On the development of the Monotremes and Ceratodus.

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* * * The following abstract is from notes of an extempore explanation by Mr. Caldwell of the specimens and embryological material recently obtained by him, and exhibited to the members of the Royal Society of N.S.W. on December 17, 1884.

Mr. Caldwell, in introducing his remarks, described the circumstances under which he had been led to the Colonies. It was three years since his master, the late Professor Balfour, F.R.S., suggested to him, when still his pupil, that it might be possible for him to leave his university for a period of two or three years to obtain the necessary material in connection with this matter. On Professor Balfour’s death, the memorial which was subscribed for in England and all over the world made this possibility much easier to him (Mr. Caldwell), for whilst he had left his post in Cambridge he was still attached by holding the Balfour Studentship. When he came out, two years ago, he found very great difficulty in getting specimens of the platypus or echidna. Whilst every one told him it was to be obtained in this river or in that, he generally found that the skin-hunter had been before him. The first few months of the present year he spent in obtaining marsupials, such as kangaroos, opossums, and native bears. A knowledge of the early stages of the marsupials was considered in the Colonies to be universal property, and every one considered himself qualified to tell him how the kangaroos produced their young. As a matter of fact, the scientific world knew already that the kangaroo produced its young in the same way as the rest of the milk-giving animals. That had been proved by Sir Richard Owen nearly fifty years ago, whilst the early stages of the development which formed the basis of modern morphological work upon the subject had not been found. Although no naturalist expected to find the kangaroo growing on the teat, no one had found the stages from impregnation up to birth of the young. This material, however, he had obtained in the last months of 1883 and the first few of the present year. He had made a number of expeditions all over New South Wales in search of marsupials, and in April of this
year he went to the Burnett River, in Queensland, where the ceratodus is found. He had remained there since that time, and whilst he obtained there the ceratodus, he also got in the same district the early stages of the ornithorhynchus and the echidna or porcupine.

He then said a few words about his camp. He found it was useless to live on the stations or far away from the river if he hoped to observe the ceratodi. It was four months before he found any trace of their mode of depositing their eggs in the river, till he found it by a chance which could only have occurred by his camping on the bank of the river. His material for observation was obtained by an aboriginal camp, he having at one time as many as fifty aborigines at work for him. They got the porcupines for him, and some he employed searching weeds for the ceratodus.

He proposed to describe the outlines of the embryology of the three main groups of animals which formed his scheme of work in Australia, and the embryology of which was, in the case of two, entirely unknown before, and in the case of marsupials unknown in the early stages. To make the matter clear to those present, he asked them to listen to a few elementary tenets he would state. Many present might think that only the hen and similar creatures laid eggs, but, as a matter of fact, all animals except the very simplest, reproduced sexually by ova. He then entered upon an explanation of the structure of the egg, illustrating his remarks by diagrams on a black-board. What he would state with regard to his investigations were not theories but were facts, and were consequently not open to argument. Within the last few weeks he had received several letters from people denying that the platypus laid eggs, and they wanted him to argue about it. That was impossible. He stated a fact; it was possible to disbelieve it; but, being a fact, it could not be argued. The interpretation of these facts he was not prepared to add, as he had come there with the simple intention of exhibiting a few specimens, and not with the intention of entering into any theoretical consideration derived from these facts.

Starting with the marsupial animals, he would go on to describe the ceratodus and then the monotremes. Marsupials were found all over Australia, and were in a way characteristic of it, as it was the only place where they had their habitat except in South America, and reaching to North America, as far as Florida and San Francisco; but they were essentially Australian. They were milk-giving animals, the same as the higher mammals such as dogs and cats; but the difference between the marsupials and the higher mammals of the old world was that the young were
born at a very early stage, and this fact carried with it a series of differences in structure which were characteristic of marsupials. But on the whole the marsupials did not differ to any great extent from the ordinary mammals, such as the cat, dog, or sheep. The main difference between these latter and the marsupials was that the embryo in the uterus before birth had no vascular attachment to the walls. There was no blood nourishment passing from the parent to the young animal. The egg of the marsupial had, in common with that of the higher mammals, a very small amount of food yolk (holoblastic). He then, by the aid of diagrams, described the structure of the egg of the marsupial. But the marsupials had a peculiar arrangement of the membranes, though the development of the egg itself was not essentially different from the development of the higher mammals.

He then passed on to the development of the ceratodus. This animal was a representative of a series of animals which once were numerous in many parts of the world. At the present day there were three living representatives of this group of animals—the ceratodus, found in Queensland only, in the Mary and Burnett Rivers; the other, the lepidosiren, found in the Amazon; and the third, the propterus, found in certain of the rivers of Africa. These three formed a class different from all other animals, inasmuch as they possessed gills, and had the form of a fish in an adult state, and at the same time they possessed lungs. The structure known in other fish as the air-bladder became in this fish highly vascular, and the aerated blood freshened by oxygen did not pass from the air-bladder through the system, but passed direct to the heart, and there they had the first indication of two chambers in the heart, and they had for the first time arterial blood in the heart of a fish. Blood was found in an arterial state in animals with lungs, but only in a venous state in animals without lungs. One of the chief objects in coming to Australia had been to study the development of the ceratodus. He went up to the Burnett River in April, and found that at that time the fish were ripe, the ovaries and testes being nearly developed; but it was not till the beginning of September that he found the first eggs of the ceratodus. He spent many weeks hunting, and, with the assistance of the blacks, turned up many hundred waterholes before he found the eggs. The eggs were laid upon the weeds. They were laid singly, resembling those of the common newt. The whole development of the ceratodus had a strong resemblance to that of the amphibians, and any one who had any acquaintance with the development of the newt would at once perceive the resemblance. These eggs were fertilized in the water in a similar way to some species of the newt. The eggs he found it very difficult to get. They were covered with an enormous
quantity of gelatinous matter which required some special means to remove. He was eight days before he got a single egg out whole. When he succeeded in getting the early stages, it remained to rear them until they were practically identical with the adult fish. This was a very difficult task, as the enemies of the ceratodus were very numerous. There were two kinds of fungi which attacked the eggs. He put in crustacea to devour the fungus, but these in turn attacked the young fish when it emerged from the egg. He was three months, till near the end of November, developing the eggs. The living fish on the table had been hatched some weeks ago, but the hind legs were not yet developed. The development of the fins would probably yield important knowledge on embryology. The egg of the ceratodus underwent a complete segmentation similar to that of the kangaroo.

He then proceeded to describe the monotremata, namely—the ornithorhynchus and echidna. These, though differing from one another, were identical in structure, and were in every way similar animals. These two living representatives formed something quite as unique in its way as the ceratodus. They were both milk-giving, and both suckled their young. When he came out he had a strong belief that the ornithorhynchus and echidna produced their young in much the same way as the marsupials, and he thought last year he had confirmatory proof of this being so; but he found he was in error. He found in the uterus of the ornithorhynchus a cellular membrane, but it was probably only part of a ruptured egg. He then, with the aid of diagrams, described the stages in the development in the platypus, pointing out the large food yolk and meroblastic segmentation. He had found that invariably the female platypus had two eggs, and these left the parent at about the age of a chick thirty-six hours after the laying of the egg, while the echidna had usually only a single one. In both the egg, covered with its shell, was nearly the same size, viz., three-quarters of an inch in the long, and half an inch in the shorter axis. With regard to the echidna, he had not determined the exact age at which the young were born. That of the platypus he had discovered by a lucky chance. He happened to kill one which had laid one egg, and had the other on its way out through the passage, and the age of this egg enabled him to determine when the eggs of the platypus were laid. His series of monotremata would be made up in the early stages by the ornithorhynchus, and in the latter by the echidna.

These were the facts determined by his researches. But the research was still in its early stages. Years would elapse before the details of the development could be discovered and interpreted. So far the material had been only roughly examined,
and it promised to produce, with the help of the instruments now at the command of the embryologist, great results. They might perhaps ask what, after all, these investigations were for. In the early days of Darwinism it was hoped to get a pedigree for every animal. This is still the object for which much excellent work is done. But now that all biologists are Darwinists, pedigree-hunting has gone out of fashion. The recognition that each living form has descended from some differently constructed ancestor is in itself a great step in advance. But there are further steps to be made, and it is by observing the minute differences between organic beings that the morphologist hopes to discover those laws which form the basis of his philosophy.

Mr. Caldwell, in answer to a question as to whether he had come to any conclusion with regard to what became of the embryo of the marsupial, and how it becomes attached to the mother's teat, said that the exact mode in which the kangaroo or other marsupial put the young to the teat was not of so much importance as the other facts. It had been observed by Professor Osborne, of America, who had seen the act, that the mother lifted it from the vulva to the teat. Marsupial embryos possess at birth a very large and sensitive tongue, which probably assists them in attaching themselves to the teat. At first the newly-born young were not attached to the teat at all. For a week or so after birth the shock of a fall is sufficient to detach the young one from the mammary gland. It was a few weeks after the first attachment that the lips grew over the extremity of the teat, but no connection actually took place between it and the mouth. By careful manipulation one could always extricate the lips of the young kangaroo from the teat. He had not personally observed how the embryo was actually moved into the pouch—he had not considered it of sufficient importance to waste any time about. He could conceive no difficulty in the lips or tongue of the mother kangaroo placing the young, which was at least an inch long when born, upon the teat. The question did not appear to him to be a matter of any importance—it did not form part of his researches.

The President conveyed the thanks of the Society to Mr. Caldwell for the interesting account of his researches and discoveries.

Mr. Caldwell states he is very anxious to find a large number of kangaroos, and would be obliged if any one knowing of a kangaroo drive in actual work, no matter in what part of the Colonies, would inform him of the locality.
List of Specimens placed on the table:

**Monotremata.**
1. Series of early stages of Ornithorhynchus, from a few hours after fertilization to the newly laid egg, of about the stage of a 36-hour chick.
2. Series of early stages of Echidna, from just before laying to the newly hatched fetus.
3. Various stages of young Echidna, from hatching up to 5 inches long.

**Dipnoi.**
1. Complete series of Ceratodus, from the unsegmented egg to hatching.
2. Stages of young Ceratodus after hatching.
3. Globe containing live Ceratodus, aged 1 month and 10 days from hatching.

**Marsupialia.**
1. Series of about thirty stages, from segmenting egg up to birth of *Phascolarctos cinereus*.
2. Ditto of *Halmaturus rufus*.
3. Specimens showing the arrangement of the embryonic membranes in *Macropus major*.