ANSWER KEY
for
"An Antipodal Mystery"

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Part I—"A Letter from Down Under"

Define a mammal: College students should have no problem defining a mammal. Here is the classical definition right out of the Oxford English Dictionary: "a member of the class of animals that suckle their young." We can expect some students to also list mammary glands and fur. If you, the teacher, want to quibble with questions such as "What is fur?" "Do tarantulas and fuzzy caterpillars have it?" this is one spot that cries out for it. But it takes time.

The second question is more interesting: We are asking students to list as many of the characteristics of a mammal that they can think of. Now, it depends how sophisticated your students are, but you can easily get a terrific inventory if students think deeply about this and start including information on immunology, kidney function, intestinal enzymes, cell function, etc. The point of the exercise is that we have an enormous reservoir of information about the group called mammals; once we know one little bit of information, such as that they suckle their young, we have also nailed much of the anatomy, physiology, biochemistry, and even some behavior.

Today's answer to the question lies in evolutionary history. All mammals share a common ancestor that had a basic pattern of mammalian traits and the descendants are variations (adaptations) on that basic model. Yesterday's biologists really didn't have a good answer to that question; they could not see into the mind of the Creator.

Part II—"A Three-Fold Nature"

This question asks the students to compare reproductive tracts of tetrapods. A little examination will reveal how similar bird (and reptile) reproductive systems are to the platypus. All three have cloacas. The birds are special here. The adult bird has only one functional ovary, oviduct, and uterus on the left side; the developing chick starts off with two but the right side degenerates. Interestingly, there are reports that the platypus may also have a similar asymmetry favoring the left side.

Students should pick up on some trends in the reproductive anatomy: (1) There is a gradual separation of the digestive, urinary, and reproductive tracts. Birds, reptiles, and monotremes have all three tracts emptying together via a cloaca. Marsupials have a separate digestive tract but a common urogenital opening. And placental mammals have a greater tendency to separate all three tracts, most easily appreciated in the human female. (2) There is a gradual fusion of the two uterine horns into a common single uterus within the placental mammals.

When viewed in this way, evolution seems obvious.

As to the question of how the young are produced, the similarity of the reproductive tracts of birds, reptiles, and platypus strongly suggests either egg laying or oviviparous birth. Today we know they lay eggs. The platypus incubates eggs in a nest while the spiny echidna carries its eggs in a groove ("pouch") on its abdomen, a precursor to the marsupial pouch! As an interesting aside: at least some marsupials (e.g., North American

opossums) have a split or double penis. During intercourse, each half of the penis presumably enters the two lateral vaginas where ejaculation occurs. The medial vagina is used as the birth canal.

Part III—"This Highly Interesting Novelty"

How should we classify the platypus? There are three different arguments presented:

- Lamarck said they belong in a separate Class, the Prototheria. The other classes were Birds, Mammals, Reptiles, and Fishes.
- Blainville said they were mammals and belonged in a separate Order, Ornithodelphia.
- Cuvier said they were mammals but placed them as a genus in the same Order as other toothless mammals, the Edentata (sloths and anteaters).

Students who have learned they are mammals must not be permitted to take that position simply because they have heard it somewhere. They must be forced to support their decision on the basis of what is presented up to this time. (How can they call them mammals if they don't have mammary glands, and the young do not appear to have mouths that could suckle?)

I think the best argument at this point is to say they belong in their own special Class. (Their characteristics strongly suggest they are somehow a link between reptiles and mammals.)

Can we make a good prediction about how the young are born on the basis of the information? I really don't think so, except that the structure of the reproductive system suggests live birth is the least likely choice. Platypus reproductive anatomy is similar to that of a reptile or bird.

Part IV—"Solving the Mystery"

Here we learn the truth: *A platypus has mammary glands but no nipples.* Milk oozes out of pores and onto the fur, where the young lap it up. Platypus babies don't have a rigid bill so there is no problem getting milk. *A platypus lays eggs with leathery flexible shells that grow inside the uterus of the mother by absorbing nutrients.* So they appear to be an earlier stage in mammalian evolution than even a marsupial; the latter bear live young, which develop from fertilized eggs. The young marsupial grows in the uterus for a while, absorbing nutrients, but no elaborate blood vascular system develops to nourish the young. No placenta is present. The young marsupial is born in an undeveloped state and is placed in the female pouch, where it attaches by its mouth to a teat for several weeks as it continues to grow. The pouch serves as a second womb. So, the trend seems to be clear in mammary development, feeding of the young *in utero,* and after birth:

- **Reptiles** = Eggs. No mammary glands.
- **Monotremes** = Eggs. Mammary glands without nipples. In echidna, a primitive groove for incubation.
- **Marsupials** = Live birth; young essentially fetal. Marsupial pouch acts as a second womb. Mammary glands with nipples.
- **Placental Mammals** = Live birth in advanced state. Mammary glands with nipples.

The data suggest that we should classify Monotremes as mammals, at least as a separate Order from other mammals.

Part V—"The Big Picture"

Darwin said that there never was a ladder, or Chain of Being. In fact, in order to show how he viewed evolution, he drew the first phylogenic tree showing myriad branches.

Today, with DNA evidence, we show that the mammalian limb of phylogeny derived from reptiles, albeit a different reptile line from that which gave rise to birds. Ancestral mammals diverged from the reptile line perhaps 225 million years ago (MYA). The earliest mammal fossil found to date is a tiny (2g) shrew-like animal about the length of a paper clip and was discovered in China. This genus *Hadrocodium* is dated at 200 MYA. It has the defining mammalian characteristics of three middle ear bones, a single jawbone, and a well-developed secondary palate. It seems to be a distinct line from the Monotremes (Prototheria), which also come on the scene at this time according to molecular evidence. The split between the marsupial (Metatheria) and placental

(Eutheria) lines occurred around 170 MYA. Below is a simplified version of the phylogenic relationship as seen by Wyss (2001):