Thinking of Biology

The paradoxical platypus

The story of the discovery of the platypus (Figure 1) teaches us much that is relevant to the nature of scientific evidence, orthodoxy, entrenched authority, the role of personalities in science, the slow overthrow of old mores, national rivalries, prejudices and priorities, the strictures of animal classification, what it takes to be described as a mammal, conservation, and extinction. A rivalry that pitted nation against nation, naturalist against naturalist, and professional against amateur endured for 85 years before the true nature of the platypus was revealed. Long after the evidence was wrested from Nature half a world away from where the debate raged, professional biologists continued to argue about this paradoxical creature. How did such a situation arise?

Discovery and description

Platypuses—duckbills, watermoles, or duckmoles, as the European settlers of New South Wales called them—are found only in Australian freshwater lakes and streams. David Collins, who arrived with the First Fleet as Deputy Judge-Advocate, provided an early description in the second edition of *An Account of the English Colony in New South Wales*:

> The Kangaroo, the Dog, the Opossum, the Flying Squirrel, the common Rat, and the large Fox-Bat (if entitled to a place in this society), made up the whole catalogue of animals that were known at this time, with the exception which must now be made of an amphibious animal, of the mole species, one of which has been lately found on the banks of a lake near the Hawkesbury. In size it was considerably larger than the land mole. The eyes were very small. The fore-legs, which were shorter than the hind, were observed at the feet, to be provided with four claws, and a membrane, or web, that spread considerably beyond them, while the feet of the hind legs were furnished, not only with this membrane or web, but with four long and sharp claws, that projected as much beyond the web, as the web projected beyond the claws of the fore feet. The tail of this animal was thick, short, and very fat; but the most extraordinary circumstance observed in its structure was, its having instead of the mouth of an animal [mammal], the upper and lower mandibles of a duck. By these it was enabled to supply itself with food, like that bird, in muddy places, or on the banks of the lakes, in which its webbed feet enabled it to swim, while on shore its long and sharp claws were employed in burrowing; nature thus providing for it in its double or amphibious character. These little animals have been frequently noticed rising to the surface of the water, and blowing like the turtle. (Collins 1802, p. 62)

by Brian K. Hall

Captain John Hunter, the second governor of the new colony, watched an Aborigine spear a platypus in Yarramundi Lagoon near the Hawkesbury River just north of Sydney in 1797. The Aborigine sat patiently at water's edge for more than an hour, observing the animal as it came to the surface to breathe, before he attempted to spear it with his short wooden spear. Hunter's fine drawing of this animal accompanied Collins's description of this "amphibious animal, of the mole species" (Figure 2). A keen naturalist and fellow of the Royal Society, Hunter supplied many animals and plants to naturalists in England. Many saw his sketch and read Collins' description before specimens became available. The incomparable English wood engraver, Thomas Bewick, published another early representation in 1800 in his justly renowned *A General History of Quadrupeds* (Bewick 1800; Figure 3).

The platypus was given its scientific name, *Platypus anatinus* (flat-foot duck), in 1799 by George Shaw, a parson turned Keeper of the Department of Natural History of the Modern Curiosities of the British Museum. His description of the platypus was based on a single skin and accompanying sketch sent by Hunter to the Literary and Philosophical Society in Newcastle-upon-Tyne in 1798. The skin of this original (type) specimen is still preserved in the British Museum. Shaw's description (Shaw 1799) was published in the tenth volume of an important natural history journal of the time, *Naturalist's Miscellany*—or, to give it its full, descriptive title: *The Naturalist's Miscellany: or Coloured Figures of Natural Objects Drawn and Described Immediately from Nature*—produced by Shaw and the illustrator Frederick P. Nodder as an outlet for all manner of discoveries from the natural world. Over 1000 different animals were illustrated in its pages between 1798 and 1882, including the kangaroo, black swan, and echidna from the Great South Land, now known as Australia.

Shaw's description was remarkably accurate, based as it was on a dried skin with a desiccated and hardened "bill" so unlike the soft, flexible bill of the living animal. Although he thought it was a mammal, its exotic, even bizarre appearance mystified Shaw:

> Of all the Mammalia yet known it seems the most extra-ordinary in its conformation; exhibiting the perfect resemblance of the beak of a Duck engrafted on the head of a quadruped. So accurate is the similitude, that, at first view, it naturally excites the idea of some de-

Figure 1. The platypus, *Ornithorhynchus anatinus*, whose combination of avian, reptilian, and mammalian features so puzzled nineteenth century naturalists and continues to fascinate people to this day. Modified from Augie (1992).

> ceptive preparation by artificial means; the very epidermis, proportions, serratures, manner of opening, and other particulars is the beak of a shoveler, or other broad-billed species of duck, presenting themselves to the view; nor is it without the most minute and rigid examination that we can persuade ourselves of its being the real beak or snout of a quadruped. (Shaw 1799, p. 384)

Three years later, the Göttingen anatomist Johann Friedrich Blumenbach, who is famous for his discoveries of mammoths and crinoids (an extinct class of echinoderms), described the platypus from a second skin sent by Hunter. Blumenbach named the animal *Ornithorhynchus paradoxus* (paradoxical bird-snout; Blumenbach 1803). The world now had two names for this exotic creature. Unknown to Shaw, however, the generic name *Platypus* had been used for a genus of beetles in 1793. Such are the strictures of the international rules of zoological nomenclature that *Platypus* had to be abandoned. However, Shaw's specific epithet stood. The platypus thus became *Ornithorhynchus anatinus*. It seems entirely appropriate that this animal, which so resembles a hybrid, should bear a hybrid name.

What was it?

Ornithorhynchus greatly puzzled and agitated naturalists of the day. Was it a mammal, as Shaw thought? Did it represent a new group of animals? Could it be a "missing link" between two well-known groups, especially between reptiles and mammals? Did it represent a new class of vertebrates, as the French anatomist Etienne Geoffroy Saint-Hilaire maintained? Or was it a hoax, as many suspected and as Shaw himself wondered, even as he wrote the initial description? Did the females lay eggs, as birds and many reptiles do? Or did they give birth to live young, as mammals do?

The creature, with its fur, duck bill, and webbed feet, would have appeared even more paradoxical had it been known that it laid eggs and suckled its young. No animal was known to do that. Furthermore, no animal was supposed to do that. In the taxonomy established for European species by European naturalists, it was axiomatic that all milk-producing animals give birth to live young, and so, by definition, are mammals. Warm-blooded egg-laying animals were birds. Cold-blooded egg-laying animals were reptiles. There was no place in this scheme for the platypus.

A hoax—the bill of a duck attached to the skin of a mole—would have been in keeping with a number of other bizarre animals fabricated and displayed as genuine in Britain and America in the late eighteenth and nineteenth centuries. Robert Knox, the Edinburgh anatomist whose name we now associate with body snatching and grave robbing (and possibly even murder) to obtain human cadavers for dissection, provided a rationale for suspicions that the platypus was a hoax in his account of the animal's anatomy:

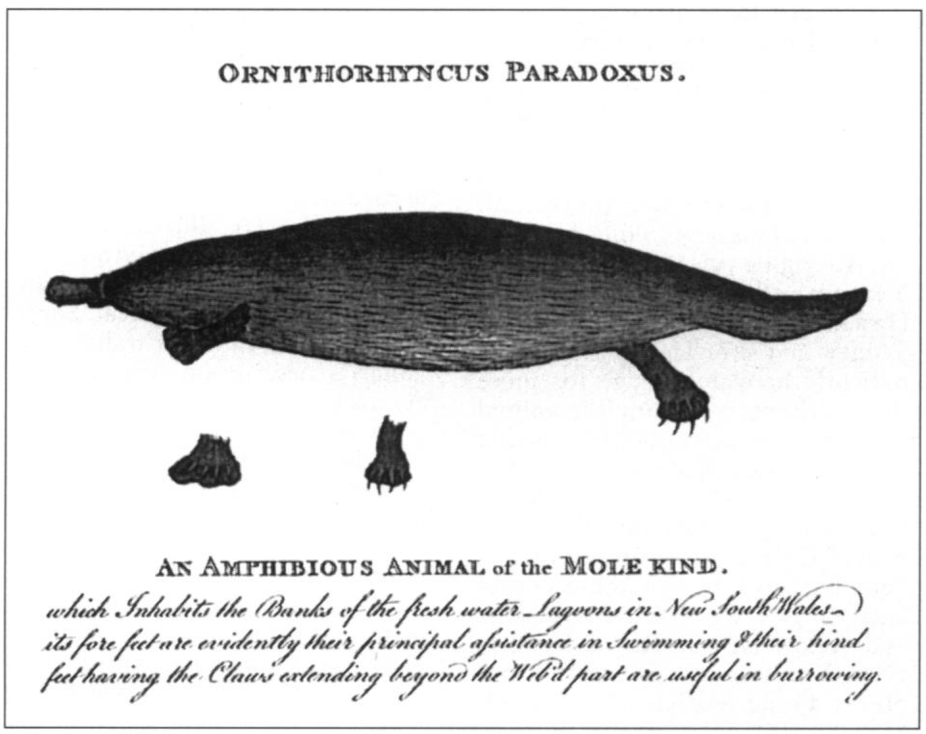

Figure 2. Governor John Hunter's drawing of the amphibious animal of the mole kind, which was drawn in 1797 and included as an engraving in the second edition of David Collins' *An Account of the English Colony in New South Wales* (Collins 1802).

It is well known that the specimens of this extraordinary animal first brought to Europe were considered by many as impositions. They reached England by vessels which had navigated the Indian seas, a circumstance in itself sufficient to rouse the suspicions of the scientific naturalist, aware of the monstrous impostures which the artful Chinese had so frequently practised on European adventurers; in short, the scientific felt inclined to class this rare production of nature with eastern mermaids and other works of art; but these conjectures were immediately dispelled by an appeal to anatomy. (Knox 1823, p. 27)

If not a hoax, then *Ornithorhynchus* was truly paradoxical. New findings only added to the paradox. In 1802, the surgeon and anatomist Sir Everard Home reported that the males had internal testes—like reptiles and unlike mammals—and that both males and females had a cloaca, a common opening for the alimentary, excretory, and reproductive tracts (Home 1802). Possession of a cloaca is a reptilian characteristic, more particularly a characteristic of reptiles that retain their eggs within the body, where the young hatch. Such a mixture of structures quickly established the notion of the platypus as a missing link between reptiles and mammals.

Other European anatomists then set to work in the "platypus industry." The great German anatomist Johann F. Meckel published four influential accounts, the first (Meckel 1823) on the nature of the spur and poison gland in males. In the second (Meckel 1824) he mentioned the existence of mammary glands, but he did not describe them until his detailed papers of a few years later (Meckel 1826, 1827). The secretion of milk in a live animal was described for the first time 6 years later by Lieutenant the Honorable Lauderdale Maule of the 39th Regiment of the British Army, which was stationed in New South Wales.

According to Maule's description (Maule 1832a, 1832b), the mammary glands were not typical; fur covered the nipples, and the glands themselves were quite small, except during lactation. However, the presence of mammary glands—no matter how unusual or atypical—satisfied many naturalists that these animals must be mammals. The absence of wings and feathers meant that they were not birds, and their warm bloodedness and the presence of a diaphragm meant that they were not reptiles. Anatomical features suggesting egg laying were, however, consistent with the platypus *not* being a mammal. Certain bones found in the pectoral girdles, otherwise known only from fossils of mammal-like reptiles (therapsids), placed the platypus at the boundary between reptiles and mammal-like reptiles, that is, made it a missing link. But was the platypus a hairy reptile? Or a mammal with a cloaca? It remained paradoxical.

Classification

Platypuses now reside in the Class Mammalia, Subclass Prototheria, Order Monotremata, and Family Ornithorhynchidae. However, in the years after their discovery, these animals were placed in an amazing range of existing taxa and had numerous taxa created especially for them.

- Shaw, the first zoologist to examine a live specimen, included them with toothless mammals, anteaters, and sloths in a group that Linnaeus called Bruta, now known as the Edentata (Shaw 1799, 1800).
- Home thought that they belonged to a new tribe of mammals (Home 1802).
- Geoffroy argued for a separate vertebrate class for the platypus and echidna, which he named Monotremata (because of the single opening for gut, urinary, and genital systems), but he was vague about their relationship to other mammals.
- Lamarck grouped platypuses and echidnas in a new nonmammalian class, the Prototheria, whereas the German anatomist J. K. W. Illiger created the division Reptantia, intermediate between reptiles and mammals.
- Henri de Blainville, the French anatomist and Georges Leopold Cuvier's successor in the Chair of Comparative Anatomy at the Paris Natural History Museum, created a separate order of mammals, the Ornithodelphia, allied to marsupials.
- Although Meckel discovered the mammary glands, he was not convinced that they were true mammalian mammary glands. He therefore argued that the platypus occupied a class by itself.

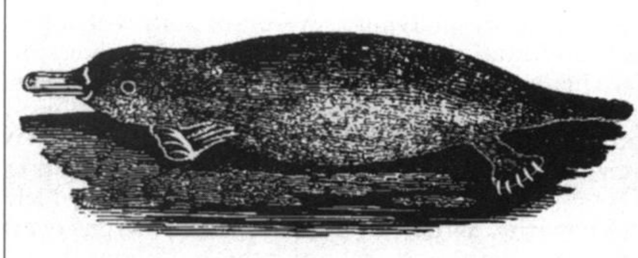

Figure 3. Thomas Bewick's engraving of the amphibious animal, the last plate in the fourth edition of *A General History of Quadrupeds* (Bewick 1805).

A fossil record would have aided these early attempts at classification. It was not until late in the nineteenth century that any specimens of what were described as species of fossil platypus were discovered. The first, *Ornithorhynchus agilis*, was described from a tibia and lower jawbone by the Director of the Queensland Museum, C. W. De Vis (1885); 95 years later it was shown to be a specimen of the living platypus, *O. anatinus*. A second fossil, designated *Ornithorhynchus maximus* by the geologist W. S. Dun (1896), is now known to be a fossil echidna, *Zaglossus robustus*.

Even now the platypus fossil record is not abundant. *Obdurodon insignis*, described by Woodburne and Tedford (1975) and Archer et al. (1979) is represented only by upper molar teeth (*Obdurodon* means "enduring teeth"), a fragment of the lower jaw, and an ilium. *Steropodon galmani*, described by Archer et al. (1985), is an early Cretaceous monotreme.[1] The teeth of both spe-

[1]See Kielan-Jaworowska et al. (1987) for a discussion of the nature of the dentition in this species and its placement earlier in mammalian evolution than suggested by Archer et al. (1985).

cies are similar to the molar teeth found in living juvenile platypuses. Modern adult platypuses do not have teeth; the juvenile teeth degenerate and are replaced by horny pads on both the upper and lower jaws. The most recent discovery—a complete skull of a new species, *Obdurodon dicksoni*, from the Miocene—also has permanent teeth but is otherwise clearly an ornithorhynchid (Archer et al. 1992).

The eggs hold the key

In the debate over the anatomy and systematic position of the platypus, national pride and supremacy were at stake. Then as now, much kudos accrued to the nation whose citizens led the scientific world. Britain was pitched against France, Englishman against Frenchman, typologist against evolutionist. Although they agreed that the duckbill was a mammal, England's representatives—Richard Owen and Home—maintained that the eggs remained within the body as in mammals, even though, at up to 17 mm in diameter, the eggs were much larger than normal mammalian eggs. Across the English Channel, France's representatives—Geoffroy and Blumenbach—insisted that the eggs were laid, as in birds and reptiles, but that platypuses represented a separate group. Meckel, Cuvier, and other Europeans maintained that platypuses were true mammals that produced live young. All saw that the key to understanding the paradoxical platypus lay in its eggs.

For a time after the discovery of mammary glands and milk production, whether platypuses laid eggs was irrelevant to the debate. The belief that all milk-producing animals give birth to live young was so strongly entrenched that reports of egg laying by platypuses were not taken seriously.

There are three patterns of egg production and birth (hatching), to any one of which platypuses might have belonged:

- **Viviparity.** Little yolk is stored in the egg; embryos are nourished through a placenta and the young are born alive, not contained in an egg. Viviparous animals include humans, mice, and rabbits. Newborn mammals are suckled at mammary glands.
- **Oviparity.** Eggs with large amounts of yolk are laid. Most embryonic development takes place outside the body of the female, and the young hatch from the eggs after they are laid. Oviparous animals include birds and reptiles.
- **Ovoviviparity.** Eggs are retained within the body, and embryos are nourished primarily from yolk reserves in the egg and not through a placenta. The young hatch within the body of the female. Ovoviviparous animals include some sharks, turtles, frogs and caecilians, and four species of salamanders.

Although Aborigines and some of the early colonists in New South Wales were convinced that platypuses laid eggs, the European scientific community "knew" otherwise. Rarely are the strongly held views of professionals overturned by the evidence of amateurs, and professionals were even less likely to be swayed by colonials or by stories provided by natives. The *Sydney Morning Herald* (1884) responded to claims of colonists that monotremes laid eggs with the statement that evidence must be "examined and reported on by scientists in whom the world has faith, then all the scientific world will stand convinced and will believe where they have not seen."

Reports in scientific journals, although they came from professionals, lacked proof. For example, the prominent surgeon Sir John Jamison wrote in the *Transactions of the Linnaean Society of London* on 18 March 1817: "The female is oviparous, and lives in burrows in the ground" (Jamison 1818). Some 21 years later, R. P. Leason referred to "the *ornithorhynchuses* or *paradoxals* with a duck's beak, which live in the waters of the rivers, and which lay eggs." In a 21 September 1864 letter to Owen, a Dr. John Nicholson of Wood's Point, Victoria, claimed that he had found two eggs in a gin case in which he had kept a female platypus overnight. These eggs were "about the size of a crow's egg, and were white, soft, and compressible, being without shell or anything approaching to a calcareous covering" (Burrell 1974). Unfortunately, the eggs disappeared before their contents could be examined. Were they the first platypus eggs to be reliably reported? Or were they the soft-shelled eggs of a local lizard placed in the gin case by a local "wag" seeking to please the good doctor?

Several other scientists published descriptions of eggs that were unlikely to be from the platypus. For example, Geoffroy published a description of a "platypus" egg in 1929, only to realize that the egg was much too large to have passed through the female's pelvic ring. The prominent Australian zoologist Launcelot Harrison, writing of this egg with the advantage of hindsight (Harrison 1921), commented that "it is at once obvious to an Australian zoologist that the egg is that of the common long-necked tortoise (*Chelodina longicollis*)." It was not unusual for the settlers or even the Aborigines to send eggs of other species to Europe, representing them as platypus eggs. Owen dissected two "platypus" eggs collected by Aborigines: one contained a snake embryo, the other a lizard. Owen owed much to his close friend George Bennett, the first Curator and Secretary of the Australian Museum, who had pursued the study of monotremes and the enigma of their egg production in New South Wales since 1829 and who was an important figure in the development of zoology in Australia (Moyal 1976). Bennett supplied the specimens on which Owen based his 25 papers on the anatomy of monotremes and marsupials. Two of these papers (on kangaroo uteri and embryos in impregnated platypus; Owen 1834a, 1834b) gained Owen election to the Royal Society in 1834.

Owen thought that the best way to resolve the issue of whether platypuses lay eggs containing live (i.e., unborn) young would be to shoot and preserve a female platypus every week during what was thought to be the breeding season (September–November), and this he directed Bennett to do. By 1860, however, Bennett was concerned that such wholesale taking of platypuses (and echidnas and emus) in the name of science would lead to their extinction. In the preface to his wonderful evocation of animal and plant life, *Gatherings of*

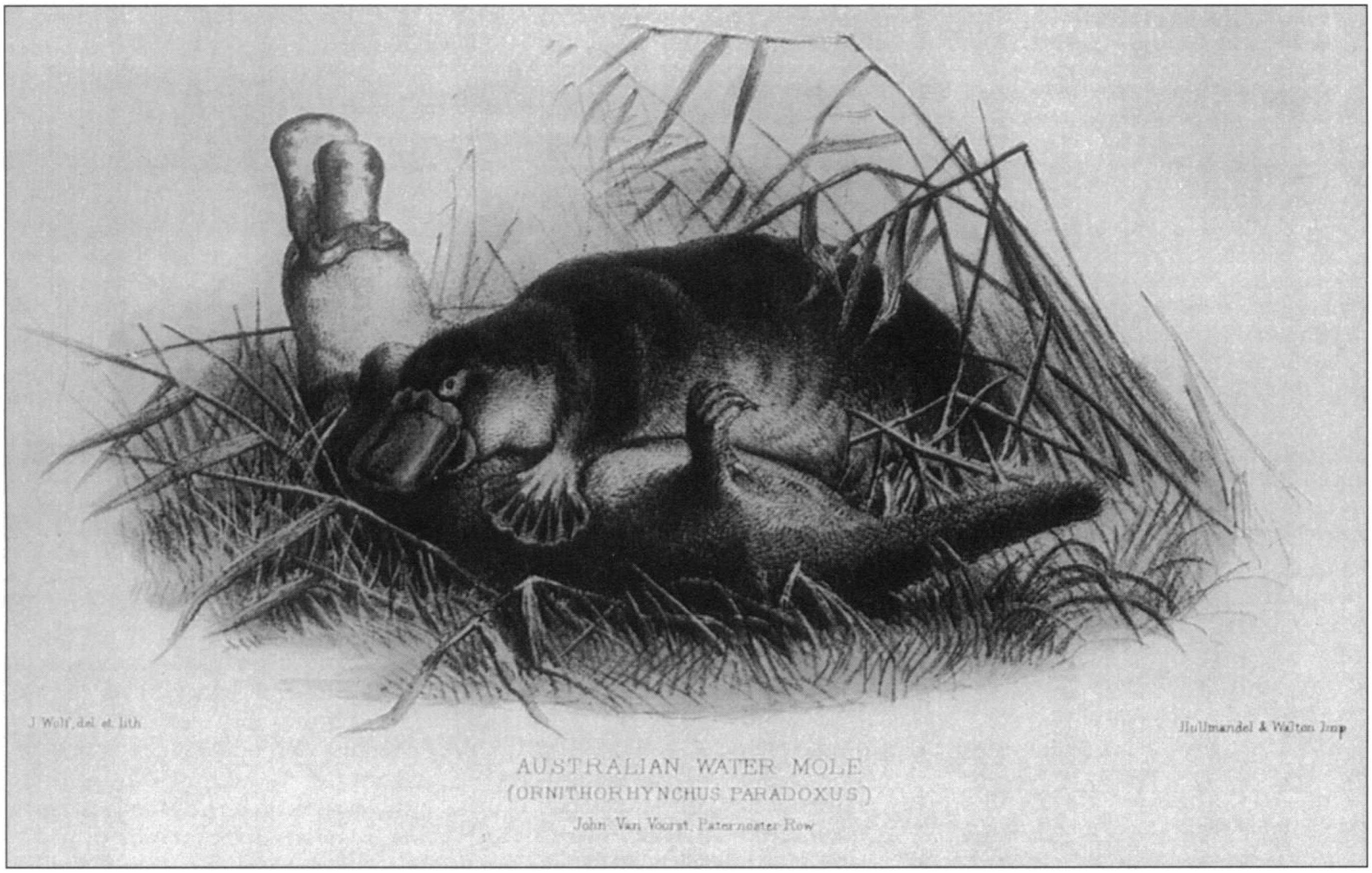

Figure 4. A lithograph of the platypus by Joseph Wolf, artist for the Zoological Society, color plate III in *Gatherings* by George Bennett (1860). (Also used on the paper cover of the 1982 reprint.)

a Naturalist in Australasia (52 pages of which are devoted to the platypus; Figure 4), Bennett wrote:

> Many of the Australian quadrupeds and birds are not only peculiar to that country, but are, even there, of comparatively rare occurrence: and such has been the war of extermination recklessly waged against, that they are in a fair way of becoming extinct. Even in our own time, several have been exterminated; and unless the hand of man be stayed from their destruction, the Ornithorhynchus and the Echidna, the Emeu and the Megapodius, like the Dodo, Moa and Notornis, will shortly exist only in the pages of the naturalist. The Author hopes that what he has been induced to say with reference to this important subject will not be without weight to every thoughtful colonist. (Bennett 1860, p. vi)

Indeed, by the turn of the century the platypus was close to extinction. Now protected by severe penalties, however, platypuses are flourishing.

Bennett sought what all considered the last piece of evidence for "mammalness"—a platypus with a fully developed embryo inside her body. Sure that the Aborigines were mistaken in their belief that platypuses laid eggs, he convinced himself from firsthand examination of impregnated uteri that they did not contain eggs that could be laid. Bennett devoted five decades to the "platypus problem," only to be pipped at the post by an obnoxious young Cambridge graduate.

"Monotremes oviparous, ovum meroblastic"

The Scottish zoologist William Hay Caldwell finally settled the issue of whether platypuses lay eggs. Caldwell graduated from Cambridge University in 1880 and 2 years later was appointed Demonstrator in Comparative Anatomy to Professor Alfred Newton. Caldwell was a student of Francis (Frank) Maitland Balfour, who had died tragically while climbing in the Swiss Alps only 7 weeks after being appointed Professor of Animal Morphology. In his memory, Cambridge University established the Balfour Studentship, which rapidly became the zoological blue ribbon of the university. Caldwell, the first recipient, used the £200 studentship, a £500 grant, the prestige and backing of the Royal Society, and letters of introduction from Newton to travel to Australia in 1884 expressly to settle the 85-year-old question of whether platypuses lay eggs. His task was to find and observe breeding animals. The chances of finding suitable specimens were, of course, slim indeed. After all, Bennett had searched for decades without success.

In April 1884, Caldwell set up camp on the banks of the Burnett River in northern Queensland and put the local Aborigines to work searching for lungfish, echidna, and platypus eggs.

> During part of June and July I spent many hours daily in the water, hunting everywhere for the eggs of *Ceratodus* [the lungfish]. Towards the end of July the blacks began to

> collect *Echidna*, and very soon I had segmenting ova from the uterus. In the second week of August I had similar stages in *Ornithorhynchus*, but it was not until the third week that I got the laid eggs from the pouch of *Echidna*. In the following week (August 24) I shot an *Ornithorhynchus* whose first egg had been laid; her second egg was in a partially dilated *os uteri*. This egg, of similar appearance to, though slightly larger than, that of *Echidna*, was at a stage equal to a 36-hour chick. (Caldwell 1888, p. 464)

A 36-hour chick embryo has 8–10 pairs of somites (forerunners of the vertebrae) and three distinct brain vesicles and shows the first signs of cranial flexure as the head begins to bend. The presence of an embryo of such an advanced stage in the uterus of a platypus clearly indicated that embryonic development began before the eggs were laid.

> On the 29th [August] I sent in the telegram 'Monotremes oviparous, ovum meroblastic' to a neighbouring station, where it would meet the passing mail-man, addressed to my friend Professor Liversidge [Dean of the recently founded Faculty of Science] of the Sydney University, asking him to forward it to the British Association at Montreal. (Caldwell 1888, p. 464)

On 2 September, Caldwell's discovery—"Monotremes oviparous, ovum meroblastic," which has few rivals for pithy succinctness—was announced in dramatic fashion to the annual meeting of the British Association for the Advancement of Science in Montreal. It took the delegates by storm. Finally, the mystery of platypus egg production was resolved. The four words in the cable each carried a wealth of meaning. Monotremes do lay eggs; those eggs contain large amounts of yolk; the yolk is not divided into cells. A large-yolked, undivided egg is what birds lay; the monotreme egg is, therefore, just like a bird's egg.

By one of those amazing coincidences of timing so common in scientific discoveries, on 25 August—one day after Caldwell shot the platypus with the developing embryo—William Haacke, curator of the South Australian Museum, found an eggshell in the pouch of an Echidna. On the very day that Caldwell's cable was read in Montreal, Haacke exhibited the echidna egg to the Royal Society of South Australia in Adelaide. If priority is assigned on the basis of communication of findings, then Caldwell and Haacke share the honors for the discovery of oviparity in monotremes (Haacke 1885, Caldwell 1885). If priority is assigned on the basis of full publication of the findings, then Haacke has priority. He published his findings in 1885, Caldwell not until 1888.

For Caldwell, *Ornithorhynchus* eggs now took second place to the lungfish, *Ceratodus*. A little over 2 months after his telegram was read in Montreal, a letter dated 8 October from Caldwell to Liversidge was communicated to the Royal Society of New South Wales.

> *Ceratodus* has interfered with *Platypus*. The *Platypus* eggs were hatched three weeks ago, and I should have been in New England by now, but *Ceratodus* is much more important. *Platypus* embryos are quite easy to get. I can't understand how they have not been got before. The fact tha(t) the monotremes are oviparous is the end of the research for many. They don't understand that it is the fact of the eggs having a lot of yelk [sic] that promises to yield valuable information. (Anonymous 1884)

Bennett spent 50 years in Australia unsuccessfully attempting to unravel the mysteries of monotreme and marsupial biology. His efforts were those of a part-time naturalist, attempting to coax out the secrets of nature, concerned for the conservation of the animals, and aided only by "two lazy aborigines," as he described them in a letter to Owen. Caldwell, on the other hand, wrenched secrets from nature, boasted of the numbers of animals he slaughtered, and put an army of Aborigines to work to achieve his ends. In 3 months of 1884 alone, he killed 70 females from a single pond in an attempt to find eggs or embryos. In July and August 1885, Caldwell employed 150 Aborigines to collect (i.e., slaughter!) 1400 echidna. Bennett was not pleased that in the space of a few months, Caldwell had resolved the mystery of platypus egg laying and scooped him (and Owen) into the bargain. An echidna found by Caldwell also scooped Bennett and Owen; when Caldwell held it upside down an egg dropped from its pouch! He sent another telegram, this time to Bennett in Sydney, to report that he had "obtained all stages development Monotremata oviparous Meroblastic." There was no mention of Haacke's discovery.

Despite this "resolution" of platypus egg laying, confusion continued for some decades. In his entry on the Monotremata in the 11th edition of the *Encyclopædia Britannica*, the renowned zoologist Richard Lydekker disavowed Caldwell's evidence, claiming that "there does not appear to be authentic evidence that the eggs in this genus are actually laid." In their entry on the platypus, however, William Henry Flower and Henry Scherren denied Haacke's priority when they wrote that Caldwell "finally established the fact that *Platypus* as well as *Echidna* is oviparous."

Platypus reproduction

Even today, complete knowledge of the platypus breeding cycle is lacking. We know that platypuses live for something like 12 years and breed for almost their entire life span—there is one report of a lactating female who is at least 11 years old. Still, after almost 200 years, there is no record that anyone has ever seen an egg being laid. Caldwell did not, although it is sometimes asserted that he did. He found a female with an egg that he assumed she had laid.

The platypus breeding season extends from July to October, depending on geographical location. From one to three eggs (two eggs, in 80% of cases) are laid in a nest at the end of a specially constructed nesting burrow. Platypuses dig two quite different burrows into the banks of streams or lakes; a short "camping burrow" used by both sexes and a nesting burrow used by the female to rear her young. Nesting burrows—as long as 30 meters and with numerous branching chambers—were first described by Maule in 1832:

> The *Platypus* burrows in the banks of rivers, choosing generally a spot

> where the water is deep and sluggish, and the bank precipitous and covered with reeds or overhung by trees. Considerably beneath the level of the stream's surface is the main entrance to a narrow passage which leads directly into the bank, bearing away from the river (at a right angle to it) and gradually rising above its highest watermark. At a distance of some few yards from the river's edge this passage branches into two others, which, describing each a circular course to the right and left, unite again in the nest itself, which is a roomy excavation, lined with leaves and moss, and situated seldom more than twelve yards from the water, or less than two feet beneath the surface of the earth. Several of their nests were, with considerable labour and difficulty, discovered. (Maule 1832a, pp. 145–146)

Nest building, and the platypus as a link between bird and beast, were evidently what Ogden Nash (1953) had in mind when he penned:

> I like the duck-billed platypus
> Because it is anomalous.
> I like the way it raises its family,
> Partly birdly, partly mammaly.

Incubation is quite brief, approximately 10 days, but it is important to remember that the embryo is already well advanced when the egg is laid. The female curls her tail around the eggs to create an "incubatorium" with a temperature of 31.5 °C, even when the outside temperature is much lower. Platypuses are superb thermoregulators,[2] surpassing their placental cousins in this important physiological function. Suckled in the incubatorium for 3–4 months while fur develops, the young attain a length of some 25–35 cm, leaving the nest in late January.

Of twentieth-century students of the platypus, Harry James Burrell has the double distinction of publishing the first major work on the platypus (Burrell 1974), based on a lifetime of study, and developing (in 1910) the first "platypussary" to maintain animals in captivity. This was no mean feat—it took him 6 hours a day to collect the 0.5 kg of earthworms, 30 crayfish, 200 mealworms, 2 frogs, and 2 eggs consumed by a 15 kg animal in a single day. This daily food intake is more than half the animal's weight! Having spent so much time studying the platypus's ability to spend so much time under water, it is ironic that Burrell died in his bath.

David Howells Fleay followed in Burrell's footsteps as "Mr. Platypus." He built and directed the Healesville Fauna Sanctuary—now the Sir Colin MacKenzie Sanctuary—in Healesville, Victoria. (Later he founded a famous tourist attraction, Fleay's Fauna Reserve, at West Burleigh, in southern Queensland.) In 1937, Fleay engineered and recorded what was until very recently the only platypus birth in captivity. Awarded the Australian Natural History Medal in 1941, he was described as "the single most active and influential naturalist in Australia."

Healesville had a long association with platypuses. In late March 1874, while H.M.S. *Challenger* was at anchor, one of her four naturalists, Henry Nottidge Moseley, visited the Government reserve for Aborigines near Healesville.

> Close by the reserve flowed the River Yarra, in which the *Platypus* abounds, the "Water Mole," as it is called here, or the "Duck-bill" (*Ornithorhynchus paradoxus*). I offered the men three half-crowns for one recently shot... It was all to no purpose. I was doomed not to see a living *Platypus* or even a Kangaroo in Australia. I saw only the footprints of the *Platypus* (like those of a duck), which the Black pointed out to me, in a regularly beaten track, made by the animals from one pond to another. The Black said that he was certain the *Platypus* did not lay eggs, and that he had several times seen the young ones, and his description of them agreed with what I knew from Dr. Bennett's researches on the subject. (Moseley 1892, pp. 227–228)

Ten years and 5 months after he was "doomed not to see a living *Platypus*," Moseley, by then Linacre Professor of Zoology and Comparative Anatomy at Oxford University, stood in Montreal as President of Section D of the British Association for the Advancement of Science to read Caldwell's cable. It was reported that "Professor Moseley thinks that it indicates the descent of man from a reptilian form of life" (Sydney Morning Herald 1884). Clearly, with such a connection to human evolution, the influence of the platypus would continue to be felt in yet another area of biology. But that is another story, which, paradoxically, raises much that is relevant to the nature of scientific evidence, orthodoxy, entrenched authority, the role of personalities in science....

[2]Not only superb thermoregulators, platypuses are also expert in the detection of small mechanical and electrical signals. Specialized mechano- and electroreceptors in pores on the skin of their supersensitive bills can detect the electric field generated by a shrimp flicking its tail several centimeters away.

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