The Story of the First Lung

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THE great step from gill-breathing to lung breathing is the one that opened a new world for the vertebrates. Now this step is not to be sought between man and the lung-breathing amphibian. It lies between the amphibian and the fish. There must have been an animal once that passed from one form to the other—the bridge between gill and lung.

The frog is a higher amphibian. We must look to a lower form. Such a one is the salamander. We must hunt for a lizard-fish.

Now our study of evolution leads us to believe that from the world of the ancient amphibians there sprang two great branches—one became a land-walking form, and, finally, man. The other became the bridge.

We know the link-form between amphibians and birds. It is the archaeopteryx, the lizard-bird. Its remains are fairly plentiful. We know that it had feathers and wings, a crocodile jaw with teeth, a long lizard tail and lizard's claws on its wing bones.

So the imagination must picture the lizard-fish as a half-and-half creature—a thing with two lungs in its breast and gills on its throat.

In 1835 Johann Natterer discovered a living creature in the Amazonian swamps that approached these requirements. It had scales and was formed like an eel. It had fully developed gills, and it had, also, a fully developed pair of lungs and all the other apparatus for lung breathing, including nostrils.

Scientists were still in bitter battle about this paradox (Lepidosiren Paradoxus they called it at last), when a similar fish was found in Africa.

For thirty years the two creatures were nightmares to science. Some declared that they were fish, and the lungs belied the finest theories. Some tried to relegate them to the amphibians, and they upset the whole world of amphibia.

Then came Darwin. And in ten years the world began to accept the two creatures as link-forms.

Through the fossils found then, we learned that in a very remote period of the world's story, very near to the very oldest, the only existing representatives of vertebrates were fish. Then, in the carboniferous age, millions of years ago and yet long after that remote fish age, the amphibians appeared. Somewhere between those two periods, then, there must have occurred the change of one or more of the fishes to lung-breathing, land-dwelling animals. That must have been the great time of the lizard-fish, if the lizard-fish were the links.

It would have been fine, then, had it been possible to discover fossil remains of lizard-fish. If one could have laid the bones of the ancient creature alongside the bones of the living one, and proved their resemblance, the world would have had a valuable, living, demonstrable proof of the truth of evolution.

But it seemed as if no such proof would ever be found. None of the ancient fossil beds showed a lizard-fish.

Then, in 1889, the land of the living link-forms, Australia, produced it. And the proof was a tooth.

One day Gerhart Krefft, curator of the museum of Sydney, Queensland, received a big four-foot long carp-like fish. And this fish had gills and scales but also a lung—one single lung.

Now as Dr. Krefft examined the mouth of the strange monster, he found, not the ordinary fishes' teeth but only four big teeth, with their crowns indented like the comb of a rooster.

And such teeth had been found long before—fossil teeth belonging to the dim past. The creature to which they had belonged was still unknown, but it had always been classed with the fishes. Agassiz had christened the unknown beings Ceratodus—meaning "horn breathers."

Now Dr. Krefft held in his hand a freshly captured thing that was not only a lizard-fish, but actually had the teeth of the lost Ceratodus.

Krefft did not hesitate to name his find Ceratodus Forsterii. Later, when the expression of the caudal end of an extinct Ceratodus was found and finally, when a well-preserved skull of one was unearthed, it was proved that the most unexpected of unexpected things had happened—a creature that had been accounted as extinct millions of years ago, was living in the world of today.

Yet for twenty years the knowledge of the living Ceratodus remained meagre. We learned that the creature used his gills to live like a fish in water during the rainy season, while in droughts he used his lungs to help him live amphibian-like in the shallow pools. But no one knew about his growth from the egg. And that was of immense importance for the study of evolution.

The early stages of development of living things in the egg are enlightening, because many creatures in this undeveloped condition are, so to speak, portraits of their ancestors of past epochs. Take a chicken or a canary bird out of an egg that has only just begun to incubate, and we find an object that has fin-like appendages and gills.

So for years Prof. Haeckel urged on the world of science the importance of studying the egg of the Ceratodus. At last Prof. Richard Semon of Jena undertook the task. It kept him away two years. It was a long fight. Floods and accidents robbed him of the fruits of his labor time and again.

But in the end he succeeded in studying the Ceratodus step by step. And it was proved at last that the creature developed, not as a fish, but as an amphibian, passing through the same stages that characterize frogs.

So in the Ceratodus we now recognize a true survivor of the lizard-fishes, and thus an ancestor of man—the particular ancestor that we have to thank for our lungs.

And the Ceratodus furnishes an illustration of how that lung developed from the gills.

The African relative of the Ceratodus swims merrily in the water and breathes honestly through his gills as long as the water lasts. When the droughts come he buries himself in the mud and breathes cheerfully through his two lungs.

But the Ceratodus can live only in streams that nevery go entirely dry. His one lung is not so able as the two lungs of the African fish.

Now where the Ceratodus lives, the extreme of drought goes only so far as to dry the main stream, leaving waterholes here and there. Into these holes crowds everything that needs water to live. Soon the densely-packed creatures exhaust the oxygen in the waterholes. The water becomes foul, and the creatures that have only gills are in dire trouble. Hordes of the true fishes die.

But the Ceratodus remains well and happy. He keeps his nostrils above the surface and breathes the upper air with his lungs.

Now let us imagine that gray, dim time when there stood mighty forests of fern and other long-past growths that we burn today as anthracite. Picture waters that experienced periodical drouths like those Australian waters of today. Now think of those ancient water holes crowded with struggling forms, and you see what an advantage the existence of a lung meant for the survival of the Ceratodus.

Of course you will object that the mere fact that the lung was an advantage could not produce one. Where did the lung come from? Ceratodus shows us. The lung did not fall on him from the blue sky.

The true fish owns a well known organ—the swimming bladder. This air-inflated bladder regulates his weight for him, giving him the same specific weight as is that of the water where he lives. Anatomically this swimming bladder belongs to the alimentary canal. In many fish there is an air connection with this canal. The inference is simple that such an air-filled sac might have served on occasion for taking air into the blood; that is, for breathing.

In certain existing forms of true fishes we have found the little beginnings of such a development.

In the Ceratodus the development became complete.

Along the wall of the swimming bladder there began to form air-sucking blood vessels; the mouth of the bladder began to lengthen from the depths of the canal toward the mouth, as it was used more and more to suck in air. The air passage became a windpipe and the swimming bladder a lung.

Now let us think further. In the course of centuries, perhaps many centuries, some of the water holes became entirely dry. Then everything died that had not advanced beyond the stage of Ceratodus, the creature of one lung, needing at least some water.

To picture any survivors, we must picture a creature that had gone beyond the old Ceratodi—a creature that had reached a still higher state of conformity to conditions, like the African two-lunged fish that can live in sun-baked mud.

And then another step. The water disappears entirely and forever at last from some of the holes. The lizard-fish that had learned to breathe with their lungs exclusively began to wriggle across country to seek wet places elsewhere.

Now geology tells us that at this time, in the Devonian epoch, most areas of the world held shallow waters that became smaller and smaller steadily, partly from evaporation and partly from draining away in the sands that now form our "old red sandstone."

The lizard-fish had to wander oftener and oftener, farther and farther. The swimming bladder lungs became strengthened more and more. The gills degenerated more and more. At last they appeared only in the unripe forms during incubation—"ancestral portraits" shown today in the unborn birds, and more plainly in the frog, while it is still a "pollywog," only to disappear entirely with growth.

The lizard-fish had become a lizard, an amphibian!

They surely are not particularly agreeable or attractive animals, these lizard-fish.

In the museum the layman would probably overlook them in his interest in the mass of fishes that seem far more curious and bizarre. And yet, how much hides behind these oldest lung-breathers in the world!

Millions of years ago those lizard-fish of the Devonian or the Carboniferous age played their role—the great advancement of life. Then they became almost lost. They disappeared from the lands where Culture, the ideal sun-blossom of Nature, unfolded itself. No tie seemed to remain between their last survivors in the swamps of Africa or South America and in two lost streams of Australia, and the line of light that began to arise in the life of earth far upward for the animal.

And yet from this line of light, from Culture, there grows one day the great desire for knowledge. And after the measureless procession of time it turns back to the lizard-fish; it seeks him in his lonely Queensland wastes and helps him to a wonderful resurrection.

It is the true resurrection of Nature through the Spirit.

WILHELM BOELSCHE.

Habits of Some of Our Common Birds

NO BIRD is better known than our common quail. Not only the sportsman, but every farmer's boy, has heard it change its whistle with the changing seasons and knows something of its habits.

Its nest is a poorly built affair, at first glance, but the bird has spent great care both in selecting a secluded spot and in concealing the eggs. Sometimes the nest is completely roofed over. Nevertheless, being built on the ground in the open fields it is exposed to every prowling coyote or bullsnake. We suppose this is one reason why the quail lays so many eggs. "Settings" of eighteen or twenty or even more are not uncommon. With this large number a few can be destroyed and still have a respectable brood of young.

The young, which are born feathered, are able to shift for themselves in a few hours. Although the mother bird looks after them in about the same way that an ordinary hen cares for her brood. They are very active little fellows, being able to run with great speed. When they are tired they will crouch down and remain perfectly quiet, depending on their resemblance to a clod or pebble for protection.

The quail's nest may be rudely constructed, but it is a palace compared to the accommodations the nighthawk furnishes for its eggs. It does not even scratch a hollow, but deposits them on the bare ground. They are apparently exposed, but are colored so like the surroundings that it is almost impossible to find them. The author once spent fifteen minutes looking for a nighthawk's eggs where they had been found previously and it was known that they were not more than twenty feet distant.

Most of us are familiar with the nesting habits of the house wren. Sometimes they choose very odd situations, such as an old hat hung under a porch or the pocket of a coat hanging on the side of a house. We know of one little jenny wren who insisted on nesting in a stocking hanging on a clothes line. They build in a cavity of some kind and always fill it full to the brim with sticks. On this mass of twigs it lines a little hollow with horse hair or some soft material and rears its brood. There is nothing a wren fears more than a snake, and supposing its enemies have the same dread of these reptiles, it frequently gets a cast-off snake skin and displays it ostentatiously around the top of its nest to frighten away intruders.

The mourning or "turtle" dove is remarkable for its gentleness and confiding habits. It builds a rude platform of twigs for its eggs in the most exposed situations, often over a well worn pathway. If its home is molested it pretends to be wounded and flutters along the ground in apparent distress, trying to lead the disturber away from its precious eggs or young.

Our blue kingfisher digs a hole in a high bank along some creek, some times going straight in for fifteen feet. At the end of this burrow the eggs are deposited. The kingfisher will sit on a branch over a stream by the hour, perfectly motionless. If a small fish happens to swim along near the surface he dashes in and catches the fish in his swordlike beak. Then he flies away to some stump, takes his victim by the tail and whacks its head on the wood or pecks it until it is dead. Then, if it is not too large, he swallows it whole, going through many comical quirks and contortions in getting it down. The kingfisher is not a good housekeeper and its hole always smells foul from the litter of crawfish and pieces of fish he leaves lying about.

Our little yellow warbler or summer yellow bird builds a beautiful tiny cup-shaped nest in a fork of some sapling, where the foliage is thickest. He is a gentle and inoffensive little fellow and forms an easy prey to that lazy vagabond, the cowbird.

The cow, or, as boys call him, the lazy bird, builds no nest of its own, but lays its eggs in some other bird's nest and depends on the foster parents to rear the young, which hatch in a shorter time than is necessary for other species. As soon as the young cowbird comes from the egg it opens its mouth for something to eat, and from that time until it is able to shift for itself the "adopted parents" are kept hustling to keep it filled. The eggs or young of the birds who rightfully belong in the nest are pushed out by the interloper and left to perish miserably on the ground.

Now, the yellow warbler is not able to push the cowbird's egg from its nest and it apparently has scruples against eating it, as a bluejay would do, so it takes a very original method to get rid of the undesirable gift which the cowbird leaves for it. When the little yellow bird finds the lazy bird's egg in its nest it straightway goes to work and builds another nest on top of the old one, burying the cowbird's egg and sometimes two or three of its own eggs with it. A new "setting" is then layed in this new nest and the brood reared. Two-storied nests of the yellow warbler are not uncommon and in one instance a nest was found with two additions to the original one.

Birds' eggs present striking variations in shape and color. We suppose that these are not altogether due to accident and that, as a rule, there is a reason for every variation. Birds which nest in cavities in trees and dark places lay white eggs, while those which nest in exposed places have them colored to imitate the surroundings. For example, the robin has dark bluish-green eggs which blend with the surrounding leaves and they are not easily distinguished by any prowling enemy who might wish to molest them.

The quail's eggs are white and conspicuous, hence a great number are layed, and even if some are destroyed there will still be enough left to make a respectable brood. Birds that nest in places where there is no danger of the eggs rolling out of the nest are usually nearly spherical in form, for that shape exposes the least surface in proportion to the amount of material used. Eggs deposited on the ground or in a situation where they might easily roll away are long and pointed. Hence if they should start to roll they would not go far, but come back in a circle. Eggs of the quail, snipes and sea birds, which nest on the bare rock, have this long and pointed shape.

If we take up the study of the food habits of birds we are apt to meet many surprises. Most of us think of the woodpeckers as living on the grubs and insects which they secure from pecking holes in trees. Yet they all have a fondness for a variety of other things, and almost half of the diet of the common yellowhammer consists of ants which it picks up from the hills, on the ground or in dead trees.

The author watched an English sparrow feeding her brood for four hours and during part of this time it was raining. The mother visited the nest with food every two minutes (average). The male came to the nest with food for the brood but once during the whole time. When we consider that a bird works from daylight to sunset we can see what an enormous amount of labor is required and what an army of insects will be destroyed during the year. Birds usually vary the food with the seasons. Some sea birds live on fish during the winter months and changing to seeds in the summer. The English sparrow prefers a seed diet itself, but rears its young almost entirely on insects. The owls are very rude in their table manners and do not stop to pick out the edible portions. When eating a mouse or gopher they simply swallow chunks of it—bones, hair and all. Of course part of this mass cannot be digested and it is rolled into a little ball and cast up in the same way that a cow brings up her cud. These pellets will usually be found on the ground around an owl tree.

The hawks and owls are preying birds, but on the whole do a great deal of good by destroying great numbers of noxious animals. The prince of robbers and murderers in the bird world is the shrike or butcher bird. This villian will sneak up behind a mother bird, setting on the nest, and peck her brains out, then fly away apparently satisfied with the killing and not even stopping to eat. One of his favorite amusements is to catch beetles and stick them on thorns along the hedges. We suppose his idea in these actions is to lay up food for a rainy day or when his hunt is unsuccessful.

Birds not only prey but are preyed upon and their coloration helps them in escaping their enemies. Usually we find the upper side dark and the under side white or lighter in color than the back. If a hawk soars above the bird the dark back blends with the ground. If the condition is reversed and the hawk looks up at the bird from below the light colored belly blends

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