HEB118: Building the Human Body

(Research Seminar: Half Course)

Course Time: Main Course Time: Tuesday and Thursday 10:30-11:45pm EST

Course Location: MCZ541
Course Restrictions: Limited to 24 students

Course Instructor: Terence D. Capellini, Ph.D
Professor, Director of Graduate Studies
Human Evolutionary Biology
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Course Website: https://canvas.harvard.edu/courses/136881

Prerequisite: LS1b (Genetics, Genomics, and Evolution). Introductory courses in paleoanthropology or anatomy helpful, but not required.

Course Description and Goals:
Humans and our primate relatives are incredibly variable. This variation results from natural selection operating on the developmental mechanisms that control anatomy and physiology. While these mechanisms remain mostly undiscovered, we are beginning to understand these complex processes due to major advances in technology that have pushed the fields of genetics, genomics and developmental biology rapidly forward. This research-centered course explores these relationships in the context of the human paleontological record. We focus on the evolution and development of the musculoskeletal system, which includes the cranium, axial skeleton and limbs, and present studies that cast light on the developmental genetic mechanisms that underlie major transitions in human evolution.

This course is divided into several different modules, each of which focuses on different anatomical regions of the body and/or evolutionary transitions in human and primate evolution. These modules are:

-Comparative primate biology, evolution, and developmental principles
-Developmental genetics and evolution of the human vertebral column
-Developmental genetics and evolution of the human pectoral and pelvic girdles
-Developmental genetics and evolution of the human fore and hindlimb
-Developmental genetics and evolution of the human skull

Course Format:
This is a "flipped" course. That means there will be approximately ***3 hours of live, in-class activities per week*** (1.5 hours on Tuesday and Thursday) devoted to discussions, in-depth instruction, labs, guest lectures, and team work on research projects. ***However, instructor lectures will be pre-recorded and (along with readings) should be viewed/read prior to each live class session***. Lectures and readings

will be posted at the beginning of each week. See the course schedule (below) for more detailed information and topics.

Course Requirements:
(1) Attendance is mandatory. Each student is permitted to miss two classes, after which a letter grade (10% points off of final course grade) will be deducted for every additional class missed. For students missing more than two classes due to extenuating circumstances (illness, death in the immediate family, etc.; COVID-19 restrictions), proper documentation is required (e.g., doctor's note, etc.).

(2) Since this is a seminar and laboratory course, it will involve considerable discussion and interrogation of current issues in paleontology, genetics, and developmental biology. Therefore, active participation is required and will be used to assess student performance.

(3) There will be four (4) quizzes counting for a total of 20% of the final grade (5% each). These will be conducted in class in a timed fashion (~20 minutes in length). You are not permitted to work with another person on these quizzes. These quizzes are geared towards evaluating your understanding of material covered in the lectures just prior to the quiz date. The first quiz will be conducted on Canvas, but the remaining three will be in class.

(4) There are two (2) mid-semester examinations counting for a total of 40% of the final grade (20% each). Both are examinations that you will work on outside of class time (i.e., they are take home exams). While the exams are open book, all submitted work should be your own, in your own words, and meet the standards of the Harvard College Honor Code (see https://honor.fas.harvard.edu/honor-code). No collaboration on these exams is allowed. Each exam will be due by the start of class-time on the date listed in the syllabus (about 1 week after they are initially distributed). These exams are geared towards evaluating your understanding of how developmental principles can be used to interpret evolutionary transformations in primate and human evolution. Each exam is graded on how well the student demonstrates comprehension and synthesis of the selected papers, as well as lecture and lab materials, and on how they convey this understanding in a concise, intelligible manner. Points will also be deducted for improper citation, grammar, and spelling. Completed exams should be uploaded on Canvas.

(5) There is one "Evo-Devo" assignment that will be worked on during the course of the semester. It will involve working as a team to integrate data from genetic, developmental biology, morphometric, and primate evolution. During this project, students will work together to learn toolsets important to this assignment during specific lab exercises/training sessions that have been placed in the early part of the semester. While these exercises will not be graded, they will significantly impact your Team's final Evo-Devo project, which will be graded, and so it is encouraged not to miss these sessions. The Evo-Devo assignment will be worth 40% of the final grade and will involve both a Team Presentation (10%) and a final Team Paper (30%). Details of this assignment will be covered in-class and outlined in a detailed handout entitled "HEB118 Final Evo-Devo Project". The project is due 11:59pm December 19th, 2024. The final paper should be uploaded on Canvas.

Thus, the evaluation criteria for the final course grade are as follows:

Quiz (5% each)	20%
Take Home (20% each)	40%
Final Presentation	10%
Final Paper	30%
Total	100%

Attendance: 10% off final grade per each missed class beyond two.

Grading Statement:
All assignments are graded on a sliding curve. Extra credit is not available for this course. Thus, it is imperative that the student stays on top of the reading and exercises, and that office hours are attended when necessary. Grades will be assigned as follows:
A = 90-100%; B = 80-89%; C = 70-79%; D = 60-69%; F < 60%
(with minus and plus grades assigned at appropriate cutoffs).

Late Work:
Quizzes must be completed by the assigned time in order to receive credit. Extensions of time may be requested from the course faculty for exams and written work. Such requests need to be made ***prior*** to the deadline and are at the discretion of the instructor. *Please note:* for joint research project work, requests should be made in collaboration with all team members when possible. Work submitted late without prior approval will be penalized -10% per day.

Required Readings:
While there is no required textbook for the course, there are required journal articles and textbook readings for each week. These articles are listed in the calendar portion of this syllabus and pdfs of each are downloadable from the course website. If there are issues with downloading these articles, it must be brought to the instructor's attention ahead of time. Readings should be completed before class time on the day they are listed, as they will be the subject of lecture and discussion.

Classroom and Laboratory Etiquette:
Help make this an intellectually friendly and productive environment by respecting others in the class. Along these lines:

(1) Please arrive on time and watch lectures and read all assigned materials before the start of each class.
(2) Before class begins turn off your cell phones and other computer related apps that may disrupt your or other student learning.
(3) It is important that during class session you do not text, instant message, or surf the web.
(4) Please, never interrupt someone speaking in class, so please give some time (10 seconds or so) after someone finishes speaking to make a comment.

Disabilities:
Students needing academic adjustments or accommodations because of a documented disability must present their Faculty Letter from the Accessible Education Office and speak with the instructor by the end of the second week of the term. Failure to do so may result in the instructor's inability to respond in a timely manner.

Academic Integrity:
All Harvard University policies regarding ethics and honorable behavior apply to this course. All mid-semester graded materials (quizzes, labs, examinations) must result from your sole effort. You may not work with anyone else on these assignments and use your class notes and readings to answer each question. On the other hand, for your final project, students will be encouraged to work with members of their team in both the analytical and writing portions of the project. For any take-home mid-semester examination/quiz/lab including the final project, any material or ideas obtained from other sources (e.g., information acquired from the web) must be supported by a legitimate source reference (i.e., from a peer reviewed article or book). Plagiarism will not be tolerated; that is, the student must not appropriate the writing of others and present it without citation to a refereed academic source. With that in mind, the student also cannot simply regurgitate ideas espoused by others, but must generate theses that are innovative, novel, and reflect the synthesis of ideas generated through learning from multiple sources. For more information on plagiarism follow the rules and guidelines found in the Student Handbook at http://handbook.fas.harvard.edu/icb/icb.do. If deemed necessary, student material can be checked for plagiarism on www.turnitin.com. Students violating these simple policies will receive a failing course grade and the issue will be forwarded to the Harvard College Honor Council for further inquiry.

Use of Artificial Intelligence:
We expect that all work students submit for this course will be their own. In instances when collaborative work is assigned, we expect for the assignment to list all team members who participated. We specifically forbid the use of ChatGPT or any other generative artificial intelligence (AI) tools at all stages of the work process, including preliminary ones. Violations of this policy will be considered academic misconduct. We draw your attention to the fact that different classes at Harvard could implement different AI policies, and it is the student's responsibility to conform to expectations for each course.

Computer Resources:
During the course, there may be training sessions involving the use genomic databases/browsers and potentially the Geneious software. The instructor will go through training sessions teaching each student how to download and use relevant software. For students desiring to perform their own genomic level analyses, access and server space will be provided. Each student will be instructed on setting up a UCSC session during the genome browser tutorial portion of this course.

If needed, please download a copy of the Geneious Software by following these steps:
(1) The software is actually downloaded directly from Geneious (www.geneious.com)
(2) After installation is complete, select "use license server"
(3) Specify server name as: rclic1.rc.fas.harvard.edu
(4) Specify port: 27004
You will also need to have a VPN connection to use Geneious. Please let me know if you are having difficulty downloading this software.

Resource Websites and Browsers:
Keeping track of genomes:
http://genomesonline.org/cgi-bin/GOLD/index.cgi

1000 genomes project website: http://www.1000genomes.org/

Blast: http://blast.ncbi.nlm.nih.gov/Blast.cgi

http://blast.ncbi.nlm.nih.gov/Blast.cgi?PROGRAM=blastn&BLAST_SPEC=TraceArchive&PAGE_TYPE=BlastSearch&PROG_DEFAULTS=on

CMS browser (selection): http://www.broadinstitute.org/mpg/cmsviewer/

ENCODE: https://genome.ucsc.edu/ENCODE/
http://www.genome.gov/10005107
http://www.encodeproject.org/ENCODE

Mouse ENCODE: http://www.mouseencode.org

Ensembl: http://www.ensembl.org/index.html

Epigenomics Roadmap: http://www.roadmapepigenomics.org/data

HGP website: http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml

HGDP Selection Browser: http://hgdp.uchicago.edu/cgi-bin/gbrowse/HGDP/

HAPMAP: http://hapmap.ncbi.nlm.nih.gov/

HaploReg: http://www.broadinstitute.org/mammals/haploreg/haploreg.php

Haplotter: http://haplotter.uchicago.edu/

UCSC Genome Browsers:
Main - https://genome.ucsc.edu/
Test - http://genome-test.cse.ucsc.edu/

UNIPROBE (TF predictions): http://the_brain.bwh.harvard.edu/uniprobe/

Vista Alignment: http://genome.lbl.gov/vista/index.shtml

Vista Enhancer Browser: http://enhancer.lbl.gov/

Additional software resources from lab/company pages:
http://pritchardlab.stanford.edu/software.html
http://kingsley.stanford.edu/Lab_Protocols.html
http://bejerano.stanford.edu/resources.html
http://web.mit.edu/manoli/
http://bustamantelab.stanford.edu/software.html
http://giladlab.uchicago.edu/Data.html
http://132.239.197.19/bli/mouse/hi-c/index.html
http://www.sanger.ac.uk/resources/software/genevar/
http://www.hsph.harvard.edu/liming-liang/software/eqtl/
http://www.ncbi.nlm.nih.gov/pubmed/22693428

Course Schedule:

Date	In class activity (Live)	Preparatory Lectures/Readings	Assignments	Instructor
9/3 (Tu)	Introduction	*Lectures:* -HEB118 2024 Introduction to Course Part I Presentation -HEB118 2024 Introduction to Course Part II Presentation *Reading:* Willmore		TC
9/5 (Th)	Bone Lab	Lecture: -HEB118 2024 Bone Biology Presentation Reading: Shipman, p18-49		GS
9/10 (Tu)	In-depth demonstration	*Lectures*: -HEB118 2024 Developmental Biology Part I Presentation -HEB118 2024 Developmental Biology Part II Presentation *Reading:* Gilbert, p5-29		TC
9/12 (Th)	Primates	**IN-CLASS**: Guest Lecture: Zarin Machanda: Introduction to Primates *Reading:* Fleagle, p11-45		ZM

9/17 (Tu)	Human evolution lab	*Lecture:* -HEB118 2024 Human Evolution Presentation *Reading:* Wood, p58-99		TC
9/19 (Th)	UCSC Browser tutorial	*Lecture:* -HEB118 2024 Developmental Genetics Part 1 Presentation *Reading:* Carroll; Kingsley	Quiz #1 (In Class; 25 minutes)	TC
9/24 (Tu)	In-depth demonstration	*Lecture:* -HEB118 2024 Developmental Genetics Part II Presentation *Reading:* Arthur, p34-53, 218-233		TC
9/26 (Th)	Vertebral lab	*Lecture:* -HEB118 2024 Vertebral Column Anatomy Presentation *Reading:* Langdon, p77-87	Exam 1 distributed (through 9/24)	TC

10/1 (Tu)	In-depth demonstration	*Lecture*: --HEB118 2024 Vertebral Column Development Presentation *Reading:* Pilbeam; Gilbert, p309-331, 415-436		TC
10/3 (Th)	Girdle lab	*Lecture:* -HEB118 2024 Girdle Anatomy Presentation *Reading:* Young (2 papers)	Exam #1 due before class	TC
10/8 (Tu)	In-depth demonstration	*Lecture:* -HEB118 2024 Girdle Development Presentation *Reading:* Lovejoy; Gilbert, p415-436, Capellini (2 pap.)		TC
10/10 (Th)	Evo-Devo discussion	*Reading:* Pilbeam; Rolian Tour of the MCZ with Mark Omura at 11am	Quiz #2 (from 9/19 through 10/8) (IN-CLASS)	GS

10/15 (Tu)	Final project discussion	No readings or presentations 10:30 Visit from Loring Burgess, Peabody Museum Collections		TC
10/17 (Th)	Limb lab	*Lecture:* -HEB118 2024 Limb Anatomy Presentation *Reading:* Langdon, p88-115		TC
10/22 (Tu)	In-depth demonstration	*Lecture:* -HEB118 2024 Limb Development Presentation *Reading:* Gilbert, p489-518		TC
10/24 (Th)	Evo-Devo discussion	*Reading:* Young; Reno	Quiz #3 (from 10/10 through 10/22) (IN CLASS) Exam #2 distributed (From 9/26 through 10/24)	TC

10/29 (Tu)	Project advising	No readings or presentations		TC
10/31 (Th)	Skull lab	*Lecture:* -HEB118 2024 Skull Anatomy Presentation *Reading:* Langdon, p50-65	Exam #2 due before class	TC
11/5 (Tu)	In-depth demonstration	*Lecture:* -HEB118 2024 Skull Development Presentation *Reading:* Gilbert, p379-391		TC
11/7 (Th)	Project advising	No readings or presentations	Quiz #4 (From 10/29 through 11/5) (IN CLASS)	TC

11/12 (Tu)	Project advising	No readings or presentations		TC
11/14 (Th)	Project advising	No readings or presentations		TC
11/19 (Tu)	Collaborative work	No readings or presentations		TC
11/21 (Th)	Collaborative work	No readings or presentations		TC

11/26 (Tu)	Collaborative work				TC
11/28 (Th)	*Thanksgiving – No Class*	No Class		No Class	
12/3 (Tu)	Final Presentations	Final Presentations		Students	
12/19 (Thursday)	Final Paper DUE	Final Paper Due	Final paper	Due:11:59pm	
