Stockton Researchers Move One Step Closer to Understanding Movement of Early Mammals Using 3-D Imaging Technology

Unified Science Center Expansion to House One of the Only Undergraduate-Focused XROMM Labs in the World

For Immediate Release; Link to animation and photo

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Galloway, NJ - The fossil record preserves the skeletal structures and last steps of Earth's past inhabitants, but with 3-D imaging, Stockton University faculty and students are one step closer to understanding the movement of the earliest small mammals to walk the planet.

Matthew Bonnan, associate professor of Biology, Jason Shulman, assistant professor of Physics, Mary Wilkes, adjunct instructor of Biology, Radha Varadharajan, a graduate, and Corey Gilbert, a senior, all of Stockton, collaborated with Angela Horner, of California State University, San Bernardino, and Elizabeth Brainerd, of Brown University, to write an academic paper, "Forelimb Kinematics of Rats Using XROMM, with Implications for Small Eutherians and Their Fossil Relatives," published this month in PLOS ONE. PLOS ONE is the world's first multidisciplinary, open access journal for scientific research.

Studying rat movement helps researchers understand how our earliest relatives moved. The forelimb skeletons of modern day rats are strikingly similar to those of the earliest mammals (referred to as eutherians), and therefore, researchers have theorized that a similar range of movement would be probable.

"Both mammals and dinosaurs evolved from a common ancestor with a low-slung, sprawled posture, somewhat like when you do a push-up. The rats are helping us see one end-point in the transition from a sprawled to a more erect posture in mammals," said Bonnan.

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The research team discovered that the humerus (upper arm bone) and radius (the forearm bone that aligns with your thumb) bones of rats can rotate on their long axes in non-trivial ways that are important to limb posture.

Paleontologists can determine behaviors of fossil vertebrates by looking at skeletal shape, but when math, physics and technology are employed, motion can be modeled.

This research represents “the first time the bone movements in the arms of rats have been visualized in three dimensions, and it sheds some light on early mammal evolution,” explained Bonnan.

A thorough understanding of modern rat movement through scientific visualization can help us recreate movement in extinct, fossil specimens.

Their research used X-ray movie cameras, known as high-speed video fluoroscopes, and a veterinary CT-scanner. Two sets of data were collected, digitized and then blended together. First, rats walked along a plank as two fluoroscopes captured X-ray movies at 250 images per second. Then, exact three-dimensional models of the rats’ limb bones were created using a CT-scanner. To connect the data, animation software was used to overlay the CT-scan models on top of the X-ray movies frame by frame. Watch a sample movie here.

“This sort of research naturally lends itself to collaboration. You can’t understand all of this on your own, and it takes a team to make it possible. This is a lesson we are trying to impart to our undergraduates,” said Bonnan.

“The lines between disciplines are blurred. The next generation of scientists will need expertise in multiple fields. This project allows our students to take steps in that direction,” said Jason Shulman.

The 3-D imaging technique is called XROMM (X-ray Reconstruction of Moving Morphology), and was developed at Brown University in 2006 to visualize rapid skeletal movement in living creatures.

Bonnan and Shulman have now brought XROMM to Stockton, so that more students can learn on state-of-the-art technology in-house. Stockton’s Unified Science Center expansion will house a custom-built XROMM laboratory, one of the only undergraduate-focused XROMM labs in the world. The equipment and laboratory were made possible by an Equipment Leasing Fund (ELF) state grant awarded to the School of Natural Sciences and Mathematics in 2013, through the efforts of Justine Ciraolo, director of Academic Laboratories and Field Facilities.

The XROMM animations show how the bones move in three-dimensional space and allow the researchers to calculate the range of movements capable at each joint.

Previous research has hypothesized that early small mammals could move on the ground and were adapted to climbing. The new paper provides further evidence supporting this hypothesis. “These sorts of insights are helpful in [narrowing down] when particular locomotor behaviors and movements became possible and how that might have affected mammalian evolution,” said Bonnan.

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"Now, Jason and I will be turning our attention to lizards which approximate the early common ancestor of mammals and dinosaurs. Ultimately, since fossil bone shapes are like data capsules from the past about animal movement, the goal is to apply what we find out in the living animals to resurrect movement in the fossils," he explained.

Bonnan is a zoologist and anatomist, and since he was 5 years old, he has been fascinated by the thrill of reconstructing long-dead animals, specifically dinosaurs, by breathing life into old bones. He recently published a book, "The Bare Bones: An Unconventional Evolutionary History of the Skeleton (Life of the Past)."

Follow the team's research on Bonnan's blog, The Evolving Paleontologist.

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