ANP 305 Spring 2015

Earth & Life Through Time:

Vertebrate Paleontology and Paleoecology in the Turkana Basin

Vertebrate fossils are important sources of information about the appearance, evolution, and extinction of major organisms. As such, they provide a valuable window into changes in climate and selection pressures, and organisms' diverse adaptive responses to these changes. They are also significant in placing hominid discoveries within a relative local chronology, and helping reconstruct environments associated with hominid finds. This course acquaints students with methods of vertebrate paleontology employed in different chronological contexts of the Turkana Basin, used to solve diverse theoretical questions.

The Turkana Basin is famous for its fossil hominids, but it also has one of the best records of vertebrate evolution in Africa. Turkana contains sites dating to the late Cretaceous, and through the late Oligocene to the present. In this class, students learn about the history of life through time, and the evolution of the major groups of vertebrates, with an emphasis on mammals and their evolutionary history in the Cenozoic of eastern Africa. Students also learn about the main methods of paleoecological and paleoenvironmental reconstruction.

Lab exercises will be organized that teach the students to understand the immense time life has existed on earth and the major stages of life's history. Students will be given a brief illustration in the field of how fossils come to be formed and what decides their preservation and distribution. They will be taught the key features that distinguish the various groups that dominate the animal kingdom. They will also be given exercises that demonstrate how features that define an animal's diet or locomotion may be measured and analyzed.

In the field the students will be taught the various methods of discovery and collection. They will be taught protocols that should be strictly followed when collecting their own fossils. They will later identify the fossils they have collected using different methods (transects, hill crawls, screening), and will write a short report of their findings. In the lab they will learn preparation techniques and how to prepare and reconstruct the fossils they have collected. Through these hands on exercises they will learn to identify the fossils they find and to recognize the various skeletal parts and taxonomically significant features.

Instructor: Dr. Mikael Fortelius mikael.fortelius@helsinki.fi
Office & Phone: Univ. of Helsinki, PO Box 64, FIN-00014, Finland
+358-9-191-508-37
Will be generally available to students for office hours during the module.

Teaching Assistants: There will be one graduate student TA and one undergraduate student TA available at the facility for the duration of the semester.

Class Meetings: Monday - Saturday, 8:00 am - 12:00 pm, and 2:30 - 5:30 pm

Text: There is no assigned textbook for this course; assigned readings will be given digitally to the students at the beginning of the course. The readings will be useful for clarifying concepts discussed in class and for supplying additional examples from those presented in lecture. Students will find that reading the material before attending lecture will make the lecture easier to follow. Other documents, review sheets, class announcements, etc, will be downloadable from the class Blackboard site (https://blackboard.stonybrook.edu).

COURSE LEARNING OBJECTIVES

The objectives of this course are to teach you to:

- Understand the application of the scientific method (i.e., how to construct and test a hypothesis).
- Be able to summarize and describe simple quantitative and qualitative observations and react to such observations critically
- Understand the nature of the fossil record and the geologic context of fossils.
- Understand the evidence for vertebrate evolution.
- Understand the biology, ecology and behavior of a number of extinct and living vertebrates.
- Understand how the biology, ecology and behavior of extinct species is reconstructed.
- Begin to develop skills needed to be a critical consumer and ultimately user of the primary scientific literature (e.g., access and use Web of Science, critical consumption of online information).
- Be able to discuss critical events and ongoing issues in vertebrate evolution.

This course satisfies the following requirements of the **DEC**:
Category E- Natural Sciences

This course satisfies the following requirements of the **SBC**:
Study the Natural World (SNW):

1. Understand the methods scientists use to explore natural phenomena including observation, hypothesis development, measurement and data collection, experimentation, and evaluation of evidence.
2. Understand the natural world and the major principles and concepts that form the basis of knowledge in the natural sciences.
3. Assess scientific information and understand the application of scientific data, concepts, and models in the natural sciences.
4. Make informed decisions on contemporary issues involving scientific information.

-In this class, via field practicals and lab experiments (see details below), students will have hands-on practice with the methods scientists use to explore natural phenomena, will gain

direct understanding of the natural world and the major principles and concepts that form the basis of knowledge in the natural sciences, learn how to Assess scientific information and understand the application of scientific data, concepts, and models, such that at the end of the module they will be able to make informed decisions on contemporary issues involving scientific information.

PREREQUISITES

This course is part of a 5-course themed cluster (field school) and there are no prerequisites except permission from the instructor and/or study abroad office. Lectures will cover the basic concepts that are required to understand the material. A science background is not necessary for the successful completion of the course.

COURSE REQUIREMENTS

Students will carry out a research project based on a topic chosen by the student, based either on published literature or on materials available locally. The project will be presented to the class and will be followed by questions and a brief discussion of the topic. Presentations will be in groups of two and each student will have about 10 minutes with 5 minutes for class discussion and questions.

Grading:

-Participation	10%
-Student presentations	30%
-Exam A	30%
-Exam B	30%

COURSE POLICES

Classroom etiquette:

While students are in class, they are expected to give their full attention to the lecture. Reading, talking, eating, texting or browsing on cell phones, leaving or packing up to leave before the professor has dismissed the class are inappropriate classroom behaviors and disruptive to other students. Also, please make sure that your watch alarms, pagers, and cell phones do not go off during class.

Attendance and preparation of assignments:

Students are expected to attend all classes; if you expect to miss one or two classes, please email your TA, who will inform to me. Unexcused absences will lower your grade. Computer glitches (such as computers that die, hard disks that crash, flash drives that are lost, etc) will not be accepted as excuses for failure to do assignments on time, to study for exams, etc.

Policy Regarding Missed Exams:

Generally, makeup examinations are not given (and the score for the missed exam is entered as zero "0"). If you would like to be considered for a makeup examination, the following conditions must be met: 1. You should have a legitimate excuse for having missed the original exam, e.g., illness, family emergency. 2. You must inform me within 48 hrs before or after the scheduled exam date that you cannot take the exam. If the above conditions apply, then you will be allowed to do a makeup exam.

Americans with Disabilities Act:
If you have a physical, psychiatric/emotional, medical or learning disability that may impact on your ability to carry out assigned course work, please contact the Disability Support Services office in the Educational Communications Center (ECC) Building, room 128 (632-6748). DSS will review your concerns and determine, with you, what accommodations are necessary and appropriate. All information and documentation of disability is confidential.

Academic Integrity:
Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at http://www.stonybrook.edu/uaa/academicjudiciary/

Critical Incident Management:
Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures.

Syllabus

Day 1- Introduction
Morning: Earth and its inhabitants - historical sketch of Earth science and paleontology
Afternoon: *Lab* - A first look at fossils. What do we know now, before we've started?

Day 2- History of Life, Evolution and Extinction
Morning: A Brief Outline of Life on Earth
Afternoon: *Practical* – A hillside taphonomy experiment

Day 3- Studying Fossils
Morning: How old is it, where did it live, what was it like?
Lab- A make-it-yourself timeline
Afternoon: History of Paleontology in the Turkana Basin (M. Leakey)

Day 4- Finding and studying fossils
Morning: *Field* excursion at South Turkwel
Afternoon: *Lab*- Identification and study of collected material

Day 5- Faunal Turnover
Morning: The extinction and origin of species

Afternoon: *Lab* - functional and comparative anatomy of fish, crocs, dinosaurs, birds, and especially mammals. Discussion and assignment of student projects

Day 6- EXAM I
Morning: Study time
Afternoon: Exam

Day 7- Rest Day

Day 8- Vertebrates Through Time I
Morning: Palaeozoic Vertebrates and Environments
Afternoon: Mesozoic Vertebrates and Environments

Day 9- Vertebrates Through Time II
Morning: Cenozoic Vertebrates and Environments
Afternoon: *Lab* - hands-on ecometrics of mammal teeth and limbs

Day 10- Field Trip
Morning & Afternoon: participation in real field work routines including recording data, and different methods of locating fossils (surface survey, transects, hill crawls and screening)

Day 11- Paleodiet
Morning: Reconstructing the Diets and Environments of Fossil Mammals
Afternoon: *Lab* - paleodiet reconstruction using mesowear

Day 12- Summing Up
Morning: Presentation of Projects
Afternoon: A second look at fossils. What do we know now, after the course?

Day 13- Exam II
Morning: Study time
Afternoon: Exam

Day 14- Class Over: Rest Day Before Next Module

Readings

Readings for individual lectures will be distributed as PDFs/photocopies before or at the beginning of the module. Students are expected to have read the papers before the day that topic is covered and come prepared with questions for discussion sessions.

Day 1-
Martin J. S. Rudwick. 1985. *The Meaning of Fossils*. University of Chicago Press.

Day 2-

Shubin, N. 2009. *Your inner fish: A journey into the 3.5 billion year history of the human body*. Vintage Books New York. Chapters:

Benton, M.J. & Twitchett, R.J. 2003. How to kill (almost) all life: the end-Permian extinction event. *TRENDS in Ecology and Evolution* 18:358-365.

Shipman, P. 1981. *The Life History of a Fossil*. Harvard University Press, Cambridge. Chapters: 2 – Why do bones and teeth become fossils? 3 – Geological setting and sedimentary environments. – 4. Spatial distribution of fossils in sediments.

Day 3-

Heikinheimo, H., Eronen, J. T., Sennikov, A., Preston, C., Oikarinen, E., Uotila, P., Mannila, H. & Fortelius, M. 2012. Convergence in the distribution patterns of Europe's plants and mammals is due to environmental forcing. *Journal of Biogeography* 39:1633-1644.

Brown, F.B., McDougall I. 2011. Geochronology of the Turkana Depression of Northern Kenya and Southern Ethiopia. *Evolutionary Anthropology* 20:217-227

Harris, J. M., M. G. Leakey, and F. H. Brown. 2006. A brief history of research at Koobi Fora, northern Kenya. *Ethnohistory* 53:35-69.

Day 4-

Walker, Rikki. 1985. *Guide to the postcranial bones of East Africa*. Norwich Pubs., UK.

Ungar, P.S. 2010. *Mammal Teeth: Origin, Evolution, and Diversity*. Johns Hopkins University Press, Baltimore. Chapters:

Leakey, MG et al. n.d. *Field protocol for fossil prospecting, documentation, collection, and curation*. Manuscript on file at TBI.

Biewener, AA. 1990. Biomechanics of terrestrial locomotion. *Science* 250: 1097-1103.

Day 5-

Jablonski, D. 2008. Extinction and the spatial dynamics of biodiversity. *PNAS* 105:11528-11535.

Jernvall, J. and M. Fortelius. 2004. Maintenance of trophic structure in fossil mammal communities: site occupancy and taxon resilience. *The American Naturalist* 164: 614-624.

Behrensmeyer, AK, Todd, NE, Potts, R & McBrinn, GE. 1997. Late Pliocene faunal turnover in the Turkana Basin, Kenya and Ethiopia. *Science* 278: 1589-1584.

Bobe, R, Behrensmeyer, AK & Chapman, R. 2002. Faunal change, environmental variability and late Pliocene hominin evolution. *Journal of Human Evolution* 42:475-497.

Day 8-

Benton, M.J. 2000. *Vertebrate Palaeontology*. Blackwell, Oxford. Relevant chapters include: 4 – The early tetrapods and amphibians. 5 – The evolution of early amniotes. 8 – The age of dinosaurs. 9 – The birds. 10 – The mammals.

Days 9 -

Blois, J.L. & Hadley, E.A. 2009. Mammalian response to Cenozoic climate change. *Annual Reviews of Earth and Planetary Science* 37:8.1-8.28.

Feakin, S.J., DeMenocal, P.B. Global and regional climate during the Cenozoic. In L. Werdelin & W. Sanders (eds.), *Cenozoic Mammals of Africa*, Chapter 4, pp 45-55. California University Press.

Fortelius, M., L. Werdelin. P. Andrews, R. L. Bernor, A. Gentry, L. Humphrey, W. Mittmann and S. Viranta. 1996. Provinciality, diversity, turnover and paleoecology in land mammal faunas of the later Miocene of western Eurasia. Pp. 414-448 in R. Bernor, V. Fahlbusch & W. Mittmann (eds.), *The Evolution of Western Eurasian Neogene Mammal Faunas*. Columbia University Press, New York.

Leakey, M.G., Grossman, A., Guitierrez, M., Fleagle, J.G. 2011. Faunal Change in the Turkana basin during the Late Oligocene and Miocene. *Evolutionary Anthropology* 20:238-253.

Leakey, MG, Feibel, CS, Bernor, RL, Harris, JM, Cerling, TE, Stewart, KM, Storrs, GW, Walker, A, Werdelin, L. & Winkler, A. 1996. Lothagam: A record of faunal change in the Late Miocene of East Africa. J*ournal of Vertebrate Paleontology* 16 (3): 556-570.

Bibi, F., Souron, A., Bocherens, H., Uno, K., & Boisserie, J.-R. 2013. Ecological change in the lower Omo Valley around 2.8 Ma. *Biol. Lett.* 9 (online). doi: 10.1098/rsbl.2012.0890.

Barnosky, A.D. 2008. Megafauna biomass tradeoff as a driver of Quaternary and future extinctions. *PNAS* 105:11543-11548.

Day 10-

Leakey, MG et al. n.d. *Field protocol for fossil prospecting, documentation, collection, and curation*. Manuscript on file at TBI.

Day 11-

Bobe, R. 2011. Fossil Mammals and Paleoenvironments in the Omo Turkana Basin. *Evolutionary Anthropology* 20:254-263

Cerling, T.E., Levin, N.E., and Passey, B.H. 2011. Stable Isotope Ecology in the Omo Turkana Basin. *Evolutionary Anthropology* 20:228-237.

Uno, K.T., Cerling, T.E., Harris, J.M., Kunimatsu, Y., Leakey, M.G., Nakatsuka, M., Hideo Nakaya, H. 2011. Late carbon isotope record of differential diet change among East African herbivores. *PNAS* 108, 6509-6514.

Fortelius, M. and Solounias, N. 2000. Functional characterization of ungulate molars using the abrasion-attrition wear gradient: a new method for reconstructing paleodiets. *Am. Mus. Novitates*. 3301:1-36.

Fortelius, M., J. T. Eronen, J. Jernvall, L. Liu, D. Pushkina, J. Rinne, A. Tesakov, I. A. Vislobokova, Z. Zhang, and L. Zhou. 2002. Fossil Mammals Resolve Regional Patterns of Eurasian Climate Change During 20 Million Years. *Evolutionary Ecology Research* 4: 1005-1016.

Eronen, J. T., M. Mirzaie Ataabadi, A. Micheels, A. Karme, R. L. Bernor, and M. Fortelius. 2009. Distribution history and climatic controls of the Late Miocene Pikermian chronofauna. *PNAS* 106 (29):11867–11871.

Mihlbachler, M.C. et al. 2011. Dietary Change and Evolution of Horses in North America. *Science* 331, 1178-1181.

Suggested General Readings and Reference:

Agustí, J. and Antón, M. 2002. *Mammoths, Sabertooths, and Hominids: 65 Million Years of Mammalian Evolution in Europe*. Columbia University Press, New York.

Alroy, J., et al. 2008. Phanerozoic trends in the global diversity of marine invertebrates. *Science* 321, 97– 100.

Barnosky, A.D. et al., 2011. Has the Earth's sixth mass extinction already arrived? *Nature* 471:51-57.

Barnosky, A.D. et al., 2012. Approaching a state shift in Earth's biosphere. *Nature* 486:52-58.

Benton, M.J. 2000. *Vertebrate Palaeontology*. Blackwell, Oxford.

Benton, M.J. 2010. The origins of modern biodiversity on land. *Philosophical Transactions of the Royal Society, Series B* 365, 3667-3679.

Bernor, R.L.B, V. Fahlbusch & W. Mittmann (eds.) 1996. *The Evolution of Western Eurasian Neogene Mammal Faunas*. Columbia University Press, New York.

Gee, H. 1999. *In Search of Deep Time: Beyond the Fossil Record to a new history of life*. New York: Free Press.

Harris, J.M. (ed) 1983. *Koobi Fora Research Project, vol. 2. The fossil ungulates: Proboscidea, Perissodactyla, and Suidae*. Oxford: Clarendon Press.

Harris, J.M., Brown, F.H. and Leakey, M.G. 1988. *Stratigraphy and Paleontology of Pliocene and Pleistocene localities west of Lake Turkana, Kenya*. Contributions in Science, Natural History Museum of Los Angeles County. 399: 1-128.

Harris, J.M. (ed) 1991. *Koobi Fora Research Project, vol. 3. The fossil ungulates: geology, fossil artiodactyls, and paleoenvironments*. Oxford: Clarendon Press.

Harris, J. M. and Leakey, M. G. (eds.) 2003. *Geology and Vertebrate Paleontology of the early Pliocene site of Kanapoi, Northern Kenya*. Contributions in Science, Natural History Museum of Los Angeles County.

Imbrie J. and Imbrie K. P. 1979. *Ice Ages Solving the Mystery*. Cambridge Massachusetts and London: Harvard University Press.

Jablonski, N. and Leakey, M.G. (eds). 2008. *The fossil monkeys: Koobi Fora Research Project Volume 6*. San Francisco: California Academy of Sciences.

Leakey, M. G. and Harris, J. M. (eds.) 2003. *Lothagam the Dawn of Humanity in eastern Africa*. New York: Columbia University Press.

MacDougall, D. 2004. *Frozen Earth, the once and future story of Ice Ages*. Berkeley, London: University of California Press.

Sepkoski, J.J., Jr. 1993. Ten Years in the Library: New Data Confirm Paleontological Patterns. *Paleobiology*, Vol. 19: 43-51.

Stott, R. 2009. *The Beak of the Finch, the story of one tiny creature and history's most spectacular scientific breakthrough*. London: Faber and Faber.

Turner, A. & Antón, M. 2004. *Evolving Eden. An Illustrated Guide to the Evolution of the African Large- Mammal Fauna*. Columbia University Press, New York.

Werdelin, L. & W Sanders (eds.), 2010. *Cenozoic Mammals of Africa*. Berkeley, Los Angeles, London: California University Press.

Weiner, J. 1995. *The Beak of the Finch*. New York: Vintage Books

Wood, B. (ed). 2011. *Wiley-Blackwell Encyclopedia of Human Evolution*. Vols 1 and 2. Chichester UK: Wiley-Blackwell.