ARCHAEOLOGICAL SCIENCE

Spring 2010 Monday 7-10 pm MIT Room 4-370
[at MIT: 3.985J/ 5.24J/ 12.011J 3-1-5]

Professor Heather Lechtman and CMRAE faculty

This subject introduces some of the pressing issues archaeology recognizes and deals with as an anthropological science. It stresses the natural science and engineering methods archaeologists use in tackling such problems and how those methods have become part of the archaeological tool kit. Like all CMRAE subjects, this one takes its strength from the blending of archaeology and state-of-the-art science/engineering. We will rely heavily on the presentation of case studies to anchor anthropological context while developing rigorous discussion of pertinent science and engineering approaches.

The subject is organized in two units, each of which represents a major focus of research and high profile issues in the modern field of archaeological science: environmental studies and material culture studies. Unit 1, Reconstructing Time, Place, and Human Ecologies in Prehistory, takes a closer look at the natural environment in which people lived and the ecologies of human-environmental interactions. Unit 2, Ancient Technologies: Transforming Materials of Nature to Items of Material Culture, focuses on the material products of human activities, the artifacts that provide our primary data about past societies and cultures.

The faculty, all specialists in their subjects, are active members of the Center for Materials Research in Archaeology and Ethnology (CMRAE). Heather Lechtman coordinates the subject and will present an introduction at the beginning of each class meeting, to provide continuity between topics and units.

Class Format

Each week the instructor will lecture during the first half of the three-hour session. After a mid-session break, we will continue with the presentation and class discussion. Laboratory demonstrations or visits to CMRAE facilities are scheduled occasionally.

Reading Assignments

The syllabus for this subject, the weekly reading assignments, and all other items relevant to the class will be online for students at the STELLAR website for this subject (no. 3.985 at MIT)

To access the website:

Use GOOGLE or any other search engine. Type in www.mit.edu. This will take you to the MIT home page.

On the home page, type in STELLAR; go to STELLAR class sites; go to Materials Science and Engineering (Course 3); go to 3.985.

Once you are at the 3.985 website, click on Materials. This will bring you to a list of items, including the class syllabus, study questions, weekly reading assignments, etc.

Before any lecture, the instructor presenting the lecture will provide a set of Study Questions that are meant to guide you in the reading the instructor has assigned in advance of her/his lecture. All the assigned reading for that lecture will be available in a section of the 3.985 website labeled by the date and instructor.

Examinations and quizzes

There will be two examinations: one at the end of Unit 1 and another at the end of Unit 2. Both are take home examinations. We will also give students five short in-class quizzes during the semester, based on assigned reading and class lectures. The schedule of examinations and quizzes is given on page 9 of the Syllabus.

SYLLABUS

UNIT 1 **RECONSTRUCTING TIME, PLACE, AND HUMAN ECOLOGIES IN PREHISTORY**

Week 1 **Introduction to the Science of Archaeology**
8 Feb.

Instructor: Professor Heather Lechtman, MIT

Week 2 **PRESIDENTS' DAY HOLIDAY**
15 Feb.

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Week 3 22 Feb. **Human Paleoecology and Understanding Past Human-Environment Interactions**

Themes/issues: Basic definitions of and distinctions between ecology, ecosystems, environments, and climates. Paleoecological approaches to reconstructing past ecosystems and human landscapes from archaeological contexts and a range of proxy data from the natural world. Environmental change and human response to short-term stress and longer-term variation in climate and resource availability. Paleodiet and subsistence practices. Potential application of knowledge of ecological crises of the past -- their causes, duration, and effects -- to modern ecological challenges. This approach emphasizes the unique ability of archaeological science to extract information from a broad range of material remains, while also examining human agency in the past and the archaeologist's interpretive process.

Scientific/engineering principles & methods: A wide range of approaches and materials will be discussed. Isotopic ratios include $^{16}O/^{18}O$ in ice and deep-sea cores to determine long-term climate patterns, and carbon isotope ratios to identify C_3, C_4, and CAM plants and their implications for agriculture and other forms of human exploitation of plant communities. Plants (pollen, wood, floral macrofossils, phytoliths, diatoms) and animals (invertebrate shells and vertebrate bones) provide clues to past environments and human activities. Geological materials (rocks, soils, sediments) indicate landscape change through tectonics, climate, and other forces. Case studies highlight the possibilities of integrating environmental and cultural data, as well as the challenges of establishing causality and contemporaneity in these data sets.

Case studies to be presented: Reconstructing ancient Maya maize agriculture from stable carbon isotope signatures; long-term cultural responses to changing climatic conditions in central Eurasia; mobility and abandonment under environmental stress among the Pueblo of the Southwestern United States; recovering a lost ecosystem in Croatia; the role of archaeology in current debates on ecology, conservation, and climate change.

Instructor: Professor Thomas Tartaron, University of Pennsylvania

Week 4 1 Mar. **Application of Remote Sensing Shallow Geophysics to Settlement Pattern Studies**

Theme/issues: How archaeologists understand past landscapes. Various site discovery methods will be explored for use in situations where preservation is good but archaeological sites are no longer visible. We will also investigate how erosion and sediment deposition can make sites difficult to detect (as well as related geoarchaeological issues). The ability to reliably identify deeply buried sites is critical to settlement pattern studies. Therefore, in this session we will explore how broad characterizations of site time and place, can give us insights into the causes and consequences of human social evolution.

Science/engineering principles & methods: Site discovery and assessment techniques introduced include marginally invasive methods such as coring, phosphate testing, and shovel tests, as well as non-destructive shallow geophysical techniques such as conductivity, resistivity, and ground penetrating radar (GPR) as well as distant platform remote sensing methods. Interpretative techniques include geoarchaeology and geographic information systems (GIS).

Case studies to be presented: Various historic and prehistoric geophysical and distant platform examples will be given with an emphisis on the settlement patterns of Viking Age Iceland from Skagafjörður.

Instructor: Dr. John Steinberg, University of Massachusetts, Boston

Week 5 8 Mar. **Organic Residue Analysis: Reconstructing the Sourcing, Production, and Trade of Ancient Organic Commodities**

Themes/issues: How archaeologists understand the complex relationships between human societies and the ecological landscapes they utilized. The use of organic residue analysis and ethnography to understand the production of ancient organic commodities. The use of a vegetative history and topography to understand the ecological sourcing of ancient organic commodities. The use of comparanda in the ancient Mediterranean to understand the nature of international exchange.

Science/engineering principles & methods: Organic residue analysis, landscape and environmental archaeology, satellite remote sensing, geographic information systems (GIS).

Case studies to be presented: Aromata production at Mochlos, Crete; the ecological relationship between Mochlos and its rural landscape; international exchange of organic commodities in the ancient Mediterranean using examples from Greece, Turkey, Israel, Egypt, and Libya.

Instructor: Dr. Andrew Koh, Tufts University

Week 6 15 Mar. **Palaeoethnobotany: What Can Plant Remains Tell Us About Past Environments and Cultures?**

Themes/issues: Plant-human relationships in the past. Reconstruction of potential vegetation, ancient diets, different aspects of plant uses, agricultural practices, and wild plant procurement.

Science/engineering principles & methods: Macro remains, pollen, phytoliths, and stable isotope analysis. Examination of deposition, preservation, and taphonomy of plant remains. Survey of systematic retrieval of samples from archaeological sites. Overview of various laboratory analyses for identification of plant remains. Summary of basic quantification methods and the interpretation of the results.

Case studies to be presented: Reconstructing diet and the environment from the Ice-man find; foodways and power relations between slaves and plantation owners in historic Virginia.

Instructors: Prof. Ksenija Borojevic, Boston University
Dr. Virginia Popper, MIT
Dr. Heather Trigg, University of Massachusetts, Boston

Week 7 22 Mar. **SPRING BREAK**

Week 8 29 Mar. **Zooarchaeology: Human-Animal Interactions through Time**

Themes/issues: Human-animal interactions through time; interpreting past environments and environmental change; human hunting behavior and the role of hunting in human evolution; the origins of domestic animals; seasonal cycles in site occupation or resource use patterns; the production, use and meaning of animals and animal products in complex societies.

Scientific/engineering principles & methods: Bone biology and growth; bone chemistry and stable isotope analysis; human and animal ecology; biometrics; taphonomy; bone density and biomechanics; experimental and actualistic studies.

Case studies to be presented: 1) Reconstructing early hominid hunting or scavenging behavior; and 2) Interpreting seasonal patterns through incremental growth studies.

Instructor: Professor David Landon, University of Massachusetts, Boston

UNIT 1 TAKE-HOME EXAMINATION DISTRIBUTED

UNIT 2 ANCIENT TECHNOLOGIES: TRANSFORMING MATERIALS OF NATURE TO ITEMS OF MATERIAL CULTURE

Week 9
5 Apr.

Battle of the Bronzes: Copper-arsenic and Copper-tin

Themes/issues: What is "bronze": metallurgists' definitions, archaeologists' definitions, technocategories suggested by the artifacts. Development and use of both alloys in Old World and New World. Archaeologists' arguments for displacement of arsenic bronze by tin bronze in the Old World: what's a better alloy – fact and fantasy. Archaeological ages and technological stages: plotting cultural evolution and social development in terms of materials technologies

Scientific/engineering principles & methods: Geological distributions of the major arsenic-bearing and tin-bearing ores; extractive metallurgy and manufacture of arsenic bronze and tin bronze; experimental smelting of Andean copper sulfarsenide ores. Comparative mechanical properties of copper-arsenic and copper-tin alloys; solid solution hardening, work hardening, hot working (forging), tensile properties, ductility

Case studies to be presented: Arsenic bronze and tin bronze in the production of silvery and golden metallic colors.

Instructor: Professor Heather Lechtman, MIT

UNIT 1 TAKE-HOME EXAMINATION DUE

Week 10
12 Apr.

Rubber Processing and Use in Ancient Mesoamerica

Themes/issues: The Mesoamerican ball game, a unifying element of all Mesoamerican cultures; the intersection of ethnohistoric, ethnographic and laboratory data to reconstruct the ancient rubber-making process; the raw materials used and their required processing – a mixture of *Castilla elastica* latex and the juice of *Ipomoea alba* morning glory vines.

Science/engineering principles & methods: Defining the behavior of rubber and polymeric materials; the chemical and mechanical properties of natural rubber and latex; how *Ipomoea alba* juice chemically alters *Castilla elastica* latex; the production of rubber with a wide array of mechanical properties – varying strength, stress/strain, toughness, fatigue, creep and wear.

Case studies to be presented: Analysis and characterization of ancient Mesoamerican rubber balls, modern processed rubber and latex; ethnographic studies of Mexican rubber processing; rubber use in the Mesoamerican ball game

Instructor: Michael Tarkanian, MIT

Week 11 19 Apr. **PATRIOTS DAY HOLIDAY**

Week 12 26 Apr **Lime Plaster: Plazas, Pavements, Masks, and Murals -- the Foundations and Failings of Maya Civilization**

Themes/issues: This lecture considers the economic, artistic, environmental, and political importance of lime plaster production among the Ancient Maya. Specific consideration is given to 1) the utility of lime plaster as a construction material and artistic medium in the lowland tropics; 2) the environmental repercussions of plaster production on a grand scale, including deforestation and wetland transformation; 3) the environmental legacy of plaster production and its use for modern settlement studies; and 4) the importance of plaster for early kings in defining and demonstrating their place in the cosmos to those they sought to rule.

Science/engineering principles & methods: Compositional analysis, experimental archaeology, remote sensing

Case studies to be presented: More than 1500 years of Maya interior and exterior plaster work are analyzed, from 7th Century BCE through to the 9th Century CE. Examples are drawn from numerous Maya sites including Nakbe, El Mirador, Tikal, and San Bartolo, Guatemala; Ek Balam, Palenque and Bonampak, Mexico; and Copan, Honduras

Instructor: Professor William Saturno, Boston University

Week 13 3 May **Monumental Glue: Reaction-based Mortars in Ancient Egypt and Rome**

Themes/issues: Monumental architecture as a metaphor for cultural assumptions. How physical constraints (raw materials, fuel availability, existing pyro- and materials technologies) and cultural expectations define choices in materials technologies. How materials technologies shape cultural assumptions and development

Science/engineering principles & methods: Hydration-, liquid-phase, and solid-state reactions; strength of materials, fracture mechanics, mechanical testing; microstructural origins of cementitious properties, microstructural analysis

Case studies to be presented: Limestone, gypsum mortars and geopolymers in Fourth Dynasty Egyptian pyramid construction; Hydraulic mortars and flowering of the concrete Roman city.

Instructor: Professor Linn Hobbs, MIT

UNIT 2 TAKE-HOME EXAMINATION DISTRIBUTED

Week 14 10 May **Materials Identification for Preservation of Museum Objects**

Themes/issues: Analytical chemistry and materials characterization play important roles in preservation and conservation of artifacts. Examples for class examination and discussion are drawn primarily from various ancient collections of the Museum of Fine Arts, Boston. Focus is on the role of analysis in understanding an object's condition (e.g. specific problems of deterioration) and in characterizing original materials that have been altered (by deterioration processes, by handling, or by previous conservation treatments)

Scientific/engineering principles & methods: Microanalytical techniques, including Fourier transform infrared microspectrometry (FTIR), gas chromatography/mass spectrometry and pyrolysis gas chromatography/mass spectrometry, and high performance liquid chromatography. Applications of these analytical tools to objects in the Museum's collections

Case studies to be presented: Projects underway in the Department of Conservation and Collections Management at the time of the class will be discussed.

Instructors: Susanne Gansicke, Associate Conservator, BMFA
Richard Newman, Head of Scientific Research, BMFA

UNIT 2 TAKE-HOME EXAMINATION DUE

EXAMINATIONS AND QUIZZES

Quiz schedule (5 quizzes)

Students will receive a set of study questions as a guide to each week's reading assignment. There will be 5 quizzes during the semester. Quiz questions will relate to study questions. Each quiz will be approximately 10 minutes long. Quizzes will be given at the beginning of class. The schedule of quizzes is given below.

Quiz #	Date	Based on readings for:
1	8 Mar.	Settlement patterns (Steinberg)
2	15 Mar.	Organic residue analysis (Koh)
3	12 Apr.	Battle of the bronzes (Lechtman)
4	26 Apr.	Rubber in ancient Mesoamerica (Tarkanian)
5	3 May	Maya lime plaster (Saturno)

Examination schedule

Unit 1 examination: This examination will include **all Unit 1 material** presented in class and in assigned readings. Take-home questions will be distributed in class at the week 8 meeting: **29 March**. **Examination papers are to be returned at the week 9 meeting: 5 April.**

Unit 2 examination: This examination will include **only Unit 2 material**, both class presentations and assigned readings. Take-home questions will be distributed in class at the week 13 meeting: **3 May**. **Examination papers are to be returned at the week 14 meeting: 10 May.**

ARCHAEOLOGICAL SCIENCE
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Spring 2010

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