An Antipodal Mystery

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Part I—A Letter from Down Under

… The river was very still on the curve where the eucalyptus dips towards the water. The light shaded near late afternoon and twilight would soon darken the outline of the wooded bank and the flat landscape stretching to the horizon. Bubbles broke the surface of the water. A small brown head, its sleek furred cap glided silently in the river's flow.

As you can imagine, my esteemed colleague, I wondered what the aborigine was spearing in the lake near Hawkesbury River close to Sidney. I soon discovered the answer. A small creature fought for its life with such force that it caught its assailant with its spur and seemed to cause much pain. I have taken the liberty of posting the skin of the specimen to you for your study. It is preserved in a keg of spirits with another antipodal beast. I send it to your keeping for the Literary and Philosophical Society of Newcastle-upon-Tyne.

I remain your servant,
John Hunter, Governor
New South Wales

Thomas Bewick looked at the letter closely, pursing his lips. He gingerly unfolded the pages of notes and drawings that spilled from the governor's weathered envelope, addressed months ago. With each passing moment his surprise increased; this creature was nothing like any animal seen before. What would he write in his next edition of *General History of Quadrupeds?* What could he possibly say? The animal seemed hardly real. Is it a mammal, he mused, or …?

Questions

Hunter's drawings seem unbelievable. Bewick suspects that this is not going to be a simple problem in classification. How should he decide what the creature is? What is the definition of a mammal?

1. Predict in as much detail as possible exactly what features a mammal would be expected to have. Consider the external as well as internal anatomy of a mammal; list all characteristics you can think of. Indicate which of these are exclusive to mammals and which are found in other vertebrates such as fish, amphibians, reptiles, and birds.

Part II—"A Three-Fold Nature"

"The cask containing the two specimens … reached Newcastle late in 1799, transported from quayside to the Society's rooms by a woman servant. She carried it on her head and, by mischance, the bottom of the cask gave way, dousing her with pungent spirits. But her dismay was reportedly the greater when, looking down, she saw not only the small chunky wombat, but the remains of 'a strange creature, half bird, half beast, lying at her feet'."

Thomas Bewick was to write that the creature "seems to be an animal *sui generis;* it appears to possess a three-fold nature, that of a fish, a bird and a quadruped, and is related to nothing that we have hitherto seen." It was about the size of a "small cat," with a bill "very similar to that of a duck," with four short legs, "the forelegs … shorter than those of the hind and their webs spread considerably beyond the claws." Bewick concluded "it resisted any attempt to arrange it in any of the useful modes of classification."

Dr. George Shaw, a Fellow of the Royal Society and Assistant Keeper of Natural History at the British Museum, also obtained a dried specimen in 1799. He wondered if it was a hoax, an animal stitched together by clever Chinese or Japanese taxidermists to deceive credulous sailors. He wrote: "I almost doubted the testimony of my own eyes." But he could not find any deception.

A specimen found its way into the hands of Professor Johann Blumenbach, a comparative anatomist of the University of Göttingen in Germany, who christened the creature *Ornithorynchus paradoxous.* "In every way a paradox," the Australian arrival raised a host of questions. Was it, as its brown fur suggested, a mammal? But where were its mammary glands? Where were its nipples? And how could a young animal suckle with that duckbill? Or was it a reptile, among which amphibians were then grouped, for this beast was surely aquatic? Or perhaps it was avian; its duck-like bill indicated an affinity with warm-blooded birds. Blumenbach was stumped. *Ornithorynchus* did not fall into any of the major classes of vertebrates—the mammals, fish, birds, and reptiles.

Other specimens were forwarded to the distinguished British anatomist Everard Home at the Royal College of Surgeons in London. The mystery deepened, for Home made a series of wonderful discoveries published in papers written from 1800–1802. The "duck-bill" beak was an exploratory organ for touching and tasting the muddy bottom of rivers as the animal searched for its food, small crustaceans and insects underwater. The beak was not hard like that of a bird; rather it was moist, soft, and highly flexible. And the reproductive organs were a surprise!

Quesitons

1. Examine the drawings on the following page showing the reproductive systems of animals. What conclusions do you make? Which seems most similar to *Ornithorynchus?*
2. What does this imply about evolution?
3. Think about how young *Ornithorynchus* are likely born. Are they born alive (viviparous)? Or are eggs laid, incubated, and then hatched (oviparous)? Or are eggs produced and then held in the body for a time and then hatched inside the mother as in some snakes (ovoviviparous)? All of these opinions of *Ornithorynchus* development were firmly held by some of the great anatomists of the time.

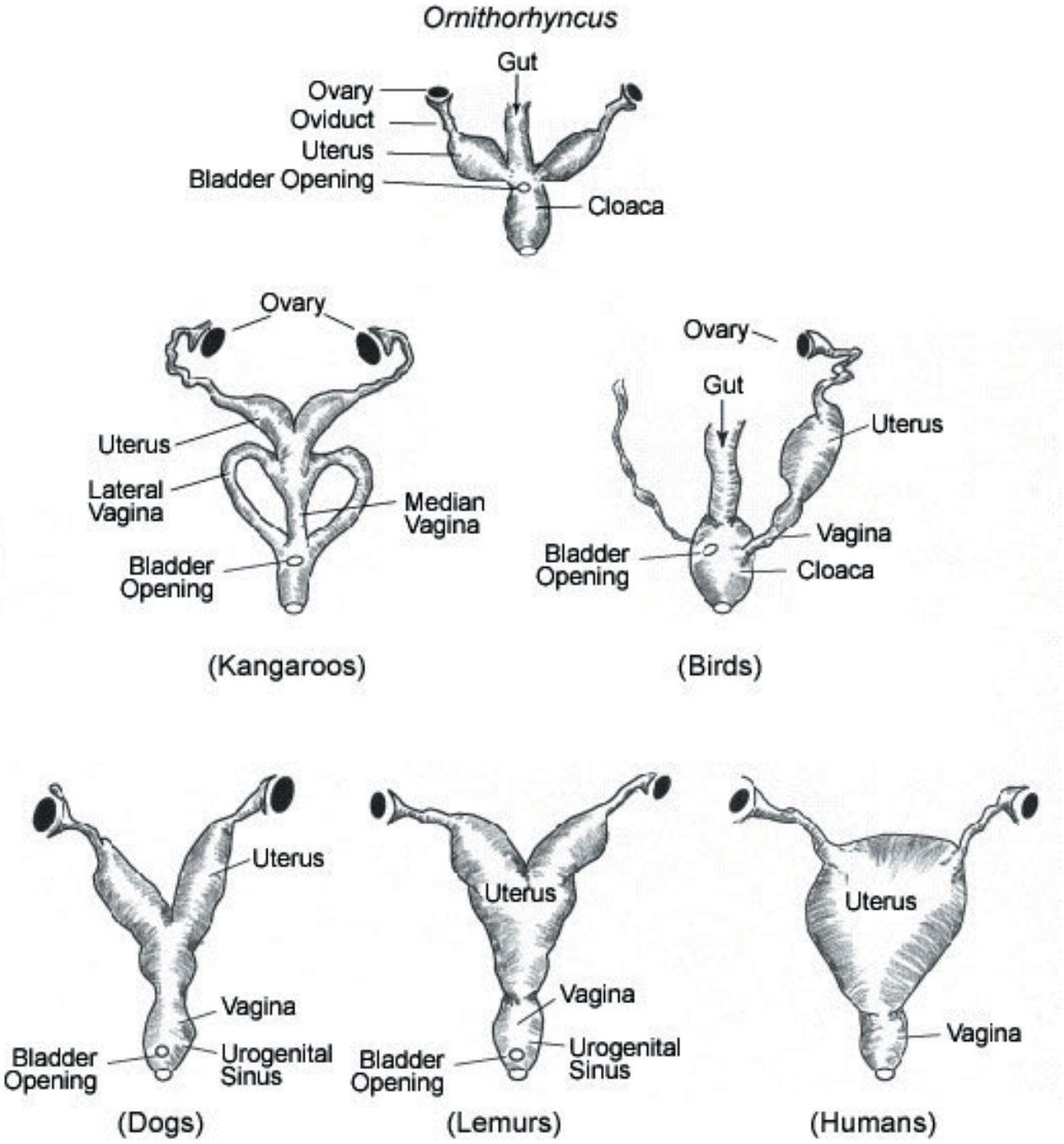

Figure 1: The female reproductive systems of six vertebrates. All dissections are depicted as if the animal were lying on its back facing the reader. All of the systems are bilaterally symmetrical except for the bird where only the left side is functional; the right side degenerates during development. The term ***cloaca*** is used for a chamber that receives the contents of the *digestive, urinary, and reproductive tracts.* The term ***urogenital sinus*** is a chamber that receives products from the *urinary and reproductive tracts;* the digestive tract empties separately via its own final chamber, the ***rectum*** (not shown). (Redrawn by Jim Stamos, based on various sources).

Part III—"This Highly Interesting Novelty"

Sir Joseph Banks, who had traveled with James Cook on his first voyage, ventured this in 1802: "Our greatest want here is to be acquainted with the manner in which the Duck Bill Animal [platypus] and the Porcupine Ant Eater [spiny echidna] which I think is of the same genus, breed, their internal structure is so very similar to that of Birds that I do not think it impossible that they should lay their Eggs or at least as Snakes and some Fish do Hatch Eggs in their Bellies."

The French zoologist Etienne Geoffroy St-Hilaire, reading Home's anatomical works, declared that both animals should be placed in a new animal class, the Monotremata, which means "one hole" to designate that the animal has a single opening (cloaca) through which it eliminates digestive and urinary wastes and reproductive products (eggs or sperm). There were three central questions about *Ornithorhyncus* that emerged from the foment of the times:

1. First, how can we fit this strange beast into the classification and taxonomic schemes that had worked so well in the Northern Hemisphere?
2. Second, how does *Ornithorhyncus* produce its young?
3. Third, what relevance does this anomalous animal have for the old ideas of a perfectly created world? What is the relevance of *Ornithorhyncus* to the idea of evolution, which was beginning to be whispered about?

Questions

Let's consider the first question: how should we classify such an animal? Classification experts like John Ray and Carl von Linneaus said that reproduction was the essential criterion for classification. Linneaus set the presence of mammary glands and the suckling of the young as the defining characteristic for the class of animals he named "Mammalia." He said that warm-blooded quadrupeds (four-legged beasts) with a four chambered heart and double circulation were viviparous and mammiferous.

Henri Marie Ducrotay de Blainville said mammals could be arranged by decreasing complexity from the primates down through the marsupials to the monotremes. He was the first to note many resemblances between platypus and echidna and the marsupials. He said that regardless of the apparent absence of mammary glands, the monotremes belonged as mammals in their own distinct order, Ornithodelphia. France's scientific leader, Georges Cuvier, pronounced they were indeed mammals but put the monotremes squarely in the order Edentata that included other toothless mammals, anteaters, and sloths.

Not everyone agreed. Although the platypus was warm-blooded, had a four chambered heart, and double circulation (two different sides of the heart, one pumping to the lung and the other to the rest of the body), birds had these traits too. And it had a duck-like bill! Everard Home reported in his 1802 paper that the structure of the ear and shoulder girdle combined both mammalian and reptilian features. The presence of a cloaca was clearly a reptilian and avian feature. The absence of a well-formed uterus and the apparent absence of nipples persuaded Home that the "duck-billed mole" was related to ovoviviparous reptiles.

Lamarck said the platypus and echidna could not be mammals without mammary glands. He placed them in a separate vertebrate class called Prototheria.

1. So what is the best solution for classification for this unusual animal? If birds, reptiles, fishes, and mammals are placed in separate classes, where should an animal like *Ornithoryncus* be classified?
2. What is the best logic for predicting how the young platypus is born: viviparous, oviparous, or ovoviviparous? What seems to be the most probable reproductive method and least probable method? And once produced, how will they be fed?

Part IV—Solving the Mystery

How do platypuses reproduce? In 1821, there was a breakthrough when Patrick Hill, a naval surgeon, wrote to the Linnean Society saying he had talked to an Aboriginal elder and "it is a fact well known to them that the animal lays two eggs about the size, shape, and colour of those of a hen; that the female sits for a considerable time on the eggs in a nest which is always found among the reeds on the surface of the water."

More importantly, in 1824, the German anatomist Johann Meckel reported that he had found mammary glands in the platypus! They appeared primitive and opened directly onto the skin without any sign of nipples. Monotremes would represent a transitional form between reptiles and mammals. Geoffrey St-Hilaire rejected this view and said the structures described by Meckel couldn't be mammary glands because the absence of nipples would make feeding difficult with a duck-bill. He stated that the monotremes belonged in their own separate mammalian order, Monotremata.

In 1831, the Hon. Lieutenant Maule, who was stationed in Australia, reported to the Zoological Society of London that he found several nests of platypus with fragments of eggshell and in one nest he found a female and two young. Two weeks later when the female died, he reported: "on skinning her while yet warm, it was observed that milk oozed through the fur on her stomach." No teats were visible.

Richard Owen, England's great comparative anatomist, received two baby platypuses from Lieutenant Maule in New South Wales, and determined in 1834 that the suckling infant's mouth was designed to take milk in the normal manner. In addition, he clearly determined that there was milk in the babies' stomachs.

Not until 1884 was the picture clear. The Scottish embryologist, William Caldwell of Cambridge, arrived in Australia and gathered a group of 150 aborigines to search the Burnett River for the elusive monotremes. He shot a platypus in the act of laying eggs: her first egg had been laid and her second was still in the partially dilated mouth of the uterus. He claimed victory. Platypus was oviparous. It laid soft-shelled eggs with large yolks that were gradually absorbed by the growing young, just as in birds and reptiles! In contrast to birds, where the calcified egg does not change in shape or size, the monotreme egg increases in size during its time in the uterus. Its flexible shell is stretched as nutrients are absorbed from the uterus.

Question

1. Do these discoveries change your view about how to classify the platypus?

Part V—The Big Picture

Turning to the third question: How does the platypus fit into the doctrine of creation? Recall that Aristotle's view of a ladder of nature (*Scala Naturae,* or Great Chain of Being) suggested that species were fixed in a position on an ascending ladder leading toward humans at the top. This may have made sense a couple of thousand years ago when only 500 species of animals were known, but as new species were discovered, with more and more intermediate or hybrid characteristics, this static view of the world seemed less and less tenable. For example, in 1803 French expeditions returned from Australia with 100,000 animal specimens; 2,500 were species new to science. Trumpeted France's scientific leader, Georges Cuvier, they had collected: "more new creatures than all traveling naturalists of recent times put together." Robert Brown, who traveled extensively around Australia's coasts, collected 465 genera and 2,000 species of plants in 1811, all new to science. Classification schemes that had been created for Europe were completely inadequate for the Southern Hemisphere. The platypus was only one of a thousand new riddles, albeit the most spectacular.

Another problem was emerging: fossils were being discovered everywhere. Many were of animals no longer alive. This suggested that some species had gone extinct. If extinction occurred, then what had happened to the ladder of life? Are there even more missing steps?

How do scientists solve this problem? Throw out the *Scala Naturae* concept altogether? France's Georges Cuvier did. He argued physical catastrophes periodically occur and destroy organisms. They were replaced after each disaster by successive creations of new and more complex unrelated species. Revise it? Cuvier's compatriot, Jean-Baptiste de Lamarck, believed there was a linear order of living organisms from simple to complex, and that organisms could move upward on the ladder via evolution—rather like an escalator. He thought extinction was impossible.

Questions

1. When Charles Darwin came into the picture, he had his own view of the *Scala Naturae*. What do you think was his view?
2. Today, we have DNA evidence as well as that from the traditional fields of comparative anatomy and physiology. Based upon everything that you know, draw a likely phylogenic tree showing the evolutionary relationships among birds, marsupials, monotremes, placental mammals, and reptiles.