Title: Hind-limb form and function in terrestrial and semi-aquatic mammals: insights into locomotor evolution of early cetaceans

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Introduction: Modern cetaceans (whales, dolphins, and porpoises) are among several other mammalian groups that re-invaded aquatic habitats approximately 52 million years ago. The fossil record indicates that their earliest ancestors were terrestrial mammals suited for life and locomotion (preferred method of movement) on land. For instance, while cetaceans today lack any external hind limbs, early cetaceans had functional hind limbs that assisted them in swimming. However, limb-dominated swimming is a form of drag-based propulsion in which the organism draws the limb backwards to generate a forward thrust. When the organism repositions the limb for the next paddle, no forward thrust is created. This is less efficient than lift-based methods of swimming. In lift-based propulsion the organism moves its body or tail up and down and forward thrust is constantly created. This ultimately saves more energy during swimming. Modern cetaceans utilize lift-based propulsion through caudal oscillation, or the vertical movements of their tails. Due to the expansion of the fossil record, we can study the hind limbs of early cetaceans to understand this transition from limb-dominated swimming to tail-dominated swimming.

Methods: To understand what the skeletal morphology looks like in mammals across different locomotion types, we borrowed skeletal specimens of modern mammals from the University of Michigan Museum of Zoology. Additional visits to University of Michigan and the National Museum of Natural History provided more data from specimens that could not be taken back to Calvin's campus. Specimens were chosen from a host of locomotion types: some mammals like deer and coyotes move by walking or running on land, some like otters are at home both on land and in the water, and yet others like seals are highly specialized for aquatic environments. After measuring the various features of each hip and femur, multivariate analyses were performed using a statistical program (R). After these initial analyses, we visited University of Michigan and Northeast Ohio Medical University to collect measurements from fossil cetaceans. Their data was added and analyzed alongside the modern mammal specimens to understand how they are changing as they are becoming more evolved for aquatic life.

Results to date: The exact biomechanical implications of our results are still being determined, but our analyses indicate that as the fossil cetaceans became more derived, the relative length of their ilium is becoming longer. This may indicate that the gluteal muscles (which attach to the ilium) may be changing and playing a different role in locomotion in later cetaceans.

Personal Impact: I have grown immensely during my time as a research assistant, both in my professional and my personal life. Through this experience, I have developed skills that will help me in graduate school and a future career as a scientist, such as understanding the methods of research and becoming familiar with statistical techniques for data analysis. I have also had the opportunity to foster my passion for the natural world, as well as the opportunity to deepen my appreciation of God's creation.