer, and from the *Salvelini* at least in form and coloration. The real characters of the genus, which seems to be distinct from *Salvelinus*, have not yet been worked out. The Huchen is a long and slender, somewhat pike-like fish, with depressed snout and strong teeth. The color is silvery, sprinkled with small black dots. It reaches a size little inferior to that of the salmon, and it is said to be an excellent food-fish. Little is known of its habits. It has, however, the reputation of being unusually voracious for a salmon.

The genus *Salvelinus* comprises the finest of the *Salmonidæ*, from the point of view of the angler or the artist. In England the species are known as charr, in contradistinction to the black-spotted species of *Salmo*, which are called trout. The former name has unfortunately been lost in America, where the name "trout" is given indiscrimi-

nately to both groups, and, still worse, to numerous other fishes (*Cestreus*, *Micropterus*, *Hexagrammus*) wholly unlike the *Salmonidæ* in all respects. It is sometimes said that the "American brook-trout is no trout, nothing but a charr," almost as though "charr" were a word of reproach. Nothing higher, however, can be said of a salmonoid than that it is a "charr." The technical character of the genus *Salvelinus* lies in the form of its vomer. This is deeper than in *Salmo;* and when the flesh is removed the bone is found to be somewhat boat-shaped above, and with the shaft depressed and out of the line of the chevron. Only the chevron is armed with teeth, and the shaft is covered by skin. In one species (*S. namaycush*) the chevron sends a projection backward which bears teeth; these teeth appearing, unless the flesh is removed, as if standing on the shaft of the bone.

In color all the charrs differ from the salmon and trout. The body in all is covered with round spots which are paler than the ground color, and crimson or gray. The lower fins are usually edged with bright colors. The sexual differences are not great. The scales, in general, are smaller than in other *Salmonidæ*, and they are imbedded in the skin to such a degree as to escape the notice of casual observers and even of most anglers.

> "One trout scale in the scales I 'd lay
> (If trout had scales), and 't will outweigh
> The wrong side of the balances."
>
> LOWELL.

The charrs inhabit, in general, only the clearest and coldest of mountain streams and lakes. They

are not migratory, or only to a limited extent. In northern regions they descend to the sea, where they grow much more rapidly, and assume a nearly uniform silvery-gray color. The different species are found in all suitable waters throughout the northern parts of both continents, except in the Rocky Mountains and Great Basin, where only the black-spotted trout occur. The number of species of charr is very uncertain, as, both in America and Europe, trivial variations and individual peculiarities have been raised to the rank of species. More types, however, seem to be represented in America than in Europe.

The only really well-authenticated species of charr in European waters is the Red Charr, Sälbling, or Ombre Chevalier (*Salvelinus alpinus*). This species is found in cold clear streams in Switzerland, Germany, and throughout Scandinavia and the British Islands. Compared with the American charr or brook-trout, it is a slenderer fish, with smaller mouth, longer fins, and smaller red spots, which are confined to the sides of the body. It is a "gregarious and deep-swimming fish, shy of taking the bait and feeding largely at night-time. It appears to require very pure and mostly deep water for its residence." It is less tenacious of life than the trout. It reaches a weight of from one to five pounds, probably rarely exceeding the latter in size. The various charr described from Siberia are far too little known to be enumerated here.

Of the American charr the one most resembling the European species is the Rangeley Lake Trout

(*Salvelinus stagnalis*). The exquisite little fish is known in the United States only from the Rangeley chain of lakes in western Maine. Quite lately specimens of what appears to be the same species have been taken in Arctic America, about Cumberland Gulf. Still later, Dr. T. H. Bean has shown its identity with the Greenland charr. Whether the species still inhabits any intervening waters is unknown. The Rangeley trout is much slenderer than the common brook-trout, with much smaller head and smaller mouth. In life it is dark blue above, and the deep red spots are confined to the sides of the body. The species rarely exceeds the length of a foot in the Rangeley Lakes, but in some other waters it reaches a much larger size. So far as is known it keeps itself in the depths of the lake until its spawning season approaches, in October, when it ascends the stream to spawn.

Another beautiful little charr, allied to *Salvelinus stagnalis*, is the Floeberg Charr (*Salvelinus arcturus*). This species has been brought from Victoria Lake and Floeberg Beach, in the extreme northern part of Arctic America, the northernmost point whence any salmonoid has been obtained.

The American Charr, or, as it is usually called, the Brook Trout (*Salvelinus fontinalis*), although one of the most beautiful of fishes, is perhaps the least graceful of all the genuine charrs. It is technically distinguished by the somewhat heavy head and large mouth, the maxillary bone reaching more or less beyond the eye. There are no teeth on the hyoid bone, traces at least of such teeth being found in nearly all other species. Its color is

somewhat different from that of the others, the red spots being large and the back more or less mottled and barred with darker olive. The dorsal and caudal fins are likewise barred or mottled, while in the other species they are generally uniform in color. The brook-trout is found only in streams east of the Mississippi and Saskatchewan. It occurs in all suitable streams of the Alleghany region and the Great Lake system, from the Chattahoochee River in northern Georgia northward at least to Labrador and Hudson Bay, the northern limits of its range being as yet not well ascertained. It varies greatly in size, according to its surroundings, those found in lakes being larger than those resident in small brooks. Those found farthest south, in the head-waters of the Chattahoochee, Savannah, Catawba, and French Broad, rarely pass the dimensions of fingerlings. The largest specimens are recorded from the sea along the Canadian coast. These frequently reach a weight of ten pounds; and from their marine and migratory habits, they may be regarded as forming a distinct variety (*Salvelinus fontinalis immaculatus*). The largest fresh-water specimens rarely exceed seven pounds in weight. Some unusually large brook-trout have been taken in the Rangeley lakes, the largest known to me having a reputed weight of eleven pounds. The brook-trout is the favorite game-fish of American waters, pre-eminent in wariness, in beauty, and in delicacy of flesh. It inhabits all clear and cold waters within its range, the large lakes and the smallest ponds, the tiniest brooks and the largest rivers; and when it can do so without soiling its

aristocratic gills on the way, it descends to the sea and grows large and fat on the animals of the ocean. Although a bold biter it is a wary fish, and it often requires much skill to capture it. It can be caught too with artificial or natural flies, minnows, crickets, worms, grasshoppers, grubs, the spawn of other fish, or even the eyes or cut pieces of other trout. It spawns in the fall, from September to late in November. It begins to reproduce at the age of two years, then having a length of about six inches. In spring-time the trout delight in rapids and swiftly running water; and in the hot months of midsummer they resort to deep, cool, and shaded pools. Later, at the approach of the spawning season, they gather around the mouths of cool, gravelly brooks whither they resort to make their beds.[1]

The trout are rapidly disappearing from our streams through the agency of the manufacturer and the summer-boarder. In the words of an excellent angler, Rev. Myron W. Reed, —

"This is the last generation of trout-fishers. The children will not be able to find any. Already there are well-trodden paths by every stream in Maine, in New York, and in Michigan. I know of but one river in North America by the side of which you will find no paper collar or other evidence of civilization. It is the Nameless River. Not that trout will cease to be. They will be hatched by machinery and raised in ponds, and fattened on chopped liver, and grow flabby and lose their spots. The trout of the restaurant will not cease to be. He is no more like the trout of the wild river than the fat and songless reed-

[1] Hallock.

bird is like the bobolink. Gross feeding and easy pond life enervate and deprave him. The trout that the children will know only by legend is the gold-springled living arrow of the white water; able to zigzag up the cataract; able to loiter in the rapids; whose dainty meat is the glancing butterfly."

The brook-trout adapts itself readily to cultivation in artificial ponds. It has been successfully transported to Europe, and is already abundant in certain streams in England and elsewhere.

The "Dolly Varden" Trout (*Salvelinus malma*) is very similar to the brook-trout, closely resembling it in size, form, color, and habits. It is found in the streams of northern California, Oregon, Washington, British Columbia, Alaska, and Kamtschatka, mostly to the westward of the Cascade Range. It often enters the sea, and specimens of eleven pounds' weight have been obtained by the writer in Puget Sound. The Dolly Varden trout is, in general, deeper in body, and less compressed than the Eastern brook-trout. The red spots are found on the back of the fish as well as on the sides, and the back and upper fins are without the marblings and blotches seen in *Salvelinus fontinalis*. In value as food, in beauty, and in gaminess, *Salvelinus malma* is very similar to its Eastern cousin.

Allied to the true charrs, and now placed by us with them in the genus *Salvelinus*, is the Great Lake Trout, otherwise known as Mackinaw Trout, Longe, or Togue (*Salvelinus namaycush*). Technically, this fish differs from the true charrs in having on its vomer a raised crest behind the chevron, and

free from the shaft. This crest is armed with strong teeth. There are also large hooked teeth on the hyoid bone, and the teeth generally are proportionately stronger than in most of the other species. The great lake-trout is grayish in color, light or dark according to its surroundings; and the body is covered with round paler spots, which are gray instead of red. The dorsal and caudal fins are marked with darker reticulations, somewhat as in the brook-trout. The great lake-trout is found in all the larger lakes from New England and New York to Wisconsin, Montana, and Alaska. It reaches a much larger size than any other *Salvelinus*, specimens of from fifteen to twenty pounds' weight being not uncommon, while it occasionally attains a weight of fifty to eighty pounds. As a food-fish it ranks high, although it may be regarded as somewhat inferior to the brook-trout or the white-fish. Compared with other salmonoids, the great lake-trout is a sluggish, heavy, and ravenous fish. It has been known to eat raw potato, liver, and corn-cobs, — refuse thrown from passing steamers. According to Herbert, "a coarse, heavy, stiff rod, and a powerful oiled hempen or flaxen line, on a winch, with a heavy sinker; a cod-hook, baited with any kind of flesh, fish, or fowl, — is the most successful, if not the most orthodox or scientific, mode of capturing him. His great size and immense strength alone give him value as a fish of game; but when hooked, he pulls strongly and fights hard, though he is a boring, deep fighter, and seldom if ever leaps out of the water, like the true salmon or brook-trout."

In the depths of Lake Superior is a variety of the great lake-trout known as the Siscowet (*Salvelinus namaycush siskawitz*), remarkable for its extraordinary fatness of flesh. The cause of this difference lies probably in some peculiarity of food, as yet unascertained.

THE DISPERSION OF FRESH-WATER FISHES.

WHEN I was a boy and went fishing in the brooks of western New York, I noticed that the different streams did not always have the same kinds of fishes in them. Two streams in particular in Wyoming County, not far from my father's farm, engaged in this respect my special attention. Their sources are not far apart, and they flow in opposite directions, on opposite sides of a low ridge, — an old glacial moraine, something more than a mile across. The Oatka Creek flows northward from this ridge, while the East Coy runs toward the southeast on the other side of it, both flowing ultimately into the same river, the Genesee.

It does not require a very careful observer to see that in these two streams the fishes are not quite the same. The streams themselves are similar enough. In each the waters are clear and fed by springs. Each flows over gravel and clay, through alluvial meadows, in many windings, and with elms and alders "in all its elbows." In both streams we were sure of finding Trout,[1] and in one of them the trout are still abundant. In both we used to catch the Brook Chub,[2] or, as we called

[1] *Salvelinus fontinalis* Mitchill.

[2] *Semotilus atromaculatus* Mitchill.

it, the "Horned Dace;" and in both were large schools of Shiners[1] and of Suckers.[2] But in every deep hole, and especially in the mill-ponds along the East Coy Creek, the Horned Pout[3] swarmed on the mucky bottoms. In every eddy, or in the deep hole worn out at the root of the elm-trees, could be seen the Sun-fish,[4] strutting in green and scarlet, with spread fins keeping intruders away from its nest. But in the Oatka Creek were found neither Horned Pout nor Sun-fish, nor have I ever heard that either has been taken there. Then besides these nobler fishes, worthy of a place on every school-boy's string, we knew by sight, if not by name, numerous smaller fishes, Darters[5] and Minnows,[6] which crept about in the gravel on the bottom of the East Coy, but which we never recognized in the Oatka.

There must be a reason for differences like these, in the streams themselves or in the nature of the fishes. The Sun-fish and the Horned Pout are home-loving fishes to a greater extent than the others which I have mentioned; still, where no obstacles prevent, they are sure to move about. There must be, then, in the Oatka some sort of barrier, or strainer, which keeping these species back permits others more adventurous to pass; and a wider knowledge of the geography of the region showed that such is the case. Farther

[1] *Notropis megalops* Rafinesque.
[2] *Catostomus teres* Mitchill.
[3] *Ameiurus melas* Rafinesque.
[4] *Lepomis gibbosus* Linnæus.
[5] *Etheostoma flabellare* Rafinesque.
[6] *Rhinichthys atronasus* Mitchill.

down in its course, the Oatka falls over a ledge of rock, forming a considerable waterfall at Rock Glen. Still lower down its waters disappear in the ground, sinking into some limestone cavern or gravel-bed, from which they reappear, after some six miles, in the large springs at Caledonia. Either of these barriers might well discourage a quiet-loving fish; while the trout and its active associates have sometime passed them, else we should not find them in the upper waters in which they alone form the fish-fauna. This problem is a simple one; a boy could work it out, and the obvious solution seems to be satisfactory.

Since those days I have been a fisherman in many waters, — not an angler exactly, but one who fishes for fish, and to whose net nothing large or small ever comes amiss; and wherever I go, I find cases like this.

We do not know all the fishes of America yet, nor all those well that we know by sight; still this knowledge will come with time and patience, and to procure it is a comparatively easy task. It is also easy to ascertain the more common inhabitants of any given stream. It is difficult, however, to obtain negative results which are really results. You cannot often say that a species does not live in a certain stream. You can only affirm that you have not yet found it there, and you can rarely fish in any stream so long that you can find nothing that you have not taken before. Still more difficult is it to gather the results of scattered observations into general statements regarding the distribution of fishes. The facts may be so few as to be

misleading, or so numerous as to be confusing; and the few writers who have taken up this subject in detail have found both these difficulties to be serious. Whatever general propositions we may maintain must be stated with the modifying clause of "other things being equal;" and other things are never quite equal. Dr. Wilder's saying that "Nature abhors a generalization" is especially applicable to all discussions of the relations of species to environment.

Still less satisfactory is our attempt to investigate the causes on which our partial generalizations depend, — to attempt to break to pieces the "other things being equal" which baffle us in our search for general laws. Scarcely anything has been written on this phase of the subject from an American point of view. This little I have tried to include with my own observations, in preparing this paper. The same problems, of course, come up on each of the other continents and in all groups of animals or plants; but most that I shall say will be confined to the question of the dispersion of fishes in the fresh waters of North America. The broader questions of the boundaries of faunæ and of faunal areas I shall bring up only incidentally.

Some of the problems to be solved were first noticed by Professor Agassiz in 1850, in his work on Lake Superior. Later (1854), in a paper on the fishes of the Tennessee River,[1] he makes the following statement: —

[1] On Fishes from Tennessee River, Alabama. American Journal of Science and Arts, xvii. 2d series, 1854, p. 26.

"The study of these features [of distribution] is of the greatest importance, inasmuch as it may eventually lead to a better understanding of the intentions implied in this seemingly arbitrary disposition of animal life. . . .

"There is still another very interesting problem respecting the geographical distribution of our fresh-water animals, which may be solved by the further investigation of the fishes of the Tennessee River. The water-course, taking the Powells, Clinch, and Holston Rivers as its head-waters, arises from the mountains of Virginia in latitude 37°; it then flows S. W. to latitude 34° 25′, when it turns W. and N. W., and finally empties into the Ohio, under the same latitude as its source in 37°.

"The question now is this: Are the fishes of this water system the same throughout its extent? In which case we should infer that water communication is the chief condition of geographical distribution of our fresh-water fishes. Or do they differ in different stations along its course? And if so, are the differences mainly controlled by the elevation of the river above the level of the sea, or determined by climatic differences corresponding to differences of latitude? We should assume that the first alternative was true if the fishes of the upper course of the river differed from those of the middle and lower courses in the same manner as in the Danube, from its source to Pesth, where this stream flows nearly for its whole length under the same parallel. We would, on the contrary, suppose the second alternative to be well founded if marked differences were observed between the fish of such tracts of the river as do not materially differ in their elevation above the sea, but flow under different latitudes. Now, a few collections from different stations along this river, like that sent me by Dr. Newman from the vicinity of Huntsville, would settle at once this question, not for the Tennessee River alone, but for

most rivers flowing under similar circumstances upon the surface of the globe. Nothing, however, short of such collections, compared closely with one another, will furnish a reliable answer. . . . Whoever will accomplish this survey will have made a highly valuable contribution to our knowledge."

Certain conclusions were also suggested by Professor Cope in his excellent memoir on the fishes of the Alleghany region[1] in 1868. From this paper I make the following quotations: —

"The distribution of fresh-water fishes is of special importance to the questions of the origin and existence of species in connection with the physical conditions of the waters and of the land. This is, of course, owing to the restricted nature of their habitat, and the impossibility of their making extended migrations. With the submergence of land beneath the sea, fresh-water fish are destroyed in proportion to the extent of the invasion of salt water, while terrestrial vertebrates can retreat before it. Hence every inland fish-fauna dates from the last total submergence of the country.

"Prior to the elevation of a given mountain chain, the courses of the rivers may generally have been entirely different from their later ones. Subsequent to this period, they can only have undergone partial modifications. As subsequent submergences can rarely have extended to the highlands where such streams originate, the fishes of such rivers can only have been destroyed so far as they were unable to reach those elevated regions, and preserve themselves from destruction from salt water by sheltering themselves in mountain streams. On the other hand,

[1] On the Distribution of Fresh-Water Fishes in the Alleghany Region of Southwestern Virginia. Journ. Acad. Nat. Sci., Phila., 1868, pp. 207–247.

a period of greater elevation of the land, and of consequent greater cold, would congeal the waters and cover their courses with glaciers. The fishes would be driven to the neighborhood of the coast, though no doubt in more southern latitudes a sufficient extent of uncongealed fresh waters would flow by a short course into the ocean, to preserve from destruction many forms of fresh-water fishes. Thus, through many vicissitudes, the fauna of a given system of rivers has had opportunity of uninterrupted descent, from the time of the elevation of the mountain range, in which it has its sources. . . .

"As regards the distinction of species in the disconnected basins of different rivers, which have been separated from an early geologic period, if species occur which are common to any two or more of them, the supporter of the theory of distinct creations must suppose that such species have been twice created, once for each hydrographic basin, or that waters flowing into the one basin have been transferred to another. The developmentalist, on the other hand, will accept the last proposition, or else suppose that time has seen an identical process and similar result of modification in these distinct regions.

"Facts of distribution in the eastern district of North America are these. Several species of fresh-water fishes occur at the same time in many Atlantic basins, from the Merrimac or from the Hudson to the James, and throughout the Mississippi Valley, and in the tributaries of the Great Lakes. On the other hand, the species of each river may be regarded as pertaining to four classes, whose distribution has direct reference to the character of the water and the food it offers: first, those of the tide-waters, of the river channels, bayous, and sluggish waters near them, or in the flat lands near the coast; second, those of the river channels of its upper course,

where the currents are more distinct; third, those of the creeks of the hill country; fourth, those of the elevated mountain streams which are subject to falls and rapids."

Farther on in the same paper, Professor Cope reaches two important general conclusions, thus stated by him: —

"I. That species not generally distributed exist in waters on different sides of the great water-shed.

"II. That the distribution of the species is not governed by the outlet of the rivers, streams having similar discharges (Holston and Kanawha, Roanoke and Susquehanna) having less in common than others having different outlets (Kanawha, or Susquehanna and James).

"In view of the first proposition, and the question of the origin of species, the possibility of an original or subsequent mingling of the fresh waters suggests itself as more probable than that of distinct origin in the different basins."

Two questions in this connection are raised by Professor Cope. The first question is this: "Has any destruction of the river faunæ taken place since the first elevation of the Alleghanies, when the same species were thrown into waters flowing in opposite directions?" Of such destruction by submergence or otherwise, Professor Cope finds no evidence. The second question is, "Has any means of communication existed, at any time, but especially since the last submergence, by which the transfer of species might occur?" Some evidence of such transfer exists in the wide distribution of certain species, especially those which

seek the highest streamlets in the mountains; but except to call attention to the cavernous character of the Subcarboniferous and Devonian limestones, Professor Cope has made little attempt to account for it.

Professor Cope finally concludes with this important generalization: —

"It would appear, from the previous considerations, that the distribution of fresh-water fishes is governed by laws similar to those controlling terrestrial vertebrates and other animals, in spite of the seemingly confined nature of their habitat."

Dr. Günther[1] has well summarized some of the known facts in regard to the manner of dispersion of fishes: —

"The ways in which the dispersal of fresh-water fishes has been effected were various. They are probably all still in operation, but most work so slowly and imperceptibly as to escape direct observation; perhaps they will be more conspicuous after science and scientific inquiry shall have reached a somewhat greater age. From the great number of fresh-water forms which we see at this present day acclimatized in, gradually acclimatizing themselves in, or periodically or sporadically migrating into, the sea, we must conclude that under certain circumstances salt water may cease to be a barrier at some period of the existence of fresh-water species, and that many of them have passed from one river through salt water into another. Secondly, the head-waters of some of the grandest rivers, the mouths of which are at opposite ends of the continents which they drain, are sometimes distant from each other a few miles only. The

[1] Guide to the Study of Fishes, 1880, p. 211.

intervening space may have been easily bridged over for the passage of fishes by a slight geological change affecting the level of the water-shed or even by temporary floods; and a communication of this kind, if existing for a limited period only, would afford the ready means of an exchange of a number of species previously peculiar to one or the other of these river or lake systems. Some fishes provided with gill-openings so narrow that the water moistening the gills cannot readily evaporate, and endowed, besides, with an extraordinary degree of vitality, like many Siluroids (*Clarias*, *Callichthys*), Eels, etc., are enabled to wander for some distance over land, and may thus reach a water-course leading them thousands of miles from their original home. Finally, fishes or their ova may be accidentally carried by water-spouts, by aquatic birds or insects, to considerable distances."

A somewhat detailed statement of the known facts, arranged in the form of twenty-eight propositions, was given by me in 1878.[1] To these some further data were added in a paper by Professor Gilbert and myself on the fishes of Arkansas and Texas,[2] published during the past year. These few memoirs, four or five in number, and dealing chiefly with other things, give about all that has been done in the way of generalization on this subject; and in none of these is the question of causes or methods in distribution dealt with in detail or to any important extent.

[1] On the Distribution of the Fishes of the Alleghany Region, of South Carolina, Georgia, and Tennessee, with Descriptions of new or little-known Species. Bull. U. S. Nat. Mus., xii. 1878, pp. 91–95.

[2] List of Fishes collected in Arkansas, Indian Territory, and Texas, in September, 1884, with Notes and Descriptions. Proc. U. S. Nat. Mus., 1886, pp. 1–25.

We now recognize about six hundred species[1] of fishes as found in the fresh waters of North

[1] The table below shows approximately the composition of the fresh-water fish-fauna of Europe, as compared with that of North America north of the Tropic of Cancer. (See a review of Seeley's "Fresh Water Fishes of Europe," *The Dial*, Chicago, June, '86, p. 35.)

FAMILIES.		EUROPE.	N. AMERICA.
Lamprey	*Petromyzontidæ*	3 species.	8 species.
Paddle-fish	*Polyodontidæ*	— "	1 "
Sturgeon	*Acipenseridæ*	10 "	6 "
Gar-pike	*Lepisosteidæ*	— "	3 "
Bow-fin	*Amiatidæ*	— "	1 "
Cat-fish	*Siluridæ*	1 "	25 "
Sucker	*Catostomidæ*	— "	51 "
Loach	*Cobitidæ*	3 "	— "
Carp	*Cyprinidæ*	61 "	230 "
Characin	*Characinidæ*	— "	1 "
Moon-eye	*Hiodontidæ*	— "	3 "
Herring	*Clupeidæ*	2 "	5 "
Gizzard-shad	*Dorosomidæ*	— "	1 "
Salmon	*Salmonidæ*	12 "	28 "
Trout-perch	*Percopsidæ*	— "	1 "
Blind-fish	*Amblyopsidæ*	— "	5 "
Killifish	*Cyprinodontidæ*	3 "	52 "
Mud-minnow	*Umbridæ*	1 "	1 "
Pike	*Esocidæ*	1 "	5 "
Alaska Black-fish	*Dalliidæ*	— "	1 "
Eel	*Anguillidæ*	2 "	1 "
Stickleback	*Gasterosteidæ*	3 "	7 "
Silverside	*Atherinidæ*	2 "	2 "
Pirate Perch	*Aphredoderidæ*	— "	1 "
Elassoma	*Elassomidæ*	— "	2 "
Sun-fish	*Centrarchidæ*	— "	37 "
Perch	*Percidæ*	11 "	72 "
Bass	*Serranidæ*	1 "	4 "
Drum	*Sciænidæ*	— "	1 "
Surf-fish	*Embiotocidæ*	— "	1 "
Cichlid	*Cichlidæ*	— "	2 "
Goby	*Gobiidæ*	2 "	6 "
Sculpin	*Cottidæ*	2 "	21 "
Blenny	*Blenniidæ*	3 "	— "
Cod	*Gadidæ*	1 "	1 "
Flounder	*Pleuronectidæ*	1 "	— "
Sole	*Soleidæ*	1 "	1 "

Total: Europe, 21 families; 126 species. North America, 34 families; 587 species.

According to Dr. Günther (Guide to the Study of Fishes, p. 243), the total number of species now known from the temperate

America, north of the Tropic of Cancer, these representing thirty-four of the natural families. As to their habits, we can divide these species rather roughly into the four categories proposed by Professor Cope, or, as we may call them, —

(1) Lowland fishes; as the Bow-fin,[1] Pirate Perch,[2] large-mouthed Black Bass,[3] Sun-fishes and some Cat-fishes.

(2) Channel-fishes; as the Channel Cat-fish,[4] the Moon-eye,[5] Gar-pike,[6] Buffalo-fishes,[7] and Drum.[8]

(3) Upland fishes; as many of the Darters, Shiners and Suckers, and the small-mouthed Black Bass.[9]

(4) Mountain-fishes; as the Brook Trout, and many of the Darters and Minnows.

To these we may add the more or less distinct classes of (5) Lake-fishes, inhabiting only waters which are deep, clear, and cold, as the various species of White-fish[10] and the Great Lake Trout;[11]

regions of Asia and Europe is about 360. The fauna of India, south of the Himalayas, is much more extensive, numbering 625 species. This latter fauna bears little resemblance to that of North America, being wholly tropical in its character.

[1] *Amiatus calvus* Linnæus.
[2] *Aphredoderus sayanus* Gilliams.
[3] *Micropterus salmoides* Lacépède.
[4] *Ictalurus punctatus* Rafinesque.
[5] *Hiodon tergisus* Le Sueur.
[6] *Lepisosteus osseus* Linnæus.
[7] *Ictiobus bubalus, cyprinella*, etc.
[8] *Aplodinotus grunniens* Rafinesque.
[9] *Micropterus dolomieu* Lacépède.
[10] *Coregonus clupeiformis, artedi*, etc.
[11] *Salvelinus namaycush* Walbaum.

(6) Anadromous fishes, or those which run up from the sea to spawn in fresh waters, as the Salmon,[1] Sturgeon,[2] Shad,[3] and Striped Bass;[4] (7) Catadromous fishes, like the Eel,[5] which pass down to spawn in the sea; and (8) brackish-water fishes, which thrive best in the debatable waters of the river-mouths, as most of the Sticklebacks and the Killifishes.

As regards the range of species, we have every possible gradation from those which seem to be confined to a single river, and are rare even in their restricted habitat, to those which are in a measure cosmopolitan,[6] ranging everywhere in suitable waters.

Still, again, we have all degrees of constancy and inconstancy in what we regard as the characters of a species. Those found only in a single river-basin are usually uniform enough; but the species having a wide range usually vary much in different localities. Such variations have at different times been taken to be the indications of as many different species. Continued explorations bring to light, from year to year, new species; but the number of new forms now discovered each year is usually less than the number of recognized species which are yearly proved to be intenable. Three complete lists of the fresh-water fishes of the United States

[1] *Salmo salar* Linnæus.
[2] *Acipenser*, sp.
[3] *Clupea sapidissima* Wilson.
[4] *Morone lineata* Bloch.
[5] *Anguilla anguilla* Linnæus.
[6] Thus the Chub-sucker (*Erimyzon sucetta*) in some of its varieties ranges everywhere from Maine to Dakota, Florida, and Texas; while a number of other species are scarcely less widely distributed.

have been published by the present writer. That of Jordan and Copeland,[1] published in 1876, enumerates 670 species. That of Jordan[2] in 1878 contains 665 species, and that of Jordan[3] in 1885, 587 species, although upwards of 75 new species were detected in the nine years which elapsed between the first and the last list. Additional specimens from intervening localities are often found to form connecting links among the nominal species, and thus several supposed species become in time merged in one. Thus the Common Channel Cat-fish[4] of our rivers has been described as a new species not less than twenty-five times, on account of differences real or imaginary, but comparatively trifling in value.

Where species can readily migrate, their uniformity is preserved; but whenever a form becomes localized its representatives assume some characters not shared by the species as a whole. When we can trace, as we often can, the disappearance by degrees of these characters, such forms no longer represent to us distinct species. In cases where the connecting forms are extinct, or at least not represented in collections, each form which is

[1] Check List of the Fishes of the Fresh Waters of North America, by David S. Jordan and Herbert E. Copeland. Bulletin of the Buffalo Society of Natural History, 1876, pp. 133–164.

[2] A Catalogue of the Fishes of the Fresh Waters of North America. Bulletin of the United States Geological Survey, 1878, pp. 407-442.

[3] A Catalogue of the Fishes known to inhabit the Waters of North America North of the Tropic of Cancer. Annual Report of the Commissioners of Fish and Fisheries for 1884 and 1885.

[4] *Ictalurus punctatus* Rafinesque.

apparently different must be regarded as a distinct species.

The variations in any type become, in general, more marked as we approach the tropics. The genera are represented, on the whole, by more species there, and it would appear that the processes of specific change go on more rapidly under the easier conditions of life in the Torrid Zone.

We recognize now in North America twenty-five distinct species of fresh-water Cat-fishes,[1] although nearly a hundred (93) nominal species of these fishes have been from time to time described. But these twenty-five species are among themselves very closely related, and all of them are subject to a variety of minor changes. It requires no strong effort of the imagination to see in them all the modified descendants of some one species of Cat-fish, not unlike our Common "Bull-head,[2] — an immigrant probably from Asia, and which has now adjusted itself to its surroundings in each of our myriad of Cat-fish breeding streams.

The word "species," then, is simply a term of convenience, including such members of a group similar to each other as are tangibly different from others, and are not known to be connected with these by intermediate forms. Such connecting links we may suppose to have existed in all cases. We are only sure that they do not now exist in our collections, so far as these have been carefully studied.

When two or more species of any genus now inhabit the same waters, they are usually species

[1] *Siluridæ.* [2] *Ameiurus nebulosus.*

whose differentiation is of long standing, — species, therefore, which can be readily distinguished from one another. When, on the other hand, we have "representative species," — closely related forms, neither of which is found within the geographical range of the other, — we can with some confidence look for intermediate forms where the territory occupied by the one bounds that inhabited by the other. In very many such cases the intermediate forms have been found; and such forms are considered as sub-species of one species, the one being regarded as the parent stock, the other as an offshoot due to the influences of different environment. Then, besides these "species" and "sub-species," groups more or less readily recognizable, there are varieties and variations of every grade, often too ill-defined to receive any sort of name, but still not without significance to the student of the origin of species. Comparing a dozen fresh specimens of almost any kind of fish from any body of water with an equal number from somewhere else, one will rarely fail to find some sort of differences, — in size, in form, in color. These differences are obviously the reflex of differences in the environment, and the collector of fishes seldom fails to recognize them as such; often it is not difficult to refer the effect to the conditions. Thus, fishes from grassy bottoms are darker than those taken from over sand, and those from a bottom of muck are darker still, the shade of color being, in some way not well understood, dependent on the color of the surroundings. Fishes in large bodies of water reach

a larger size than the same species in smaller streams or ponds. Fishes from foul or sediment-laden waters are paler in color and slenderer in form than those from waters which are clear and pure. Again, it is often true that specimens from northern waters are less slender in body than those from farther south; and so on. Other things being equal, the more remote the localities from each other, the greater are these differences.

In our fresh-water fishes each species on an average has been described as new from three to four times, on account of minor variations, real or supposed. In Europe, where the fishes have been studied longer and by more different men, upwards of six or eight nominal species have been described for each one that is now considered distinct.

It is evident, from these and other facts, that the idea of a separate creation for each species of fishes in each river basin, as entertained by Agassiz, is wholly incompatible with our present knowledge of the specific distinctions or of the geographical distribution of fishes. This is an unbroken gradation in the variations from the least to the greatest, — from the peculiarities of the individual, through local varieties, geographical sub-species, species, sub-genera, genera, families, super-families, and so on, until all fish-like vertebrates are included in a single bond of union.

It is, however, evident that not all American types of fishes had their origin in America, or even first assumed in America their present forms. Some of these are perhaps immigrants from northern Asia, where they still have their nearest

relatives. Still others are evidently modified importations from the sea; and of these some are very recent immigrants, landlocked species which have changed very little from the parent stock.

The character and possible origin of each of the thirty-four families of North American fresh-water fishes may be briefly summarized as follows: —

The *Lampreys* are evidently of marine origin, as the marine species are still anadromous. The fresh-water species, compared with the marine ones, are smaller in size and weaker in organization, and represent larval conditions or arrests of development of the latter form.

The *Paddle-fish* is allied to extinct ganoid types. The group is now represented by one species in America and another in central Asia.

The *Sturgeons*, like the Lampreys, are anadromous. But two of the American species are now confined to the fresh waters, and one of these belongs to a peculiar genus (*Scaphirhynchus*), which (like *Polyodon*) has representatives also in central Asia. As to whether the parent stock in either case is American or Asiatic, I know of no positive evidence.

The *Gar-pikes* and the *Bow-fins* are strictly American types allied to extinct ganoid forms, and doubtless developed from such in the waters they now inhabit.

The *Cat-fishes* of America are all probably descendants of a common stock, not allied to South American forms, but probably finding its nearest relatives in India. A single species of this type now exists in China (*Ameiurus cantonensis*); but

this is perhaps a returned emigrant from America, rather than a direct offshoot of the parent stock.

The *Suckers* are modified *Cyprinidæ*, probably developed originally in America, although one species has spread from Alaska to Siberia, and another very peculiar form exists in China. Whatever its origin, this group is now one of the most characteristic of our fauna.

The *Cyprinidæ* of western America are more or less closely related to Old World types, and some of them, like the Old World species, reach a great size. East of the Rocky Mountains are found a multitude of species, mostly of small size and weak organization, which seem to be degenerate or reduced representatives of Old World types, and which have for the most part no immediate relatives among the latter. The majority of these species are now placed in a single genus, *Notropis*, which is found only in America, and is one of the most characteristic of our fish-fauna.

The *Characins* belong to the tropics, especially to South America. The single species which crosses the Rio Grande is doubtless an immigrant from Mexico. The same remarks apply also to the *Cichlids*, — a group especially characteristic of tropical America, one species of which reaches southern Texas.

The *Moon-eyes* are characteristically American type, with no near relatives elsewhere in the world. Their ancestors were probably immigrants from the sea.

The *Herring* permanently resident in our fresh waters are simply landlocked representatives of

species still found in the sea along our coasts. Other species are anadromous, ascending the rivers in the spring.

The *Gizzard-shad* is indifferently marine, anadromous, or landlocked, and is still extending its range in sluggish waters through the agency of canals.

The various forms of *Salmonidæ* abound in the streams and lakes of all northern regions. The larger species are marine and anadromous, the smaller confined to lakes and brooks; but all seek streams or at least shallower waters for the purpose of spawning. The whole group had probably a marine origin; the more strictly fresh-water species being, as is usually the case, smaller in size, weaker in organization, and with feebler dentition. It is often assumed that this group has had its origin in the Atlantic; but whether in America or in Europe, we have no means of inferring.

The *Trout-perch* show a curious combination of characters of spiny and soft-rayed fishes. The single species is probably, as suggested by Agassiz, a relic of an ancient fauna.

The *Blind-fishes* are also very unique in their organization. Two of the known species have well-developed eyes, and live in lowland streams and springs. Such are doubtless ancestors of the eyeless forms of the cave streams, but the immediate progenitors and relatives of these seem to be extinct. They were probably fresh-water rather than marine forms, and of the same general stock as the ancestors of the Killifishes, Mud-minnows, and Pike.

The *Killifishes* have their greatest abundance in tropical America, which is perhaps the place of their origin. They are especially fishes of the brackish waters, rarely going far out to sea. Some of them ascend streams; and these frequent spring waters, and waters which are clear and cold.

The two species of *Mud-minnow* are now very widely separated as to habitat, although very similar to each other in structure. The one belongs properly to our Great Lake Fauna, the other to the streams of Austria. The two are probably remains of a past fauna, in which the group was more fully represented. Our Mud-minnow[1] is one of the most tenacious of life of all our fishes, and will often live for weeks in damp muck after the waters of a pond have evaporated.

Of the five known species of *Pike*, one is cosmopolitan, being spread over northern Asia and Europe as well as America, while the other species are somewhat restricted in their range. The Common Pike[2] is probably the parent stock of all; but whether originally American or not, we cannot say. The affinities of the Mud-minnow with the Pike are not remote, and doubtless forms between the two have existed.

The *Black-fish*[3] of Alaska is another relative of the Mud-minnow and Pike. The single known species is found in Alaska and eastern Siberia. It too is probably an isolated relic of a disappearing group.

[1] *Umbra limi* Kirtland.

[2] *Esox lucius* Linnæus.

[3] *Dallia pectoralis* Bean.

The *Common Eel*[1] is more or less regularly catadromous. It is doubtless of marine origin; and the same species is widely diffused in America and Europe, though curiously wanting on our Pacific coasts, as well as in South America.

The *Sticklebacks* and the *Silversides* are seashore fishes, the former of cold, the latter of warm regions. Some species of both are now permanent residents in fresh water. The Sticklebacks especially show all degrees of transition, the strictly fluviatile forms being as usual smaller in size and weaker in armature than the marine ones.

The *Pirate Perches* and the *Elassoma* are two very small families, related to each other, and distantly related perhaps to the Sun-fishes. They are probably remains of some older fauna, and are possibly allied to the *Berycoids;* but this relation, if real, is not very close.

The *Sun-fishes* are peculiarly North American, nothing similar being found in any other region. Their ancestry is probably to be sought among the marine *Serranidæ*, the large-mouthed Black Bass[2] being probably the member of the former group nearest the parent stock.

The fresh-water (striped) *Bass*[3] are evidently allied to the anadromous members of the same group.

The *Perch* family is perhaps originally an offshoot from the Sea Bass. It has, however, received a peculiar development in American waters.

[1] *Anguilla anguilla* Linnæus.

[2] *Micropterus salmoides* Lacépède.

[3] *Morone chrysops*, *mississippiensis*, etc.

The large group or genus of *Darters*[1] is composed of small, brilliantly colored Perches, whose structure is especially adapted for life on the rocky bottoms of small clear streams. The relations of these species to the typical Perches have been admirably discussed by Professor S. A. Forbes, from whose paper[2] I make the following quotations: —

"We must inquire, therefore, into the causes which have operated on a group of Percoids to limit their range to such apparently unfavorable conditions, to diminish their size, to develop unduly the paired fins and reduce the air-bladder, to remove the scales of several species more or less completely, . . . and to restrict their food chiefly to a few forms [of insect-larvæ and crustacea].

"No species can long maintain itself anywhere which cannot in some way find a sufficient supply of food and also protect itself against its enemies. In its contests with its enemies it may acquire defensive structures or powers of escape sufficient for its protection, or it may become adapted to some place of refuge where other fishes will not follow. What better refuge could a harassed fish desire than the hiding-places among stones in the shallows of a stream where the water dashes ceaselessly by with a swiftness few fish can stem? And if at the same time the refugee develop a swimming power which enables it to dart like a flash against the strongest current, its safety would seem to be insured. But what food could it find in such a place? Let us turn over the stones in such a stream, sweeping the roiled water at the same time with a small cloth net, and we shall find larva

[1] *Etheostoma.*

[2] A Catalogue of the Native Fishes of Illinois. Report of the Illinois Fish Commissioners, 1884, p. 95.

of *Chironomus* and small Ephemerids, and other such prey and little else, — food too minute and difficult of access to support a large fish, but answering very well if our immigrant can *keep down his size*. . . . The limited supply of food early arrests the growth of the young; while every fish which passes the allowable maximum is forced for food to brave the dangers of the deeper waters, where the chances are that it falls a prey. On the other hand, the smaller the size of those which escape this alternative, the less likely will they be to attract the appetite of the small gar or other guerilla, which may occasionally raid their retreat, and the more easily will they slip about under stones in search of their microscopic game.

"Like other fishes, the darters must have their periods of repose, all the more urgent because of the constant struggle with the swift current which their habitat imposes. Shut out from the deep, still pools and slow eddies where the larger species lurk, they are forced to spend their leisure on or beneath the bottom of the stream, resting on their extended ventrals and anal, or wholly buried in the sand. . . .

"Doubtless the search for food has much to do with this selection in a habitat. I have found that the young of nearly all species of our fresh-water fishes are competitors for food, feeding almost entirely on *Entomostraca* and the larvæ of minute Diptera. As a tree sends out its roots in all directions in search of nourishment, so each of the larger divisions of animals extends its various groups into every place where available food occurs, each group becoming adapted to the special features of its situation. Given this supply of certain kinds of food, nearly inaccessible to the ordinary fish, it is to be expected that some fishes would become especially fitted to its utilization. Thus the *Etheostomatinæ* [Darters] as a group are to be

explained, in a word, by the hypothesis of the progressive adaptation of the young of certain *Percidæ* to a peculiar place of refuge and a peculiar food-supply.

"Perhaps we may, without violence, call these the mountaineers among fishes. Forced from the populous and fertile valleys of the river beds and lake bottoms, they have taken refuge from their enemies in the rocky highlands, where the free waters play in ceaseless torrents, and there they have wrested from stubborn Nature a meagre living. Although diminished in size by their continual struggle with the elements, they have developed an activity and hardihood, a vigor of life, and glow of high color almost unknown among the easier livers of the lower lands."

It is noteworthy that among the European genera of *Percidæ*, one of them, *Aspro*, has assumed a similar habitat, and adapted — apparently as a result of its surroundings — characters similar to those of *Etheostoma*. It is not likely that *Aspro* is an ancestor of *Etheostoma*, still less likely that *Aspro* is descended from the latter genus. The similar development of the two seems rather a case of *analogous variation*, the influence of similar conditions in different places on similar organisms.

It is remarkable, also, that in mountain regions in which no *Percidæ* are found, fishes very similar to the Darters in appearance and habits, though totally different in structure, have by analogous agencies been developed. Loaches, Cat-fishes, Gobies, Characins, Sculpins, in different parts of the world inhabit swift mountain streams, and in a similar way become dwarfed and concentrated, taking the place in their respective habitats which

the Darters occupy in the waters of the Mississippi Valley.

By the same process of "analogous variation" the *Cichlidæ* of South America parallel the Sunfishes of the United States, although in structure and in origin the two groups are diverse.

The single species each of *Drum*,[1] *Surf-fish*,[2] and *Cod*[3] found in our fresh waters are evidently immigrants from the sea, although not of recent origin. The several species of Sculpin have apparently come from two separate marine stocks, — the one (*Cottus*) comparatively ancient and probably originating in the Pacific, the other (*Triglopsis*) more modern and descended from an Atlantic species (*Acanthocottus quadricornis*, L.). The former type is now diffused in all cold waters of North America, Europe, and northern Asia. The latter belongs only to the depths of the Great Lakes.

The *Flounders* and *Soles* when found in fresh waters are merely temporary sojourners from the sea.

We can say, in general, that in all waters not absolutely uninhabitable there are fishes. The processes of natural selection have given to each kind of river or lake species of fishes adapted to the conditions of life which obtain there. There is no condition of water, of bottom, of depth, of speed of current, but finds some species with characters adjusted to it. These adjustments are, for the most part, of long standing; and the fauna

[1] *Aplodinotus grunniens* Rafinesque.
[2] *Hysterocarpus traski* Gibbons.
[3] *Lota lota* Linnæus.

of any single stream has, as a rule, been produced by immigration from other regions or from other streams. Each species has an ascertainable range of distribution, and within this range we may be reasonably certain to find it in any suitable waters.

But every species has beyond question some sort of limit to its distribution, some sort of barrier which it has never passed in all the years of its existence. That this is true becomes evident when we compare the fish-faunæ of widely separated rivers. Thus the Sacramento, Connecticut, Rio Grande, and St. John's Rivers have not a single species in common; and with one or two exceptions, not a species is common to any two of them. None of these[1] has any species peculiar to itself, and each shares a large part of its fish-fauna with the water-basin next to it. It is probably true that the faunæ of no two distinct hydrographic basins are wholly identical, while on the other hand there are very few species confined to a single one. The supposed cases of this character, some twenty in number, occur chiefly in the streams of the South Atlantic States and of Arizona. All of these need, however, the confirmation of further exploration. It is certain that in no case has an entire river-fauna[2] originated independently from the divergence into separate species of the descendants of a single type.

The existence of boundaries to the range of

[1] Except possibly the Sacramento.

[2] Unless the fauna of certain cave-streams in the United States and Cuba be regarded as forming an exception.

species implies, therefore, the existence of barriers to their diffusion. We may now consider these barriers; and, in the same connection, the degree to which they may be overcome.

Least important of these are the barriers which may exist within the limits of any single basin, and which tend to prevent a free diffusion through its waters of species inhabiting any portion of it. In streams flowing southward, or across different parallels of latitude, the difference in climate becomes a matter of importance. The distribution of species is governed very largely by the temperature of the water. Each species has its range in this respect, — the free-swimming fishes, notably the Trout, being most affected by it; the mud-loving or bottom fishes, like the Cat-fishes, least. The latter can reach the cool bottoms in hot weather, or the warm bottoms in cold weather, thus keeping their own temperature more even than that of the surface of the water. Although water-communication is perfectly free for most of the length of the Mississippi, there is a material difference between the faunæ of the stream in Minnesota and in Louisiana. This difference is caused chiefly by the difference in temperature occupying the difference in latitude. That a similar difference in longitude, with free water communication, has no appreciable importance, is shown by the almost absolute identity of the fish-faunæ of Lake Winnebago and Lake Champlain. While many large fishes range freely up and down the Mississippi, a majority of the species do not do so, and the fauna of the upper Mississippi has more in

common with that of the tributaries of Lake Michigan than it has with that of the Red River or the Arkansas. The influence of climate is again shown in the paucity of the fauna of the cold waters of Lake Superior, as compared with that of Lake Michigan. The majority of our species cannot endure the cold. In general, therefore, cold or Northern waters contain fewer species than Southern waters do, though the number of individuals of any one kind may be greater. This is shown in all waters, fresh or salt. The fisheries of the Northern seas are more extensive than those of the Tropics. There are more fishes there, but they are far less varied in kind. The writer once caught seventy-five species of fishes in a single haul of the seine at Key West, while on Cape Cod he obtained with the same net but forty-five species in the course of a week's work. Thus it comes that the angler, contented with many fishes of few kinds, goes to Northern streams to fish, while the naturalist goes to the South.

But in most streams the difference in latitude is insignificant, and the chief differences in temperature come from differences in elevation, or from the distance of the waters from the colder source. Often the lowland waters are so different in character as to produce a marked change in the quality of their fauna. These lowland waters may form a barrier to the free movements of upland fishes; but that this barrier is not impassable is shown by the identity of the fishes in the streams[1] of the

[1] For example, Elk River, Duck River, etc.

uplands of middle Tennessee with those of the Holston and French Broad. Again, streams of the Ozark Mountains, similar in character to the rivers of East Tennessee, have an essentially similar fish-fauna, although between the Ozarks and the Cumberland range lies an area of lowland bayous, into which such fishes are never known to penetrate. We can, however, imagine that these upland fishes may be sometimes swept down from one side or the other into the Mississippi, from which they might ascend on the other side. But such transfers certainly do not often happen. This is apparent from the fact that the two faunæ[1] are not quite identical, and in some cases the same species are represented by perceptibly different varieties on one side and the other. The time of the commingling of these faunæ is perhaps now past, and it may have occurred only when the climate of the intervening regions was colder than at present.

The effect of waterfalls and cascades as a barrier to the diffusion of most species is self-evident; but the importance of such obstacles is less, in the course of time, than might be expected. In one way or another very many species have passed these barriers. The falls of the Cumberland limit

[1] There are three species of Darters (*Etheostoma copelandi* Jordan; *Etheostoma evides* Jordan and Copeland; *Etheostoma scierum* Swain) which are now known only from the Ozark region or beyond and from the uplands of Indiana, not yet having been found at any point between Indiana and Missouri. These constitute perhaps isolated colonies, now separated from the parent stock in Arkansas by the prairie districts of Illinois, a region at present uninhabitable for these fishes. But the non-occurrence of these species over the intervening areas needs confirmation, as do most similar cases of anomalous distribution.

the range of most of the larger fishes of the river, but the streams above it have their quota of Darters and Minnows. It is evident that the past history of the stream must enter as a factor into this discussion, but this past history it is not always possible to trace. Dams or artificial waterfalls now check the free movement of many species, especially those of migratory habits; while, conversely, numerous other species have extended their range through the agency of canals.[1]

Every year fishes are swept down the rivers by the winter's floods; and in the spring, as the spawning season approaches, almost every species is found working its way up the stream. In some cases, notably the Quinnat Salmon[2] and the Blueback Salmon,[3] the length of these migrations is surprisingly great. To some species rapids and shallows have proved a sufficient barrier, and other kinds have been kept back by unfavorable conditions of various sorts. Streams whose waters are always charged with silt or sediment, as the Missouri, Arkansas, or Brazos, do not invite fishes; and even the occasional floods of red mud such as disfigure otherwise clear streams, like the Red River or the Colorado (of Texas), are unfavorable. Extremely unfavorable also is the condition which obtains in many rivers of the Southwest; as for example, the Red River, the Sabine, and the Trinity, which are full from bank to bank in winter and

[1] Thus, *Dorosoma cepedianum* Le Sueur, and *Clupea chrysochloris* Rafinesque, have found their way into Lake Michigan through canals.

[2] *Oncorhynchus tschawytscha* Walbaum.

[3] *Oncorhynchus nerka* Walbaum.

spring, and which dwindle to mere rivulets in the autumn droughts.

In general, those streams which have conditions most favorable to fish-life will be found to contain the greatest number of species. Such streams invite immigration; and in them the struggle for existence is individual against individual, species against species, and not a mere struggle with hard conditions of life. Some of the conditions most favorable to the existence in any stream of a large number of species of fishes are the following, the most important of which is the one mentioned first: connection with a large hydrographic basin; a warm climate; clear water; a moderate current; a bottom of gravel (preferably covered by a growth of weeds); little fluctuation during the year in the volume of the stream or in the character of the water.

Limestone streams usually yield more species than streams flowing over sandstone, and either more than the streams of regions having metamorphic rocks. Sandy bottoms usually are not favorable to fishes. In general, glacial drift makes a suitable river bottom, but the higher temperature usual in regions beyond the limits of the drift gives to certain Southern streams conditions still more favorable. These conditions are all well realized in the Washita River in Arkansas, and in various tributaries of the Tennessee, Cumberland, and Ohio; and in these, among American streams, the greatest number of species has been recorded.

The isolation and the low temperature of the rivers of New England have given to them a very

scanty fish-fauna as compared with the rivers of the South and West. This fact has been noticed by Professor Agassiz, who has called New England a "zoölogical island." [1]

In spite of the fact that barriers of every sort are sometimes crossed by fresh-water fishes, we must still regard the matter of freedom of water communication as the essential one in determining the range of most species. The larger the river basin, the greater the variety of conditions likely to be offered in it, and the greater the number of its species. In case of the divergence of new forms by the processes called "natural selection," the greater the number of such forms which may have spread through its waters; the more extended any river basin, the greater are the chances that any given species may sometime find its way into it; hence the greater the number of species that actually occur in it, and, freedom of movement being assumed, the greater the number of species to be found in any one of its affluents.

Of the six hundred species of fishes found in the rivers of the United States, about two hundred have been recorded from the basin of the Mississippi. From fifty to one hundred of these

[1] "In this isolated region of North America, in this zoölogical island of New England, as we may call it, we find neither Lepidosteus, nor Amia, nor Polyodon, nor Amblodon (*Aplodinotus*), nor Grystes (*Micropterus*), nor Centrarchus, nor Pomoxis, nor Ambloplites, nor Calliurus (*Chænobryttus*), nor Carpiodes, nor Hyodon, nor indeed any of the characteristic forms of North American fishes so common everywhere else, with the exception of two Pomotis (*Lepomis*), one Boleosoma, and a few Catostomus." — Agassiz, *Amer. Journ. Sci. Arts*, 1854.

species can be found in any one of the tributary streams of the size, say, of the Housatonic River or the Charles. In the Connecticut River there are but about eighteen species permanently resident; and the number found in the streams of Texas is not much larger, the best-known of these, the Rio Colorado, having yielded but twenty-four species.

The waters of the Great Basin have not yet been fully explored. The number of species now known from this region is about seventy-five. This number includes the fauna of the upper Rio Grande, the Snake River, and the Colorado, as well as the fishes of the tributaries of the Great Salt Lake. This list is composed almost entirely of a few genera of Suckers,[1] Minnows,[2] and Trout.[3] None of the Cat-fishes, Perch, Darters, or Sunfishes, Moon-eyes, Pike, Killifishes, and none of the ordinary Eastern types of Minnows[4] have passed the barrier of the Rocky Mountains.

West of the Sierra Nevada, the fauna is still more scanty, but fifty species being enumerated. This fauna, except for certain immigrants[5] from the sea, is of the same general character as that of the Great Basin, though most of the species are different. This latter fact would indicate a considerable change, or "evolution," since the contents of the two faunæ were last mingled. There

[1] *Catostomus*, *Pantosteus*, *Chasmistes*.

[2] *Squalius*, *Gila*, *Ptychocheilus*, etc.

[3] *Salmo mykiss* and its varieties.

[4] Genera *Notropis*, *Chrosomus*, etc.

[5] As the fresh-water Surf-fish (*Hysterocarpus traski*) and the species of Salmon.

is a considerable difference between the fauna of the Columbia and that of the Sacramento. The species which these two basins have in common are chiefly those which at times pass out into the sea. The rivers of Alaska contain but few species, barely a dozen in all, most of these being found also in Siberia and Kamtschatka. In the scantiness of its faunal list, the Yukon agrees with the Mackenzie River, and with Arctic rivers generally.

There can be no doubt that the general tendency is for each species to extend its range more and more widely until all localities suitable for its growth are included. The various agencies of dispersal which have existed in the past are still in operation. There is apparently no limit to their action. It is probable that new "colonies" of one species or another may be planted each year in waters not heretofore inhabited by such species. But such colonies become permanent only where the conditions are so favorable that the species can hold its own in the struggle for food and subsistence. That various modifications in the habitat of certain species have been caused by human agencies is of course too well known to need discussion here.

We may next consider the question of watersheds, or barriers which separate one river basin from another.

Of such barriers in the United States, the most important and most effective is unquestionably that of the main chain of the Rocky Mountains. This is due in part to its great height, still more to its great breadth, and most of all, perhaps, to

the fact that it is nowhere broken by the passage of a river. But two species — the Red-throated, or Rocky Mountain Trout,[1] and the Rocky Mountain White-fish[2] — are found on both sides of it, at least within the limits of the United States; while many genera, and even several families, find in it either an eastern or a western limit to their range. In a few instances representative species, probably modifications or separated branches of the same stock, occur on opposite sides of the range, but there are not many cases of correspondence even thus close. The two faunæ are practically distinct. Even the widely distributed Red-spotted, or "Dolly Varden" Trout,[3] of the Columbia River and its affluents, does not cross to the east side of the mountains; nor does the Great Lake Trout[4] nor the Montana Grayling[5] ever make its way to the West.

It is easy to account for this separation of the faunæ; but how shall we explain the almost universal diffusion of the White-fish and the Trout in suitable waters on both sides of the dividing ridge? We may notice that these two are the species which ascend highest in the mountains, the White-fish inhabiting the mountain pools and lakes, the Trout ascending all brooks and rapids in search of their fountain-heads. In many cases the ultimate dividing ridge is not very broad, and we may imagine

[1] *Salmo mykiss* Walbaum (=*purpuratus* Pallas).
[2] *Coregonus williamsoni* Girard.
[3] *Salvelinus malma* Walbaum.
[4] *Salvelinus namaycush* Walbaum.
[5] *Thymallus signifer ontariensis* Valenciennes.

that at some time spawn or even young fishes may have been carried across by birds or other animals, or by man, — or more likely by the dash of some summer whirlwind. Once carried across in favorable circumstances, the species might survive and spread.

I saw last summer an example of how such transfer of species may be accomplished, which shows that we need not be left to draw on the imagination to invent possible means of transit.

There are few water-sheds in the world better defined than the mountain range which forms the "backbone" of Norway. I lately climbed a peak in this range, the Suletind. From its summit I could look down into the valleys of the Lära and the Bägna, flowing in opposite directions to opposite sides of the peninsula. To the north of the Suletind is a large double lake called the Sletningenvand. The maps show this lake to be one of the chief sources of the westward-flowing river Lära. This lake is in August swollen by the melting of the snows, and at the time of my visit it was visibly the source of both these rivers. From its southeastern side flowed a large brook into the valley of the Bägna, and from its southwestern corner, equally distinctly, came the waters which fed the Lära. This lake, like similar mountain ponds in all northern countries, abounds in trout; and these trout certainly have for part of the year an uninterrupted line of water communication from the Sognefjord on the west of Norway to the Christianiafjord on the southeast, — from the North Sea to the Baltic. Part of the year the lake

has probably but a single outlet through the Lära. A higher temperature would entirely cut off the flow into the Bägna, and a still higher one might dry up the lake altogether. This Sletningenvand,[1] with its two outlets on the summit of a sharp water-shed, may serve to show us how other lakes, permanent or temporary, may elsewhere have acted as agencies for the transfer of fishes. We can also see how it might be that certain mountain fishes should be so transferred while the fishes of the upland waters may be left behind. In some such way as this we may imagine the Trout and the White-fish to have attained their present wide range in the Rocky Mountain region; and in similar manner perhaps the Eastern Brook Trout[2] and some other mountain species[3] may have been carried across the Alleghanies.

[1] Since the above was written I have been informed by Professor John M. Coulter, who was one of the first explorers of the Yellowstone Park, that such a condition still exists on the Rocky Mountain Divide. In the Yellowstone Park is a marshy tract, traversable by fishes in the rainy season, and known as the "Two-Ocean Water." In this tract rise tributaries both of the Snake River and of the Yellowstone. Similar conditions apparently exist on other parts of the Divide, both in Montana and in Wyoming.

Professor John C. Branner calls my attention to a marshy upland which separates the valley of the La Plata from that of the Amazon, and which permits the free movement of fishes from the Paraguay River to the Tapajos. It is well known that through the Cassiquiare River the Rio Negro, another branch of the Amazon, is joined to the Orinoco River. It is thus evident that almost all the waters of eastern South America form a single basin, so far as the fishes are concerned.

[2] *Salvelinus fontinalis* Mitchill.

[3] *Notropis rubricroceus* Cope; *Rhinichthys atronasus* Mitchill; etc.

The Sierra Nevada constitutes also a very important barrier to the diffusion of species. This is, however, broken by the passage of the Columbia River, and many species thus find their way across it. That the waters to the west of it are not unfavorable for the growth of eastern fishes is shown by the fact of the rapid spread of the Common Eastern Cat-fish,[1] or Horned Pout, when transported from the Schuylkill to the Sacramento. This fish is now one of the important food-fishes of the San Francisco markets. It has become, in fact, an especial favorite with the Chinaman, — himself also an immigrant, and presenting certain analogies with the fish in question, as well in temperament as in habits.

The mountain mass of Mount Shasta is, as already stated, a considerable barrier to the range of fishes, though a number of species find their way around it through the sea. The lower and irregular ridges of the Coast Range are of small importance in this regard, as the streams of their east slope reach the sea on the west through San Francisco Bay. Yet the San Joaquin contains a few species, not yet recorded from the smaller rivers of southwestern California.

The main chain of the Alleghanies forms a barrier of importance separating the rich fish-fauna of the Tennessee and Ohio basins from the scantier faunæ of the Atlantic streams. Yet this barrier is crossed by many more species than is the case with either the Rocky Mountains or the Sierra Nevada. It is lower, narrower, and much more

[1] *Ameiurus nebulosus* Le Sueur.

broken, — as in New York, in Pennsylvania, and in Georgia there are several streams which pass through it or around it. The much greater age of the Alleghany chain, as compared with the Rocky Mountains, seems not to be an element of any importance in this connection. Of the fish which cross this chain, the most prominent is the Brook Trout,[1] which is found in all suitable waters from Hudson's Bay to the head of the Chattahoochee. A few other species are locally found in the head-waters of certain streams on opposite sides of the range. An example of this is the little red "Fall-fish," [2] found only in the mountain tributaries of the Savannah and the Tennessee. We may suppose the same agencies to have assisted these species that we have imagined in the case of the Rocky Mountain Trout, and such agencies were doubtless more operative in the times immediately following the glacial epoch than they are now. Professor Cope calls attention also to the numerous caverns existing in these mountains, as a sufficient medium for the transfer of many species. I doubt whether the main chains of the Blue Ridge or the Great Smoky can be crossed in that way, though such channels are not rare in the sub-carboniferous limestones of the Cumberland range.

The passage of species from stream to stream along the Atlantic slope deserves a moment's notice. It is, under present conditions, impossible for any mountain or upland fish, as the Trout or the Miller's Thumb,[3] to cross from the Potomac

[1] *Salvelinus fontinalis.* [2] *Notropis rubricroceus* Cope.
[3] *Cottus richardsoni* Agassiz.

River to the James, or from the Neuse to the Santee, by descending to the lower courses of the rivers, and thence passing along either through the swamps or by way of the sea. The lower courses of these streams, warm and muddy, are uninhabitable by such fishes. Such transfers are, however, possible farther north. From the rivers of Canada and from many rivers of New England the Trout does descend to the sea and into the sea, and farther north the White-fish does this also. Thus these fishes readily pass from one river basin to another. As this is the case now everywhere in the North, it may have been the case farther south in the time of the glacial cold. We may, I think, imagine a condition of things in which the snow-fields of the Alleghany chain might have played some part in aiding the diffusion of cold-loving fishes. A permanent snow-field on the Blue Ridge in western North Carolina might render almost any stream in the Carolinas suitable for trout, from its source to its mouth. An increased volume of colder water might carry the trout of the head-streams of the Catawba and the Savannah as far down as the sea. We can even imagine that the trout reached these streams in the first place through such agencies, though of this there is no positive evidence. For the presence of trout in the upper Chattahoochee, we must account in some other way.

It is noteworthy that the upland fishes are nearly the same in all these streams, until we reach the southern limit of possible glacial influence. South of western North Carolina, the

faunæ of the different river basins appear to be more distinct from one another. Certain ripple-loving types[1] are represented by closely related but unquestionably different species in each river basin, and it would appear that a thorough mingling of the upland species in these rivers has never taken place.

With the lowland species of the Southern rivers it is different. Few of these are confined within narrow limits. The streams of the whole South Atlantic and Gulf Coast flow into shallow bays, mostly bounded by sand-spits or sand-bars which the rivers themselves have brought down. In these bays the waters are often neither fresh nor salt; or rather, they are alternately fresh and salt, the former condition being that of the winter and spring. Many species descend into these

[1] The best examples of this are the following: in the Santee basin are found *Notropis pyrrhomelas*, *Notropis niveus*, and *Notropis chloristius;* in the Altamaha, *Notropis xænurus* and *Notropis callisemus;* in the Chattahoochee, *Notropis hypselopterus* and *Notropis eurystomus;* in the Alabama, *Notropis cœruleus*, *Notropis trichroistius*, and *Notropis callistius*. In the Alabama, Escambia, Pearl, and numerous other rivers, is found *Notropis cercostigma*. This species descends to the sea in the cool streams of the pine-woods. Its range is wider than that of the others, and in the rivers of Texas it reappears in the form of a scarcely distinct variety, *Notropis venustus*. In the Tennessee and Cumberland, and in the rivers of the Ozark range, is *Notropis galacturus;* and in the upper Arkansas *Notropis camurus*, — all distinct species of the same general type. Northward, in all the streams from the Potomac to the Oswego, and westward to the Des Moines and the Arkansas, occurs a single species of this type, *Notropis whipplei*. But this species is not known from any of the streams inhabited by any of the other species mentioned, although very likely it is the parent stock of them all.

bays, thus finding every facility for transfer from river to river. There is a continuous inland passage in fresh or brackish waters, traversable by such fishes, from Chesapeake Bay nearly to Cape Fear; and similar conditions exist on the coasts of Louisiana, Texas, and much of Florida. In Perdido Bay I have found fresh-water Minnows[1] and Silversides[2] living together with marine Gobies[3] and salt-water Eels.[4] Fresh-water Alligator Gars[5] and marine Sharks compete for the garbage thrown over from the Pensacola wharves. In Lake Pontchartrain the fauna is a remarkable mixture of fresh-water fishes from the Mississippi and marine fishes from the Gulf. Channel-cats, Sharks, Sea-crabs, Sun-fishes, and Mullets can all be found there together. It is therefore to be expected that the lowland fauna of all the rivers of the Gulf States would closely resemble that of the lower Mississippi; and this, in fact, is the case.

The streams of southern Florida and those of southwestern Texas offer some peculiarities connected with their warmer climate. The Florida streams contain a few peculiar fishes;[6] while the rivers of Texas, with the same general fauna as those farther north, have also a few distinctly tropical types,[7] immigrants from the lowlands of Mexico.

The fresh waters of Cuba are inhabited by fishes unlike those found in the United States. Some

[1] *Notropis cercostigma*; *Notropis xænocephalus*.
[2] *Labidesthes sicculus*.
[3] *Gobiosoma molestum*.
[4] *Myrophis punctatus*.
[5] *Lepisosteus tristœchus*.
[6] *Jordanella*, *Rivulus*, *Heterandria*, etc.
[7] *Heros*, *Tetragonopterus*.

of these are evidently indigenous, derived in the waters they now inhabit directly from marine forms. Two of these are eyeless species,[1] inhabiting streams in the caverns. They have no relatives in the fresh waters of any other region, the Blind-fishes[2] of our caves being of a wholly different type. Some of the Cuban fishes are common to the fresh waters of the other West Indies. Of Northern types, only one, the Alligator Gar,[3] is found in Cuba, and this is evidently a filibuster immigrant from the coasts of Florida.

The low and irregular water-shed which separates the tributaries of Lake Michigan and Lake Erie from those of the Ohio is of little importance in determining the range of species. Many of the distinctively Northern fishes are found in the head-waters of the Wabash and the Scioto. The considerable difference in the general fauna of the Ohio Valley as compared with that of the streams of Michigan is due to the higher temperature of the former region, rather than to any existing barriers between the river and the Great Lakes. In northern Indiana the water-shed is often swampy, and in many places large ponds exist in the early spring.

At times of heavy rains many species will move through considerable distances by means of temporary ponds and brooks. Fishes that have thus emigrated often reach places ordinarily inacces-

[1] *Lucifuga* and *Stygicola*, fishes allied to the Cod, and belonging to the family of *Brotulidæ*.

[2] *Amblyopsis*, *Typhlichthys*.

[3] *Lepisosteus tristœchus*.

sible, and people finding them in such localities often imagine that they have "rained down." Once, near Indianapolis, after a heavy shower, I found in a furrow in a corn-field a small Pike,[1] some half a mile from the creek in which he should belong. The fish was swimming along in a temporary brook, apparently wholly unconscious that he was not in his native stream. Migratory fishes, which ascend small streams to spawn, are especially likely to be transferred in this way. By some such means any of the water-sheds in Ohio, Indiana, or Illinois may be passed.

It is certain that the limits of Lake Erie and Lake Michigan were once more extended than now. It is reasonably probable that some of the territory now drained by the Wabash and the Illinois was once covered by the waters of Lake Michigan. The Cisco[2] of Lake Tippecanoe, Lake Geneva, and the lakes of the Oconomowoc chain, is evidently a modified descendant of the so-called Lake Herring.[3] Its origin most likely dates from the time when these small deep lakes of Indiana and Wisconsin were connected with Lake Michigan. The changes in habits which the Cisco has undergone are considerable. The changes in external characters are but trifling. The presence of the Cisco in these lakes and its periodical disappearance — that is, retreat into deep water when not in the breeding season — has given rise to much nonsensical discussion as to whether any or all of

[1] *Esox vermiculatus* Le Sueur.

[2] *Coregonus artedi sisco*, Jordan.

[3] *Coregonus artedi* Le Sueur.

these lakes are still joined to Lake Michigan by subterranean channels. Several of the larger fishes, properly characteristic of the Great Lake Region,[1] are occasionally taken in the Ohio River, where they are usually recognized as rare stragglers. The difference in physical conditions is probably the sole cause of their scarcity in the Ohio basin.

The similarity of the fishes in the different streams and lakes of the Great Basin is doubtless to be attributed to the general mingling of their waters which took place during and after the glacial epoch. Since that period the climate in that region has grown hotter and drier, until the overflow of the various lakes into the Columbia basin through the Snake River has long since ceased. These lakes have become isolated from each other, and many of them have become salt or alkaline and therefore uninhabitable. In some of these lakes certain species may now have become extinct which still remain in others. In some cases, perhaps, the differences in surrounding may have caused divergence into distinct species of what was once one parent stock. The Suckers in Lake Tahoe[2] and those in Utah Lake are certainly now different from each other and from those in the Columbia. The Trout[3] in the same waters can be regarded as more or less tangible varieties only, while the White-fishes[4] show no differences at all. The differences in the present

[1] As, *Lota lota maculosa ; Percopsis guttatus ; Esox masquinongy.*

[2] *Catostomus tahoensis*, in Lake Tahoe ; *Catostomus macrocheilus* and *discobolus*, in the Columbia ; *Catostomus fecundus*, *Catostomus ardens ; Chasmistes liorus* and *Pantosteus generosus*, in Utah Lake.

[3] *Salmo mykiss*, et vars. *henshawi* and *virginalis.*

[4] *Coregonus williamsoni.*

faunæ of Lake Tahoe and Utah Lake must be chiefly due to influences which have acted since the glacial epoch, when the whole Utah Basin was part of the drainage of the Columbia.

Connected perhaps with changes due to glacial influences is the presence in the deep waters of the Great Lakes of certain marine types,[1] as shown by the explorations of Professor Sidney I. Smith and others. One of these is a genus of fishes,[2] of which the nearest allies now inhabit the Arctic Seas. In his review of the fish-fauna of Finland,[3] Professor A. J. Malmgren finds a number of Arctic species in the waters of Finland which are not found either in the North Sea or in the southern portions of the Baltic. These fishes are said to "agree with their 'forefathers' in the Glacial Ocean in every point, but remain comparatively smaller, leaner, almost starved." Professor Lovén[4] also has shown that numerous small animals of marine origin are found in the deep lakes of Sweden and Finland as well as in the Gulf of Bothnia. These anomalies of distribution are explained by Lovén and Malmgren on the supposition of the former continuity of the Baltic through the Gulf of Bothnia with the Glacial Ocean. During the second half of the glacial period, according to Lovén, "the greater part of Finland and of the

[1] Species of *Mysis* and other genera of Crustaceans, similar to species described by Sars and others, in lakes of Sweden and Finland.

[2] *Triglopsis thompsoni* Girard, a near ally of the marine species *Acanthocottus quadricornis* L.

[3] Kritisk Öfversigt af Finlands Fisk-Fauna: Helsingfors, 1863.

[4] See Günther, Zoological Record for 1864, p. 137.

middle of Sweden was submerged, and the Baltic was a great gulf of the Glacial Ocean, and not connected with the German Ocean. By the gradual elevation of the Scandinavian Continent, the Baltic became disconnected from the Glacial Ocean, and the great lakes separated from the Baltic. In consequence of the gradual change of the salt water into fresh, the marine fauna became gradually extinct, with the exception of the glacial forms mentioned above."

It is possible that the presence of marine types in our Great Lakes is to be regarded as due to some depression of the land which would connect their waters with those of the Gulf of St. Lawrence. On this point, however, our data are still incomplete.

To certain species of upland or mountain fishes, the depression of the Mississippi basin itself forms a barrier which cannot be passed. The Black-spotted Trout,[1] very closely related species of which abound in all waters of northern Asia, Europe, and western North America, has nowhere crossed the basin of the Mississippi, although one of its species finds no difficulty in passing Behring Strait. The Trout and White-fish of the Rocky Mountain region are all species different from those of the Great Lakes or the streams of the Alleghany system. To the Grayling, the Trout,

[1] *Salmo fario* L., in Europe; *Salmo labrax* Pallas, etc., in Asia; *Salmo gairdneri* Richardson, in streams of the Pacific Coast. *Salmo mykiss* Walbaum, in Kamtschatka, Alaska, and throughout the Rocky Mountain range to the Mexican boundary, and the head-waters of the Kansas, Platte, and Missouri.

the White-fish, the Pike, and to arctic and sub-arctic species generally, Behring Strait have evidently proved no serious obstacle to diffusion; and it is not unlikely that much of the close resemblance of the fresh-water faunæ of northern Europe, Asia, and North America is due to this fact. To attempt to decide from which side the first migration came in regard to each group of fishes might be interesting; but without a wider range of facts than is now in our possession, such attempts would be mere guesswork and without value. The interlocking of the fish-faunæ of Asia and North America presents, however, a number of interesting problems, for numerous migrations in both directions have doubtless taken place.

I could go on indefinitely with the discussion of special cases, each more or less interesting or suggestive in itself, but the general conclusion is in all cases the same. The present distribution of fishes is the result of the long-continued action of forces still in operation. The species have entered our waters in many invasions from the Old World or from the sea. Each species has been subjected to the various influences implied in the term "natural selection," and under varying conditions its representatives have undergone many different modifications. Each of the six hundred species we now know may be conceived as making every year inroads on territory occupied by other species. If these colonies are able to hold their own in the struggle for possession, they will multiply in the new conditions, and the range of the species becomes widened. If the surroundings are different,

new species or varieties may be formed with time; and these new forms may again invade the territory of the parent species. Again, colony after colony of species after species may be destroyed by other species or by uncongenial surroundings.

The ultimate result of centuries on centuries of the restlessness of individuals is seen in the facts of geographical distribution. Only in the most general way can the history of any species be traced; but could we know it all, it would be as long and as eventful a story as the history of the colonization and settlement of North America by immigrants from Europe. But by the fishes each river in America has been a hundred times discovered, its colonization a hundred times attempted. In these efforts there is no co-operation. Every individual is for himself, every struggle a struggle of life and death; for each fish is a cannibal, and to each species each member of every other species is an alien and a savage.

THE NOMENCLATURE OF AMERICAN BIRDS.[1]

FEW scientific books of recent years have been awaited with so much interest as the "Check-List" of birds and its accompanying "Code," published by the American Ornithologists' Union. To those interested in systematic ornithology the work is, of course, of the highest importance, as giving an authoritative settlement, so far as authority can settle anything in science, of the much-vexed questions in bird nomenclature. But to the systematic workers in other departments of zoölogy, and even to botanists, its interest is scarcely less great. For we who work in other fields are very willing to recognize the fact that the great questions which underlie all systematic nomenclature must be first met and settled by the ornithologists. The abundance and attractiveness of birds, and the ease with which they may be collected and studied, have combined to render ornithology one of the best cultivated of all departments of science. In spite of a good deal of crude or "amateur" work, which, in one way or another, gets published, it is, I think, not too much to say that in all the various matters which make up the groundwork of systematic science — in the discrimination

[1] A Review of the "Code of Nomenclature and Check-List of the American Ornithologists' Union."

of species and varieties, in the study of the relations of these groups to each other and to their environment — American ornithology stands in the very front of systematic science.

We may therefore, in the various stages through which our ornithology has passed or is passing, read the future history of our own branches of science. In many regards the ornithologists are fighting our battles for us, and we may take advantage of the results won by their efforts. Thus the discussion of climatic influences on the character of species, first seriously taken up by Mr. Joel A. Allen in 1871, which has culminated in the trinomial system of nomenclature, has relieved workers in other fields from the need of urging the same considerations. As soon as our facts are sufficient for us to use the trinomial system, we shall find it ready for our service, perfected in all its details. Again, the absolute importance of the law of priority has impressed itself on the ornithologists in spite of themselves; for in past times the students of birds have been among those who have most sinned against this law. The efforts of Cassin, Coues, Stejneger and others to ascertain the facts in regard to old names, have shown that no possible middle ground exists between chaos and law in matters of nomenclature. It is quite true, as the authors of the "Code" have insisted, that "nomenclature is a means and not an end in science." But the experience of ornithologists has shown us that in systematic zoölogy and in zoögeography, this means is one absolutely essential to any end of importance. A system of

nomenclature based on common fairness and on common-sense, and stable because above the reach of individual whim or choice, is as necessary to success in this kind of work as a sharp scalpel is to good work in anatomy. So long as no rules superior to the caprice of the individual or the traditions of some museum are recognized, so long is systematic work a mere burlesque, and our schemes of classification anything but a mirror of Nature.

But besides the positive advances made by the ornithologists, from which others may profit when the time comes, there is something for us to learn from the results of their less fortunate experiments. An illustration of this may be taken from the last "Check-List" of Dr. Coues. This work is in many respects most valuable. In it, however, so much learning has been expended in the mending and remodelling of scientific names, as fairly to bring purism in this regard to a *reductio ad absurdum*. Hence the Committee on the new code, with Dr. Coues at its head, are forced to declare that "a name is only a name, and has no necessary meaning," and therefore no necessarily correct orthography. Its only proper spelling is the way its author first spelled it. After this experience the work of strengthening the lame and halting words is hardly likely to be continued in other fields of science.

Another illustration may be drawn from the excessive multiplication of genera, — a stage through which ornithology has naturally passed, and which other sciences, profiting from this experience, may possibly be able to avoid.

The "Code" may be considered first in its adaptation to the needs of ornithologists. In this respect there is little to criticise. The fact that the ornithologists have been able to agree upon it, and that they have applied it in detail to the production of a check-list, would show that for their use the rules are good and sufficient. There are in the "Code" some traces of compromise, — cases in which the sharpness of a positive ruling is somewhat blunted by exceptions. Some of these doubtless arise from difference of opinion among the ornithologists, and others, perhaps, from peculiarities in the literature of ornithology. But whether these modifications be unavoidable or not, it must be remembered that no compromise can be binding on future authors, and exceptions not necessary in the nature of the case will be ignored.

A serious difficulty with all preceding codes of nomenclature has been the lack of explicitness in dealing with details. It has been hoped by zoölogists generally that in this "Code" all the more important difficulties would be fairly met and disposed of in ways which could be followed in other sciences. In other words, we have hoped that this "Code" would be one for zoölogists and botanists generally, and not solely for ornithologists. That such a hope was in the minds of the Committee also, is evident from the care with which they have considered and worked over all previous codes, as well as from their own explicit statement (page 11): "These rules were considered in their bearing upon zoölogy at large, as well as upon ornithology alone; it being obvious that sound principles of

nomenclature should be susceptible of general application." From this view-point, then, should the "Code" be judged; and any rules or provisions based on compromise of opinions, as well as any arising from special peculiarities of birds or of ornithological literature, must be regarded as blemishes in the "Code."

Speaking only for himself and for his special line of work, the present writer wishes to express his great satisfaction with the "Code." In all its essential features the "Code" must commend itself at once to those who have made questions of nomenclature a subject of serious thought, and its rules for the most part need only formulation to secure adoption. But this is not quite true, I think, of all of them. Where so much has been done, and so well done, any word of criticism seems thankless. A few points, however, occur to the writer, viewing this code of rules from the standpoint of his own experience. The first of these is in regard to Canon XVII.[1] in so far as

[1] Canon XVII. reads as follows: "Preference between competitive specific names published simultaneously in the same work, or in two works of the same actual or ostensible date (no exact date being ascertainable), is to be decided as follows: —

"1. Of names the equal pertinency of which may be in question, preference shall be given to that which is open to least doubt.

"2. Of names of undoubtedly equal pertinency, (*a*) that founded upon the male is to be preferred to that founded upon the female; (*b*) that founded on the adult to that on the young; and (*c*) that founded on the nuptial condition to that of the pre- or post-nuptial conditions.

"3. Of names of undoubtedly equal pertinency, and founded upon the same condition of sex, age, or season, that is to be preferred which stands first in the book."

this applies to different names given in the same work to the same group.

It is certain that Clause 2 in this canon is based on special peculiarities of ornithology, while Clauses 1 and 3 are doubtless due to compromise among ornithologists. The question of equal pertinency of description is very often a subjective one, and this rule gives room to individual judgment or caprice, and this it is the business of the "Code" to eliminate. As to Clause 2 we may notice that in most groups of animals, as in the fishes for example, we cannot discriminate in any such way between males, females, and young, or between the various nuptial and non-nuptial conditions. The clause is for ornithologists alone, and by other naturalists it must of necessity be disregarded. Of synonymous names which admit of positive identification, and which are printed in the same book, we shall doubtless continue to use that name which *stands first upon the page*, without regard to other considerations. I believe that the law of primogeniture is made to apply in the case of twins. The chief aim of the law of priority, like that of the law of primogeniture, is not the survival of the fittest, nor yet justice, but simply *fixity*. The present Canon XVII. will not secure fixity. The same remarks apply to Canon XVIII., which refers to synonymous genera of the same date of publication.

In the cases of Canons XXI. and XXIII., which treat of the restriction of composite genera in which no type has been clearly indicated by the author, some important matters are left obscure. It is

not stated to what degree, if at all, we may be allowed to select the type of such a genus by (metaphorically) questioning its author as to which species he himself would have regarded as typical. This method of selecting a type for the comprehensive genera of Linnæus[1] and others has been practised by certain writers; and where the indications are unquestionable, this seems a very just method of procedure. Nor is it clear from the "Code," whether the results of the application of Canon XXI. (by which the earliest restriction of a comprehensive genus is held to be valid) could be set aside either by the application of the process of elimination (as set forth in Canon XXIII.), or on account of the supposed views of the author of the genus. There are thus three different ways for selecting the type of a comprehensive genus, all three of them sanctioned by the "Code." These three methods will often lead to different results, and the "Code" nowhere states which is in case of conflict entitled to precedence. My own idea is that if the author has indicated in any unequivocal way which species was in his mind typical, that species should be regarded as the type. If no such selection is unquestionable, the species (originally contained in the genus) which is selected as type by the earliest author

[1] Professor A. E. Verrill has called my attention to the fact that Linnæus himself has distinctly stated that he regards the type of each of his genera as being "the best known European or officinal species." I have not been able to verify this statement; but if it is correct, it ought not to be overlooked in the process of selecting types for the Linnæan genera.

who undertakes to restrict the comprehensive genus should be taken as the type. If no such restriction has taken place, the process of elimination, as laid down in Canon XXIII., may be applied. In both the latter cases, only those restrictions *knowingly made* should be considered.

The "Code" agrees with most others in the rejection of "*nomina nuda*" (bare names introduced without explanation), but it differs from most others in regarding a "typonym" (or generic name established only by the indication of a typical species, and without diagnosis) as something more than a "bare name," and as therefore worthy of recognition. In this regard the "Code," justly or not, is most likely to receive criticism from workers in other fields. Most other departments of zoölogy have but little to do with "new genera," defined solely by the specification of a type-species. These "typonyms" have been generally discarded as the useless product of lazy or "literary" naturalists on the general ground formulated by Professor Cope, that "science[1] is science and

[1] The following are Professor Cope's remarks on this point: "In the Proceedings of the United States National Museum, Professor Gill insists on the adoption of a generic name proposed by himself without description, in preference to a name proposed later, by another author, whose description contains some errors. The opposite course had been pursued by Professors Jordan and Gilbert, — a circumstance which gives rise to the criticism in question. Professor Gill admits the facts to be as above stated, and thereupon makes the following remarks: 'What is the advantage of any description? According to the rules of the British and American Associations for the Advancement of Science, a description is necessary as the basis of permanent nomenclature, but like many of the other rules propounded in those codes, there is no

not literature," and that its names are meaningless except as "handles to facts." It is, however, apparently the general feeling of ornithologists, that names of this sort are too firmly fixed in their science to be now set aside. The Committee goes so far as to say (page 52) that "the mere mention of a type has been found to be often a better index to an author's meaning than is frequently

proper logical basis therefor.' Professor Gill then proceeds to make the usual statements about the inadequacy of the earlier generic descriptions, etc., — a mode of reasoning generally resorted to under similar circumstances.

"In taking his position, it is evident that Professor Gill and his school (for he is not alone in his views) have to contend not only with the wisdom of the American and British Associations, but with that of the other bodies above mentioned. It would seem superfluous for us to defend a fortification so strongly held; but the heresy in question has had considerable run in America, and it is fitting that linen should be washed where it has been soiled. In brief, then, one reason why a description is necessary in adding a new name to scientific nomenclature is that science is science and not literature, — a distinction occasionally lost sight of by a few writers on natural history. In other words, it deals with things, and not words; and the only connection words have with science is to represent things. As this cannot be done without a preliminary definition, names alone (*nomina nuda*) do not belong to science at all, but to the arts of composition and literature. Second, the inconvenience of the substitution of literary methods for scientific methods in scientific work is so great that scientists have felt compelled to protect themselves against these 'literary fellows.' By insisting on definitions, these gentlemen are placed in a somewhat embarrassing position. They do not wish to forego the pleasure of creating a new lexicon, but to compose a diagnosis is for them a very serious business. Literature, a critic says, deals with 'manner,' while science treats of 'matter,' and a diagnosis is a concentrated extract of matter. Between the two horns of the dilemma he will generally (not always, we are sorry to say) prefer the less conspicuous course, and abandon nomenclature as a profession." — *American Naturalist*, Nov. 8, 1881.

a diagnosis or a long description." This may be true; but it is equivalent to saying that if a given author will tell us what he is talking about, we can form a better idea of his meaning than we shall have if we listen to his statements. Possibly the line must be drawn somewhere between the "typonym" and the "*nomen nudum;*" but both are valueless in fact, and it is a pity that any science should feel compelled to notice either.

Canons XLIV. and XLV., requiring *absolute* identification to secure priority, will offer some difficulties in practice; and it is in this regard that most fluctuations in nomenclature in future are likely to occur. Really "absolute" identification of descriptions is often difficult among birds, and in more obscure groups it becomes less and less easy of attainment.

With these exceptions, the rules of the "Code" seem to the present writer to be above cavil, and to fill the needs of other naturalists quite as well as they do those of ornithologists. With the exceptions of Canons XVII. and XVIII., which seem to him unwise, and which, in fact, he cannot use at all, and possibly that of Canon XLII. in so far as this recognizes the validity of typonyms, the entire "Code" must certainly be adopted by workers in ichthyology. I hope and believe that other branches of science will find these rules equally satisfactory, and that this may soon become in all important respects the code of nomenclature for zoölogy and botany as well as for American ornithology.

AN ECCENTRIC NATURALIST.

IT is now nearly seventy years since the first student of our Western fishes crossed the Falls of the Ohio and stood on Indiana soil. He came on foot, with a note-book in one hand and a hickory stick in the other, and his capacious pockets were full of wild-flowers, shells, and toads. He wore "a long, loose coat of yellow nankeen, stained yellower by the clay of the roads, and variegated by the juices of plants." In short, in all respects of dress, manners, and appearance, he would be described by the modern name of "tramp." Nevertheless, no more remarkable figure has ever appeared in the annals of Indiana or in the annals of science. To me it has always possessed a peculiar interest; and so, for a few moments, I wish to call up before you the figure of Rafinesque, with his yellow nankeen coat, "his sharp tanned face, and his bundle of plants, under which a pedler would groan," before it recedes into the shadows of oblivion.

Constantine Samuel Rafinesque was born in Constantinople in the year 1784. His father was a French merchant from Marseilles doing business in Constantinople, and his mother was a German girl, born in Greece, of the family name of Schmaltz. Rafinesque himself, son of a Franco-Turkish father

and a Græco-German mother, was an American. Before he was a year old his life-long travels began, his parents visiting ports of Asia and Africa on their way to Marseilles. As a result of this trip, we have the discovery, afterward characteristically announced by him to the world, that "infants are not subject to sea-sickness." At Marseilles his future career was determined for him; or, in his own language: "It was among the flowers and fruits of that delightful region that I first began to enjoy life, and I became a botanist. Afterward, the first prize I received in school was a book of animals, and I am become a zoölogist and a naturalist. My early voyage made me a traveller. Thus, some accidents or early events have an influence on our fate through life, or unfold our inclinations."[1]

Rafinesque read books of travel, those of Captain Cook, Le Vaillant, and Pallas especially; and his soul was fired with the desire "to be a great traveller like them. . . . And I became such," he adds tersely. At the age of eleven he had begun an herbarium, and had learned to read the Latin in which scientific books of the last century were written. "I never was in a regular college," he says, "nor lost my time on dead languages; but I spent it in reading alone, and by reading ten times more than is read in the schools. I have undertaken to read the Latin and Greek, as

[1] This and most of the other verbal quotations in this paper are taken from an "Autobiography of Rafinesque," of which a copy exists in the Library of Congress. A few quotations have been somewhat abridged.

well as the Hebrew, Sanskrit, Chinese, and fifty other languages, as I felt the need or inclination to study them." At the age of twelve he published his first scientific paper, "Notes on the Apennines," as seen from the back of a mule on a journey from Leghorn to Genoa. Rafinesque was now old enough to choose his calling in life. He decided to become a merchant; for, said he, "commerce and travel are linked." At this time came the first outbreaks of the French Revolution, when the peasants of Provence began to dream of "castles on fire and castles combustible;" so Rafinesque's prudent father sent his money out of France and his two sons to America.

In Philadelphia, Constantine Rafinesque became a merchant's clerk, and his spare time was devoted to the study of botany. He tried also to study the birds; but he says, "The first bird I shot was a poor chickadee, whose death appeared a cruelty, and I never became much of a hunter." During his vacations Rafinesque travelled on foot over parts of Pennsylvania and Virginia. He visited President Jefferson, who, he tells us, asked him to call again. In 1805, receiving an offer of business in Sicily, Rafinesque returned to Europe. He spent ten years in Sicily, — the land, as he sums it up, "of fruitful soil, delightful climate, excellent productions, perfidious men, and deceitful women." Here in Sicily he discovered the medicinal squill, which, aided by the equally medicinal paregoric, was once a great specific for all childish ailments. He commenced gathering this in large quantities for shipment to England and Russia. The Sici-

lians thought that he was using it as a dye-stuff; "and this," said he, "I let them believe." Nearly two hundred thousand pounds had been shipped by him before the secret of the trade was discovered, since which time the Sicilians have prosecuted the business on their own account. He began to turn his attention to the animals of the sea, and here arose his passion for ichthyology. The red-shirted Sicilian fishermen used to bring to him the strange creatures which came in their nets. In 1810 he published two works on the fishes of Sicily, and for our first knowledge of very many of the Mediterranean fishes we are indebted to these Sicilian papers of Rafinesque. It is unfortunately true, however, that very little real gain to science has come through this knowledge. Rafinesque's descriptions in these works are so brief, so hasty, and so often drawn from memory, that later naturalists have been put to great trouble in trying to make them out. A peculiar, restless, impatient enthusiasm is characteristic of all his writings, — the ardor of the explorer without the patience of the investigator.[1]

In Sicily, Rafinesque was visited by the English ornithologist, William Swainson. Swainson seems to have been a great admirer of "the eccentric naturalist," as he called him. Of him Rafinesque says: "Swainson often went with me to the mountains. He carried a butterfly-net to catch insects

[1] Dr. Elliott Coues has wittily suggested that as the words "grot*esque*," "pictur*esque*," and the like, are used to designate certain literary styles, the adjective "rafin*esque*" may be similarly employed for work like that of the author now under consideration.

with, and was taken for a crazy man or a wizard. As he hardly spoke Italian, I had once to save him from being stoned out of a field, where he was thought to seek a treasure buried by the Greeks." Rafinesque now invented a new way of distilling brandy. He established a brandy-distillery, where, said he, "I made a very good brandy, equal to any made in Spain, without ever tasting a drop of it, since I hate all strong liquors. This prevented me from relishing this new employment, and so I gave it up after a time."

Finally, disgust with the Sicilians and fear of the French wars caused Rafinesque, who was, as he says, "a peaceful man," to look again toward the United States. In 1815 he sailed again for America, with all his worldly goods, including his reams of unpublished manuscripts, his bushels of shells, and a multitude of drawings of objects in natural history. According to his own account, the extent of his collections at that time was enormous, and from the great number of scattered treatises on all manner of subjects which he published in later years, whenever he could get them printed, it is fair to suppose that his pile of manuscripts was equally great. A considerable number of his note-books, and of papers for which, fortunately for scientific nomenclature, he failed to find a publisher, are now preserved in the United States National Museum. These manuscripts are remarkable for two things, — the beauty of the quaint French penmanship, and the badness of the accompanying drawings. His numerous note-books, written in French, represent each the observations

of a busy summer; and these observations, for the most part unchecked by the comparison of specimens, he prepared for the press during the winter. To this manner of working, perhaps unavoidable in his case, many of Rafinesque's errors and blunders are certainly due. In one of these note-books I find, among a series of notes in French, the following remarkable observation in English: "*The girls at Fort Edward eat clay!*" In another place I find a list of the new genera of fishes in Cuvier's "Règne Animal" (1817) which were known to him. Many of these are designated as synonymous with genera proposed by Rafinesque in his "Caratteri" in 1810. With this list is the remark that these genera of Cuvier are identical with such and such genera "proposed by me in 1810, but don't you tell it!"

Rafinesque was six months on the ocean in this second voyage to America. Finally, just as the ship was entering Long Island Sound, the pilot let her drift against one of the rocks which lie outside of the harbor of New London. The vessel filled and sank, giving the passengers barely time to escape with their lives. "I reached New London at midnight," says Rafinesque, "in a most deplorable situation. I had lost everything, — my fortune, my share in the cargo, my collections and labors of twenty years past, my books, my manuscripts, and even my clothes, — all I possessed, except some scattered funds and some little insurance-money. Some hearts of stone have since dared to doubt of these facts, or rejoice at my losses. Yes, I have found men vile enough to laugh with-

out shame at my misfortunes, instead of condoling with me. But I have met also with friends who have deplored my loss and helped me in need."

I shall pass rapidly over Rafinesque's career until his settlement in Kentucky. He travelled widely in America, in the summer, always on foot. "Horses were offered to me," he said, "but I never liked riding them, and dismounting for every flower. Horses do not suit botanists." He now came westward, following the course of the Ohio, and exploring for the first time the botany of the country. He came to Indiana, and for a short time was associated with the community then lately established by Owen and Maclure at New Harmony on the Wabash. Though this New Harmony experiment was a failure, as all communities must be in which the drone and the worker alike have access to the honey-cells, yet the debt due it from American science is very great. Although far in the backwoods, and in the long notorious county of Posey, New Harmony was for a time fairly to be called the centre of American science; and even after half a century has gone by its rolls bear few names brighter than those of Thomas Say, David Dale Owen, and Charles Albert Le Sueur.

Rafinesque soon left New Harmony, and became Professor of Natural History and the Modern Languages in Transylvania University, at Lexington, Kentucky. He was, I believe, the very first teacher of natural history in the West, and his experiences were not more cheerful than those of most pioneers. They would not give him at

Lexington the degree of Master of Arts, he says, "because I had not studied Greek in a college, although I knew more languages than all the American colleges united. But it was granted at last; but that of Doctor of Medicine was not granted, because I would not superintend anatomical dissections." He continues: —

"Mr. Holley, the president of the university, despised and hated the natural sciences, and he wished to drive me out altogether. To evince his hatred against science and its discoveries, he had broken open my rooms in my absence, given one to the students, and thrown all my effects, books, and collections into the other. He had deprived me of my situation as librarian, and tried to turn me out of the college. I took lodgings in town, and carried there all my effects, leaving the college with curses both on it and Holley, which reached them both soon after; for Holley died of the yellow fever in New Orleans and the college was burned with all its contents."

In one of his summer trips Rafinesque became acquainted with Audubon, who was then painting birds and keeping a little "grocery-store" down the river, at Henderson, Kentucky. Rafinesque reached Henderson in a boat, carrying on his back a bundle of plants which resembled dried clover. He accidentally met Audubon, and asked him to tell him where the naturalist lived. The ornithologist introduced himself, and Rafinesque handed him a letter from a friend in the East, commending him to Audubon as an "odd fish, which might not be described in the published treatises." The story of the interview is thus described by Audubon:

"His attire struck me as exceedingly remarkable. A long, loose coat of yellow nankeen, much the worse for the many rubs it had got in its time, hung about him loosely, like a sack. A waistcoat of the same, with enormous pockets and buttoned up to the chin, reached below over a pair of tight pantaloons, the lower part of which was buttoned down over his ankles. His beard was long, and his lank black hair hung loosely over his shoulders. His forehead was broad and prominent, indicating a mind of strong power. His words impressed an assurance of rigid truth; and as he directed the conversation to the natural sciences, I listened to him with great delight.

"That night, after we were all abed, I heard of a sudden a great uproar in the naturalist's room. I got up and opened the door, when to my astonishment I saw my guest running naked, holding the handle of my favorite Cremona, the body of which he had battered to pieces in attempting to kill the bats which had entered the open window! I stood amazed; but he continued jumping and running around and around till he was fairly exhausted, when he begged me to procure one of the animals for him, as he felt convinced that they belonged to a new species. Although I was convinced of the contrary, I took up the bow of my demolished violin, and giving a smart tip to each bat as it came up, we soon had specimens enough."

A part of the story of this visit, which Audubon does not tell, may be briefly related here: Audubon was a great artist, and his paintings of birds and flowers excited the wonder and admiration of Rafinesque, as it has that of the generations since his time. But Audubon was something of a wag withal, and some spirit of mischief led him to revenge the loss of his violin on the too ready credulity of his guest. He showed him gravely

some ten grotesque drawings of impossible fishes which he had observed "down the river," with notes on their habits, and a list of the names by which they were known by the French and English settlers. These Rafinesque duly copied into his note-books, and later he published descriptions of them as representatives of new genera, such as *Pogostoma*, *Aplocentrus*, *Litholepis*, *Pilodictis*, *Pomacampsis*, and the like.

These singular genera, so like and yet so unlike to anything yet known, have been a standing puzzle to students of fishes. Various attempts at identification of them have been made, but in no case have satisfactory results been reached. Many of the hard things which have been said of Rafinesque's work rest on these unlucky genera,[1] "communicated to me by Mr. Audubon." The true story of this practical joke was told me by the venerable Dr. Kirtland, who in turn received it from Dr. Bachman, the brother-in-law and scientific associate of Audubon. In the private note-books of Rafinesque I have since found his copies of these drawings, and a glance at these is sufficient to show the extent to which science through him has been victimized.

About this time Rafinesque turned his mind again toward invention. He invented the present arrangement of coupon bonds, or, as he called it, "the divitial invention." Savings-banks were pro-

[1] I am informed by Dr. J. A. Allen that there are also some unidentified genera of herons, similarly described by Rafinesque from drawings kindly shown him by Mr. Audubon. Apparently these also date from the same unlucky practical joke.

jected by him, as well as "steam ploughs," "aquatic railroads," fire-proof houses, and other contrivances which he was unable to perfect. He took much delight in the study of the customs and languages of the Indians. In so doing, if the stories are true, he became, in a way, associated with the origin of Mormonism; for it is said that his theory that the Indians came from Asia by way of Siberia, and were perhaps the descendants of the ten lost tribes of Israel, gave the first suggestion to Solomon Spaulding for his book of the prophet Mormon. In any case, whether this be true or not, it is certain that Rafinesque is still cited as high authority by the Latter-Day Saints when the genuineness of the book of Mormon is questioned.

Rafinesque now returned to Philadelphia, and published "The Atlantic Journal and Friend of Knowledge," "Annals of Nature," and other serials, of which he was editor, publisher, and usually sole contributor. After a time he became sole subscriber, also, — a condition of affairs which greatly exasperated him against the Americans and their want of appreciation of science. He published several historical treatises, and contemplated a "Complete History of the Globe," with all its contents. An elaborate poem of his, dreary enough, is entitled "The World; or, Instability." He made many enemies among the American botanists of his time by his overbearing ways, his scorn of their customs and traditions, and especially by his advocacy of crude and undigested though necessary reforms, so that at last most of them decided to ignore his very existence. In those days, in

matters of classification, the rule of Linnæus was supreme, and any effort to recast his artificial groupings was looked at as heretical in the extreme. The attempt at a natural classification of plants, which has made the fame of Jussieu, had the full sympathy of Rafinesque; but to his American contemporaries such work could lead only to confusion. Then, again, in some few of its phases, Rafinesque anticipated the modern doctrine of the origin of species. That the related species of such genera as *Rosa*, *Quercus*, *Trifolium*, have had a common origin, — a view the correctness of which no well-informed botanist of our day can possibly doubt, — Rafinesque then maintained against the combined indignation and disgust of all his fellow-workers. His writings on these subjects read better to-day than when, forty-five years ago, they were sharply reviewed by one of our then young and promising botanists, Dr. Asa Gray.

But the botanists had good reason to complain of the application of Rafinesque's theories of evolution. To him, the production of a new species was a rapid process, — a hundred years was time enough, — and when he saw the tendency in diverging varieties toward the formation of new species, he was eager to anticipate Nature (and his fellow-botanists as well), and give it a new name. He became a monomaniac on the subject of new species. He was uncontrolled in this matter by the influence of other writers, — that incredulous conservatism as to another's discoveries which furnishes a salutary balance to enthusiastic workers. Before his death so much had

he seen, and so little had he compared, that he had described certainly twice as many fishes, and probably nearly twice as many plants and shells, as really existed in the regions over which he travelled. He once sent for publication a paper seriously describing, in regular natural history style, twelve new species of thunder and lightning which he had observed near the Falls of the Ohio.

Then, too, Rafinesque studied in the field, collecting and observing in the summer, comparing and writing in the winter. When one is chasing a frog in a canebrake, or climbing a cliff in search of a rare flower, he cannot have a library and a museum at his back. The exact work of our modern museums and laboratories was almost unknown in his day. Then, again, he depended too much on his memory for facts and details; and, as Professor Agassiz used to say, "the memory must not be kept too full, or it will spill over."

Thus it came about that the name and work of Rafinesque fell into utter neglect. His writings, scattered here and there in small pamphlets, cheap editions published at his own expense, had been sold as paper-rags, or used to kindle fires by those to whom they were sent, and later authors could not find them. His "Ichthyologia Ohiensis," once sold for a dollar, is now quoted at fifty dollars, and the present writer has seen but two copies of it. In the absence of means to form a just opinion of his work, it became the habit to pass him by with a sneer, as the "inspired idiot . . . whose fertile imagination has peopled the waters of the Ohio." Until lately, only Professor Agas-

siz[1] has said a word in mitigation of the harsh verdict passed on Rafinesque by his fellow-workers and their immediate successors. Agassiz says, very justly: —

"I am satisfied that Rafinesque was a better man than he appeared. His misfortune was his prurient desire for novelties, and his rashness in publishing them. . . . Tracing his course as a naturalist during his residence in this country, it is plain that he alarmed those with whom he had intercourse, by his innovations, and that they preferred to lean upon the authority of the great naturalist of the age [Cuvier], who, however, knew little of the special history of the country, rather than to trust a somewhat hasty man who was living among them, and who had collected a vast amount of information from all parts of the States upon a variety of subjects then entirely new to science."[2]

In a sketch of "A Neglected Naturalist," Professor Herbert E. Copeland has said: —

"To many of our untiring naturalists, who sixty years ago accepted the perils and privations of the far West, to collect and describe its animals and plants, we have given the only reward they sought, — a grateful remembrance of their work. Audubon died full of riches and honor, with the knowledge that his memory would be cherished as long as birds should sing. Wilson is the 'father of American ornithology,' and his mistakes and faults are forgotten

[1] So early as 1844, Professor Agassiz wrote to Charles Lucien Bonaparte: "I think that there is a justice due to Rafinesque. However poor his descriptions, he first recognized the necessity of multiplying genera in ichthyology, and this at a time when the thing was far more difficult than now."

[2] Agassiz, American Journal of Science and Arts, 1854, p. 354.

in our admiration of his great achievements. Le Sueur is remembered as the 'first to explore the ichthyology of the great American lakes. Laboring with these, and greatest of them all in respect to the extent and range of his accomplishments, is one whose name has been nearly forgotten, and who is oftenest mentioned in the field of his best labors with pity or contempt." [1]

It is doubtless true that while, as Professor Agassiz has said, Rafinesque "was a better man than he appeared," and while he was undoubtedly a man of great learning and of greater energy, his work does not deserve a high place in the records of science. And his failure seems due to two things: first, his lack of attention to details, a defect which has vitiated all of his work; and, second, his versatility, which led him to attempt work in every field of learning. As to this, he says himself: —

"It is a positive fact that in knowledge I have been a botanist, naturalist, geologist, geographer, historian, poet, philosopher, philologist, economist, philanthropist. By profession a traveller, merchant, manufacturer, brewer, collector, improver, teacher, surveyor, draughtsman, architect, engineer, pulmist, author, editor, bookseller, librarian, secretary, and I hardly know what I may not become as yet, since, whenever I apply myself to anything which I like, I never fail to succeed, if depending on myself alone, unless impeded or prevented by the lack of means, or the hostility of the foes of mankind."

But a traveller Rafinesque chiefly considered himself; and to him all his pursuits, scientific, linguistic, historical, were but episodes in a life of

[1] American Naturalist, 1876.

travel. Two lines of doggerel French were his motto: —

"Un voyageur dès le berceau,
Je le serai jusqu'au tombeau"

"A traveller from the cradle,
I 'm a traveller to the tomb."

Long before the invention of railroads and steamboats he had travelled over most of southern Europe and eastern North America. Without money except as he earned it, he had gathered shells and plants and fishes on every shore from the Hellespont to the Wabash.

Concerning one element of Rafinesque's character I am able to find no record. If he ever loved any man or woman, except as a possible patron and therefore aid to his schemes of travel, he himself gives no record of it. He speaks kindly of Audubon; but Audubon had furnished him with specimens and paintings of flowers and fishes. He speaks generously of Clifford, at Lexington; but Clifford had given him an asylum when he was turned out of Transylvania University. No woman is mentioned in his Autobiography except his mother and sister, and these but briefly. His own travels, discoveries, and publications filled his whole mind and soul.

Rafinesque died in Philadelphia, in 1840, at the age of fifty-six. He had been living obscurely in miserable lodgings; for his dried plants, and his books published at his own expense, brought him but a scanty income. His scientific reputation had not reached his fellow-lodgers, and his landlord thought him "a crazy herb-doctor." He died

alone, and left no salable assets; and his landlord refused to allow his friends — such friends as he had — to enter the house to give him a decent burial. He wished to make good the unpaid rent by selling the body to a medical college; but at night, so the story goes, a physician who had studied botany with Rafinesque got a few friends together, and broke into the garret and carried away the body, which they buried in a little churchyard outside the city limits, now obliterated by the growth of Philadelphia.

American naturalists have greater honor now than forty years ago. Rafinesque died unnoticed, and was buried only by stealth. A whole nation wept for Agassiz. But a difference was in the men as well as in the times. Both were great naturalists and learned men. Both had left high reputations in Europe to cast their lot with America. Agassiz's great heart went out toward every one with whom he came in contact; but Rafinesque loved no man or woman, and died, as he had lived, alone. If some one who loved him had followed him to the last, it might have been with Rafinesque as with Albrecht Dürer: "'*Emigravit*' is the inscription on the headstone where he lies." But there was no one; and there is neither headstone nor inscription, and we know not even the place where he rests after his long journey.

A CUBAN FISHERMAN.

"AH, but you must see Don Felipe, — he knows all about fishes!" is the first advice which the naturalist receives when he begins to make collections of fishes in the markets of Havana. The writer once had occasion to make such a collection, and he soon found that among fishermen and fishmongers the phrase "amigo de Don Felipe" was ever a passport to honest dealing and to a real desire to aid him in his work. For every fisherman in Havana knows Don Felipe, and looks upon him as a personal friend. Each one regards the fame which Don Felipe's studies of the fishes is vaguely understood to have brought him in that little-known world outside of Havana as in some sort reflected on himself. The writer was told, by a dealer in the Pescadería Grande, that for twenty years Don Felipe Poey was there in the markets every day, when at noon the fishes came in from the boats, and that he knew more about the fishes of Cuba than even the fishermen themselves. And now that Don Felipe no longer visits the markets, he is not forgotten there, and many a rare specimen still finds its way from the Pescadería to Don Felipe's study in the Calle San Nicolas.

Felipe Poey y Aloy was born in Havana, May 26, 1799. His father was French, his mother Spanish; but Poey early renounced his French citizenship for that of Cuba. His education was received in Havana, and after studying law he became, in 1823, an advocate in that city. But his tastes lay in the direction of natural history, and for this he gradually abandoned his practice as a lawyer. Very early he had made discoveries of mollusks, insects, and especially of fishes, which were new to science. In 1825 he was married to Maria de Jésus Aguirre, a very intelligent lady who is still the companion of his studies. In 1826 he sailed for Paris, taking with him eighty-five drawings of Cuban fishes and a collection of thirty-five species, preserved in a barrel of brandy. These drawings and specimens he placed at the service of Cuvier and Valenciennes, who were then beginning the publication of their work on the "Natural History of the Fishes." The notes and drawings of Poey proved of much service to the great ichthyologists. A few new species were based on them, and Poey had the satisfaction of finding his own name and observations cited by Cuvier and Valenciennes even more frequently than those of his famous predecessor, Don Antonio Parra,[1] who had published, in 1787, the first account of the Fishes of Cuba.[2] A set of duplicates of these notes and drawings is still retained by Professor Poey. While

[1] Y tuve el honor de ser citado por él (Cuvier) y por su colaborador Valenciennes, más frecuentemente que D. Antonio Parra. — POEY.

[2] Diferentes Piezas de Historia Natural de la Isla de Cuba.

in Paris, Poey was one of the original members who founded the Entomological Society of France.

On returning to Havana in 1833, Poey gave himself still more fully to the study of natural history, and greater practice gave to his drawings and notes more exactness and value. With the appearance of the successive volumes of the "Histoire Naturelle des Poissons," he attempted to identify the fishes of his market, as well as to study their osteology and general anatomy. Animals other than fishes he also tried to study, but in most groups he found the literature in so scattered and unsatisfactory a condition that he rarely ventured to publish the results of his observations. Among the fishes, however, thanks to the general work of Cuvier and Valenciennes, and later to that of Dr. Günther, he felt comparatively sure of his results, and ventured to name as new those which he could not identify. The land-snails of Cuba, too, Poey and his associate, Dr. Juan Gundlach, were able to identify and describe with certainty, as all the species then known were included in the "Monographium Heliceorum Viventium" of Dr. Ludwig Pfeiffer.

In the year 1842 Poey was appointed to the professorship of Comparative Anatomy and Zoölogy in the Royal University of Havana, which chair he still holds, after forty-five years. The University of Havana occupies an ancient monastery building in the heart of the city. Like most such edifices in Cuba and Spain, it is a low building around a paved court, and its whitewashed, time-stained walls have an air of great antiquity. The univer-

sity has now some twelve hundred students, the great majority of whom are in those departments which lead toward wealth, or social or political preferment, as law, medicine, and pharmacy. Comparatively few pursue literary or philosophical studies, and still fewer are interested in the biological sciences. In the department of botany there are now but two students, and the number in zoölogy is probably not much greater.

Although Professor Poey is evidently held in very high respect in the university, in which he has long been dean of the faculty of science, I cannot imagine that he ever received much help or sympathy in his scientific work from that quarter, or indeed from any other in Cuba. His friends and countrymen are doubtless glad to be of assistance to so amiable a gentleman as the Señor Don Felipe, but they have very little intelligent sympathy for the claims of science. The university library contains but little which could be of help in Professor Poey's zoölogical studies. He has therefore been compelled to gather a private library of ichthyology. This library has with time become very rich and valuable, many of his co-workers in the study of fishes, notably Dr. Bleeker, having presented him with complete series of their published works. Two of Poey's daughters who still reside with him in Havana have been of much help to him in the preparation of drawings and manuscripts.

The museum of the university occupies two little rooms,—the one devoted chiefly to Cuban minerals; the other containing mostly mammals, birds, and

fishes mounted by Poey himself in the earlier days of his professorship. The number of these is not great, nor have many additions been made during the last twenty years. Most of the types of the new species described by Professor Poey have been, after being fully studied by him and represented in life-size drawings, sent to the United States National Museum, to the Museum of Comparative Zoölogy, or to the Museum at Madrid. Duplicates have been rarely retained in Havana, the cost of keeping up a permanent collection being too great. As a result, Professor Poey's work has suffered from lack of means of comparing specimens taken at different times. There is no zoölogical laboratory in Cuba except the private study of Professor Poey; and here, for want of room and for other reasons, drawings have, to a great extent, taken the place of specimens.

The publication of the observations of Professor Poey on the animals of Cuba was begun in 1851, in a series of papers entitled "Memorias sobre la Historia Natural de la Isla de Cuba." These papers were issued at intervals from 1851 to 1860, and together form two octavo volumes of about 450 pages each. The first volume contains chiefly descriptions of mollusks and insects. The second volume is devoted mainly to the fishes. As is natural in the exploration of a new field, these volumes are largely occupied with the description of new species. They give evidence of the disadvantages arising from solitary work, without the aid of the association and criticism of others, and without the broader knowledge of the relations of groups which

comes from the study of more than one fauna. On the other hand, Professor Poey enjoyed the great advantage of having an almost exhaustless supply of material; for there are few ports where fishes are brought in in such quantities, or in such variety, as in the markets of Havana.

It is the fashion in some quarters to decry the work of the describer of new forms. This is unjust as well as absurd. All honest study has its place; and till the pioneer work of exact determination of species is performed, there is little opportunity for fruitful work on the part of the embryologist or the anatomist. It is of little use to record the structure or the development of an animal, while the animal itself is unknown.

The "Memorias" were at once recognized as the most important work on the fishes of Cuba; and as was said long ago by Professor Cope, this work is a *sine qua non* in the study of the ichthyology of tropical America.

The nomenclature and grouping of the species in the "Conspectus Piscium Cubensium," contained in the "Memorias," was in 1862 the subject of a critical paper by Dr. Theodore Gill.[1] This article, and subsequent ones by the same author, exerted much influence on Poey's work. He was always ready to profit by the suggestions and advice of other writers, especially of those more favorably situated than he in regard to libraries and museums; from Professor Gill's papers he gained clearer

[1] "Remarks on the Genera and other Groups of Cuban Fishes," Proceedings of the Academy of Natural Sciences, Philadelphia, 1862, pp. 235 *et seq.*

views of the relations of forms, and of the connection of the Cuban fauna with that of other regions. On the other hand, he was led to adopt, against his own judgment in many instances, that minute subdivision of genera which has been a fashion in American ichthyology, and which has been in some quarters a reproach to American science.

In 1868 the results of the revision of his classification were embodied in a second catalogue of the Cuban fishes, entitled "Synopsis Piscium Cubensium." This forms the concluding chapter of a series of papers, entitled "Repertorio Físico-natural de la Isla de Cuba," which embody the results of a general scientific survey of the island. Of this survey Professor Poey was director. In 1875 the entire list of species was again revised, and the third and best catalogue of Cuban fishes was published under the title of "Enumeratio Piscium Cubensium." Besides these larger works, many shorter papers by Poey occur in the "Proceedings of the Academy of Natural Sciences" of Philadelphia, the "Annals of the New York Lyceum," and the "Anales de la Sociedad de Historia Natural de Madrid." He is also the author of a Geography of Cuba, and of a treatise on Mineralogy, used in the Havana schools. A number of poems from his pen have likewise been published, but these I have not seen.

The great work of Poey's life is the still unpublished "Ictiología Cubana." This is to contain a detailed account of each of the fishes of Cuba. It is to be composed, according to a published statement of Poey, which I here translate, —

"of a thick volume of text, Spanish folio, and of an atlas of ten volumes larger folio (eighteen by thirteen inches). The plates are made with a light indication of the colors, which are described in the text. All are original, drawn from nature by the author. . . . The text contains the scientific name of each species, the common name, the complete synonymy, a description of the colors, distinctive peculiarities, relations of the varieties, comparisons, critical observations, and the history of the fish. It contains, moreover, the characters of classes, sub-classes, orders, families, genera, and species. The total number of plates in the Atlas is 1,040. These show 758 species of Cuban fishes, represented by 1,300 individuals in all stages of growth. All except the sharks are drawn of life-size. These 758 species, together with 24 mentioned at the end of the work, make up 782 species of Cuban fishes. Of these, 105 are doubtful, and therefore are left without specific names. I hold them in suspense till I can receive further data from the study of other specimens. There are, therefore, 677 species well determined, of which more than half have been first made known by me. Not more than a dozen species in the list have not been examined by me. These are inserted on the authority of writers who claim to have received their specimens from Cuba, and who appear to be worthy of confidence. The preparation of the text has cost me an immense amount of time and labor, by the preparatory studies which it has required. In the determination of the species it is rarely that a single one has not occupied me for an entire week. I have wished to make known the certain as certain, and the doubtful as doubtful, so that I shall declare nothing to be new unless it is so in reality."

The manuscripts of this great work are now in duplicate. Professor Poey retains one copy; the

other has been purchased by the Spanish Government for $4,000. It is earnestly hoped by Professor Poey and his friends that the Government will soon order its publication; but, unfortunately, there seems to be no certainty of this. The manuscripts and drawings of the "Ictiología Cubana" were placed on exhibition by the Spanish Government in the Exposition of Amsterdam in 1883. In testimonial of their worth, Professor Poey has received from King William III. the decoration of the order of the "Lion Néerlandais." Before this, as the most distinguished of Spanish naturalists, he had received from the King of Spain the title of "Encomendador de la Orden de Isabella la Católica."

Among the manuscripts of Poey is one bearing the title of "Corona Poeyana." This is a list of the species of animals and plants which other naturalists have named for him as "Poeyi" or "Poeyanus," in friendly recognition of the value of his work. This list is a long one, but the kindly tributes which it implies have not been undeserved.

There is no characteristic of Poey's work more striking than its entire lack of prejudice, or, in other words, the teachableness of the man himself. A certain zoölogist was once described to me by Dr. Kirtland as "a little man who could n't be told anything." His character was in this regard just the reverse of that of Professor Poey. Among all the naturalists of our time, I know of none more willing to learn, whatever the source from which information may come. He has no theories which he is not ready to set aside when a better suggestion

appears. Unlike some other systematic writers, he exhibits no preference for his own names or subdivisions, but is as ready, if the evidence seems to require it, to smother one of his own species or genera as those of another. His work shows little sign of falling off in quality. The clearness of his judgment and the accuracy of his memory seem unimpaired. It is difficult in conversing with him to realize that he was born in the last century, and that in his earlier studies he was a contemporary of Lamarck, Cuvier, and of Geoffroy Saint-Hilaire. Many men are older at fifty than Poey at eighty-five.

Old age and its accompanying infirmities are now narrowing the circle of Professor's Poey's life. His walks seldom extend themselves beyond the confines of his study and the little courtyard, shaded by tropical trees, into which his door opens. Some two hours each day he still devotes to the study of fishes. He eagerly reads every new work on his favorite science, and is as anxious as ever to obtain the freshest ideas on classification, or the latest points in synonymy. As an evidence of his freedom of mind and lack of prejudice I may cite his acceptance of the various scientific theories and conclusions embraced in the name "Darwinism," and his general acceptance of the philosophy of evolution as developed by Herbert Spencer, an author for whom he has expressed to me a special admiration. This is the more remarkable when we remember that almost his whole life has been passed in Cuba, — a condition where all tendencies of society and of Church are away from such studies and speculations.

Like most men who have studied Nature for love of her, Poey possesses a deeply religious spirit. Everything to him proclaims the presence of Divinity. "I believe with Lamarck," he has said, "that there is nothing but God in the Universe, and that by the word *Nature* we ought to understand an order of things . . . Him whose true name we cannot decipher; who in the burning bush, questioned by Moses, said, '*I am that I am;*' who on Mount Sinai called himself Jehovah, and whom in our mortal tongue, with filial tenderness, we call God."[1]

Poey is rather above the medium height, heavily built, and in his younger days he possessed unusual physical activity and vigor. In appearance he offers a marked contrast to most of his countrymen, the Cubans. His complexion is fair, his hair — now white — was never dark, and his gray eyes suggest the Saxon rather than the Spaniard. As he once said to me, "Comme naturaliste, je ne suis pas espagnol: je suis cosmopolite." His full forehead, strong features, and handsome, smooth-shaven face are not misleading evidences of a pure and benevolent life. He has a most happy temperament, and his smile is peculiarly genial and cheery. Simple, direct, unaffected, he is one of the most delightful of men. Of all men whom I have known, none has better than he learned the art of growing old.

[1] Memorias de Cuba, vol. ii. p. 414.

DARWIN.

IN each field of human thought there stand some few great names which mark the epochs in its history. In the study of the living things upon the earth these names are three, — Linnæus, Cuvier, and Darwin. Old as the world was when Linnæus was born, before him scarcely any one had thought of flowers and birds and butterflies as objects of serious study. The "Christian Era" of biology begins with the year 1758; [1] and the death of the great Swede who rocked the cradle of the infant science took place little more than a century ago.

Linnæus has taught us to name and describe the objects of Nature, that knowledge once gained may be communicated to others. Cuvier has taught us to see unity of structure underlying the greatest diversity of appearance, and to group these objects together in accordance with this unity. Darwin has given us the clew as to the meaning of this unity, — that unity in structure is brotherhood in fact.

Charles Robert Darwin was born in the town of Shrewsbury, Feb. 12, 1809, and died at his country

[1] The date of the tenth edition of Linnæus' "Systema Naturæ." Botanists usually begin farther back, at 1737, the date of the "Genera Plantarum."

home at Down, in Kent, on the 19th day of April, 1882, at the age of seventy-three years. A life more calm and peaceful than his, the world does not often see. At home, in the country, surrounded by his family, far away from the noise of politics and undisturbed by clashing systems of philosophy, he worked on in patience. For years, almost an invalid, still feeling the effects of his long seasickness while on the voyage of the "Beagle;" averse to display or controversy; sure of the strength of truth, — which some generation would hear, if his own did not, — he sat and watched his flowers and vines and trees and pigeons, reporting from time to time the things he saw and their underlying meanings. "For years," said one of Darwin's servants to me, "Mr. Darwin used to spend his days in the greenhouse with his plants, tying strings to them and trying to make them do things." Nevertheless, this age is the age of Darwin! No life in this bustling nineteenth century has left so deep an impress on our thought. And this impress must deepen as the years roll on, until, if ever, the time shall come when what we now know of the laws of God shall have faded away, and our successors shall begin again to learn like little children their A B C from Mother Nature. "Mother Nature," says Huxley, "is singularly obdurate to honeyed words. Only those who understand the ways of things, and can silently and effectively use them, get much good out of her."

In 1831 Darwin was sent out as naturalist on board of Her Majesty's Ship "Beagle," which was to take five years for a cruise around the world.

These five years of minute, detailed observation formed the best of Darwin's scientific training, and they have been the basis of all his later work. The primary results of this voyage were a number of papers and treatises on matters connected with his observations on the geological structure and the fauna and flora of the regions visited, — works which brought their author at once to the front rank among the scientific men of England. Then for a long time Darwin published nothing; and it was not until after twenty-five years of elaboration and verification that the main results of the voyage of the "Beagle," his own observations on the changes of animals and plants under varying conditions, came to light in the volume on the "Origin of Species." This was in 1859.

That Darwin had not been idle during these twenty-five years is shown by his own words, — words which may be read with profit by any young man who is anxious for sudden greatness, who wishes to gather his strawberries before they are ripe. He says: —

"When on board H. M. S. 'Beagle' as naturalist, I was much struck with certain facts in the distribution of the organic beings inhabiting South America, and in the geological relations of the present to the past inhabitants of the continent. These facts seemed to throw some light on the origin of species, — that mystery of mysteries, as it has been called by one of our greatest philosophers. On my return home it occurred to me (in 1837) that something might perhaps be made out on this question by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it. After five

years I allowed myself to speculate on the subject, and drew up some short notes. These I enlarged, in 1844, into a sketch of the conclusions which then seemed to me probable. From that period to the present day I have steadily pursued the same object. I hope that I may be excused for entering on these personal details, as I give them to show that I have not been hasty in coming to a conclusion."

Let me speak of certain traits of this work, the "Origin of Species," which give it a position almost alone among books of science. There is in it no statement of fact of any importance which, during the twenty-five years since it was first published, has been shown to be false. In its theoretical part there is no argument which has been shown to be unfair or fallacious. In these twenty-five years no serious objection has been raised to any important conclusion of his which was not at the time fully anticipated and frankly met by him. Indeed, there are but few of these objections which with our present knowledge are not much less weighty than Darwin then admitted. The progress of science has bridged over many chasms in the evidence.

There is in this work nowhere a suggestion of special pleading or of over-statement. The writer is a judge and not an advocate, and from his decisions there has been no successful appeal. There is in this or any other of Darwin's works scarcely a line of controversial writing. He has been the faithful mirror of Nature. The relations of Nature to metaphysics he has left to others. The tornadoes which have blown about the "Origin of Species" have left him undisturbed. The word

"evolution" is not his word. He felt, perhaps, that most systems of philosophy are like air-plants which thrive equally well in any soil. With just facts enough for their roots to cling to, they may grow and bloom perennially, without other food than the air.

From the standpoint of the naturalist the great work of Darwin has been the total change in our conception of the meaning of species. It was declared by Linnæus, and repeated by his successors, that "there are as many different species now as there were different forms created in the beginning by the Infinite Being." In accordance with this statement we have been taught to look upon a species in biology as a fixed entity, a perennial succession of individuals, similar to one another, from the creation at one end of the series to the extinction at the other. We have been told over and over again that the variations of a species are kept within fixed limits by definite laws, and that one species can never encroach on the traits of any other species, nor ever permanently assume any characters other than those with which it was created. Darwin maintained that the form under which any species is known to us is simply a phase in the history of the succession of living forms which constitute that species. He has shown that, in fact, species are not thus held in check, — that with the line of descent goes gradual modification. Thus the living representatives of no species today are quite like their ancestry of centuries ago.

The two things which most impress the mind of the student of Nature are these: First, the enor-

mous diversity among living things; and second, their even more surprising unity. The half million known forms of animals and plants may be readily reduced to less than a dozen special forms or types. The problem is to account for the origin of this diversity in life in some way which shall not leave the essential unity out of sight.

The number of different forms of life on the earth, now recognized as different species, is far beyond the usual conception of those who have not made such matters a special object of study. This old book which I hold in my hand is a copy of the half of the tenth edition of the "Systema Naturæ," which treats of all the known species of animals. In its eight hundred and twenty-three pages, some four thousand different kinds of animals are named and briefly described. These four thousand species were all that were known in the world by civilized man a little more than a century ago. But for every one of these enumerated by Linnæus, more than fifty kinds are known to the naturalists of to-day, and the number of species still unknown doubtless far exceeds the list of those already recorded. Every year, for the last quarter of a century, there has been published in London a plump octavo volume known as the "Zoölogical Record." Each of these volumes is larger than the whole "Systema Naturæ." Each volume is filled with the names of the animals new to science which have been added to our lists during the year of which it treats. Every one of these volumes contains the names of two or three times as many animals as are mentioned in the whole "Systema

Naturæ." Yet the field shows no signs of exhaustion. As these volumes stand on the shelf together side by side, it is easy to see that the later volumes are the thickest; and the "Record" for the present year is the largest of all. And what is true of the increase of knowledge in Systematic Zoölogy, is even more marked in the case of Botany. Such then is the variety in the life of the globe, — a variety of which Linnæus and his successors had never dared to dream.

And yet great as this variety is, there are only a few types of structure among animals and plants, after all, — some eight or ten general modes of development — and all the rest are minor variations from these few types. The law which tends to keep the species uniform is the law (or the fact, which we cannot wholly explain) that living beings resemble their ancestors. And as each living being has twice as many ancestors behind it as either its father or its mother had, so does the influence of remote ancestry diminish with each succeeding generation. With this law or fact of unity through heredity goes another law (or fact) that no two living beings are ever exactly alike, small variations of all sorts are constantly appearing; and of the multitude of these variations some few will be preserved, and favorable circumstances will cause them to be repeated and augmented.

Life then is changing on the earth, in spite of the action of heredity. Past life must differ from present life, and so in the life of past ages we may trace the ancestry of the life of to-day. The agencies which thus gradually modify species are

numerous, and some of them are imperfectly understood. One of these — and in Mr. Darwin's view, the predominant one — has been the survival of the fittest in the struggle for existence.

I cannot in the limits of this address illustrate in detail what is implied in that which has been called "natural selection" by Mr. Darwin, and by Mr. Spencer the "survival of the fittest." In Mr. Darwin's words, —

"A struggle for existence inevitably follows from the high rate at which all organic beings tend to increase. Every being which during its lifetime produces several eggs or seeds must suffer destruction during some period of its life and during some season or occasional year; otherwise, on the principle of geometrical increase, its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are produced than can possibly survive, there must in every case be a struggle for existence, either one individual with others of the same species, or with the individuals of different species, or with the physical conditions of life. Although some species may be increasing in numbers, all cannot do so, for the world would not hold them."

A calculation has been lately made that at the normal rate of increase from a pair of English sparrows, if none were to die except of old age, it would take but twenty years to give one sparrow to every square inch of the State of Indiana. But such increase is actually impossible; for more than a hundred other species of resident birds are disputing the same territory, and there cannot be place or food for all. With such conditions, the struggle for existence between sparrow and sparrow, and

between sparrows and other birds, grows yearly more severe. Each year now the sparrow gains a little and the other birds lose correspondingly; but sooner or later with each species a point will be reached when the loss exactly balances the increase. This produces a condition of apparent equilibrium, — the equilibrium of Nature; a sort of armed neutrality which a superficial observer mistakes for real peace and permanence. But this equilibrium is broken as soon as any individual or group of individuals appears that can do something more than merely hold their own in a struggle for existence. Slight deviations from the ancestral type, for better or worse, are constantly appearing in Nature. Of the infinite number of these small variations which may affect the individual, some will be found to be of advantage to him in this struggle for existence. Be it ever so slight, this help in time will count. The individuals thus aided will live and multiply, and their type is the type of the species preserved. Those individuals who do not share this advantage, or who may be handicapped by disadvantageous variation, die and leave no descendants. Thus the advantage of the individual becomes the gain of the species, and thus in the character of the species does the fitness of the individual survive.

It is this progress through competition, this survival of the fittest to live in the struggle for existence, to which the term "natural selection" has been applied. Different estimates of the relative importance of the action of natural selection and of other agencies modifying the history of a species

will be made by different minds. That this, however, is one of the great controlling factors in the production of diversity in the life of the earth, cannot be questioned.

Darwin's work was addressed at first only to naturalists, with no expectation that the public would pay any attention to it. He had confidence that the younger and more observant of his fellow-workers would find in their own work confirmation of his conclusions. The times were riper than he had dreamed. He has outlived nearly all of his scientific opponents, the greatest and perhaps the last of whom was Agassiz. To-day there is not one whose scientific studies have been such as to give him a right to speak, whose views are not in substantial accord with those of the "Origin of Species."[1] Darwin's work has destroyed forever the closet-formed idea of a "species" in biology as something fundamentally different from a variety or a race.

Let me take an illustration. Camille Dareste, writing of the hundred or more alleged species of the True Eel (*Anguilla*) says: —

"There are at least four distinct types, resulting from the combination of a certain number of characters; but

[1] I say this advisedly. I know that some half dozen geologists and biologists of high repute still hold to the dogma of the immutability of species. Not one of these, so far as I know, has ever made any serious special study of species in any group, — of their relations to each other, their variations, their embryology or their geographical distribution. I cannot see how one who has not done this has any right to believe that species are practically unchangeable in face of the almost unanimous testimony of all who have made such matters a life-study.

the study of a very large number of specimens belonging to these four specific types has convinced me that each of these characters may vary independently, and that, consequently, certain individuals exhibit a combination of characters belonging to two distinct types. It is therefore impossible to establish clearly defined barriers separating these two types. The genus *Anguilla* exhibits, then, a phenomenon which is found in many other genera, and even in the genus *Homo* itself, and which can be explained in only two ways: Either these four forms have had a common origin and are races merely, and not species; or else they are distinct in origin and are true species, but have been more or less commingled, and have produced by their mingling intermediate forms, which coexist with those which were primitive. Science is not in the position to decide between these two alternatives."

It is on idle problems like this as to the reality of species that the strength of naturalists of the past century has been largely wasted. Which of the forms we study are species, and therefore represent separate acts of the Creator, and which are mere varieties, chance products of varying surroundings, and therefore to be despised and ignored? Scarcely ever did two earnest students of any group reach an agreement in this respect, for agreement is only possible when material is lacking. A single additional specimen often unsettles every conclusion, and the contents of all museums are but the slightest fragment of the life of the globe. "We can only predicate and define species at all," says Dr. Coues, "from the mere circumstance of missing links. Our species are the twigs of a tree separated from the parent stem.

We name and arrange them arbitrarily in default of means of reconstructing the whole tree in accordance with Nature's ramifications." Among Dareste's eels we may have one species, or four, or forty, as our collection may be deficient in connecting forms, or as we may choose to magnify or to disregard slight differences. There are just as many kinds of eels as there are races of men or of dogs. Future naturalists will again describe those eels; but they will know them for what they are, — the varying descendants of some one degenerated type of fishes crawling in the weeds and ooze of many seas and rivers, and thus variously modified by their surroundings.

The old notion of a species has passed away forever. We can no more return to it than astronomers can return to the Ptolemaic notion of the solar system. The same lesson comes up from every hand. It is the common experience of all students of species in every field. We have learned it from Gray and Engelmann and Coulter, and each of the many students of American botany. We have learned it from Baird and Allen and Coues and Ridgway and Stejneger, and from all who have made life studies of American birds. We have learned it from Cope and Marsh and Leidy, and from all who have rummaged in the tombs where our ancestors lie buried. I do not know of a naturalist in the world who has made a thoughtful study of the relations of species in any group, who entertains the old notion as to their distinct origin. There is not one who could hold this view and look an animal in the face.

And for this change we have to thank Darwin. "It is easy to plough when the field is cleared;" and what he first saw clearly, we cannot fail to see now. The fact is, that every student of species and of the facts of geographical distribution before or after Darwin, has reached willingly or unwillingly the conclusion that species are not immutable; that those differences by which he tried to discriminate the groups of organisms which he called species were not differences originating in the act of creation, but produced in some way by outside influences, or by the reaction in the organism from adjustment to these influences. One might safely pledge himself to convert to some phase of the development theory any honest and intelligent man, whatever his preconceived opinions, who would spend a month in the careful study of a large collection of specimens in any group of Natural History, in which the existing species are found over wide areas on the surface of the earth. The study of squirrels, eels, cat-fishes, cray-fishes, pine-trees, asters, butterflies, clams, snails, horses, or men, — any of these will serve perfectly to accomplish this purpose.

The general acceptance of the Darwinian theory by naturalists is not due exclusively to the influence of the "Origin of Species," or to any of the numerous commentaries and expositions which have come from other hands. It arises from the results of the studies themselves. The idea of development gives the only clew by which the naturalist can be guided in his work. If the affinities of species are not related to the law of heredity, they

are unintelligible. If the variation of species is really immutability in disguise, we cannot trust our senses. It is said — I know not on what authority — that the distinguished ichthyologist Albert Günther was converted to Darwinism by a study of the British salmon. Whether this is true or not, such a study could have no other effect. If a personal reference be permitted, I may say that I was brought to my present beliefs by a study of the minnows and darters of the Mississippi Valley. In the study of species one has no choice except that between some form of a development theory and a hopeless, unscientific agnosticism; and in all forms of biological investigation — the study of Comparative Anatomy, Morphology, Embryology — similar results are invariably reached.

I have purposely avoided the use of the word "evolution" in connection with Darwin's work. "Evolution" is a term belonging to metaphysics rather than to biology. The theory of evolution is that there is in all things a tendency to become specialized and differentiated, — that, in accordance with this tendency, nebulous masses have become concentrated into planets, and that all forms of life have changed from the simple to the complex, from the low to the high, from homogeneity to variety. From the study of the history of the globe and its life we find that many changes such as this theory contemplates have indeed taken place; that progress has been the rule and retrogression the exception. Degraded forms exist in all groups, as degraded races among men; but

advancing forms are far more common. Degradation of type is merely the result of withdrawal from the stress of the struggle for existence. Evolution, in a general way, is certainly a fact, whether it be a law of Nature or not, if indeed the two ideas be not identical. A law, as defined by Darwin, is simply the "ascertained sequence of events," and in that sense we can certainly speak of evolution as a law of Nature. But the development of the theory of evolution belongs rather to the domain of metaphysics, and with the metaphysicians I may leave it. There is such an amount and variety of arrant nonsense now afloat under the name of "evolution" that one may well hesitate before accepting the designation of "evolutionist." The name now needs a special definition every time that it is used. The popular mind seems to have reduced it to this: "Evolution is something about man and monkeys which contradicts the Bible," and many of our self-constituted champions of evolution are scarcely more fortunate in their interpretations of the term.

Darwin's work might have gone on, as I have already said, with scarcely a notice from the world outside, had not the question of the origin of mankind become concerned in the controversy. For the human race is likewise a species, and from its physical side it must be discussed with other species. The study of these relations gave us in 1871 the volumes on the "Descent of Man." If we suppose, as we must, that the various forms of lower animals and plants had their origin in pre-existing forms, more or less unlike them, we may

conceive it to be true of man also. That it is in fact true of man, we know; for not many thousands of years ago our ancestors in Europe were barbarians, cave-dwellers, lake-dwellers, and dwellers in hollow trees, with only the rude implements they shaped from metal and flint. Surprisingly like us in form and structure, though far below us in skill and intelligence, are the many races of apes and monkeys. And among these, or rather behind these, for these too are changing with the changing conditions of life, must our ancestry be traced.

If anything is certain in science, it is this. What we call homology represents something real, some law of Nature, something other than the results of mere chance. When I compare my arm with that of my neighbor, I find some differences, — differences in size, in proportions. But these are superficial, and there is the underlying correspondence of each bone and muscle, each nerve-fibre, artery, and vein. When I compare my arm with the foreleg of a dog, I find more striking differences, for the dog's station in life is quite unlike my own, and his arm he uses for quite different purposes. When I compare my arm with the wing of a bird, or the pectoral fin of a fish, the results are still similar. Though the differences in each case become more and more striking, and the resemblances less easy to trace, yet the same resemblances exist, and a closer study shows that these resemblances far outweigh the differences.

We say, then, that homology is real, and what-

ever power or influence or cause has acted on fishes to provide them with pectoral fins has given to birds wings, to the dog forelegs, and to me and my neighbor arms. The arms are appendages more highly finished and suited to more purposes; but all are formed of the same pieces, arranged in the same way, and all bear the stamp of the same maker. But when I compare my arm with the claw of a lobster, the limb of a tree, the arm of a starfish, or an arm of a sea, all resemblances in structure disappear, and we have only chance analogies.

This then is certain: In Nature homology exists, and among us back-boned animals all structures, all functions, and at least some of the mental operations show distinct homology. The essence of the development theory is this: Homology is the stamp of heredity. Homology means blood relationship. No other meaning has ever been shown, nor is there the slightest evidence that any other interpretation is possible. Blood relationship implies a common action of heredity, and heredity is the only known source of the likenesses we call homology. "Owing to the imperfection of language," said Dr. Erasmus Darwin, a century ago, "the offspring is termed a new animal; but it is in truth a branch or elongation of the parent, since a part of the embryon-animal is or was a part of the parent, and therefore may retain some of the habits of the parent system."

I resemble my neighbor so closely that people say that we look like brothers. My little boy shows similar exactness of homology to me, and people

say that he is the very image of his father. My neighbor on the left shows a wider divergence, but then he too is evidently an Anglo-Saxon. Angle or Saxon, we are all of one blood, not many generations back. A little farther away the whole Aryan race becomes one; and in Adam we are all one, even with our poor relations, the negro and the Chinaman. If we knew them all, the chain of ancestors would be as unbroken as the chain which connects the boy and the man, or the chain which joins the American of to-day with his Angle and Saxon and Aryan ancestors. Where homologies exist there is somewhere the elements of a genealogical tree.

But still poorer relations we have in numbers, and they too carry on their faces the unmistakable evidence of kinship by blood. In every bone and muscle my dog shows his likeness to me, and even in every function of his feeble little brain the resemblance is apparent. Let me say again, we have no explanation of homology other than that of kinship by blood. This is Darwinism, and this is a lesson of all biological science. There is substantially the same evidence — the same in kind and not much less in degree — for believing that my dog and myself are related by blood in some form of distant cousinship as there is to show a similar relationship between myself and any one of my neighbors about me to-day. History, as deduced from the registers in our family-Bibles, shows no trace of relationship in either the one case or the other. Our records go back for a few generations only, and the great past is lost. In either case our

acknowledged kinship is only an inference based on known facts in homology.

No two groups of animals can show homologies with each other more clearly than does the man with the monkey. Either these homologies show kinship or else they are mere mockeries, like the face we see in the pansy flower. If homologies are mockeries, then indeed our science has made no progress, for that was the belief of the Middle Ages.

So much for what we know. Our objections to sharing our ancestry with monkeys and other mammals, if we have any, rest on considerations outside the domain of knowledge. Nor do they rest on religious grounds. Those who think so, deceive themselves. Could it be proved by absolute demonstration, such as science can seldom give, that an unbroken line of descent connects the barbarous man of the past with his back-boned brethren of the farther past, how could that affect Christianity? The Darwinian theory concerns only the question of the methods of creation, — the "secondary causes" in the providence of God. It can in no way come in conflict with the teachings of Christ. The mission of religion is spiritual, not physical. Christianity gives no answer to our questions of science. It does not rise or fall with any steps in the growth of knowledge. It rests on the eternal needs of the human soul. It is anchored to no floating hypothesis. It builds on the "Rock of Ages." Over the door of Linnæus' cottage at Hammarby stood this motto, *Innocue vivito: numen adest*, — "Live blameless: God is near!" "This,"

said Linnæus, "is the wisdom of my life." And between such wisdom and scientific knowledge there can never be any real conflict.

But if man's ancestry is joined to that of other animals by a chain in which our knowledge can find no break, how about the origin of his soul? When did man begin to have a soul, if, as most of us think, the lower animals have none? What is the line between animal and man?

Perhaps we cannot answer this. Perhaps we can never know. Problems as difficult as this come nearer to our lives. Each of us and of all men has grown from the form of a helpless child, the child by degrees from an embryo smaller at first than the head of a pin. All the changes it undergoes are gradual. "Nature," says Linnæus, "makes no leaps." At what age does this embryo become the man? At what age does man become "a living soul"? We cannot tell; we do not know, unless, with the author of Genesis, we conceive the essential character of manhood to be the acquisition of the knowledge of good and evil. As it is with the individual, so with the species. Embryologists tell us that the physical life of the individual is an epitome of the history of the whole group to which it belongs. The embryonic life of man corresponds, so far as we can trace it, to the history of that branch of the group of vertebrates which has culminated in man. *Unter jedem Grab liegt eine Weltgeschichte*, says a German proverb, — "Under every grave lies a world-history." This sentence is true in a physical as well as in a spiritual sense, and it contains a philosophy deeper than its author

dreamed. When we speak of the "infancy of the race," we use language as true in science as appropriate in poetry.

The question of the origin of man, though perhaps the most interesting problem in science, offers to the student of Nature peculiar difficulties. Materials for exact knowledge are few, and prejudices are strong, and all tendencies favor an immediate decision on doubtful points, though the evidence be far from sufficient. Of not one man, nor monkey, nor bird, nor beast in half a million does a trace remain after a thousand years, — not a bone, not a relic, not a thought. Living on the surface, we crumble into dust; and the current phases of our life, a few centuries out of hundreds, are all of man's history we can surely know. Many links are missing still, and most of these we can never find. Our early ancestry we can only infer from our knowledge of our contemporaries.

Whatever the final outcome of the study of the origin of man, Christianity cannot suffer. It has not suffered in the past from other discussions of this sort. Theologians and philosophers have suffered, but not religion. "Extinguished theologians," says Huxley, "lie about the cradle of every science, as the strangled snakes beside that of the infant Hercules." Looking over the history of human thought, we see the attempt to fasten to Christianity each decaying belief in science. That the earth is round, that it moves about the sun, that it is old, that granite ever was melted, — all these beliefs, now part of our common knowledge, have been declared contrary to religion, and Christian

men who knew these things to be true have suffered all manner of evil for their sake. We see God's hand in Nature everywhere; but everywhere he works with Law and Order. We have found that even comets have orbits; that valleys were dug out by water, and hills worn down by ice; and that all we have ever known to be done on the earth has been done in accordance with law.

What, indeed, do we mean by special creation as opposed to natural selection? What knowledge or idea have we of it? We no longer picture the Creator as fashioning men and dogs and horses of clay, and then breathing into them the breath of life. If each of the half million species which we now know, and each of the millions of species now extinct, has been the subject of a special creation, then special creation is but another name for the law by which species are produced. We understand in some measure the method of birth, the method by which individuals are created. Why should we think, in fact, that species are created in any other way? Why is not the method of creation of species, as of individuals, the method of birth? We have, in fact, abundant evidence that the method of creation is the method of birth; and among all the mysteries that surround us there is none more wonderful than this. God made us as God made all things, but He made us in God's way. God may be great enough, in the words of Kingsley, not only to "make all things, but to make all things make themselves." *Omne vivum ex vivo*, "All life from life," is a maxim of the older naturalists; and neither the materialist, to whom all life is

but the attribute of the carbon compounds, nor the dogmatist, to whom the advent of a species is an interruption of the laws of the universe, has yet set it aside. Says Mr. Darwin: —

"To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of an individual. When I view all beings, not as special creations, but as the lineal descendants of some few beings who lived before the first bed of the Silurian was deposited, they seem to me to become ennobled. There is a grandeur in this view of life, with its several powers having been originally breathed by the Creator into a few forms or into one, and that while this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been and are being evolved."

With the growth of the race has steadily grown our conception of the omnipotence of God. Our ancestors felt, as many races of men still feel, that they were forsaken unless each household had a god of its own. For numerous as the greater gods were, they could care for nothing lower than kings. They could hardly believe that the god of their tribe could be God of the Gentiles also. That he should dwell in temples not made with hands, removed him far from human sight. That there could be two continents, was deemed impossible, for one God could not watch them both. That the earth was the central and sole inhabited planet, rested on the same limited conception of the

power of God. That the beginning of all things was a little while ago, is another phase of the same idea, as is the idea of a Special Creation for every form of animals and plants. A Chinese sage, whose words remain, but whose name has been lost in the ages between him and us, has said: "He cannot be concealed; he will appear without showing himself, effect renovation without moving, and create perfection without acting. It is the law of heaven and earth, whose way is solid, substantial, vast, and unchanging."

Not long ago I walked across the Kentish pastures to the little village of Down. I visited Darwin's home, a stately old-fashioned country mansion surrounded by trees and shut in by an ivy-covered wall. I talked with the villagers, who had been his neighbors all their lives, and to whom he was not the world-renowned naturalist, but the good gray man whom everybody knew and loved. I learned some things which the books do not tell us of his simple, kindly ways, his warm friendships, and his quiet but wide-reaching charities. I have from this a clearer picture of Darwin as he really was. His love for his wife and children, his love for birds and flowers and trees, his love for simplicity and truth, — all these stand as the clear background before which rises the noblest work in science.

Twenty-five years ago, obloquy, ridicule, and abuse were heaped on the name of Darwin from all sides, sometimes even from his scientific associates. He has outlived it all, and two years ago his mother country paid him the highest tribute in her power.

He lies in Westminster Abbey by the side of Isaac Newton, one of the many noble predecessors who have made his own life possible. Among all who have written or spoken since then, whatever their religious or scientific faith, by none has an unkind word been said. His was a gentle, patient, and reverent spirit, and by his life not only science, but our conception of Christianity, has been advanced and ennobled.

THE STORY OF A STONE.

ONCE on a time, a great many years ago, so many many years that one grows very tired in trying to think how long ago it was; in those old days when the great Northwest consisted of a few ragged and treeless hills, full of copper and quartz, bordered by a dreary waste of sand-flats, over which the Gulf of Mexico rolled its warm and turbid waters as far north as Escanaba and Eau Claire; in the days when Marquette Harbor opened out towards Baffin's Bay, and the Northern Ocean washed the crest of Mount Washington and wrote its name upon the Pictured Rocks; when the tide of the Pacific, hemmed in by no snow-capped Sierras, came rushing through the Golden Gate between the Ozarks and the north peninsula of Michigan, and swept over Plymouth Rock, and surged up against Bunker Hill; in the days when it would have been fun to study geography, for there were no capitals, nor any products, and all the towns were seaports; — in fact, an immensely long time ago there lived somewhere in the northeastern part of the State of Wisconsin, not far from the city of Oconto, a little jelly-fish. It was a curious little fellow, about the shape of half an apple, and the size of a pin's head; and it floated around in the water, and ate little

things, and opened and shut its umbrella pretty much as the jelly-fishes do now on a sunny day off Nahant Beach when the tide is coming in. It had a great many little feelers that hung down all around like so many little snakes; so it was named Medusa, after a queer woman who lived a long while ago, when all sorts of stories were true. She wore snakes instead of hair, and used to turn people into stone images if they dared to make faces at her. So this little Medusa floated around, and opened and shut her umbrella for a good while, — a month or two, perhaps, we don't know how long. Then one morning, down among the sea-weeds, she laid a whole lot of tiny eggs, transparent as crab-apple jelly, and smaller than the dew-drop on the end of a pine leaf. That was the last thing she did; so she died, and our story henceforth concerns only one of those little eggs.

One day the sun shone down into the water,— the same sun that shines over the Oconto saw-mills now, — and touched these eggs with life; and a little fellow whom we will call Favosites, because that was his name, woke up inside of the egg, and came out into the world. He was only a little piece of floating jelly, shaped like a cartridge pointed at both ends, or like a grain of barley, although very much smaller. He had a great number of little paddles on his sides. These kept flapping all the time, so that he was constantly in motion. And at night all these little paddles shone with a rich green light, to show him the way through the water. It would have done you good to see them some night when all the little fellows had their

lamps burning at once, and every wave as it rose and fell was all aglow with Nature's fireworks, which do not burn the fingers, and leave no smell of sulphur.

So the little Favosites kept scudding along in the water, dodging from one side to the other to avoid the ugly creatures that tried to eat him. There were crabs and clams of a fashion neither you nor I shall ever see alive. There were huge animals with great eyes, savage jaws like the beak of a snapping turtle and surrounded by long feelers. They sat in the end of a long round shell, shaped like a length of stove-pipe, and glowered like an owl in a hollow log; and there were smaller ones that looked like lobsters in a dinner-horn. But none of these caught the little fellow, else I should not have had this story to tell.

At last, having paddled about long enough, Favosites thought of settling in life. So he looked around till he found a flat bit of shell that just suited him. Then he sat down upon it and grew fast, like old Holger Danske in the Danish myth, or Frederic Barbarossa in the German one. He did not go to sleep, however, but proceeded to make himself a home. He had no head, but between his shoulders he made an opening which would serve him for mouth and stomach. Then he put a whole row of feelers out, and commenced catching little worms and floating eggs and bits of jelly and bits of lime, — everything he could get, — and cramming them into his mouth. He had a great many curious ways, but the funniest of them all was what he did with the bits of lime. He kept

taking them in, and tried to wall himself up inside with them, as a person would "stone a well," or as though a man should swallow pebbles, and stow them away in his feet and all around under the skin, till he had filled himself all full with them, as the man filled Jim Smiley's frog.

Little Favosites became lonesome all alone in the bottom of that old ocean among so many outlandish neighbors. So one night when he was fast asleep, and dreaming as only a coral animal can dream, there sprouted out from his side, somewhere near where his sixth rib might have been if he had had any ribs, another little Favosites; and this one very soon began to eat worms and to wall himself up as if for dear life. Then from these two another and another little bud came out, and other little Favosites were formed. They all kept growing up higher and cramming themselves fuller and fuller of stone, till at last there were so many and they were so crowded together that there was not room for them to grow round, and so they had to become six-sided like the cells of a honeycomb. Once in a while some one in the company would feel jealous because the others got more of the worms, or would feel uneasy at sitting still so long and swallowing lime. Such a one would secede from the little union without even saying "good-by," and would put on the airs of the grandmother Medusa, and would sail around in the water, opening and shutting its umbrella, at last laying more eggs, which for all we know may have hatched out into more Favosites.

So the old Favosites died, or ran away, or were walled up by the younger ones, and new ones filled their places, and the colony thrived for a long while, until it had accumulated a large stock of lime.

But one day there came a freshet in the Menomonee River, or in some other river, and piles of dirt and sand and mud were brought down, and all the little Favosites' mouths were filled with it. This they did not like, and so they died; but we know that the rock-house they were building was not spoiled, for we have it here. But it was tumbled about a good deal in the dirt, and the rolling pebbles knocked the corners off, and the mud worked into the cracks, and its beautiful color was destroyed. There it lay in the mud for ages, till the earth gave a great long heave that raised Wisconsin out of the ocean, and the mud around our little Favosites packed and dried into hard rock and closed it in. So it became part of the dry land, and lay embedded in the rocks for centuries and centuries, while the old-fashioned ferns grew above it, and whispered to it strange stories of what was going on above ground in the land where things were living.

Then the time of the first fishes came, and the other animals looked in wonder at them, as the Indians looked on Columbus. Some of them were like the little gar-pike of our river here, only much larger, — big as a stove-pipe, and with a crust as hard as a turtle's. Then there were sharks, of strange forms, and some of them had teeth like bowie-knives, with tempers to match. And the

time of the old fishes came and went, and many more times came and went, but still Favosites lay in the ground at Oconto.

Then came the long, hot, wet summer, when the mists hung over the earth so thick that you might have had to cut your way through them with a knife; and great ferns and rushes, big as an oak and tall as a steeple, grew in the swamps of Indiana and Illinois. Their green plumes were so long and so densely interwoven that the Man of the Moon might have fancied that the earth was feathering out. Then all about, huge reptiles, with jaws like the gates of doom and teeth like cross-cut saws, and little reptiles with wings like bats, crawled, and swam, and flew.

But the ferns died, and the reptiles died, and the rush-trees fell in the swamps, and the Illinois and the Sangamon and the Wabash and all the other rivers covered them up. They stewed away under layers of clay and sand, till at last they turned into coal and wept bitter tears of petroleum. But all this while Favosites lay in the rocks in Wisconsin.

Then the mists cleared away, and the sun shone, and the grass began to grow, and strange animals came from somewhere or nowhere to feed upon it. There were queer little striped horses, with three or four hoofs on each foot, and no bigger than a Newfoundland dog, but as smart as ever you saw. There were great hairy elephants with teeth like sticks of wood. There were hogs with noses so long that they could sit on their hind legs and root. And there were many still stranger creatures which

no man ever saw alive. But still Favosites lay in the ground and waited.

And the long, long summer passed by, and the autumn and the Indian summer. At last the winter came, and it snowed and snowed, and it was so cold that the snow did not go off till the Fourth of July. Then it snowed and snowed till the snow did not go off at all. And then it became so cold that it snowed all the time, till the snow covered the animals, and then the trees, and then the mountains. Then it would thaw a little, and streams of water would run over the snow. Then it would freeze again, and the snow would pack into solid ice. So it went on snowing and thawing and freezing, till nothing but snow-banks could be seen in Wisconsin, and most of Indiana was fit only for a skating-rink. And the animals and plants which could get away, all went south to live, and the others died and were frozen into the snow.

So it went on for a great many years. I dare not tell you how long, for you might not believe me. Then the spring came, the south winds blew, and the snow began to thaw. Then the ice came sliding down from the mountains and hills, and from the north toward the south. It went on, tearing up rocks, little and big, from the size of a chip to the size of a house, crushing forests as you would crush an egg-shell, and wiping out rivers as you would wipe out a chalk-mark. So it came pushing, grinding, thundering along, — not very fast, you understand, but with tremendous force, like a plough drawn by a million oxen, for a thousand feet of ice is very heavy. And the ice-plough scraped

over Oconto, and little Favosites was torn from the place where he had lain so long; but by good fortune he happened to fall into a crevice of the ice where he was not much crowded, else he would have been ground to powder and I should not have had this story to tell. And the ice melted as it slid along, and it made great torrents of water, which, as they swept onward, covered the land with clay and pebbles. At last the ice came to a great swamp overgrown with tamarack and balsam. It melted here; and all the rocks and stones and dirt it had carried, — little Favosites and all, — were dumped into one great heap.

It was a very long time after, and man had been created, and America had been discovered, and the War of the Revolution and the War of the Rebellion had all been fought to the end, and a great many things had happened, when one day a farmer living near Grand Chûte, in Outagamie County, Wisconsin, was ploughing up his clover-field to sow to winter wheat. He picked up in the furrow a curious little bit of "petrified honeycomb," a good deal worn and dirty, but still showing plainly the honey-cells and the bee-bread. Then he put it into his pocket and carried it home, and gave it to his boy Charley to take to the teacher and hear what he would say about it. And this is what he said.

AN ASCENT OF THE MATTERHORN.

AN old miner of '49 whom I once met in California said to me, as we came in sight of the snowy crests of Tuolumne and Calaveras: "These mountains are not appreciated in California. We used to dig and dig in them, and that was the end of it. The fact is, stranger, a man ought to have two lives, — one to get a living in, the other to look at the mountains."

But there are some on whom the mountains have the first claim; and so there has arisen the Alpenclub, — the guild of mountain-lovers whose "feet are beautiful upon the mountains," and to which such men as De Saussure and Agassiz and Tyndall and Balfour have been proud to belong.

And thus it happened that on the tenth day of August, 1881, a party of young people from Indiana, mountain-lovers of varying degrees, walked over the snowy pass called the Matterjoch, which leads from Italy across the Pennine Alps into Switzerland. And ever before us and above us as we came up the green valley of Tournanche, ever before us as we toiled up the pass, — above us everywhere, dark, majestic, inaccessible, rose the huge pyramid of the grandest of the Alps. No one who has ever seen it can ever forget its form. It burns itself into the memory as nothing else in all

Europe does. Shut your eyes for a moment, you who have been at Zermatt, and straight before you and above you, its long hand clutching at the sky, you will see the Matterhorn! It is not the highest mountain of the Alps. Its gigantic neighbors — Monte Rosa, the Mischabelhorn, the Weisshorn, as well as Mont Blanc — are all higher, — a little; but no other mountain in the world makes such use of its height as the Matterhorn. Other high mountains have great rounded heads, white with the snows of eternity. Their harsher angles are worn away by the long action of the glaciers. But the Matterhorn is a creature of the sun and frost. No glacier has worn its angles into curves. Its slopes are too steep for snow to cling to, and all the snow which winter or summer falls upon it rolls down its sides and lies in three great ice-heaps at the bottom. These are the Furggen glacier, the Matterhorn glacier, and the glacier of Tiefenmatten.

We had wandered about Zermatt for a day or two, seeing the sights in the usual way, and all the while the Matterhorn hung above our heads and dared us to come. At last we could stand it no longer; and one evening when the "stalwarts" were gathered together on the stone-wall in front of the Hôtel Monte Rosa, Gilbert said unto Beach, "We must do something big before we leave this place. Let us go up the Matterhorn!" And Beach said, "We must indeed. I will go if Jordan will."

But Jordan felt doubtful. He knew that a mountain which eclipsed the full moon would be a hard

road for a heavy man to toil up. Besides, the story of the first climbers was fresh in his mind. But the boys were persistent, and they said, "You have talked and talked about mountains, and you have never done a single big thing among them; and it is time you did!" And so they kept it up. And I remembered that Tyndall had thought it worth his while to try again and again to go up this mountain, and so had my Italian namesake, the geologist Giordano. Then why not I?

At last we three shook hands upon it, and went back to the hotel to make arrangements. Afterwards three others joined us, making six in all.[1] And we sought out "John the Baptist," and made him our chief guide, and directed him to provide food and ropes for eleven, and we were "in for" the Matterhorn.

Meanwhile the boys wrote letters home, — letters full of descriptions of the Matterhorn, which kept their mothers and sisters awake o' nights for a week. And the sketches of the mountain with which they embellished them were wonderful to behold. In the evening some of them strolled out to the little graveyard at Zermatt, — to the tombs of Hadow, Hudson, and Michel Croz, the first victims of the Matterhorn, — "for inspiration," they said; and some of them composed epitaphs, which they have not yet needed.

At one o'clock the next morning the porter of the Hôtel Monte Rosa knocked at our doors, and

[1] Professor Charles H. Gilbert, Professor Melville B. Anderson, Mr. William W. Spangler, Mr. William E. Beach, Mr. Walter O. Williams, and the writer.

announced that breakfast was ready. We rose in a hurry, ate everything on the table, — our invariable custom in Switzerland, — and by half-past one our alpenstocks were rattling loudly on the stone pavements of the narrow streets of Zermatt. Our five guides were ready, each laden with ropes, ice-axe, and provisions, and we were on the road up the mountain.

Let me say a word about the guides. Most of the able-bodied men in the Swiss valleys are in the summer guides or porters in the mountains. The average guide is a rather heavy, slow-spoken fellow, who buys a good deal of food for you and eats it himself, who drinks great quantities of villanous sour red wine at your expense, hauls you around like a bundle of meal, and finally, as he leaves you, waxes eloquent on the subject of *Trinkgeld.* But there are guides and guides, and some of them are men of force and intelligence, who have, and who deserve to have, a wide reputation. Among those, known all over Europe for strength and courage, was Michel Croz of Chamouny, who fell from the Matterhorn in 1865. Among those destined to be thus known is the young man whom we fortunately selected as our chief guide, — Jean Baptiste Aymonod of Val Tournanche.

"John the Baptist," as we called him, is a very robust and muscular young man of medium height, with a smooth face, light hair, gentle, blue eyes, and a firm, expressive mouth. He is soft-voiced and slow-spoken, — as are most of the Swiss guides, — and he is endowed with a graciousness of manner and purity of speech hardly to be looked for in a

herdsman's boy, risking his life on the rocks and ice for two hundred dollars a year. His face shows the effects of mountaineering, for his nose has sometime been broken by a falling stone.

Our next guide, Victor Maquignaz, is older than John, and larger, — a big burly mountaineer, brave and trusty, who speaks French with variations, a surprising dialect born of the mountains, in a high, uncertain falsetto, like the voice of a wheelbarrow that needs oiling. Next came François Bic, — a tall, intelligent, positive fellow, a good mountaineer, but who would be better liked if his eye were less closely fixed on the *Trinkgeld*. Next came his brother, Daniel Bic, — a muscular man in full beard and spectacles, looking like a German *Doktor*, who had never been up the Matterhorn before, and evidently wished never to go again. Finally, there was Elie Pession, whom we surnamed "the Invalid," — a strong-looking fellow with a heavy black beard, whose heart sank into his boots when he stood in the presence of danger.

All these guides were French, and all belonged to the valley of Tournanche, — the deep valley which extends to the southward from the Matterhorn on the Italian side, corresponding to the valley of Zermatt, which extends on the Swiss side toward the northward.

As we started out that night, it seemed that we had never seen the world look so beautiful. The moon was full, and hung gracefully over the left shoulder of the Matterhorn, and the sky was without a cloud. Through dark fir-forests we went, by the side of a foaming torrent, then over flower-carpeted

pastures and steep grassy slopes, the great mountain ever in front and the glistening snows of the Dent Blanche and the Breithorn flanking it on either side.

At sunrise we came to the first cabin, at the foot of the upper pyramid of the Matterhorn, on a narrow crest of rocks which separates the Furggen glacier from the Matterhorn glacier. This cabin, built by the Swiss Alpenclub, is quite a comfortable place, with plenty of straw, blankets, and fuel. Many who climb the mountain spend the night here, setting out at sunrise for the summit. The walls of the cabin are covered with lead-pencil inscriptions in every tongue. One of these, in particular, is noteworthy as being higher above the sea-level than any other poetry in the English language.

"Little Matt Horner
Sat in the corner,
And vowed he would not be climbed:
We tried it, you know,
But found so much snow
We very politely declined."

This is not much as poetry; but it is worthy of notice that in a climate and at an altitude in which ordinary spring poetry is frozen through and through in a minute, this little blossom has survived.

For a few moments we watched the sun rising over the glaciers of the Weissthor pass, and then John the Baptist had us again under way. We stood right at the foot of the mountain; but the nearer we came the steeper it looked, and there

was no sign of a possible path. Precipices of bare, loose rocks, with gullies filled with snow and slippery ice, were before us, and nothing else. We went on a little way until we came to a snowy ridge, on which was a heap of large stones. "This," said John the Baptist, "was the chalet of Monsieur Whymper." Then the path began to grow narrow, and abysses opened below us. John called a halt, and said that we must now be very careful; we must watch nothing but our feet; we must talk as little as possible; we must keep our mouths shut and breathe through our noses; and finally, we must chew chocolate or caramels all the time, — for this, he said, would keep our throats from being parched. This began to look like serious work; so we left off looking at the sunrise and the glaciers, watched our shoes, chewed our chocolate, and moved on.

The path started out along a shelf of rock about a foot wide, the surface of which, in accordance with the southward dip of the strata, slanted toward the mountain. Above the path was a wall of rock some ten feet high, and at the top of this was a similar shelf, but somewhat broader than the one on which we were walking. Below us was a slippery wall of rock, perhaps a hundred feet high, at the foot of which lay the ice of the Furggen glacier. In summer the glacier slides away from the mountain, the supply of snow not being great enough to balance its loss by melting. Between the mountain and the glacier is therefore a deep chasm, or *Bergschrund*, — a damp, chilly, uninviting looking place, bordered on one side by

rocks, on the other by blue ice, from the edge of which often hang long icicles. We walked on in silence above this *Bergschrund*, thinking that our way would be easier by-and-by, when suddenly our path ceased. At this point John the Baptist left us, and climbing fly-like up the side of the rock, he showed us our path about ten feet higher up on another shelf formed by a projecting stratum. He threw the end of his rope to the guide Victor, who put it around his waist. Then John stood in the attitude of the Colossus on the edge of the precipice, and hauled him up. Next came my turn, and I dangled serenely over the edge of the mountain, while John and Victor pulled on the rope. This mode of mountain climbing gives a view that you can get in no other way of the mountains on the other side. And so one by one came up the rest.

But our path did not improve as we went on. From this point to the top, about six hours' climb, there was not a single yard of level walking or, indeed, of any walking at all. One could not anywhere take three steps without watching each step and making a mental calculation as to whether his feet would hold. There was hardly a place where a stumble or a slip of the foot would not, except for the help of others, send the person who slipped to the foot of the mountain. Every step was on the edge of a precipice, and every step made the precipice higher, — though there is little real choice between falling a hundred feet and falling a mile. The boys appreciated this, and fell not at all. They clung with fingers and toes to every

projecting point, and nothing short of an earthquake could have gotten that mountain away from them.

I have called the Matterhorn a creature of the sun and frost. It is now but a wreck, — the core of a far greater mountain whose rocks have been hurled down into the valleys by the "strong gods" of the sun and air, and have thence been scattered over Switzerland and Italy by the glaciers of the Great Ice Age. It stands in the altitude of perpetual frost, but bathed by the warm sunshine of Italy. On every clear day its rock sides become warm in the sun. All ordinary clouds are below its summit, and each cloud that touches it in summer covers its surface with light snow. Then this snow melts again in the sunshine, and causes water to trickle in all the joints and clefts of the rocks. Then at night the mountain grows cold, — in clear nights intensely cold, — the water freezes in these fissures, and expanding widens them, thus pushing the outermost blocks of rock nearer and nearer the edge of the precipice. At last a gust of wind or a careless foot may cause one of these loose rocks to topple over. Down it falls, loosening many more on its way, the whole series plunging with an ever-increasing roar till it reaches the ice of the Furggen glacier. Into the glacier the falling rocks dive, scattering the ice masses, as a stone thrown into a pond causes the water to spatter. Once in the ice the stones move on more leisurely, until after years they reach the point where the glacier melts and gives up its dead, when they pass into the universal rubbish-heap, — the moraine, at the bottom. These

are the *pierres qui roulent*, — "the stones that roll," the dread of the mountaineer. Most high mountains are fashioned by the glaciers themselves; but the glacier has no hold on the Matterhorn. Glaciers make white domes of mountains; frost makes black pinnacles and spires.

The guides had now tied us together, and the value of the rope in mountaineering soon became very evident to us. In all difficult or dangerous excursions in the high Alps, the persons making the excursion are tied together by ropes. Usually four or five are joined to one rope, the rope being tied around the waist of each. It is the duty of each one to see that the rope below him is kept drawn tight, so that if any person happens to stumble or slip, the aid of the others will keep him on his feet. In very difficult excursions, like the one here described, usually but one person moves at a time, the other three on the rope each holding his position as well as possible until the fourth one has reached a position of safety.

The way we went was in most cases like this. First John the Baptist would scramble up some ledge of rocks, clinging by fingers and toes to projecting points, or reaching some higher crag by means of his ice-axe. When he found a suitable foothold he would shout to me, and I would crawl up to his position, while the next man would edge up to where I was, — and so on. When we came to a specially bad place, a *mauvais pas*, where the rocks were unusually loose and the hold precarious, I would shout up to him before following him, "Êtes-vous bien placé?" ("Are you well

placed?") If John was "well placed" he would shout, "En avance!" ("Come on!") I would then call out, "Tirez!" ("Pull!") He would then draw up on the rope, which action made it much easier for me to scramble up than it would have been without this assistance. Then it became my turn to help up the next man; but he usually crawled up unaided, — having an aversion to being helped, which I did not share, but for which I was duly thankful.

After working along in this way for about three hours, John the Baptist told me to look up and I would see the upper hut and the ropes which came down from it. High above us we could see a little stone shanty under the shelter of a huge pinnacle of rock on the edge of a sharp precipice some fifty feet high. Down this precipice hung a rope, fast to an iron staple above, swinging loosely below. We had read in the guide-books that "ropes have been placed in the more difficult places on the Matterhorn." We had imagined something such as we had seen in other mountains,— a rope railing alongside of a steep and narrow path. We were hardly expecting to go up hand over hand on a rope swinging loosely over infinity.

John the Baptist started up on the rope, resting his toes on the projecting points of the rocks, where opportunity offered, until he reached a little shelf, an inch or two wide, where he could stand on one foot. It was growing very cold; the rope was white with frost. I put on my gloves and climbed up for a little distance; but when I came to rest my full weight of two hundred and ten pounds on

the rope, my gloves would not cling to it. I felt myself slowly sliding downward. It was not a pleasant sensation. I thought that I should probably stop on reaching the knot on the end of the rope; but I *might* go too fast, and, jerking John the Baptist from his narrow perch, we would form the nucleus of a small avalanche moving towards Zermatt. But I stopped, and taking off my gloves I tried it again, — this time with better success.

At last, after a long and toilsome scramble we all reached the upper hut, where we lay down on the hay for a little rest and another round of tough bread, sour wine, and chocolate. This hut I shall have occasion to describe farther on.

As we went on, clouds had begun to gather about us, and after a little the wind rose and it began to snow. We lost sight of the earth altogether, and everything below us became a bottomless abyss. Soon we came to the narrow ridge on the shoulder of the Matterhorn where for a short distance the northeast angle of the mountain which we were ascending is no wider than the back of a very lean horse. It is too narrow for one to stand on or even to sit on with comfort. On either side as we crawled along we could look downward seemingly to the very bottom of things. Above this point the first climbers fell from the mountain. I asked John about it, but he would not talk. "I was not here then," he said.

After this we came around to the eastern face again. Here we could see the summit, some five hundred feet above us, — a ragged wall of rock, steeper than any slope we had yet ascended and its

top still seeming to hang over our heads. How to get up was evident from the long lines of hanging ropes. We went up these slowly, one after another; and at last we came to prefer these ledges with their ropes to the lower slopes, which, although less steep, offer nothing but rocks and snow to cling to. One of these ropes had had one of its strands cut by the sharp edge of some rock, and the other two strands were partly untwisted. This rope may break for somebody, but it did not break for us.

It is hard enough to climb this part of the mountain with the aid of the ropes. It seems next to impossible without it; yet some one carried up these ropes and the iron staples by which they are hung, and fastened them all there. The man who did this was John the Baptist. At last the ropes ceased, and crossing over to the north side of the mountain, we found there an easier slope by which we soon reached the summit. It was now a little after noon.

The top of the mountain is a narrow crest, lying nearly east and west and rising toward a point on the Swiss side. This crest is about twenty feet long and from one to three feet wide. Its north side is a rocky slope, while the south side is nearly perpendicular, and at the time of our visit it was covered with a long overhanging snow-bank or "cornice." It was as cold as midwinter. The north wind whistled and howled, so that we dared not rise to our feet, and the snow fell thick and fast. I should hardly say that the snow fell; it is made up there, and every cloud which touches the mountain is a snow-storm. Most of the time

we could see nothing; the whole earth was represented by the little summit-ridge, which was all that we could see of the Matterhorn. Once in a while a little eddy in the clouds on the south side of the mountain would give us a glimpse of Le Breuil and the valley of Tournanche two miles below us; and occasionally our nearest mountain neighbor, the Dent Blanche, disclosed her snow-crowned head.

We did not stay long on the summit. It was not very warm, and we wished to give the others a chance. We wrote our names on a card, and placed it in an empty bottle which the mountain keeps as a register for visitors. Victor broke off with his ice-axe the uppermost point of the mountain, a piece of dark green hornblende. I put this in my pocket as a trophy, and we were ready to descend.

In going downward, our motion was much like that of one of the caterpillars or "measuring-worms" which come upon the maple-trees in the spring. The strongest guide in each section was placed last in the series, so as to be "well placed," and to hold the others back in case any one should slip. This guide starts first in each series, and goes down to the niche of the next man below him. When he is again "well placed," the next man advances, and in turn the third and the fourth, — the one standing lowest moving where it is possible the length of one section of the connecting rope, after which the others again edge downward to him. The progress is of course very slow, and three fourths of the time each man is engaged in resting, with his

heels "well placed" on some projecting shelf of rock.

At times in our descent we felt the force of the *tourment*, a wind peculiar to the high mountains, — a sort of snow-laden whirlwind, or "wind made visible." This wind goes furiously over the mountain-side, tearing off loose rocks, starting avalanches, and tossing about the banks of snow. Whenever one of these struck us, we lay flat and clung to the rocks, lest we should be literally blown off the mountain. One of our company, I remember, wore a narrow brimmed hat drawn down tightly over his ears; the tourment took it and whirled it high into the air. The learned professor fell flat on the ground, while every hair of his head caught the rotary motion and stood straight out.

As we went farther, we noticed more and more the treacherous character of the stones on the mountain side. The whole outer coat of the mountain is loose, scarcely a rock anywhere on the Swiss side being firmly attached. Into all the joints of the strata the water from the melting snow finds its way, and by the freezing of this water the joints are widened and the blocks of hornblende are daily pushed nearer and nearer to the edge. Thus nothing is firm; nothing is stable, and each year the mountain offers a new face to the weather.

Going down the mountain is more difficult than going up. This is not only on account of the mental strain of constantly looking over precipices, but because of the looseness of the rocks. Stepping down on a stone, one is more apt to detach it than

when he cautiously clings to it from below. However careful we may be, some stones will fall; and while this may not hurt us, it may hurt some one below us. Then occasionally some stone would detach itself naturally, and go rattling down to the bottom of the mountain, followed by a host of smaller ones, leaving as they pass a strong "smell of sulphur," which, as Whymper says, "tells us who sent them."

The Matterhorn, as I have said, is one of the steepest and slipperiest of mountains, and everywhere it offers but scanty hold to the climber. There is, however, in all this little real danger to men strong of limb and steady of head, accompanied by good guides. But there is one danger which is real, one which is almost constantly present and against which no skill nor strength can wholly guard, — and that is the danger from falling stones. This risk would be slight with a small party, but our company of eleven, probably the largest ever on the Matterhorn, made so long a line that a stone loosened by the uppermost would acquire a fearful velocity before reaching the last. Not more than five persons should be on the Matterhorn at once.

The head of our column had reached the foot of one of the last ropes which come down from the summit, and was waiting for the others to descend. One of the very last in the company was laboriously crawling over a large projecting rock, when it suddenly became loosened. I remember hearing some one scream "LOOK OUT!" and then suddenly it seemed to me that all sunshine and hope

had gone out of the mountain. The great rock fell about thirty feet. Striking a lower shelf, it broke into three or four pieces. One of these, weighing about a hundred pounds, flew over my head and over the heads of John and Victor. The man below us had turned to look back when he heard the noise; the rock struck him in the face, knocked him instantly off the ledge and out of our sight, and then plunged down the side of the mountain.

We were all paralyzed for an instant, — the guides as well as the rest. I remember calling to John to give me rope, so that I could go down to Victor, and let him go down to Gilbert. By the time we got down, Gilbert was struggling to his feet. He had fallen as far as the rope would let him. His face and clothes were covered with blood which flowed from a deep cut like a sabre gash across his nose and forehead. A stiff-brimmed hat which he wore had been cut fairly in two, and its resistance had helped to weaken the force of the blow. We decided that no bone was broken, although the wound was a most serious one. Once at the bottom, we could take care of him perhaps; but should he faint, or be unable or unwilling to walk, we should have a difficult task to carry him down. We tied up the cuts with all the silk handkerchiefs in the party, covered them with snow, and put over them all a thick woollen hood, which John the Baptist carried for use in time of need. In five minutes we were moving again. We were unable wholly to stop the flow of blood, and our course was marked by a red trail. Gilbert's face was soon entirely covered by a red clot; his eyelids swelled

so that he could not see, and after a little he lapsed into a half-unconscious state, in which he seemed to realize only that he had fallen from the mountain, that it was very cold, and that he must always walk. And at times he would give up and lie down in the snow, when we would use every argument in our power to induce him to rise and go on again. It took us four hours to reach the upper cabin, a distance perhaps equal to two "squares" in a city street.

Had our wounded man been otherwise than light of weight, strong of limb, and immensely resolute, we might not have gotten down at all; and a night on the bare side of the mountain meant simply freezing to death. It is hard enough for a well man to go safely down the Matterhorn, far harder than to go up; but for a man blind and faint, it became terrible. "C'est un homme fort et brave" ("He is a man brave and strong"), said John the Baptist. If Gilbert had been as heavy as I, we should have had a task indeed. I remember thinking at the time that it was fortunate that I was n't hit.

At one time I saw Gilbert slip, and with Victor, who half led, half carried him, fall like a shot. But John the Baptist was always "well placed" and held them. At another time we heard a terrible uproar, and three or four rods away we saw an immense avalanche of stones coming down. This was made of a dozen large rocks of the size of a wagon, with hundreds of little ones yelping in the rear. It was a grand sight; but we were little in the mood for it. "C'est une montagne terrible" ("It is a terrible mountain"), said John the Baptist.

The guide Pession had been in a shiver of mortal terror ever since the accident, and for the rest of the day was worse than useless. "You must pardon him," said John the Baptist, "for he has a wife and children in Val Tournanche."

At seven o'clock we reached the upper hut. We put Gilbert on the hay; after which he refused to move, and soon went to sleep. John decided to remain there over night, with Victor, Spangler, and myself, and to send the others down to Zermatt. After many adventures, which I need not here relate, the others reached the bottom in safety. Meanwhile, we five arranged for lodgings in the upper hut, some thirteen thousand feet above the sea, — one of the highest "houses" in Christendom.

This hut is simply a pile of stones more like the den of some beast than a cabin. It is built between a pinnacle of rock and a precipice, its stone roof rising in a slope from the edge of the latter to the former. The height of the room within is perhaps five feet on the highest or upper side. Its length is some ten feet, and its width about six. On the south end is a little door or hole for entrance, and on the floor on the north end are three coarse blankets and a few armfuls of hay. A little bench, a small table, a tin-pail, and a basket of shavings complete the equipment.

John the Baptist sent us to bed at once, — one on each side of Gilbert, to keep him warm. But nobody kept us warm. Our clothes were wet, and my off side was against a frosty rock, which carried away heat faster than I could generate it. The young man in one of Grimm's fairy-tales, who

"did not know how to shiver," would certainly have found the coveted experience there. We did little else all night long. Moreover, the floor was very uneven, and the tin wine-flask which did duty as a pillow was far from being "soft as downy pillows are." There was not much encouragement for sleeping. All night long our patient kept on ascending mountains, and recalling his experiences of the day. At about the first watch of the night, he shouted out, "Attention! Attention toujours!" At another time he called us all up with this remark, "Here we will stop walking and take wheelbarrows." When everything else was quiet, the snow thawed on the roof and kept little streams of sooty water trickling over our faces. John and Victor lay on the bare ground; and at intervals, when they could stand it no longer, they would kindle a fire of shavings, and wake us up to take a drink around of chocolate.

I have seen cold nights elsewhere, but nothing to compare with this. The storm ceased early in the night, the clouds blew over, and a sharp, crystalline midwinter coldness penetrated everywhere. We could every few minutes hear the mountain snap, as the water froze in the fissures of its rocks. I sometimes spend the night now-a-days waiting for a belated train in the little hotel of some prairie "railroad junction" in Indiana or Illinois, at the time of the January blizzards. The single window in the little bedroom will fit loosely in its place. One pane of glass may be replaced by an old hat, the second by a newspaper, and a third be wanting altogether. The bed may have but one sheet, a

hard husk mattress, and an insufficient equipment of comfortless quilts, as heavy and as warm as though made of sheet-lead. With all these conditions and worse as I have sometimes found them, I have now only to lie still and think back to that night on the Matterhorn, and the whole atmosphere becomes fairly tropical.

In the morning we rose early and went out to look at the sunrise. The air was intensely clear. The whole Matterhorn was white with new-fallen snow and glistening with frost. Far below us the clouds hung white and heavy over the valley of Zermatt, their thick folds hiding all of the landscape which was not snow-covered, their upper outlines seemingly continuous with the white surface of the great glaciers. Far beyond the valley of Zermatt rose the giants of the Oberland. Nearer to us were the Dent Blanche, the Weisshorn, the Rothhorn, the three peaks of the Mischabel, and to the right of these the Allalin, the Strahlhorn, the Rympfischhorn, and a host of other "horns," named and unnamed, rose before us. To the east was the long crescent of Monte Rosa, the Cima di Jazzi, the Lyskamm, Zwillinge, and Breithorn, with the great Gorner glacier winding about their feet. It was the sight of a life-time, which can never fade from the memory.

> "With drifts of snow, fantastic wreath on wreath;
> And peak on peak against the turquoise blue,
> The Alps like towering campanili stand,
> Wondrous with pinnacles of frozen rain,
> Silvery, crystal, like the prism in hue.
> Oh, tell me, love, if this be Switzerland, —
> Or is it but the frostwork on the pane?" — ALDRICH.

Our invalid was better in the morning, but cold, disgusted, and impatient. His swollen eyelids each looked like a ripe plum. He said that he could not open his eyes. I told him to lie still and keep them shut then, — a remark which he thought peculiarly unfeeling. We decided to send this Knight of the Sorrowful Figure with John and Victor down to Zermatt, while Spangler and I would wait and play "mumble-the-peg" until their return, which might be next day and might be — never! Not a cheerful prospect; but, as the jester said in the woods of Arden, "Travellers must be contented."

Before they had fairly started, however, we heard shouting from below; and soon the two guides Bic reached us from the lower cabin, in which they had spent the night. We therefore again moved on, but very slowly. The new-fallen snow made the walking very difficult, and much sitting down in slippery places reduced our clothing to a total wreck, concerning which the less said the better. There were many "*mauvais pas*;" but we passed them all at last, and towards noon we reached the lower cabin. The doctor from Zermatt was there, and also four able-bodied ruffians bearing a sedan-chair. We were now safe at last; and after another drink around of chocolate, — there was nothing else left, — we started for Zermatt.

Our welcome in the village was most enthusiastic. Everybody — English, German, French — was delighted to see us, and the "Matterhornbesteiger" were the heroes of the hour. In the

chapel at Zermatt prayers were offered for the Queen of England and on our account for President Garfield, and thanks were given for our safe return.

As for our own party, an Englishman who was there afterwards said: "I never saw anything like it. Every one of those Americans rushed right out into the street and crowded around, and I actually thought that every one of those ladies was going to kiss the Professor!"

But not one of them did!

I afterwards received from "John the Baptist" the following letter, which will be of interest as the composition of an illiterate but very intelligent man. I give it *literatim*. It will be noticed that while the construction of the sentences is generally correct, the words are mostly spelled by ear, — not an easy thing to do in the French language.

VALTOURNENCHE, le 16 Decbre, 1881.

MONSIEUR JORDAN.

CHER MONSIEUR, — J'ai reçus vôtres lettres le 15 courent, laquelle a été pour moi un grand plaisir, premièrement en aprenant que M^er^ Gilbert était parfaitement géri. Je regretais toujours de ne pa vous avoir prié de me donner de ses nouvelles en arivents dans vôtres patrie. Je vous prier de le saluer bien de ma part, et en même tempts le remercier du cadou que vous m'avez remis en son nom à Saas. En second lieu je vois avec plaisir que vous ne vous êtes pas contenter de me payer largement mes servisses de l'été passé. Vous voulez encore travailler pour me donner une renomée parmi les Américains, s'est plus que je ne merite. Je vous en remercie infiniment. Je regrète beaucoup d'être dans l'impossibilité de pouvour vous en rendre le reciproque. Je ne

peut faire autre chose que de vous souéter des jours heureux plain de Santées et d'Amour pour les Alpes Pennines. . . . Je vous prie de saluer toutes l'honorables compagnie que vous aviez avec vous l'été passé. Maquignaz et les Bics vous font ses salutations.

Recevez une bonne poigné de main de celui qui voudroit être longtents

Vôtre serviteur,

AYMONOD BAPTISTE.[1]

[1] The following is a translation of this letter : —

VAL TOURNANCHE, Dec. 16, 1881.

MR. JORDAN :

DEAR SIR, — I have received your letter of the fifth current, which has been for me a great pleasure, firstly in learning that Mr. Gilbert was perfectly cured. I regretted always not to have asked you to give me news from him in arriving in your own country. I pray you to salute him well for my part, and at the same time to thank him for the present which you gave me in his name at Saas. In the second place, I see with pleasure that you have not contented yourself with paying me liberally for my services of last summer. You wish still to work to give me a fame among Americans. It is more than I merit. I thank you for it infinitely. I regret much being in the impossibility of being able to render you a reciprocal service. I can do nothing more than to wish you happy days full of health and of love for the Pennine Alps. . . . I pray you to salute all the honorable company which you had with you last year. Maquignaz and the Bics send you their salutations.

Receive a good shake of the hand from him who would long be

Your servant,

AYMONOD BAPTISTE.

THE EVOLUTION OF THE COLLEGE CURRICULUM.

A RECENT writer on the German system of education, turning from his subject for a moment's contemplation of the American system, is moved to say that the most striking characteristic of the latter is simply its want of system. Instead of being part of a definite whole, well ordered or ill ordered as the case may be, each feature of the American system has been developed with little regard to its relation to the others; and this confusion in development has been made worse by our characteristic misapplication of names, an example of which is seen in our indiscriminate use of the terms "college" and "university." In many a so-called college in America the chief work done is the teaching of the elements of grammar and arithmetic. The "university idea" is often regarded as fully met by the addition to such a college of a Normal School, a professor or two in Law or Theology, and a self-supporting "College of Music."

Yet in spite of all eccentricities in name or form, we can recognize the existence of a certain definite type of school which we may call the American college. There are many variations in this type of school, — variations due to geographical position,

to the excess or deficiency in denominational zeal, or to the exigencies of the struggle for existence. For the fiercest conflicts of the average American college have not been with the black giant Ignorance, but with the traditional wolf at the door. In other words, this new country has not been liberal in its support of higher education; and moreover the funds available for this purpose have been used to found a multitude of weak schools rather than to make a few schools strong. There have been several reasons why this is so, and there are some reasons why it has been well that it is so; but these questions I do not care to discuss now. The law of the survival of the fittest can be depended on to rectify sooner or later all mistakes of this kind. Suffice it to say that we recognize the existence of the American college, and that this college possesses a more or less definite college curriculum. Of the changes in this curriculum I wish now to speak.

I shall not try to follow out in detail its history prior to the time when its germs were brought to us from England in the landing of the Pilgrims. We can go back in England to the time when the philosophy of Aristotle constituted the college course. Then the entire curriculum was taught by a single teacher, the man of universal knowledge. This teacher for the most part gave his instruction by dictation. The students noted down the contents of old books, which the master himself had copied before; the place of the teacher was simply that of a medium of communication between the ancient manuscripts and their later duplicates.

With the revival of learning came the advent of the study of Latin as a language having a literature, and later the study of Greek; both Latin and Greek, as literary studies, being considered extremely dangerous as well as heretical at the time of their introduction into the curriculum. Both were then resisted by the full force of the conservative party of the day. After the revival of learning came about with time the English college curriculum, with its *Tripos*, or three pedestals of Greek, Latin, and Mathematics. Of this the American curriculum has been a lineal descendant.

The American college curriculum at the time when most of us became acquainted with it was a very definite thing, time-honored, and commanding a certain respect from its correspondence with the theory on which it is based. Its fundamental idea was discipline of the mind. Its mode of effecting this was, in large part, by shutting the student's eyes to the distracting and inconsequential present, and fixing his gaze on that which was great and good and hard to understand in the past. The main work of the course consisted of drill in grammar and mathematics, and the results of this training were bound together by a final exposition at the hands of the President of such of the speculations of philosophers as seemed to him safe and substantial. This work lasted — for reasons so old as to be long since forgotten — just four years, and it was preceded by a certain very definite amount of drill, of much the same kind which was regarded as a necessary preliminary to the other work.

Whatever may be our opinion as to the desirability of such a course for ourselves or for our sons or daughters, it is impossible not to regard the old-time classical course with a feeling of respect. It was based on a theory of education, and its promoters were loyal to this theory. If only the boys for whom its pigeon-holes were arranged could have been of uniform size and quality, the system would have been perfect. That it was not quite perfect was clearly the fault of human nature, which furnished a very variable article of boy for the educators to work upon, and caused them to reach by uniform processes widely different results. What these variations were, is well known to us and needs no explanation. We know that there are some boys whose natural food is the Greek root. There are others whose dreams expand in conic sections, and whose longings for the finite or the infinite always follow certain paraboloid or ellipsoid curves. There are some to whom the turgid sentences of Cicero are the poetry of utterance; and there are others who with none of these tastes grow and blossom in the sunlight of comradery, undisturbed by the harassing influences of books and bookish men. To all these kinds of students this old-time classical course brought satisfaction, and the days they spent in Princeton or Harvard or Amherst were the brightest of their lives. Such have rarely failed to try to provide for their children the same training which they found so satisfying to themselves.

But there were other students, not less fond of study, who were restless under these conditions.

There were some to whom the structure of the oriole's nest was more marvellous as well as more poetical than the structure of an ode of Horace. There were others who found in modern history or literature or philosophy an inspiration which they did not draw from that which is old. By the side of this inspiration the grammatical drill of the schools seemed a lifeless thing. And so it has happened that many whom we now regard as great in our literature or our science were held in low esteem in the colleges in which they graduated, — if indeed they ever graduated at all. For the scale of marks connected with the college curriculum took little account of the soul of man, but only of the docility and regularity (virtues of themselves of no mean order) with which the college discipline was taken. And as these qualities are not alone the qualities which win success, either real or spurious, in after life, it came to be believed that college honors meant future failure, — that the college valedictorian was the man who was never to be heard of again; and in this popular error, easily disproved by statistics, there was just enough of truth to keep it from being forgotten.

No doubt the ancient classical course was a powerful agency for culture to many, — to most students perhaps who came within its influence. But it was not so to all. Culture is an elusive thing, and the machinery which will secure it for you may have no such effect on me. So that, among the students of the old *régime*, some never found culture, and some found it only in a surreptitious study of the world outside. Complaints were not

wanting, that in this curriculum of Latin, Greek, Mathematics, and a varnish of Philosophy, not all the studies pursued were useful studies. Much of this complaint was unjust, for a college is not a school of technology. Higher education is not learning a trade, nor is its purpose to enable its possessor to get a living. Lowell's definition of a university as "a place where nothing useful is taught," is, I think, one by which we as college teachers must loyally stand. But some of this complaint has been just. No part of a man's education is of much value to him, unless it is in some way concerned with his future growth Thousands of students never look at a Latin book after leaving college. This matters nothing, if the skill they have acquired in reading Latin gives them greater mastery over their future study or a deeper insight into the problems of life. This matters much, if this knowledge has in no wise given either insight or mastery. For in such case a knowledge of Horace and Homer would be as useless as the learning by heart of the laws of the Medes and the Persians or an enumeration in order of all the kings of Shanghai or Yvetôt. The tree of knowledge is known by its fruits. "Culture," says the younger Holmes, "in the form of fruitless knowledge, I utterly abhor!"

Now, to those who found culture, the college course had served its end; to others, it had not. It was good or bad, not in itself, but in its results. It is idle for us to say, "It is sufficient for all;" "It is sufficient for none." The discussion of these rival theses has not helped much in the

solution of the educational problem. Emerson says: —

"The Ancient Languages, with great beauty of structure, contain wonderful remains of genius, which draw, and always will draw, certain like-minded men, Greek men and Roman men, in all countries to their study; but by a wonderful drowsiness of usage they had exacted the study of all men. Once (say two centuries ago) Latin and Greek had a strict relation to all the science and culture there was in Europe, and mathematics had a momentary importance at some era of physical science. These things became stereotyped as education, as the manner of men is. But the good spirit never cared for the colleges, and though all men and boys were now drilled in Latin, Greek, and Mathematics, it had quite left these shells high and dry on the beach, and was now creating and feeding other matters at other ends of the world."

Thus, as the years went on, other sources of culture became more and more emphatic in their claims. The workers in the various fields of science, each year becoming more numerous and more active, opened out great vistas of the works of God, and he who had seen nothing of these might well have his claims to culture doubted. Philology, History, Philosophy, other than that stamped with the approval of the safe old masters, each put in its claims, as also the vast wealth of the literatures of modern Europe. A citizen of the Republic must know something of the laws which govern national prosperity, and a teacher of the people should know something of the theory according to which people are taught. When

these subjects are left out of the college curriculum, the clamor for their admittance becomes unbearably loud. If all are admitted, the same curriculum becomes like an American horse-car, with standing room only and no space to turn around.

What shall the colleges do? Shut out these subjects they cannot; for to exclude all modern studies and modern ideas, to step out of the current of modern life, is practically to exclude all students. Rightly or wrongly, the students want these things, and sooner or later the American college must give what the students want. The supply must meet the demand or there will be no demand. No doubt we as professors know better what is good for the student than the student does himself; but unless we can convince him of that we must let him have, to a great extent, his own way as to what his studies shall be. We can see that he does his work well, and we can help him in many ways; but the direction of his efforts must in the end rest with him.

The colleges of America stand in a different position in this regard from similar schools in England or Germany. These last are parts of a definite system. Their financial support is such that there is no need of paying any special attention to popular demands, if these demands are deemed theoretically undesirable. Moreover, the college degree in England and its equivalent in Germany forms a passport of admission to social, educational, or political privileges inaccessible to the man without this degree. Hence entrance

to the college or gymnasium or the university is, among the educated classes in these countries, a matter of course to a much greater extent than can be the case in America. The Bachelor's degree in America, or even the Doctor's degree, carries no privileges of any sort worth the name. Very few of our students would work for a degree if it were believed that the title were all they got. Thus it comes about that in America the average student goes to college or is sent to college for the help to be gotten from study rather than for the sake of graduation. And he must be convinced, or his parents must be convinced, that this good is a real good, or he will not seek it. Thus the difference in the conditions under which our colleges work has tended to modify and modernize the curriculum more rapidly than has been the case in the corresponding schools in Europe.

Many devices have been adopted for dealing with the modern studies. Some have admitted them as extras, or, in the expressive language of a New York College President, as "side-fixings," reserving the old-time *Tripos* as the solid part of the scholastic meal. But no matter how little a hold these modern studies had, their presence has weakened the force of the old-time discipline. It is a law of physics that two bodies cannot occupy the same space, not even though one of them be badly squeezed. And these subjects will submit to squeezing no better than the others. So part of the old course must be crowded out and part of the new must be admitted on terms of more or less perfect equality with the former; or

else some degree of selection must be permitted, that students may choose between new and new or between new and old.

Another conceivable arrangement would be to omit none of the old work, but to lengthen the course, with each study added to the curriculum, until each could receive a proper share of the student's attention. But this cannot well be done. Four years is the fixed length of the American college course; and this being an arbitrary thing, with no sort of reason for it, there can be no successful argument against it. Besides, we live in hurrying times; and to our students time is money, and the only money some of the best of them have. To the majority of those reached by our colleges, even the traditional four years seems a long time to spend in school after reaching manhood.

In various ways it was sought to harmonize the new education with the old. But the average American college has finally adjusted itself to a second phase in the history of the curriculum, which for convenience I may call the patchwork stage. In this arrangement most of the higher mathematics has been crowded out, the Greek has been shortened and the Latin also; while other subjects, in greater or less amounts, have been more or less grudgingly admitted. The amount and kind of these subjects is rarely determined by any prearranged plan or in accordance with any sort of definite theory of education. As a matter of fact, each college has a certain number of professors, this determined by the Board of Trustees, in accordance with real or imaginary

needs of the college, or with the real or imaginary claims of candidates for recognition. Then in the Faculty meetings each one of these professors claims what he wants and receives what he can get, in accordance with the law of the survival of the fittest and the rule of the majority. Thus the curriculum in each college becomes the resultant of many forces, in a condition of unstable equilibrium. It is altered, not in accordance with the educational needs of the students, but when one professor gives place in the Faculty to another more or less energetic or clamorous than he.

Occasionally in these patchwork courses of study, the traces of some master-hand is visible, — some method in its madness which shows that somebody has tried to work out an idea. But this is rarely so, I think; and in the arrangement of most courses of study, nothing higher has been thought of than expediency and the exigencies of compromise. From the struggle between the representatives of rival subjects in an overloaded course, has come about, by way of compromise, the establishment of different courses of study, in each of which it is assumed that some scholastic faction will have the ascendency. In some colleges these various courses have been put on an exact equality, but in most cases a more or less positive pressure has been brought to bear in favor of the classical course, and especially away from the sciences. This is well, I think; for in most of our colleges the instruction in science is still absurdly inadequate, and wholly valueless for the main end of scientific instruction, — the training

of the judgment through its exercise on first-hand knowledge. Wherever science is yet in the meshes of bookishness, it is best that students should be turned away from it. Wherever its limbs are free, it will hold its own, whatever the pressure from those who do not value it as a factor in education. In other words, a competent teacher of science need never complain of obstacles in his way, for the odds are all on his side. The same thing is true, I believe, of a competent teacher in any other department. A growing man incites growth; but even mould will not grow on a fossil. Some ten years ago I heard a College President boast that although his college had two other courses, yet three fourths of his students had been kept in the classical course. My question was, What sort of teaching have you in science? There was nothing worth speaking of; only husks which the swine would not eat, and the most hungry student could not.

As I have said, I do not think that the average college curriculum, as we have known it in this second stage, is the result of any sort of theory of education, of any appreciation of the relative value of studies, or of any thought as to the best order in which such subjects could be arranged. I have myself taken part in the preparation of too many such courses to have much respect for them. They are simply the results of an attempt to put a maximum of topics into a minimum of terms, — to squeeze ten years of subjects into four years of time. The predominance of one group of subjects in a course reflects the predominance of some pro-

fessor in that line of work. The idea of discipline, more or less prominent in the lower years, is usually forgotten entirely in the Junior and Senior years. The idea of the German schools that the source of all power is concentration, — or, as Emerson expresses it, "The one prudence in life is concentration, the one evil dissipation," — was wholly abandoned. The theory arose that a college is not a place for thorough work of any sort. Its purpose is to give a broad and well-rounded culture, to train men to "stand foursquare to every wind that blows," — such a culture as comes from a slight knowledge of many things, accompanied by thoroughness in nothing. Indeed, the desire of the student to know some one thing well was characterized as "undue specialization," and every effort was made to induce the student to turn with equal eagerness from study to study, — to Physic, Logic, Greek, or History; equally interested, equally superficial, in each. The study of the text-book was exalted, and a subject was said to be completed when its alphabet and a few preliminary definitions were more or less perfectly memorized. Thus it came about that the average student regarded all studies with equal indifference. If a momentary spark of interest was evoked, it must fade out in a few days, as the subject in question gave place to some other. The procession moved in haste, and the student could not loiter if he was to keep his place in the line.

It was said in justification of this course of study that the function of the college is to offer a taste of all sorts of knowledge. The student could try

all, and select that which he liked best as the future work of his life. Thoroughness is for men, not boys, and it is a part of life-work rather than of school discipline. But every influence of the college was away from this end. The value of persistent study, as the Germans know it, was never made known to the student. His professors were not specialists. They knew nothing from first-hand, and they undervalued in all ways the power which comes from knowing what one knows. So they taught only definitions and classifications and names and dates and scrap-work generally. There was little temptation to study; for the business of the professor was repetition, not investigation. It was in reference to such work as this that Agassiz said of Harvard College, some twenty years ago, that it was no university, — "only a respectable high-school, where they taught the *dregs* of learning." A candidate for a chair in an Illinois college demanded of the Board of Trustees that he must be allowed some time for study. He was not elected; for the Board said that they wanted no man who had to study his lessons. They wanted a professor who knew already all that he had to teach. Men of second-hand scholarship are, of necessity, men of low ideals, however carefully this fact may be disguised; a man of high ideals of scholarship must be an investigator. He must know and think for himself; and only such as do this can be really great as teachers.

One vice of this system is its constant implication that when after a few weeks a study is dropped, it is thereby completed, — as though any subject

could be completed in a college course! For the first term or the first year spent in the study of any subject whatever, cannot give that subject. It gives only the elements of it, the dregs of it, the juiceless skeleton, on which future work must add the flesh and blood. Culture does not consist in the knowledge of any particular subject or set of subjects, nor is it the result of any order or method by which such studies are taken. Its essential feature is in the attitude which its possessor holds towards the world and towards the best that has been or can be thought or done in it. Its central quality is growth. The student gets nutriment from what he digests. "A cultivated woman," says a wise teacher of women, "can afford to be ignorant of a great many things, but she must never stop growing." Just so with the cultivated man. And to the young man or young woman who would grow, there is no agency so effective as the influence of a great teacher. "Have a university in shanties, — nay, in tents," says Cardinal Newman, "but have great teachers in it." "Under and around and above all mere acquirements," says the writer whom I have just quoted, "is this subtle infection of character, making the essence of the higher education as different from mere erudition as the fresh smell of the tender grape is from sheepskin." The school of all schools in America which has had the greatest influence on American scientific teaching was held in an old barn on an uninhabited island some eighteen miles from the shore. It lasted barely three months, and in effect it had but one teacher. The school at Penikese existed

in the personal presence of Agassiz; and when he died, it vanished.

The final theory of the patchwork stage of the curriculum has been, as I have said, that of breadth of culture. The student should possess the elements of everything, that no part of the world should be a sealed book, that no part of his mind should be developed at the expense of any other. But the result was, in a general way, oftener confusion than culture. The bed-rock of the mind was never reached. So far as mental training was concerned, almost every result of this curriculum was distinctly inferior to that secured by the old classical course. In broadening and modernizing the curriculum, its sharpness as an implement was lost. The only real gain in the change, according to Professor Bain, has been "the relaxation of the grip of Classicism." Another was perhaps that many who got nothing from the old course could with the right kind of teachers get something from this. But a criticism I once heard at one of our college exhibitions was still pertinent as to most of the work done by either professor or student under this *régime:* "What the boys want is to plough a little deeper. There is nothing like subsoiling!"

From the second to the third stage in its history the curriculum of the American college is now passing. This is marked by the advent of the elective system. It is impossible to study everything or even many things in four years. Thoroughness of any sort is incompatible with the so-called breadth of culture characteristic of the patchwork era. True breadth of culture comes

from breadth of life, and four years in college cannot give it. The elective system, when carried out in its entirety, involves the following elements: (1) A substantial and thorough course preparatory to the college course, — this course including much that is now taught in the Freshman and Sophomore years in most of our Western colleges; (2) The placing of all subjects taught in the college course on an equality so far as the degree is concerned.

The theory on which this system is based may be briefly stated as this: No two students require exactly the same line of work in order that their time in college may be spent to the best advantage. The college student is the best judge of his own needs, or at any rate he can arrange his work for himself better than it can be done beforehand by any committee or by any consensus of educational philosophers. The student may make mistakes in this, as he may elsewhere in much more important things in life; but here, as elsewhere, he must bear the responsibility of these mistakes. The development of this sense of responsibility is one of the most effective agencies the college has to promote the moral culture of the student. It is better for the student himself that he should sometimes make mistakes than that he should throughout his work be arbitrarily directed by others. Freedom is an essential to scholarship as to manhood. In Emerson's words, "Free should the scholar be, — free and brave." Not long since I met a young German scholar, a graduate of a Prussian gymnasium, who has enrolled himself as

a student of English in an American college. To him the free air of the American school was its one good thing. It develops a self-reliant manhood in the youth at an age at which the student of the gymnasium is yet in leading strings. In furnishing the best of mental training in certain fixed and narrow lines, the German student is deprived of that strength which comes from self-help and individual responsibility. It is no mere accident that the need of severe college discipline to guard against the various forms of traditional college mischief has steadily declined with the advent of freedom of choice in study.

The elective system, too, enables the student to bring himself into contact with the best teachers, — a matter vastly more important than that he should select the best studies. And this system, therefore, involves a not unhealthy competition among the instructors themselves. Incompetent, superficial, or fossilized men will be crowded out or frozen out, and the law of the survival of the fittest will rule in the college faculties as elsewhere in Nature.

The elective system has been adopted in greater or less degree by most of our leading colleges; while there are now very few schools, large or small, which do not make some provision for elective studies. That some degree of freedom of choice in higher education is desirable, no one now questions. The main differences of opinion relate to the proportion which these elective studies ought to bear to those which are absolutely required, and to the age or degree of advance-

ment at which election is safe; for no one advocates freedom of choice from infancy. There is no such thing as a perfect curriculum, and all college courses must represent in some degree a compromise among varying influences, or else an adaption to the needs of a certain class of students to the exclusion of others. All systems are liable to abuse; and as there have been many students who made a farce of the classical course, or who made it a mere excuse for four years spent in boating or billiards or in social pleasures, so in the same way can a farce be made of the freedom allowed under the elective system.

Some of the chief deficiencies of the elective system may be summed up under the following heads: —

1. There are some students who from pure laziness select only the easiest studies, and go through college with the very least work which is possible. But this is no new thing, and it is not for such students that the colleges exist. The college should not obstruct the work of its earnest men to keep its idlers and sneaks from wasting their useless time. As Dr. Angell has said: "No plan will make the college career of lazy men brilliant. . . . The work of the college should be organized to meet the needs of the earnest and aspiring students rather than the infirmities and defects of the indolent." That most students as a matter of fact do select the easiest studies is not true, as statistics certainly show. It is, in fact, simple nonsense to call any study easy, if pursued in a serious manner for a serious purpose. If any subject

draws to itself the idlers solely because it is easy, the fault lies with the teacher. The success of the elective system, as of any system, demands the removal of inefficient teachers. The elective system can never wholly succeed unless each teacher has the power and the will to enforce good work, to remove from his classes all idle or inefficient students.

2. It is again objected that students having freedom of choice are likely to select erratic courses in accordance with temporary whims, rather than with any theory of educational development. This again is true; but it is likewise true that the course apparently the most erratic may be the one which brings the student in contact with the strongest men. If a Harvard student of a few years ago could have made his college course exclusively of Botany, Embryology, Greek, Anatomy, and Early English, it would seem a singular combination. It would sound differently if it were said that his teachers in college were chiefly Asa Gray, Goodwin, Holmes, Lowell, and Agassiz. It is also true, I think, that the average course as chosen by the students themselves is as capable of serious defence as the average established course, evolved from the pulling and hauling and patching and fitting of the average college Faculty.

3. Another criticism is that the elective system offers special temptation to undue or premature specialization. This is true; and premature specialization, like other forms of precocious virtue, is much to be deprecated. But experience does not lead me to think that the danger of "undue spe-

cialization" is at all a serious one. The current, in college and out, is all setting the other way. The fact that any man dares to specialize at all, shows that he has a certain independence of character, for the odds are against it. Specialization implies thoroughness, and I believe that thorough knowledge of something is the backbone of culture. Special knowledge of any sort gives to each man the base line by which other attainments may be measured; and this unit of measurement in scholarship can be acquired in no other way. There can be, I think, no scholarship worthy of the name, without some form of special knowledge or special training as its central axis. The self-respect of the scholar comes from thorough work. The man who feels sure that he can know or can do something is assured at once from the danger of turgid conceit as from that of limp humility. He can hold up his head among men with a certainty as to his proper place among them.

I have often heard college graduates complain, "Oh, if I had only studied something in particular!" "Oh, if I had only learned how to study!" "Oh, if the time I have wasted in Latin had been spent in something else!" "Oh, if the time I have wasted in something else had been spent in Latin!" There are few college men of the present generation who would not be better scholars to-day if half their curriculum had been omitted (not much matter what half) and the time had been spent on the remaining subjects. But you may say, "Would you let a man graduate ignorant of Chemistry, of Latin, of Logic, of Botany?"

Well, yes, if superficiality in everything is the alternative. It is well for a scholar to know something of each of these and of each of the subjects in the most extended curriculum. But he purchases this knowledge too dearly if he buys it at the expense of thoroughness in some line of study in which a real interest has been awakened. "A mistake is made," says a recent writer, "in treating studies like boarders. They are taken in and housed at so much a term, and at its end hostess and guest part with mutual good-will." Some closer relation than this is essential to scholarship.

Then, again, with certain men in college the alternative is either a close specialization or no college life at all. Sometimes a man may wish in college to devote his entire time to a single subject, as Physics or History, making himself an authority on that subject, but without any effort for broad culture at all. This is not often a wise course; but wise or not, no one will deny that a college career spent in this way is better than none at all, and in after years such men are rarely a source of shame to their Alma Mater. There is a certain well-known naturalist whom I could name, who was some ten years ago excluded from the Indiana University, not because he was idle or vicious or weak, but because he wanted to spend most of his time in the study of Natural History. The college had then no place for such a man as that, though the same college is proud of him now. Who is to say that it was better for him to leave college than that he should be allowed to follow his own bent? No knowledge comes amiss to an investi-

gator, but no investigator can afford to sacrifice his specialty for the sake of breadth of culture. Thoroughness is the main point, after all, and should take precedence over versatility. I do not mean to be understood as advocating narrowness of sympathy or narrowness of culture of any sort. The broadest education is none too broad for him who aspires to lead in any part of the world of thought. But the forces of the mind, to continue the figure, should not be scattered in guerilla-bands, but marshalled toward leadership.

4. Still another criticism of the elective system is just the reverse of this. The elective system permits undue scattering. It allows a student to flit from one subject to another, thus acquiring versatility without real training. This seems to me a more serious fault than any of the others. It can be remedied in part by a system of major and minor studies, or a division of the work into specialties to be pursued for a considerable length of time, and electives which may be dropped after a simple mastery of their elements. Some such arrangement as this seems to me a desirable check upon the elective plan, as it tends to insure persistence in something, while retaining most of the flexibility of the latter system.

There is still much to be said in favor of the college in which discipline pure and simple is made the chief aim of all the work. In such a school those subjects — Languages, Sciences, and Philosophy — which serve the ends of training best should be taught, and such subjects only. Whether anything more suitable for this purpose than the

Ancient Classics and Mathematics has yet been found, I shall not try to say; but the aims of such a course should be the same in kind as that of the classical curriculum. It may perhaps be possible to teach better things and in a better way than was done in the classical schools; but all attempts at combining in a prescribed curriculum mental discipline and a wide range of subjects must result in failure, so far as training the mind is concerned. You cannot teach everything to every student. Either the college or the student must choose.

Some of the weakest features of our college system centre, it seems to me, about the conventional term of four years, and the conventional Bachelor's degree. Students are encouraged to work for the degree rather than for culture; all work of the student is estimated by the bulk rather than by the quality. In an ideal condition of things the student's work ought not to be estimated at all. Marks and terms are clumsy devices, more suitable for measuring cord-wood than culture. The degree is the official seal of completion set on something which in the nature of things can never be completed. For the college is not a machine for filling the student on the sausage-stuffer plan. It is, at best, a place for self-culture. All culture is self-culture, or it is no culture at all. Libraries, apparatus, museums, teachers even, are useless to the student, unless the student use them. Teachers give inspiration and criticism; fellow-students do the same; but the road to wisdom is a solitary road to be traversed in Indian file.

We may lay on the Bachelor's degree at once

too much stress or too little. Too much; for the degree is treated as if it were an end in itself. Too little; for every college in our land gives this degree to men whose sole claim to higher education consists in a four years' residence in a college town, a four years' "exposure to scholastic influences." They make their count of marks on the college books; and if by hook or crook they can keep "regular," the march of time will carry them through. Then again the competition for numbers among our would-be "populous schools" often leads to discrepancies between the actual requirements and those laid down in the published catalogues. Thus low standards are adopted for mere numbers' sake. And besides the reputable institutions, all sorts of mushroom establishments in private hands have in the Western States been authorized by law to grant the Bachelor's degree, with practically no scholastic requirements at all.

When the colleges in the patchwork era attempted to teach in four years a little of everything, it was found that by the same process a little of everything could likewise be given in two years, or even in one year, by carrying the process of condensation a little farther. I received a letter not long ago from the President of an alleged college in Kansas, — a school which gives the Bachelor's degree on a course a year or two long, begun at any time, and with no special preparation. He said that he had exactly one year of daily recitations to devote to all the sciences, each completed in turn. He was especially anxious to make no

mistake in the logical order of arrangement of these sciences, — whether it should be Chemistry, Physics, Geology, Physiology, Zoölogy, and Botany, or whether the order would be better if reversed. Of course, the only answer I could make was that the order was of little importance, and that if a year was all the time he had for all of them, it would be better to omit any five or at least any four, and to spend his time on the rest. But my advice was not followed, and I have no doubt that he found room at last to work all of them in, and a term of Astronomy and one of Political Economy besides.

I quote, from the catalogue of an alleged "college" in Indiana, a statement in regard to its "Scientific Course" of one year's duration, which leads to a degree called "Bachelor of Science:" "The graduates [of this course] are polished speakers as well as accurate mathematicians, thorough scientists, and accomplished Latin scholars. Graduates from this department fill good positions, and are everywhere known as leaders, because of their energy, perseverance, enthusiasm, and never-ceasing activity," — and so on. The so-called "insurmountable barrier" to a degree "formed by the long courses of the colleges and State Normal Schools," is at once blown away, and all obstacles which debar indolence and ignorance from the privileges of scholarship once for all removed.

I have a friend in this town (Indianapolis), a most estimable gentleman in the real estate and rental business, who some forty years ago received from the legislature of the State of Indiana a char-

ter which constituted him a "University," entitled to hold $200,000 in property free from all taxes, "to confer all academic degrees, and to enjoy all the rights and privileges of the most favored institutions." This gentleman has been merciful to his fellow-citizens. He has gone about his business and has conferred no degrees, not even on himself. But he has the legal right to do it, and this incident shows with what laxness the laws of our own and other States view the granting of collegiate degrees. Such is the degradation of the Bachelor's degree, which has already brought the name of American graduate into contempt.

Still, at the best, the Bachelor's degree is an empty name. It is not in America, as in Europe, a key to any sort of personal advancement. And it is better that it should be so. It is better for each man to stand on his own merits as shown by his own work, not as attested by any college faculty. "The student may flourish his college diploma," says Dr. J. P. Lesley, "but the world cares little for that baby badge." In certain educational circles, perhaps, a college degree is a help, or rather it may represent a certain minimum of culture which is expected of all its members. We suppose that a college professor must hold a college degree. But this is not always the case. I can count on my fingers, taking every one, a list of some of the ablest of Indiana's college teachers to-day, who have never been graduated from any college. Most of these hold honorary degrees, it is true; but such degrees are empty tributes of the college to success of one sort or another, won without the college's help.

It is true, no doubt, that the hope of a degree coaxes some men to stay in college longer than they otherwise would. This seems a good thing, but is it? Higher education is not working for a degree. It may be incompatible with it. It is putting a cheap price on culture to induce the student to take it, not because he wants it, but because he wants something else. If a student's work is purely perfunctory, the sooner he leaves it for something real the better. If the degree is merely a bait to lure him on, it is unworthy alike of the college and of the student.

Shall we then abandon the Bachelor's degree, and give to each student merely the certificates of the professors under whom he has studied? Some day, perhaps, but certainly not yet. It was a French writer, Joubert, who said, "All *truth* it is not well to tell; but all *truths* it will be well to tell when we can all tell them together." There is the wisdom of the serpent in this saying. Degrees are childish things, and it would be well to lay them aside; but this we cannot do till we can all do it together. Some ten years ago, Chancellor Gregory of the State University of Illinois held the opinion that the college degrees were undesirable adjuncts of college training. It was decided that by the University of Illinois no degrees should be granted. But this decision worked adversely to the interests of the college. Many students came there to study, who went elsewhere to complete their work. The degree might be useless, but the students wanted it, and went to other colleges where degrees were still given. The times were not ready for this change,

and the giving of degrees has been resumed — wisely, I think — by the institution in question.

The same end is being reached in another way by the University of Virginia and some others which are following its lead. In these schools the Bachelor's degree receives little or no attention, being practically merged in the higher requirements for the degree of Master of Arts. By merging both these in the still higher degree of Doctor of Philosophy, we have a condition similar to that in the German Universities, where only the Doctor's degree is now given. Towards this condition our universities are tending; and through the change of the college into the university the Bachelor's degree may in time disappear. But this reform — if reform it be — can be the work of no one man or one school. It must come as a natural result of the development of the college.

So much for the phases, past and present, of the college curriculum in America. What of the future? Will there be a fourth, a fifth, a sixth stage in its development; or is the system now full-grown, and the elective plan, as we know it, its full fruition?

We can be sure that the world is still moving. Nothing is stable, nothing is perpetual, nothing is sufficient. With the new needs and the new men of the future will come new departments, new methods, and new ideas. The curriculum in its original sense of a little race-course, with thirty-six hurdles to be leaped in thirty-six months, with a crown of laurel berries at the end, will very soon be no more. Special courses of study in as many

special departments are already taking its place. The traditional four years of college training will disappear; and with it the sharp lines which have so long set apart the Freshmen, Sophomores, Juniors, and Seniors. Later on, but not far in the next century, the Bachelor's degree will cease to be regarded; and its kindred, the degree of the Master and the Doctor, may perhaps not survive it long. All these things are forms, and forms only, — not substance; and the substance of our higher education is fast outgrowing them. College marks, college honors, college courses, college degrees, — all these things belong, with the college cap and gown and the wreath of laurel berries, to the babyhood of culture. They are part of our inheritance from the past, — from the time when scholarship was not manhood, when the life of the student had no relation to the life of the world.

The American college of the future will be a place for self-culture. In the words of Emerson: "Colleges can only serve us when they aim not to drill, but to create; when they gather from far every ray of various genius to their hospitable halls, and by the concentrated fires set the hearts of their youth on flame."

The chief need of a college organization is to bring great teachers together, that their combined influence may effect results which cannot be reached in isolation. In other words, the use of a college is to produce a college atmosphere, — such an atmosphere as formed itself around Arnold at Rugby, around Döllinger at Munich, around Werner at Freiberg, around Agassiz at Cambridge,

around Mark Hopkins at Williamstown, — around all great teachers everywhere. The various so-called colleges and universities in America will gradually differentiate into universities and preparatory schools, and the ultimate line of division will be one of money as well as one of management. To do university work requires better-trained professors, and many more of them, than to teach the elements of Latin, Greek, and Mathematics. This means more salaries and larger salaries than are now paid. Schools ill endowed or not endowed at all cannot attempt this. Those who can do it will do it, and the success of Johns Hopkins University shows how this is to be done. The ideas of *Lehrfreiheit* and *Lernfreiheit*, — freedom of teaching and freedom of study, — on which the German university is based, will become a central feature of the American college system.

The college as a separate factor in our educational system may in time disappear by its mergence into the preparatory school on the one hand and into the university on the other. We should then reach a condition of things not unlike that seen in Germany, where nothing intervenes between the public high school or gymnasium, in which all work is prescribed, and the university itself, in which all work is free. The position of the preparatory school in this connection is by no means one to be despised. A strong preparatory school is far more valuable to the community than a weak college. The work of the secondary schools is the foundation of everything higher. It should be broadened and deepened so as to

include all subjects which experience shows to belong to the necessary groundwork of higher education. I need not go over a list of these subjects. The future will make its own list, and the efforts of the colleges will not change it.

But here, it seems to me, is one of the chief difficulties in the way of our colleges, east and west. No school in Indiana seems content to be a preparatory school. Each one aims to give a general education; to be a university in a small way, a "university for the poor," — a poor university. In the words of Lowell: "The public schools teach too little or too much: too little, if education is to go no further; too many things, if what is taught is to be taught thoroughly. And the more they seem to teach, the less likely is education to go further; for it is one of the weaknesses of democracy to be satisfied with the second best if it appear to answer the purpose tolerably well, and to be cheaper, as it never is in the long run." In other words, the high schools, too, are in the patchwork era, and popular feeling tends to keep them there, to satisfy by a show of education the vast majority of their students who are likely to go no farther. The growth in educational systems is from above downwards, and the right kind of preparatory schools will arise only in response to the demands of real universities. In historical sequence Oxford must precede Rugby, and the German university must come before the gymnasium. The American high school will not reach, I think, the standard of the German gymnasium, which gives training not inferior in amount or kind

to that of our best classical colleges; for in the American system the university methods of work will begin lower down than in Germany. This is associated with our qualities as a people as compared with the Germans. The American youth of twenty-one is more independent, more self-reliant, and so far as his relation to the world is concerned, more mature than the average German student is at twenty-five. America is, of all lands, the land of protestantism; and in education, as in other things, every American is a law unto himself. This fact has its bad side as well as its good side, but is a fact nevertheless; and as educators of Americans we must take it into account.

The old forms in education are passing away; the old barriers are being taken down; the old restraints are being removed or relegated to the days of boyhood and girlhood. All this we can see, for it takes place before our eyes; it is taking place under our hands, and this whether we wish it or not. The college boy is becoming a man, and the college woman now stands beside him. Not all are ready for freedom, perhaps, who have freedom thrust upon them. There are not a few students to whom an enforced discipline is the only road to scholarship. But with all imaginable drawbacks our college work in America yields every year better results than it has ever yielded before. We may be sure that in the future, even more than in the past, the American college, the American university, will stand in the front rank of civilizing influences.

APPENDIX.

APPENDIX.

LIST OF THE SCIENTIFIC PAPERS OF DAVID S. JORDAN.

1873 TO 1887.

1873.

1. THE COLORS OF VEGETATION. American Naturalist, February, 1873; pp. 65–70.
2. HOOF-ROT IN SHEEP. Prairie Farmer, 1873.

1874.

3. A POPULAR KEY TO THE BIRDS, REPTILES, BATRACHIANS, AND FISHES OF THE NORTHERN UNITED STATES EAST OF THE MISSISSIPPI RIVER. Appleton, Wis., May, 1874; pp. 100. (Jordan and Van Vleck. Balfour H. Van Vleck, Bost. Soc. Nat. Hist., Boston, Mass.)
4. THE FLORA OF PENIKESE ISLAND. Amer. Nat., April; pp. 193–197.
5. A KEY TO THE HIGHER ALGÆ OF THE ATLANTIC COAST BETWEEN NEWFOUNDLAND AND FLORIDA. Amer. Nat., July and August, 1874.

1875.

6. THE SISCO OF LAKE TIPPECANOE. Amer. Nat., March, 1875; pp. 135–138.
7. THE SISCO OF LAKE TIPPECANOE AND ITS RELATIVES. Rept. Geol. Surv., Indiana, for 1875.
8. A SYNOPSIS OF THE FISHES TO BE LOOKED FOR IN INDIANA. Rept. Geol. Surv., Indiana, for 1875.

1876.

9. THE GENUS POMOXYS RAFINESQUE. Proc. Acad. Nat. Sci., Philadelphia, 1876; pp. 68–71. (Jordan and Copeland. Herbert Edson Copeland, Indianapolis, Ind.)

10. Concerning the Fishes of the Ichthyologia Ohiensis. Bull. Buffalo Soc. Nat. Hist., 1876; pp. 91–97.
11. Manual of the Vertebrates of the Northern United States, including the District east of the Mississippi River and north of North Carolina and Tennessee, exclusive of Marine Species. Chicago, 1876; June.
12. Johnny Darters. Amer. Nat., June, 1876; pp. 335–341. (Jordan and Copeland.)

1877.

13. The Sand Darter. Amer. Nat., February, 1877; pp. 86–88. (Jordan and Copeland.)
14. List of Fishes of Indiana. Indiana Farmer, Jan. 17, 1877. (Jordan and Gilbert. Charles Henry Gilbert, Ph. D., University of Cincinnati, Cincinnati, Ohio.)
15. A Story of a Stone. St. Nicholas, February, 1877; (reprinted in Indiana School Journal, Sheldon's Fourth Reader, and elsewhere.)
16. Check List of the Fishes of the Fresh Waters of North America. Bull. Buffalo Soc. Nat. Hist., II., 1876; pp. 133–164; February, 1877. (Jordan and Copeland.)
17. On the Fishes of Northern Indiana. Proc. Acad. Nat. Sci., Philadelphia, June, 1877; pp. 42–82.
18. On the Genera of North American Fresh-Water Fishes. Proc. Acad. Nat. Sci., Philadelphia, 1877; pp. 83–104. (Jordan and Gilbert.)
19. A partial Synopsis of the Fishes of Upper Georgia. Ann. Lyc. Nat. Hist., New York, vol. xi., 1876; pp. 307–377. June, 1877.
20. Contributions to North American Ichthyology, I. Review of Rafinesque's Memoirs on North American Fishes. Bull. U. S. Nat. Mus., IX., 1877; p. 53.
21. Contributions to North American Ichthyology, II. A. Notes on *Cottidæ*, *Etheostomatidæ*, *Percidæ*, *Centrarchidæ*, etc., with Revisions of Genera and Descriptions of new or little known Species. B. Synopsis of the *Siluridæ* of the United States. Bull. U. S. Nat. Mus., X., 1877; pp. 116.
22. On Lagochila, a new Genus of Catostomoid Fishes. Proc. Acad. Nat. Sci., Philadelphia, 1877; pp. 280–283. (Jordan and Brayton. Alembert Winthrop Brayton, M.D., Indianapolis, Ind.)
23. On the Distribution of Fresh-Water Fishes. Amer. Nat., October, 1877; pp. 607–613.

1878.

24. On the Distribution of Fresh-Water Fishes of the United States. Ann. N. Y. Acad. Sci., I., 1877; pp. 92–120; 1878.
25. A Catalogue of the Fishes of Illinois. Bull. Illinois Lab. Nat. Hist., II., Bloomington, Ill., June, 1878.

26. CATALOGUE OF THE FISHES OF INDIANA. In Twenty-seventh Annual Report Indiana State Board of Agriculture, 1877, vol. xix. Indianapolis, 1878.

27. MANUAL OF THE VERTEBRATES OF THE NORTHERN UNITED STATES, including the District east of the Mississippi River and north of North Carolina and Tennessee, exclusive of Marine Species. Second edition, revised and enlarged. Chicago, June, 1878; pp. 407.

28. CONTRIBUTIONS TO NORTH AMERICAN ICHTHYOLOGY, based, primarily, on the Collections of the United States National Museum. III. A. On the Distribution of the Fishes of the Alleghany Region of South Carolina, Georgia, and Tennessee, with Descriptions of new or little known Species. (Jordan and Brayton.) B. A Synopsis of the Family *Catostomidæ*. Bull. U. S. Nat. Mus., XII., 1878; pp. 237.

29. NOTES ON A COLLECTION OF FISHES FROM CLACKAMAS RIVER, OREGON. Proc. U. S. Nat. Mus., 1878; p. 691.

30. NOTES ON A COLLECTION OF FISHES FROM THE RIO GRANDE, AT BROWNSVILLE, TEXAS. Bull. U. S. Geol. Surv. Terr., IV., 1878; pp. 397–406.

31. A CATALOGUE OF THE FISHES OF THE FRESH WATERS OF NORTH AMERICA. Bull. U. S. Geol. Surv. Terr., IV., 1878; pp. 407–442.

32. NOTES ON A COLLECTION OF FISHES FROM THE RIO GRANDE, AT BROWNSVILLE, TEXAS, continued. Bull. U. S. Geol. Surv. Terr., IV., 1878; pp. 663–667.

33. REPORT ON THE COLLECTION OF FISHES MADE BY DR. ELLIOTT COUES, U. S. A., IN DAKOTA AND MONTANA, DURING THE SEASONS OF 1873 AND 1874. Bull. U. S. Geol. Surv., IV., 1878; pp. 777–799.

34. NOTES ON THE FISHES OF BEAUFORT HARBOR, NORTH CAROLINA. Proc. U. S. Nat. Mus., 1878; pp. 365–388. (Jordan and Gilbert.)

35. REPORT ON THE FISHES COLLECTED DURING THE YEARS 1875, 1876, AND 1877, IN CALIFORNIA AND NEVADA. Rept. Geol. Surv. W. 100th Mer. for 1878. Appendix K.; pp 187–200. (Jordan and Henshaw. H. W. Henshaw, U. S. Geol. Survey, Washington, D. C.)

1880.

36. MANUAL OF THE VERTEBRATES OF THE NORTHERN UNITED STATES, including the District east of the Mississippi River and orth of North Carolina and Tennessee, exclusive of Marine Species. Third edition, revised and enlarged. Chicago, 1880; pp. 406.

37. NOTES ON CERTAIN TYPICAL SPECIMENS OF AMERICAN FISHES IN THE BRITISH MUSEUM AND IN THE MUSEUM D'HISTOIRE NATURELLE AT PARIS. Proc. U. S. Nat. Mus., 1879; pp. 218–226. January, 1880.

38. Descriptions of new Species of North American Fishes. Proc. U. S. Nat. Mus., 1879; p. 235. January, 1880.
39. Notes on a Collection of Fishes obtained in the Streams of Guanajuato, and in Chapala Lake, Mexico, by Prof. A. Duges. Proc. U. S. Nat. Mus., 1879; p. 298. March, 1880.
40. Notes on a Collection of Fishes from East Florida, obtained by Dr. J. A. Henshall. Proc. U. S. Nat. Mus., 1880; pp. 17–21.
41. Notes on a Collection of Fishes from St. John's River, Florida, obtained by Mr. A. H. Curtiss. Proc. U. S. Nat. Mus., 1880; p. 22.
42. Notes on a Collection of Fishes from San Diego, California. Proc. U. S. Nat. Mus., 1880; pp. 23–34. (Jordan and Gilbert.)
43. Description of a new Flounder (*Xystreurys liolepis*) from Santa Catalina Island, California. Proc. U. S. Nat. Mus., 1880; pp. 34–36. (Jordan and Gilbert.)
44. Description of a new Ray (*Platyrhina triseriata*) from the Coast of California. Proc. U. S. Nat. Mus., 1880; pp. 36–38. (Jordan and Gilbert.)
45. Description of a new Species of "Rock Cod" (*Sebastichthys serriceps*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 38–40. (Jordan and Gilbert.)
46. On the Occurrence of Cephaloscyllium laticeps (Dumeril) Gill on the Coast of California. Proc. Nat. Mus., 1880; pp. 40–42. (Jordan and Gilbert.)
47. On the Oil Shark of Southern California (*Galeorhinus galeus*). Proc. Nat. Mus., 1880; p. 42. (Jordan and Gilbert.)
48. Description of a new Flounder (*Pleuronichthys verticalis*) from the Coast of California, with Notes on other Species. Proc. Nat. Mus., 1880; pp. 49–51. (Jordan and Gilbert.)
49. Notes on Sharks from the Coast of California. Proc. Nat. Mus., 1880; pp. 51–52. (Jordan and Gilbert.)
50. On the Generic Relations of Platyrhina exasperata. Proc. Nat. Mus., 1880; p. 53. (Jordan and Gilbert.)
51. Description of a new Species of Sebastichthys (*Sebastichthys miniatus*) from Monterey Bay, California. Proc. Nat. Mus., 1880; pp. 70–73. (Jordan and Gilbert.)
52. Description of a new Species of Rock-Fish (*Sebastichthys carnatus*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 73–75. (Jordan and Gilbert.)
53. Description of a new Species of Ray (*Raia stellulata*) from Monterey, California. Proc. Nat. Mus., 1880; pp. 133–135. (Jordan and Gilbert.)
54. Descriptions of new Species of Xiphister and Apodichthys from Monterey, California. Proc. Nat. Mus., 1880; pp. 135–140. (Jordan and Gilbert.)

55. Description of two new Species of Sebastichthys (*Sebastichthys entomelas* and *Sebastichthys rhodochloris*) from Monterey Bay, California. Proc. Nat. Mus., 1880; pp. 142–146. (Jordan and Gilbert.)
56. Description of a new Agonoid Fish (*Brachyopsis xyosternus*) from Monterey Bay, California. Proc. Nat. Mus., 1880; pp. 152–154. (Jordan and Gilbert.)
57. Description of a new Flounder (*Hippoglossoides exilis*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 154–156. (Jordan and Gilbert.)
58. Description of a new Species of Ray (*Raia rhina*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 251–253. (Jordan and Gilbert.)
59. Description of two new Species of Fishes (*Ascelichthys rhodorus* and *Scytalina cerdale*) from Neah Bay, Washington Territory. Proc. Nat. Mus., 1880; pp. 264–268. (Jordan and Gilbert.)
60. Description of two new Species of Scopeloid Fishes (*Sudis ringens* and *Myctophum crenulare*) from Santa Barbara Channel, California. Proc. Nat. Mus., 1880; pp. 273–276. (Jordan and Gilbert.)
61. Description of two new Species of Flounders (*Parophrys ischyrus* and *Hippoglossoides elassodon*) from Puget Sound. Proc. Nat. Mus., 1880; pp. 276–280. (Jordan and Gilbert.)
62. Description of seven new Species of Sebastoid Fishes from the Coast of California. Proc. Nat. Mus., 1880; pp. 287–298. (Jordan and Gilbert.)
63. Description of a new Embiotocoid (*Abeona aurora*) from Monterey, California, with Notes on a related Species. Proc. Nat. Mus., 1880; pp. 299–301. (Jordan and Gilbert.)
64. Description of a new Flounder (*Platysomatichthys stomias*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 301–303. (Jordan and Gilbert.)
65. Description of a new Embiotocoid Fish (*Cymatogaster rosaceus*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 303–305. (Jordan and Gilbert.)
66. Description of a new Species of Deep-Water Fish (*Icichthys lockingtoni*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 305–308. (Jordan and Gilbert.)
67. Description of a new Embiotocoid Fish (*Ditrema atripes*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 320–322. (Jordan and Gilbert.)
68. Description of a new Scorpænoid Fish (*Sebastichthys maliger*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 322–324. (Jordan and Gilbert.)
69. Note on a forgotten Paper of Dr. Ayres, and its Bearing on the Nomenclature of the Cyprinoid Fishes of the San Francisco Markets. Proc. Nat. Mus., 1880; pp. 325–327.

70. Note on Sema and Dacentrus. Proc. Nat. Mus., 1880; p. 327.
71. Description of a new Scorpænoid Fish (*Sebastichthys proriger*) from Monterey Bay, California. Proc. Nat. Mus., 1880; pp. 327–329. (Jordan and Gilbert.)
72. Description of a new Agonoid (*Agonus vulsus*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 330–332. (Jordan and Gilbert.)
73. Description of a new Species of Hemirhamphus (*Hemirhamphus rosæ*) from the Coast of California. Proc. Nat. Mus., 1880; pp. 335–336. (Jordan and Gilbert.)
74. Description of a new Species of Notidanoid Shark (*Hexanchus corinus*) from the Pacific Coast of the United States. Proc. Nat. Mus., 1880; pp. 352–355. (Jordan and Gilbert.)
75. Description of a new Species of Nemichthys (*Nemichthys avocetta*) from Puget Sound. Proc. Nat. Mus., 1880; pp. 409–410. (Jordan and Gilbert.)
76. Description of a new Species of Paralepis (*Paralepis coruscans*) from the Straits of Juan de Fuca. Proc. Nat. Mus., 1880; pp. 411–413. (Jordan and Gilbert.)
77. List of the Fishes of the Pacific Coast of the United States, with a Table showing the Distribution of the Species. Proc. Nat. Mus., 1880; pp. 452–458. (Jordan and Gilbert.)
78. Scientific Names of the Black Bass. Forest and Stream, Nov. 28, 1880; p. 340. (Reprinted in Henshall's "Book of the Black Bass.")
79. Description of a new Species of Caranx (*Caranx beani*) from Beaufort, North Carolina. Proc. Nat. Mus., 1880; pp. 486–488.
80. On the Generic Relations of Belone exilis, Grd. Proc. Nat. Mus., 1880; p. 459. (Jordan and Gilbert.)
81. Notes on a Collection of Fishes from Utah Lake. Proc. Nat. Mus, 1880; p. 459. (Jordan and Gilbert.)
82. Description of a new Species of Rock Fish (*Sebastichthys chrysomelas*) from the Coast of California. Proc. Nat. Mus., 1880; p. 465. (Jordan and Gilbert.)

1881.

83. Observations on the Salmon of the Pacific. Amer. Nat., March, 1881; pp. 177–186. (Jordan and Gilbert.)
84. Check List of Duplicates of Fishes from the Pacific Coast of North America, distributed by the Smithsonian Institution in behalf of the United States National Museum, 1881. Proc. U. S. Nat. Mus., 1881; pp. 1–18. (Jordan and Jouy. Pierre Louis Jouy, Smithsonian Institution, Washington, D. C.)
85. Notes on the Fishes of the Pacific Coast of the United States. Proc. Nat. Mus., 1881: pp. 29–70. (Jordan and Gilbert.)
86. Description of Sebastichthys mystinus. Proc. Nat. Mus., 1881; pp. 70–72. (Jordan and Gilbert.)

87. Description of a new Species of Ptychochilus (*Ptychochilus harfordi*) from Sacramento River. Proc. Nat. Mus., 1881; pp. 72–73. (Jordan and Gilbert.)
88. Note on Raia inornata. Proc. Nat. Mus., 1881; pp. 73–74. (Jordan and Gilbert.)
89. Story of a Salmon. Popular Science Monthly, May, 1881; pp. 1–6.
90. On the Movements of Plants. Review of Darwin's "Power of Movement in Plants." Dial, March, 1881.
91. Notes on a Collection of Fishes made by Lieut. Henry E. Nichols, U. S. N., on the West Coast of Mexico, with Descriptions of new Species. Proc. Nat. Mus., 1881; pp. 225–233. (Jordan and Gilbert.)
92. List of Fishes collected by Lieut. Henry E. Nichols, U. S. N, in the Gulf of California, and on the West Coast of Lower California, with Descriptions of four new Species. Proc. Nat. Mus., 1881; pp. 273–279. (Jordan and Gilbert)
93. Description of thirty-three new Species of Fishes from Mazatlan, Mexico. Proc. Nat. Mus., 1881; pp. 338–365. (Jordan and Gilbert.)
94. Description of a new Species of Pomadasys from Mazatlan, with a Key to the Species known to inhabit the Pacific Coasts of Tropical America. Proc. Nat. Mus., 1881; pp. 383–388. (Jordan and Gilbert.)
95. Description of a new Species of Xenichthys (*Xenichthys xenurus*) from the West Coast of Central America. Proc. Nat. Mus., 1881; p. 454. (Jordan and Gilbert.)
96. Description of five new Species of Fishes from Mazatlan, Mexico. Proc. Nat. Mus., 1881; pp. 458–463. (Jordan and Gilbert.)
97. An Ascent of the Matterhorn. Our Continent, Nov. 2, 1881.

1882.

98. Description of four new Species of Sharks from Mazatlan, Mexico. Proc. Nat. Mus., 1882; pp. 102–110. (Jordan and Gilbert.)
99. Description of a new Shark (*Carcharias lamiella*) from San Diego, California. Proc. Nat. Mus., 1882; pp. 110–111. (Jordan and Gilbert.)
100. Bull-Trout and Pompano. Forest and Stream, April 20, 1882.
101. Darwin. Dial, May, 1882; p. 2.
102. Huxley's Science and Culture. Review in Dial, May, 1882; p. 9.
103. Descriptions of nineteen new Species of Fishes from the Bay of Panama. Bull. U. S. Fish. Comm.; pp. 306–365. June, 1882. (Jordan and Gilbert.)
104. Some Ichthyological Terms. Forest and Stream, Aug. 20, 1882.

105. The Air we Breathe. Review of Tyndall's "Floating Matter in the Air." Dial, September, 1882; pp. 90–93.
106. Notes on Fishes observed about Pensacola, Florida, and Galveston, Texas, with Descriptions of new Species. Proc. Nat. Mus., 1882; pp. 241–307. (Jordan and Gilbert.)
107. Description of a new Species of Blenny (*Isesthes Gilberti*) from Santa Barbara, California. Proc. Nat. Mus., 1882; pp. 349–351.
108. Description of a new Species of Conodon (*Conodon serrifer*) from Boca Soledad, Lower California. Proc. Nat. Mus., 1882; pp. 351–352. (Jordan and Gilbert.)
109. Catalogue of the Fishes collected by Mr. John Xantus at Cape San Lucas, which are now in the United States National Museum, with Descriptions of eight new Species. Proc. Nat. Mus., 1882; pp. 353–371. (Jordan and Gilbert.)
110. List of Fishes collected by Mr. John Xantus at Colima, Mexico. Proc. Nat. Mus., 1882; pp. 371–372. (Jordan and Gilbert.)
111. List of Fishes collected at Panama by Capt. John M. Dow, now in the United States National Museum. Proc. Nat. Mus., 1882; pp. 373–378. (Jordan and Gilbert.)
112. List of a Collection of Fishes made by Mr. L. Belding, near Cape San Lucas, Lower California. Proc. Nat. Mus., 1882; pp. 378–381. (Jordan and Gilbert.)
113. List of Fishes collected at Panama by Rev. Mr. Rowell, now preserved in the United States National Museum. Proc. Nat. Mus., 1882; pp. 381–382. (Jordan and Gilbert.)
114. Descriptions of two new Species of Fishes (*Sebastichthys umbrosus* and *Citharichthys stigmæus*) collected at Santa Barbara, California, by Andrea Larco. Proc. Nat. Mus., 1882; pp. 410–412. (Jordan and Gilbert.)
115. The Gasper-Gou. Forest and Stream, Oct. 5, 1882; p. 192.
116. A Review of the Siluroid Fishes found on the Pacific Coast of Tropical America, with Descriptions of three new Species. Bull. U. S. Fish. Comm., 1882; pp. 34–54. (Jordan and Gilbert.)
117. List of Fishes collected at Mazatlan, Mexico, by Charles H. Gilbert. Bull. U. S. Fish Comm., 1882; pp. 105–108. (Jordan and Gilbert.)
118. List of Fishes collected at Panama by Charles H. Gilbert. Bull. U. S. Fish Comm., 1882; pp. 109–111. (Jordan and Gilbert.)
119. An Ascent of the Matterhorn. Our Continent, Nov. 8, 1882.
120. Description of a new Species of Goby (*Gobiosoma ios*) from Vancouver's Island. Proc. Nat. Mus., 1882; pp. 437–438. (Jordan and Gilbert.)
121. The Blue-Back Trout (*Salvelinus oquassa*). Forest and Stream, December, 1882; p. 389.

122. Dr. Henshall's Scientific Nomenclature again. American Angler, Dec. 16, 1882; p. 391.
123. The Nomenclature of our Birds. Dial, December, 1882; pp. 165–167. Review of the Coues Check List.
124. Report on the Fishes of Ohio. Sec. IV., Report of the Geological Survey of Ohio, vol. iv. pp. 735–1002. December, 1882.

1883.

125. Striped Bass or Rock-Fish. Forest and Stream, Jan. 4, 1883; p. 450.
126. New Methods of Anatomical Dissection. Dial, January, 1883; pp. 202–203. Review of Wilder and Gage's Anatomical Technology as applied to the Domestic Cat.
127. Contributions to North American Ichthyology, based primarily on the Collections of the United States National Museum. IV. A Synopsis of the Fishes of North America. Bull. U. S. Nat. Mus., XVI., 1882; pp. 1145. January, 1883. (Jordan and Gilbert.)
128. Notes on the Nomenclature of certain North American Fishes. Proc. U. S. Nat. Mus., 1883; pp. 110–111. (Jordan and Gilbert.)
129. Description of two new Species of Fishes (*Aprion ariommus* and *Ophidium beani*) from Pensacola, Florida. Proc. U. S. Nat. Mus., 1883; pp. 142–144. (Jordan and Gilbert.)
130. A Review of the American Caranginæ. Proc. U. S. Nat. Mus., 1883; pp. 188–207. (Jordan and Gilbert.)
131. Note on the Genera of Petromyzontidæ. Proc. U. S. Nat. Mus., 1883; p. 208. (Jordan and Gilbert.)
132. Description of a new Murænoid Eel (*Sidera chlevastes*) from the Galapagos Islands. Proc. U. S. Nat. Mus., 1883; pp. 208–209. (Jordan and Gilbert.)
133. Description of a new Species of Rhinobatus (*Rhinobatus glaucostigma*) from Mazatlan, Mexico. Proc. U. S. Nat. Mus., 1883; pp. 210–211. (Jordan and Gilbert.)
134. List of Fishes collected in the Clear Fork of the Cumberland, Whitley County, Kentucky, with Descriptions of three new Species. Proc. U. S. Nat. Mus, 1883; pp. 248–257. (Jordan and Swain. Joseph Swain, Indiana University, Bloomington, Ind.)
135. Notes on American Fishes, preserved in the Museums of London, Paris, Berlin, and Copenhagen. Proc. Acad. Nat. Sci., Philadelphia, 1883; pp. 281–293.
136. Review of Boulenger's Catalogue of Batrachia Gradientia in the British Museum. Science, January, 1883.
137. Sketch of Felipe Poey. Popular Science Monthly, 1883; pp. 547–552.

1884.

138. Some Gossip about Darwin. American Naturalist, January, 1884; p. 108.

139. The Beginning of Life. Dial, February, 1884; p. 231. (Review of G. Hilton Scribner's, "Where did Life Begin?")

140. Review of Yarrow's Check List of North American Reptilia and Batrachia. Science, Feb. 29, 1884.

141. Notes on the Fisheries of the Florida Keys. Bull. U. S. Fish. Comm., 1884; p. 77. (Also published in American Field and American Angler.)

142. Notes on Fishes improperly included in the Fauna of the United States. Proc. Acad. Nat. Sci., Philadelphia, 1884; pp. 99-103.

143. A Review of the Genus Calamus. Proc. U. S. Nat. Mus., 1884; pp. 14–24. (Jordan and Gilbert.)

144. Descriptions of ten new Species of Fishes from Key West, Florida. Proc. U. S. Nat. Mus., 1884; pp. 24–32. (Jordan and Gilbert.).

145. Note on Caranx Ruber and Caranx Bartholomœi. Proc. U. S. Nat. Mus., 1884; pp. 32–33. (Jordan and Gilbert.)

146. Notes on the Fishes collected at Pensacola, Florida, by Silas Stearns, with Descriptions of two new Species. Proc. U. S. Nat. Mus., 1884; pp. 33–40.

147. Notes on Ælurichthys eydouxi and Porichthys porosissimus. Proc. U. S. Nat. Mus., 1884; pp. 40–41.

148. List of Fishes from Egmont Key, Florida, in the Museum of Yale College, with Description of two new Species. Proc. Acad. Nat. Sci., Philadelphia, 1884; p. 42.

149. The Canadian Sea Trout (*Salvelinus fontinalis immaculatus*). American Field, July, 1884.

150. The Rainbow Trout (*Salmo gairdneri irideus*). Forest and Stream, July, 1884.

151. Note on Calamus proridens, a new Species of Calamus. Proc. U. S. Nat. Mus., 1884; p. 50. (Jordan and Gilbert.)

152. Descriptions of Scaroid Fishes from Havana and Key West, including five new Species. Proc. U. S. Nat. Mus., 1884; pp. 81–102. (Jordan and Swain.)

153. List of Fishes collected at Key West, Florida, with Notes and Descriptions. Proc. U. S. Nat. Mus., 1884; pp. 103–150.

154. An Identification of the Figures of Fishes in Catesby's Natural History of Carolina, Florida, and the Bahama Islands. Proc. U. S. Nat. Mus., 1884; pp. 190–199.

155. Notes on Fishes collected by David S. Jordan at Cedar Keys, Florida. Proc. U. S. Nat. Mus., 1884; p. 230. (Jordan and Swain.)

156. List of Fishes observed in the St. John's River at Jacksonville, Florida. Proc. U. S. Nat. Mus., 1884; pp. 235–236. (Jordan and Meek. Seth E. Meek, Eureka College, Eureka, Ill.)

157. Notes on Fishes collected at Guaymas, Mexico, by Mr. H. V. Emeric, with a Description of *Gobiosoma histrio*, a new Species. Proc. U. S. Nat. Mus., 1884; pp. 260–261.

158. A Review of the American Species of Marine Mugilidæ. Proc. U. S. Nat. Mus., 1884; pp. 261–275. (Jordan and Swain.)

159. A Review of the Species of the Genus Hæmulon. Proc. U. S. Nat. Mus., 1884; pp. 281–317. (Jordan and Swain.)

160. List of Fishes collected in the Vicinity of New Orleans by Dr. R. W. Shufeldt, U. S. A. Proc. U. S. Nat. Mus., 1884; pp. 318–322.

161. List of Fishes collected in Lake Jessup and Indian River, Florida, by Mr. R. E. Earll, with Descriptions of two new Species. Proc. U. S. Nat. Mus , 1884; pp. 322–324.

162. A Review of the American Species of Epinephelus and related Genera. Proc. U. S. Nat. Mus., 1884; pp. 358–410. (Jordan and Swain.)

163. A Review of the Species Lutjaninæ and Hoplopagrinæ found in American Waters. Proc. U. S. Nat. Mus., 1884; pp. 427–474. (Jordan and Swain.)

164. Description of four new Species of Cyprinidæ in the United States National Museum. Proc. U. S. Nat. Mus., 1884; pp. 474–477. (Jordan and Meek.)

165. Description of four new Species of Pœcilichthys in the United States National Museum. Proc. U. S. Nat. Mus., 1884; pp. 477–482.

166. Description of Sciæna sciera, a new Species of Sciæna from Panama. Proc. U. S. Nat. Mus., 1884; p. 480. (Jordan and Gilbert.)

167. Description of Zygonectes zonifer, a new Species of Zygonectes, from Nashville, Georgia. Proc. U. S. Nat. Mus., 1884; p. 482. (Jordan and Meek.)

168. Proposed Propagation of Catfish as a Food Fish. Bull. U. S. Fish. Comm., 1884; p. 292.

169. Description of three new Species of Fishes (*Prionotus stearnsi*, *Prionotus ophryas*, and *Anthias vivanus*) collected at Pensacola by Mr. Silas Stearns. Proc. U. S. Nat. Mus., 1884; pp. 541–545. (Jordan and Swain.)

170. Supplementary Notes on North American Fishes. Proc. U. S. Nat. Mus., 1884; pp. 545–548.

171. Description of a new Species of Hybognathus (*Hybognathus hayi*) from Mississippi. Proc. U. S. Nat. Mus., 1884; pp. 548–550.

1885.

172. List of Fishes collected in Iowa and Missouri in August, 1884, with Descriptions of three new Species. Proc. U. S. Nat. Mus., 1885; pp. 1–17. (Jordan and Meek.)

173. A Review of the American Species of Flying-Fishes (*Exocœtus*). Proc. U. S. Nat. Mus., 1885; pp. 44–67. (Jordan and Meek.)

174. Notes on Skeletons of the Etheostomatinæ. Proc. U. S. Nat. Mus., 1885; pp. 68–72. (Jordan and Eigenmann. Carl H. Eigenmann, Indiana University, Bloomington, Ind.)

175. Note on the Scientific Name of the Yellow Perch, the Striped Bass, and other North American Fishes. Proc. U. S. Nat. Mus., 1885; pp. 72–73.

176. Note on Mr. Garman's Paper on the American Salmon and Trout. Proc. U. S. Nat. Mus., 1885; pp. 81–83.

177. Identification of the Species of Cyprinidæ and Catostomidæ, described by Dr. Charles Girard in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1806. Proc. U. S. Nat. Mus., 1885; pp. 118–127.

178. On the Etheostoma variatum of Kirtland. Proc. U. S. Nat. Mus., 1885; pp. 163–165.

179. Note on Epinephelus nigritus. Proc. U. S. Nat. Mus., 1885; pp. 208–209.

180. A Catalogue of the Fishes known to inhabit the Waters of North America north of the Tropic of Cancer, with Notes on the Species discovered in 1883 and 1884. Washington: Government Printing Office (October) 1885. (Also in the Annual Report of the Commissioner of Fish and Fisheries for 1884, p. 185.)

181. A List of the Fishes known from the Pacific Coast of Tropical America, from the Tropic of Cancer to Panama. Proc. U. S. Nat. Mus., 1885; pp. 361–394.

182. Note on some Linnæan Names of American Fishes. Proc. U. S. Nat. Mus., 1885; pp. 394–396.

183. The Habits and the Value for Food of the American Channel Catfish (*Ictalurus punctatus*, Rafinesque). Bull. U. S. Fish Comm., 1885; p. 34.

184. Notes on Fishes observed in Lake Superior. Bull. U. S. Fish Comm., 1885; p. 191.

185. The Mountain or Salmon Trout of Oregon. Bull. U. S. Fish Comm., 1885; p. 310.

186. The Fisheries and Fishery Industries of the United States, prepared through the co-operation of the Commissioner of Fisheries and the Superintendent of the Tenth Census, by George Brown Goode, Assistant Director of the U. S. National Museum, and a Staff of Associates. Section 1, Natural History of useful Aquatic Animals, with an Atlas of two hundred and twenty-seven Plates. Washington: Government Printing Office, 1884 (February, 1885). (Quarto, p. 895. Discussions of Fresh-Water Fishes, chiefly by Dr. Jordan; of Pacific Coast Fishes, chiefly by Jordan and Gilbert.)

187. A Manual of the Vertebrates of the Eastern United States, including the Region east of the Mississippi River and

north of the northern Boundary of North Carolina and Tennessee, exclusive of Marine Species. Fourth edition; revised and enlarged. Chicago: Jansen, McClurg, & Co., 1885.

188. THE STANDARD NATURAL HISTORY. Vol. II. S. E. Cassino & Co., Boston, 1885. (Part relating to soft-rayed fishes.)

1886.

189. LIST OF FISHES COLLECTED IN ARKANSAS, INDIAN TERRITORY, AND TEXAS, IN SEPTEMBER, 1884, with Notes and Descriptions. Proc. U. S. Nat. Mus., 1886; pp. 1–25. (Jordan and Gilbert.)

190. NOTES ON FISHES COLLECTED AT BEAUFORT, NORTH CAROLINA, with a revised List of the Species known from that Locality. Proc. U. S. Nat. Mus., 1886; pp. 25–30.

191. LIST OF FISHES COLLECTED AT HAVANA, CUBA, IN DECEMBER, 1883, with Notes and Descriptions. Proc. U. S. Nat. Mus., 1886; pp. 31–55.

192. A REVIEW OF THE GENERA AND SPECIES OF JULIDINÆ FOUND IN AMERICAN WATERS. Proc. U. S. Nat. Mus., 1886; pp. 56–70. (Jordan and Hughes. Elizabeth G. Hughes, Indiana University, Bloomington, Ind.)

193. NOTES ON SOME FISHES COLLECTED AT PENSACOLA BY MR. SILAS STEARNS, with Descriptions of one new Species (*Chætodon aya*). Proc. U. S. Nat. Mus., 1886; pp. 225–229.

194. A REVIEW OF THE AMERICAN SPECIES OF TETRAODONTIDÆ. Proc. U. S. Nat. Mus., 1886; pp. 230–247. (Jordan and Edwards. Charles L. Edwards, Minneapolis, Minn.)

195. RAFINESQUE. Popular Science Monthly, November, 1886.

196. A REVIEW OF THE AMERICAN SPECIES OF THE GENUS PRIONOTUS. Proc. U. S. Nat. Mus., 1886; pp. 327–338. (Jordan and Hughes.)

197. A REVIEW OF THE AMERICAN SPECIES OF BELONIDÆ. Proc. U. S. Nat. Mus., 1886; pp. 338–361. (Jordan and Fordice. Morton W. Fordice, Indiana University, Bloomington, Ind.)

198. A REVIEW OF SEELEY'S "THE FRESH-WATER FISHES OF EUROPE." Dial, June, 1886; pp. 34–35.

199. A REVIEW OF THE "A. O. U. CODE AND CHECK LIST OF NORTH AMERICAN BIRDS." The Auk, July, 1886; pp. 393–398.

200. DESCRIPTION OF SIX NEW SPECIES OF FISHES FROM THE GULF OF MEXICO, with Notes on other Species. Proc. U. S. Nat. Mus., 1886; pp. 466–476. (Jordan and Evermann. Barton Warren Evermann, Indiana State Normal School, Terre Haute, Ind.)

201. A REVIEW OF THE GOBIIDÆ OF NORTH AMERICA. Proc. U. S. Nat. Mus., 1886; pp. 477–518. (Jordan and Eigenmann.)

202. NOTES ON TYPICAL SPECIMENS OF FISHES DESCRIBED BY CUVIER AND VALENCIENNES, AND PRESERVED IN THE MUSÉE D'HISTOIRE NATURELLE IN PARIS. Proc. U. S. Nat. Mus., 1886; p. 525.

203. A Preliminary List of the Fishes of the West Indies. Proc. U. S. Nat. Mus., 1886.
204. Ulrich von Hutten. The Current, Dec. 4 and 11, 1886.

1887.

205. The Origin of the Fittest. A Review of Professor E. D. Cope's "Origin of the Fittest." The Dial, March, 1887.
206. Thoreau and John Brown. The Current, April, 1887.
207. Note on Polynemus californiensis Thominot. Proc. U. S. Nat. Mus., 1887.
208. The Food-Fishes of Indiana. Rept. Dept. Agr. Ind. for 1886. August, 1887. (Jordan and Evermann.)
209. A Review of the Flounders and Soles (*Pleuronectidæ*) of America and Europe. Rept. U. S. Fish Comm. for 1886. August, 1887. (Jordan and Goss. David Kop Goss, Bloomington, Ind.)
210. A Review of the Sciænoid Fishes of America and Europe. Rept. U. S. Fish Comm. for 1886. September, 1887. (Jordan and Eigenmann.)
211. Science Sketches. Chicago: A. C. McClurg & Co., September, 1887; pp. 261. (A collection of eleven essays, some of them reprinted; among them the following hitherto unpublished.)
212. The Dispersion of Fresh-Water Fishes. Science Sketches, pp. 82–132. (President's Address, Indiana Academy of Sciences, December, 1886.)
213. Darwin. Science Sketches, pp. 171–195. (An address before the Indiana State Normal School, May, 1885.)
214. The Evolution of the College Curriculum. Science Sketches, pp. 228–260. (President's Address before the Indiana College Association, December, 1886.)