General Education Foundations of Scientific Inquiry (FSI) Course Information Sheet

Please submit this sheet for each proposed course along with 1) a syllabus describing the key components of the course that will be taught regardless of the instructor and 2) assignment guidelines.

Department, Course Number, and Title MS&E, MAT SCI 33, Materials Structure and Technology in Archaeology and Architecture (MST: A2)

Indicate when the department anticipates offering this course in 2020-21 and give anticipated enrollment:
Fall: Enrollment ____ Winter: Enrollment ____ Spring: Enrollment 60-80 Summer: Enrollment 20

As stated in the guidelines regarding courses in the Foundations of Scientific Inquiry (FSI), the aim of these course offerings is:

To ensure that students gain a fundamental understanding of how scientists formulate and answer questions about the operation of both the physical and biological world. These courses also deal with some of the most important issues, developments, and methodologies in contemporary science and technology, addressing such topics as the origin of the universe, environmental degradation, and the decoding of the human genome. Through lectures, experiential learning opportunities such as laboratories, writing, and intensive discussions students consider the important roles played by the laws of physics and chemistry in society, biology, earth and environmental sciences, and astrophysics and cosmology.

General Education FSI Student Goals: Courses fulfilling the GE FSI will provide a minimum of four units and should align with some (not necessarily all) of the following seven general goals:

1. Students will actively engage in the scientific process of inquiry, analysis, problem-solving, and quantitative reasoning.
2. Students will acquire an informed appreciation of scientists, scientific research, and technology.
3. Students will experience the interdisciplinary nature of science.
4. Students will develop information literacy.
5. Students will make evidence-based decisions in a wide array of science and non-science contexts.
6. Students will develop scientific literacy by addressing current, critical issues and topics in science that are personally meaningful in daily life and/or connected to the needs of society.
7. Students will recognize fundamental scientific principles and the connections between different domains of science.

General Education FSI Student Learning Outcomes: Each course should have student learning outcomes listed in the syllabus. These outcomes may be tied to a specific discipline but should be associated with the seven broad categories listed above (please see **Appendix I** for a sample list of possible learning outcomes supporting each goal).

General Guidelines for GE FSI Courses: GE Courses may be upper or lower division, but they should have no prerequisites. Any student should be able to take them and understand the material with the background expected from all UCLA students. While the course may include material related to the history of science and the social and cultural implications of scientific research, **at least half** of the course should be devoted to students actively engaging in the scientific process of inquiry, analysis, problem-solving, and quantitative reasoning (Goal #1).

Please indicate the area/s which you believe this course should satisfy.

Life Science: ☐ Physical Science: ☑ Life Science Lab*: ☐ Physical Science Lab*: ☑

**Please see the additional student learning outcomes and expectations for courses approved as GE FSI Labs.*

The GE FSI Assessment Project Resource Team would be delighted to meet with you to assist in filling out this form. Please contact us at RRamachandran@teaching.ucla.edu if you wish to arrange a meeting.

We are interested in understanding the alignment of your course learning outcomes with the GE FSI learning goals. First, identify measurable learning outcomes from your course and enter them in the first column of Table 1. You may add more rows as needed. If you need to state new learning outcomes, see Appendix I for a sample list of possible learning outcomes supporting each goal. Should you wish to choose any of these outcomes, you may simply indicate its number, e.g., 6a. Next, indicate how your learning outcomes relate to the GE FSI learning goals 1 through 7 (see previous page), by placing X's in the appropriate boxes. Note that all GE FSI courses must address Goal #1.

Table 1: Alignment of Course Learning Outcomes with GE FSI Learning Goals

	Your Course Learning Outcomes	Select GE FSI Goal #						
		1	2	3	4	5	6	7
1	1a	✔						
2	Develop an ability to apply knowledge of science, technology,	✔	✔	✔	✔	✔	✔	✔
3	Develop an ability to design and conduct experiments, as well	✔		✔	✔			
4	Develop an ability to function in multidisciplinary teams and	✔		✔				✔
5	Develop an ability to think critically and to identify, formulate,	✔	✔	✔	✔	✔	✔	
6	Acquire knowledge of past and contemporary issues	✔				✔	✔	

Considering each of the GE FSI goals that you marked with X's in the table above, please provide information about related course activities and assignments.

Table 2: Course Activities and Assignments that Support the Learning Goals

Course Learning Outcome No. from Table 1	Course Activities How will progress towards meeting this outcome be facilitated? In other words, what types of course activities will be provided to assist students in achieving the learning goal?	Course Assignments How will students in the course demonstrate their ability to meet this goal? Please describe and provide a sample assignment, such as a term paper, exam, essay prompt, etc.
1	Students will actively engage in the scientific process of inquiry, analysis,	Through individual written paper, group presentation, discussion of scientific
2	Studying the technology and materials of archaeological objects through	Individual research paper on technological innovations of the past,
3	Through demos, hands-on activities and discussions of experimental results	Formal discussion of papers and experimental results, individual and
4	Through formal lectures learning the perspective of different scientists, group	Individual research paper, group presentation and formal discussions of
5	A combination of all course activities: formal lectures, individual and group	Individual research paper, group presentation, lab reports, formal
6	As the course focuses on ancient materials and technology, students will	Individual research paper, group presentations, site visits and formal

Please provide information on estimated weekly hours for the class.

A) STUDENT CONTACT PER WEEK (if not applicable write N/A)

Activity	Number of hours per week
Lecture	4
Discussion Section	
Labs	2
Experiential (Community-engagement, internships, other	
Field Trips	4
A) TOTAL student contact per week	10

B) OUT-OF-CLASS HOURS PER WEEK (if not applicable write N/A)

Activity	Number of hours per week
General Review and Preparation	
Reading	1
Group Projects	1
Preparation for Quizzes & Exams	
Information Literacy Exercises	
Written Assignments	2
Research Activity	1
B) TOTAL Out-of-class time per week	5

GRAND TOTAL (A) + (B) must equal at least 15 hours/week: 15 (hours)

Additional Student Learning Outcomes for experiential learning courses approved as "GE FSI Labs"

GE FSI Lab Definition and Expectations: A hands-on laboratory, computer simulation, demonstration, or field experience that involves active participation in experimental observation, data generation and collection using the techniques, methodologies, and approaches of modern-day scientists. Any lab should be conducted under sufficient supervision by the instructor or a Teaching Assistant (TA). Furthermore, the instructor and TAs should meet regularly outside of class time (minimum weekly or biweekly) to practice performing the lab procedures and/or to review the experimental results.

Please <u>select one or more</u> of the following learning outcomes for your course (select all that apply):

■ 1. Students will design, implement, and evaluate an experimental strategy for answering scientific questions, testing a hypothesis, or solving a problem.

■ 2. When possible, students will replicate experiments to allow testing for and interpretation of statistical significance.

■ 3. Students will apply commonly used mathematical concepts and statistical methods (e.g., basic addition, subtraction, multiplication, division, averages, standard deviation, t-test for significance) in their analysis of different types of scientific data they collect.

■ 4. Students will be able to visually depict a quantitative dataset as a chart, graph, table, or mathematical equation.

■ 5. Students will be able to concisely summarize trends and patterns deduced from quantitative and qualitative data to make informed conclusions about their experimental results.

■ 6. When interpreting their results, students will distinguish between the most important and extraneous findings (i.e. identify those that are critical to addressing a question, solving a problem, or supporting/refuting a hypothesis).

■ 7. When interpreting their results, students will infer relationships between controls and experimental variables as well as assess causality and correlation among variables.

■ 8. Students will be able to troubleshoot experimental procedures or methods of analysis to develop a sound scientific rationale for deducing what went wrong and why.

Please present concise explanation of how your course satisfies these criteria.

How will students in this course actively experiment and engage in the hands-on process of gathering, analyzing, and interpreting data? How will progress towards meeting the student learning outcomes for "labs" be measured/assessed? In other words, what types of assignments will be given to determine whether students are achieving the learning outcomes?	Instruction will be based on formal lectures/seminars (including presentations by local experts) supplemented by demos and hands-on object based-learning that involve examination and analysis of materials, data collection, data analysis and data interpretation based on a) handling and reverse engineering of archaeological materials experience (handling museum objects relevant to the week's class) and b) synthesis of materials and processing. The course will also include discussion, and site visits to museums (for regular course) and archaeological sites and museums (for the summer program). For hands-on activities, students will be working in groups (groups of 6-8 for the regular 10-week course and group of 4 for the summer program) and supervised by a faculty member

Appendix I. Student Learning Goals with Nested Learning Outcomes for All General Education (GE) Foundations in Scientific Inquiry Courses

Course Goals (1-7) and Student Learning Outcomes (a, b, c, etc.) for all "GE FSI" courses:

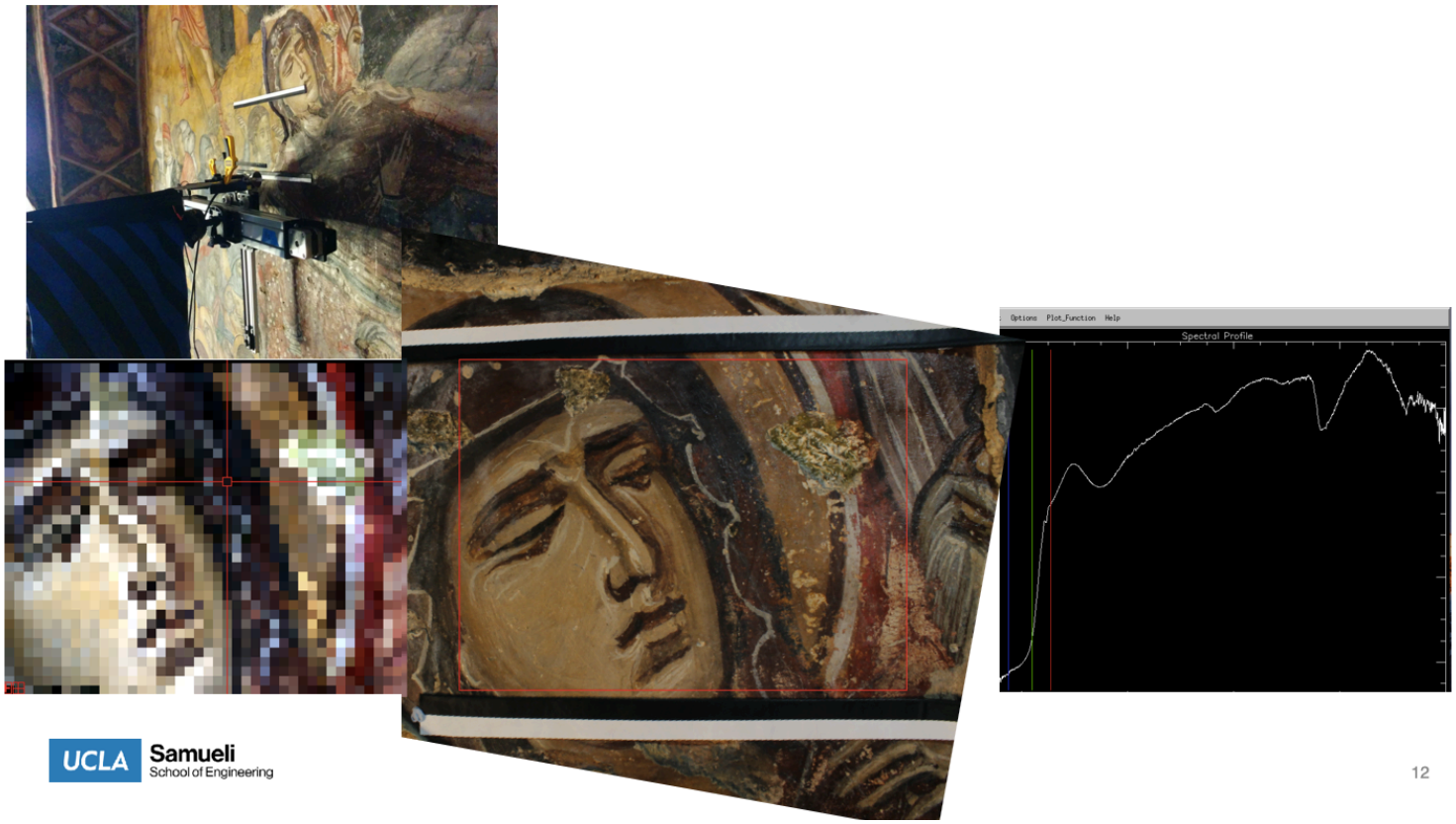
1. Students will actively engage in the scientific process of inquiry, analysis, problem-solving, and quantitative reasoning.
    a. Students will explain how scientists answer scientific questions, test a hypothesis, or solve a problem.
    b. Students will make reasonable predictions of experimental outcomes based on observation, measurements, and/or prior knowledge surmised from the scientific literature or other reliable, validated, accurate information sources.
    c. Students will break down, reason through, and solve complex quantitative problem sets.
    d. Students will be confident working with numerical data.
    e. Students will estimate and complete calculations to solve a quantitative problem.
    f. Students will recognize different objects and apply units of measurement at relevant scales (quantity, size, time) and orders of magnitude.
2. Students will acquire an informed appreciation of scientists, scientific research, and technology.
    a. Students will value their academic experiences in a science course that is outside their primary field of study.
    b. Students will recognize the benefits of science to society or their everyday life.
    c. Students will express interest in contributing to the sciences (e.g., engaging in research or scientific discourse with others).
    d. Non-science students will see scientists as role models, helping them to identify as scientists themselves.
3. Students will experience the interdisciplinary nature of science.
    a. Students will investigate topics from a variety of scientific fields.
    b. Students will explore the perspectives of multiple diverse scientists.
    c. Students will make logical connections between key concepts from multiple scientific disciplines.
4. Students will develop information literacy.
    a. Students will be mindful of information they encounter, recognizing contexts or situations when it is necessary to seek out other sources or data.
    b. Students will identify, locate, and critically evaluate information sources and datasets to ensure they are reliable, validated, accurate, and scholarly (i.e. associated with citations in peer-reviewed, public research studies).
    c. Students will explain the peer-review process in science and its role in critical evaluation and validation of published, scientific findings.
5. Students will make evidence-based decisions in a wide array of science and non-science contexts.
    a. Students will distinguish between opinion and fact (i.e. recognize data-supported conclusions).
    b. Students will use reliable, validated, accurate, and scholarly information sources and datasets before accepting or formulating a conclusion.
    c. Students will draw conclusions or make judgements about experimental results informed by critical thinking, that is, a comprehensive exploration of ideas and systematic engagement with the scientific process.
6. Students will develop scientific literacy by addressing current, critical issues and topics in science that are personally meaningful in daily life and/or connected to the needs of society (e.g., climate change, vaccination, GMOs, evolution).
    a. Students will clearly state the significance or relevance of a research question or problem (i.e. state why scientists are motivated to study the issue or topic).
    b. Students will discuss societal impacts by citing examples of the ways in which scientists and scientific research contribute to society.
    c. Students will describe the interactions between humans and their physical world and the positive and negative effects of this interaction.
    d. Students will explain why issues perceived as "controversial" in the public domain are not considered "controversial" in among scientists.
7. Students will recognize fundamental scientific principles and the connections between different domains of science.
    a. Students will describe the nature, organization, and evolution of living systems.
    b. Students will explain the origin and physical processes of the planet earth and the surrounding universe.
    c. Students will differentiate between a scientific theory, hypothesis, fact, or law.

COURSE MAT SCI 33

Materials Structure and Technology in Archaeology and Architecture (MST-A^2)

Duration/Period – Spring Quarter 2021

Enrolled # of students: 60-80 - One TA for every 20 students



Instructor

PROF. IOANNA KAKOULLI, MATERIALS SCIENCE AND ENGINEERING DEPARTMENT
KAKOULLI@UCLA.EDU

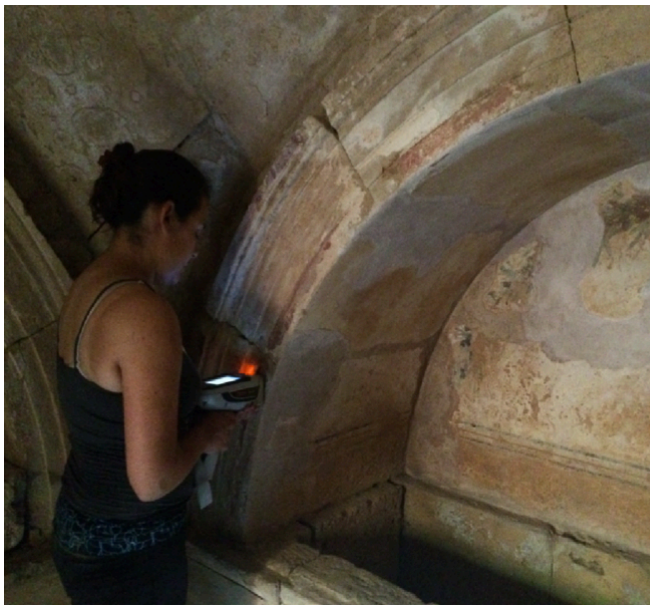
COURSE SYLLABUS

Course Catalogue Title - Materials Structure and Technology in Archaeology and Architecture (MST-A2)

*Approved by CIMS and it is already listed in the UCLA registrar's academics page/course-descriptions:

https://www.registrar.ucla.edu/Academics/Course-Descriptions/Course-Details?SA=MAT+SCI&funsel=3

** Expected Class size for regular course: 60-80 students with a TA for every 20 students.*



UCLA student in Cyprus examining Roman tomb painting using portable XRF

Course Number – MAT SCI 33

Units – Fixed for 5

Instructional – Seminar and Lab

TIE Code – SEMR (Seminar Research/Creative)

GE Requirement – Petition for: Foundations of Scientific Inquiry and Lab/Demo

GE Credit Acknowledgment: Upon successful completion of this course, students will satisfy one General Education requirement in one foundation area, namely Physical Sciences (Lab/Demo component) in the Foundations of Scientific Inquiry. Students will gain proficiency in Physical Sciences and the basics of Materials Science and Engineering through the study of archaeological materials and ancient technology with focus on the production processes, physical, chemical and mechanical properties of ceramics, glass, glazes, building materials and colorants within their archaeological and art historical context. The course will also deal with environmental degradation of these materials and also how ancient materials can inspire the technology of the future. The course's focus and structure based on formal lectures, demo/laboratory practicals with the hands-on examination and analysis of materials, paper reading and critical review of papers assigned in each week's readings, individual written research paper, group project/presentations and site visits, will provide a basis for the the Physical Science credit.

Writing II – Petition for: Writing II requirement.

Requisites – No

Course Description

Exploration of three classes of materials and composites, and relationships that exist between structural elements of materials and their properties: vitreous materials, building material binders, and pigments and colorants. Through study of ancient materials and technology in archaeology and architecture, exploration of relationships among processing, structure, properties, and performance for: vitreous materials--ceramics, frits, and glass; building material binders--aerial lime-based mortars, natural and artificial hydraulic lime/cements and concretes; and pigments and colorants (natural and synthetic organic, inorganic, and organic/inorganic hybrids). Through reverse engineering processing, exploration of ancient engineering materials (their micro/nano structure and physical, chemical, and mechanical properties), and their durability and sustainability as time-proven examples of technology innovation and/or invention.

The study of these materials and their cross-disciplinary exploration at the interface between science, archaeology and art, **culminates in the writing of individual research papers** (based on literature review) and **a collaborative research project/group presentation**.

The writing of a research paper requirement, introduces students to the discipline-specific research and writing. This is a WII course, in which students will closely engage in the recursive writing process of drafting and revising. They will also apply critical thinking skills to regular in-class writing exercises, as well as assignments spanning a few discipline-specific genres, such as research articles and literature review papers, leaning more towards an informationally dense writing kind. Students will also learn to respectfully dialogue and give feedback to one another during class discussions and peer reviews of their written drafts. Letter grading.

Justification

This course is designed to provide students with an experience that blends STEM education and a rigorous scientific approach with social science and humanities theory and methodologies, turning STEM into STEAM (Science, Technology, Engineering, Arts and Mathematics) and preparing 21st century scientists for a global society. The course using archaeological materials as the vehicle aims to introduce students to the basics of materials science and engineering and principles of chemistry, and physics, as well as, methodologies and processes applied by humanistic and social sciences. This course complements existing courses in the department of materials science and engineering and introduces a new sub-discipline at undergraduate level, that of archaeological materials science. In addition to learning materials properties through reverse engineering, students can also be inspired by ancient technology and the properties of ancient materials for the design of novel materials for modern applications. An example is the synthesis of novel 1D or 2D nanoscale materials based on Egyptian blue - an ancient colorant - with near infrared luminescence properties

to be used as optical material or biomarkers. On the other hand, this course enables students to actively participate in the archeological materials science disciplinary conversations. They demonstrate their understanding of the discipline-specific research methods and terminology in the writing of a publishable article review and a collaborative research project.

This course designed to bring engineering students together with students from non-engineering majors aims to form a diverse group of learners engaged in exploring a multidisciplinary topic while developing skills that are hallmarks of a liberal arts education.

Grading Basis – Letter grade only

The conversion from percentage grade to letter grade is presented in the table below:

% Grade	Letter Grade	% Grade	Letter Grade
100	A+	79	C+
99	A+	78	C+
98	A+	77	C+
97	A	76	C
96	A	75	C
95	A	74	C
94	A	73	C-
93	A-	72	C-
92	A-	71	C-
91	A-	70	C-
90	A-	69	D+
89	B+	68	D+
88	B+	67	D+
87	B+	66	D
86	B	65	D
85	B	64	D
84	B	63	D-

83	B-	62	D-
82	B-	61	D-
81	B-	60	D-
80	B-	59-0	Not passed

Assignments

Students will be evaluated mainly based on their performance in an **individual written research paper** and a **group project/presentation**, **lab work reports**, **paper discussion** and a **final exam**. The weighting of the final grade will be based on 100 points:

Individual Written Research Paper (Midterm I)	25%
Group Project & Presentation (Midterm II)	25%
Lab Work	20%
Paper Discussion	10%
Final Exam	20%

Midterm I (Individual Written Research Paper) and Midterm II (Group Project/ Presentations) Guidelines:

Midterm I (Individual Written Research Paper) aims to improve undergraduate writing skills and prepare students for writing their dissertation and/or publishing research papers in science areas. Using an instructional **scaffolding approach** and following **guidelines on writing a research paper** (see below: ***Guide to writing a Research Paper and Research Paper Scaffolding Process)*** students learn how to develop written arguments and describe research, analyze data and evaluate differences in theories. To practice these skills, students work on individual writing assignments, leading up to a 15-page research paper (~3500 words) excluding the abstract, figure captions and references. **Through systematic revision and evaluation** on the students research process and methodology (process of writing the research paper, how to do the research, assembling of articles and materials pertinent to the research question, narrowing down the focus, analyzing facts and writing the conclusions) by the instructor and TAs, **students will create a good quality paper with revised prose and strong bridging arguments** (please see below: ***Research Scaffolding Process: Individual Written Research Paper***).

Midterm II (Group Project/Presentation) aims to improve undergraduate team working and presentation skills and prepare students for conference presentations and public lectures. Using the same generic instructional scaffolding approach and guidelines for research as for Midterm I, students learn how to develop research arguments and describe research, analyze data and evaluate differences in theories. To practice these skills, students work on collaborative in-class and out of class writing and presentation assignments leading to the final research project presentation. Through systematic revision and evaluation of their research project by the instructor, TAs and peers, students will create a well-structured, well timed and clear presentation.

Half of the students (group I) enrolled in the class will have Midterm I (Individual Written Research Paper) on Week 5 and Midterm II (Group Project/Presentation) on Week 10. The other half of students (group II) will have Midterm II (Group Project/Presentation) on Week 5 and Midterm I (Individual Written Research Paper) on Week 10. Research topics for Midterm I and II with submission deadline Week 5 will use the first thematic of the course: i.e. vitreous materials (ceramic, frit, glass). Research topics for Midterm I and II with submission deadline Week 10 will use the second and third thematic that include: mortars, cements, wall paintings, pigments and colorants.

Examples of research topics include but not limited to:

- Biodegradation of archaeological glass;
- Egyptian blue, an ancient high fired ceramic pigment: structure and properties;
- Durability of the Roman concrete: inspiration for the design of modern eco-friendly constructions;
- Alteration of copper-based pigments in ancient wall paintings.

**Subjects for individual written research papers and group project/presentations will be discussed with the instructor.*

Research Scaffolding Process: Individual Research Paper (MIDTERM I)

MIDTERM I (INDIVIDUAL RESEARCH PAPER)	INDIVIDUAL MEETINGS WITH STUDENTS OF GROUP I	INDIVIDUAL MEETINGS WITH STUDENTS OF GROUP II
	WEEK 1	WEEK 6
SELECT TOPIC/DEFINE RESEARCH QUESTION; HOOK: WHAT IS INTERESTING ABOUT THIS QUESTION?	ASSIST STUDENTS SELECT THE TOPIC OF THEIR INDIVIDUAL RESEARCH AND IDENTIFY WHAT IS INTERESTING ABOUT THE RESEARCH QUESTION THEY HAVE CHOSEN (HOOK).	
HOW TO SEARCH FOR ARTICLES/USE SEARCH ENGINES & KEYWORDS AND HOW TO IDENTIFY AND COLLECT FACTS	REMIND AND SHOW STUDENTS THAT THEIR RESEARCH QUESTION CAN PROVIDE THE KEYWORDS FOR A TARGETED INTERNET SEARCH. ASSIST STUDENTS IDENTIFY THE BEST INTERNET SEARCH ENGINES FOR THE TOPIC. ASSIST STUDENTS SEARCH FOR RELEVANT PAPERS FOR THEIR PAPER. *Explain that information found in the articles may lead students to broaden their research question. Emphasize that students need to find articles from at least five different reliable sources that provide "clues" to answering their research question.*	
INSTRUCT STUDENTS HOW TO USE ENDNOTE OR OTHER BIBLIOGRAPHIC REFERENCE SOFTWARE AND HOW TO USE CAPTIONS AND CROSS REFERENCES	HELP STUDENTS WITH WORD PROCESSING AND HOW THEY CAN CITE AS THEY WRITE BY USING BIBLIOGRAPHIC SOFTWARE SUCH AS ENDNOTE. HELP STUDENTS USE CAPTIONS (FOR FIGURES, TABLES, EQUATIONS ETC) AND HOW TO CROSS REFERENCE IN THE TEXT.	
	WEEK 2	WEEK 7
SUBMIT SELECTED BIBLIOGRAPHY (~15 ARTICLES) LISTING THE RELEVANT FACTS FROM EACH PAPER SUPPORTING THE RESEARCH QUESTION.	PROVIDE FEEDBACK ON THE BIBLIOGRAPHY SUBMITTED. ASSIST STUDENTS WITH IDENTIFYING FACTS, THE ANALYSIS OF FACTS AND THE DEVELOPMENT OF A RESEARCH OUTLINE. *Have students find the specific information (facts) in each article that helps answer their research question, and highlight the relevant passages. Check that students have correctly identified and marked relevant information before they proceed with the analysis.*	
ANALYSIS OF FACTS AND DEVELOPING A RESEARCH OUTLINE	DISCUSS HOW THEY CAN ANALYZE FACTS. *Explain how they will compare the information they have gathered from various sources to identify themes.* *Explain the process of analysis. Show how making a numbered list of possible themes, drawn from the different perspectives proposed in the literature, can be useful for analysis.* DISCUSS THE OUTLINE (STRUCTURE) OF THE PAPER.	
	WEEK 3	WEEK 8
SUBMIT FIRST DRAFT WITH ANALYSIS OF THE STUDIES/PAPERS SELECTED	SUBMIT FIRST DRAFT AND PROVIDE FEEDBACK (ON THE STRUCTURE OF THE PAPER, FACTS, ANALYSIS AND CONCLUSIONS, ILLUSTRATIONS AND REFERENCES)	
	WEEK 4	WEEK 9
SUBMIT SECOND DRAFT OF WRITTEN PAPER AND FORMATTED ACCORDING TO GUIDELINES	SUBMIT SECOND DRAFT AND PROVIDE FEEDBACK	
	WEEK 5	WEEK 10
FINAL PAPER	SUBMIT FINAL PAPER (SUBMISSION ELECTRONICALLY VIA THE COURSEWEB)	

It should be noted, that although drafts will not be graded, they constitute a part of the grade for the assignment; the final paper cannot be submitted without having completed successfully the previous drafts.

* *Use of Research Scaffold template provided - see Appendix 1*

Guide to writing the Research Paper:

A research paper based on literature review (review article) addresses a specific topic by evaluating research done by others in a particular area. You will read and evaluate studies done by others, instead of conducting a new study yourself. As an author, you will weave your paper around a certain thesis (a statement or theory that is put forward as a premise to be maintained or proved) or problem/research question you wish to address, evaluate the quality and the meaning of the studies done before, and arrives at a conclusion about the problem based on the studies evaluated.

A research paper based on a review article is not a book report. Such paper must be a synthesis of the results of your search, organized around your chosen theme. The article should be your evaluation of the literature and of the issue at stake. This is a challenging piece of work. You must:

1. Organize information and relate it to your thesis or problem/research question

2. Synthesize results into a summary of what is and isn't known

3. Identify contradictions, inconsistencies, and gaps in the research

4. Identify and analyze controversy when it appears in the literature

5. Develop questions for further research

6. Draw conclusions based on your evaluation of the studies presented

**Adapted from the UCLA Undergraduate Science Journal: https://uclausj.weebly.com/submit-an-article.html.*

Writing a Research Paper: Preliminary Research

Before writing, you must:

1. Select a topic (to be discussed with the instructor). The topic should be:

    a. A well-studied field. An area of science that is well-studied will give you more topics to choose from (e.g., more series of studies on the same problem). It will also have many more authors, perspectives, theories, and controversies than a field that only a few people study.

    b. Of current interest. You should pick a topic that is currently being researched, not an issue that no one has touched in thirty years. Though many of your sources may be old, you should be able to find research being done on this topic today.

    c. Of interest to you. Don't just pick a topic because it's a hot field of study. Pick one that you are personally interested or involved in.

d. Narrow. Estimate how long of a research paper you want to produce = i.e. 3500 words max.

e. Controversial or diverse (opinion-wise). You should pick a topic that has at least two completing hypothesis to explain/test it. Then you will be able to compare, contrast, and analyze. You might consider picking several topics, reading several articles on each of them, and selecting the topic that you think will make the best review.

2. Search for articles. If you have chosen too broad a topic, this can be very challenging. Even with a narrow topic, finding relevant articles can be tough. Here are some tips:

a. Try online searches using resources like ***Google Scholar, WorldWideScience, Science.gov; Microsoft Academic*** etc.. These allow you to search by keyword or author, and they often have the article available in an electronic format.

b. Ask your instructor who will be able to point you to the “classic” papers on this topic.

c. When you find a relevant article, scan its references. Usually, you will find several more relevant articles cited.

d. Look for older review articles on similar topics. Review articles written five or ten years ago can fill you in on the history of the topic and point you in the direction of later research.

3. Select the relevant studies and relevant information. Not all of the studies you have found will be relevant to your thesis/problem/research question. Also, only certain portions of each study might be relevant to you. Don’t bog your reader down with too much – sift out the relevant studies and information.

4. Write an outline. As you read about your topic and gather your information, draft an outline of what your review will cover and in what order. Ideally, you should go through several drafts as you read more about your topic. Annotate your outline with which studies you will discuss where, when, why, and how. This will help you when you start to structure the actual paper. The next step is to analyze the studies you have chosen.

Writing a Research Paper: Analyzing the Literature

In a review article-type paper you must be able to evaluate the techniques used, results obtained, conclusions drawn, and errors present in each study, and then apply your evaluation to your topic.

Below are some questions to help you start thinking about each study. For each research study you read, ask yourself:

1. Has the author formulated a thesis/research question? What is the problem or issue being addressed? Is this problem relevant to my review? Is the problem clearly stated? Is the significance of the problem discussed (i.e., why should the reader care about this study?)

2. What are the strengths and limitations of the way the author has formulated the problem? Could the problem be approached more effectively from another perspective?

3. Is this paper primarily theoretical, experimental, interpretive? A combination? Could the study have been better if conducted in a different framework? (i.e., could a theoretical study have been strengthened by actual experiment?)

4. What is the author's theoretical framework? *For example, in the field of Mars geology, many authors build their papers on the idea that Mars was once a warm, wet planet, instead of the cold, dry planet we see today. Others start with the assumption that Mars has always been cold and dry.* The theories to which the authors subscribe manifest themselves through their assumptions, interpretations, and conclusions. What assumptions have your authors made? And how do those assumptions affect the conclusions they draw?

5. Has the author evaluated the literature relevant to the problem/issue? Does the author discuss studies that contradict his/her thesis as well as those that support it?

6. How effective is the study's design? Is the method for investigating the problem appropriate? What errors does the method introduce? How accurate and valid are the measurements?

7. Is the analysis of the data accurate and relevant to the research question?

8. Are the conclusions validly based upon the data and analysis?

9. Has the author objectively carried out the study, or only "proved" what he already believes?

10. Does this study contribute to our understanding of the problem? How is it useful to us?

11. How does this study fit into my review? How does its problem relate to the problem I will address? How will I use its conclusions, methods, or limitations to illustrate the point I am trying to make?

12. Does this study support my thesis/problem/research question or not? Do I need to re-evaluate my thesis?

Writing a Research Paper: Structure & Writing

Your article should revolve around **your thesis/problem/research question**.

Since no two theses are alike, no two review articles will be structured exactly alike; however, there is a general format that review articles should follow:

- Abstract
    - Write this last

    - A summary of your main thesis/research question and the studies you examine in your review
- Introduction
    - Introduce your topic
    - Outline what you will discuss throughout the review
    - Tell your audience why it is important that you reviewed the literature in your topic area
- Body
    - Can take different forms depending on your topic
    - Break it up into sections if this is helpful (i.e. if you are studying three different processes/methodologies for the synthesis of a material for example, then you can break your body into three main sections)
    - Go through all of the literature in detail, in an organized fashion
- Discussion/Conclusion
    - Restate your thesis/problem/main question
    - Wrap up your review by drawing everything together and making sure it is clear what conclusions you draw about your topic or field of study based on the research studies you read and analyzed.
- References
    - Make sure your references are formatted correctly and all present
    - This paper is all about the references! Cite everything that you discuss. For tips on when and how to cite, visit the next page on the drop-down menu under "Writing in the Sciences!"

**Adapted from the UCLA Undergraduate Science Journal: https://uclausj.weebly.com/submit-an-article.html.*

Questions to Ask Yourself about Your Research Paper

As you are writing your paper, keep the following questions in mind. When you have finished, go through and make sure you answer each of these questions for yourself:

1. Do I present a specific thesis, problem, or research question? (Make sure you're not just summarizing a field of study!)

2. Who is my audience? Will readers find my literature review relevant and useful?

3. What is the scope of my review paper? What types of publications did I use (journals, books, popular media, government documents, or person communication)?

4. What am I reviewing? Is my issue addressing theory, methodology, policy, quantitative research, or qualitative research? A combination? Make sure this is clear in your review!

5. Has my search for studies been broad enough to contain all the relevant studies?

6. Has my search been narrow enough to exclude irrelevant studies?

7. Have I included enough sources? (Usually, anything less than a dozen sources is far too few for a literature review.)

8. Is the literature I've chosen actually relevant to my thesis/research question? Does every study I've chosen to include shed some light on the problem my article is addressing?

9. Have I critically analyzed the studies or do I just summarize the articles?

10. Have I discussed the strengths and weaknesses of the studies?

11. Have I cited and discussed studies that contradict my perspective?

12. Is my paper more than just a descriptive summary? Is it organized into useful, informative sections that present different ideas revolving around my thesis/research question?

Individual Written Paper Submission Instructions:

Manuscripts should be submitted online at CCLE. The manuscript submission deadline is WEEK 5 for students group I and WEEK 10 for students group II.

Manuscript (Research Paper) Formatting:

Manuscripts of **3500 word limit** (~12 double spaced pages) excluding abstract, references, and captions; max of 4 figures or tables (or a combination of these); references ~15, should be submitted as a single PDF file containing the following three elements in order:

1. Text: Text should not have figures embedded within it.
    - Font size: 11pt (applies to all text, including titles and headings)
    - Typeface: Times New Roman (with the exception of equations and computer code). Headings and subheadings should be in bold and ALL CAP.
    - Spacing: Double-spaced
    - Page margins: 1 inch
    - Page numbers: Bottom of page
    - Equations should be left-justified.
    - Computer code should be written in Courier New typeface instead of Times New Roman.
2. Figure/Table Legends: Figure/table legends must be listed after the text. Each figure/table legend must be on a separate page and should contain the following:

- Figure/table label (e.g. Figure 1., Table 1.)
- Caption including 1) a one-sentence title in bold and 2) a detailed description of the figure/table.
    - Caption should include details such as sample size, error bars specifically indicated as standard error or standard deviation, explicit values for bar graphs, best fit line equations, etc.

3. Figures/Tables: Figures/tables should be listed after the list of figure/table legends. Each table or graph must be created in Microsoft Excel and converted to a TIF (.tif) image that has at least 300 dpi (pixels/inch) resolution. Each figure/table must be on a separate page and accompanied by the following:
    - Figure/table label (e.g. Figure 1., Table 1.)
    - Indication of color vs. black/white: Due to budget constraints, each figure should have an indication of whether color is necessary for its comprehension.

Research Paper Contents:

1. **Title:** Should reflect the topic of the review (example shown below)
    - Title should be on a separate page, and accompanied by the author's name and affiliation(s).
    - Character limit: 75 characters (including spaces)
    - Date: should be included on the same page
2. **Abstract:** The author must provide a brief summary of the thesis/research question, the major studies investigated, and conclusions drawn. The abstract should not cite any references. Please note that review articles should not simply summarize another review article. **Word limit: 250 words.** Should be a single paragraph.
3. **Introduction:** This section should introduce the topic and the thesis/research question, and discuss why this topic is significant. The author should clearly define exactly what this article will discuss, outline the order in which you will discuss it, and give the reader any background information needed to understand the coming sections. The introduction
    - Should contain at least 2 paragraphs
    - Should reference 1-2 articles per paragraph
    - Must contain at least 1 figure

4. **Body (FACTS):** The structure of this section varies depending on topic. A review article describing three different methodologies, might divide the body of the article into three sections, each discussing one of the methods. In these sections, authors must be sure to describe and evaluate the studies in detail, comparing them and discussing their implications.

5. **Discussion (ANALYSIS) and Conclusions:** This section should contain a restatement of the thesis/research question and the purpose of the article, then discussing the conclusions that were drawn. Authors should also discuss the implications of their study and where they think research in this field should be directed.

6. **References:** The author should include in this section all articles that are published or in press. Manuscripts submitted to USJ should follow the citation style described in the following section. Authors should not cite any unpublished or preliminary data.

7. **Figures:** Figures may include schematics that illustrate experimental design and charts that present data. Photographs may be used as figures only if they are crucial to the readers' understanding of the topic.

    - ***Figure captions:*** Each caption should include a one-sentence title that summarizes the content of the figure, and a detailed description that explains pertinent information and any abbreviations used. Captions should summarize the data such that a reader can comprehend the figure without having to refer to the text.

        - Written consent is required from the source of the figure, if it is not your own. This can be in the form of an email. This consent is necessary for figures from published journals, but is not needed for figures from government websites.

        - For each figure/table, authors should submit a version with the necessary text (ex: labels) and a version without the text (for layout purposes)

Citation Style:

Recommending using bibliographic management tools such as Zotero and Endnote (see Resources section). Published sources should be cited both in-text and listed in the references section. Abstracts of work presented at meetings should not be cited.

1. **In-text citations:** Citation numbers should be placed in parentheses and italicized: (1, 2, 4) (8-10, 13) (19-21). Numbers should not be superscript.

2. **Reference list:** The reference list should be numbered, with numbers matching the order of occurrence in the article. References should be formatted as described below:

    - ***Journal articles:*** Author names should be written with first and middle initials separated by a space, followed by the surname. The word "and" should not be used to separate

author names. If an article has more than 5 authors, the first author name should be followed by “et al.” (italicized). Abbreviated journal names should be used.

Example: William R. Harvey, Signe Nedergaard, Sodium-independent active transport of potassium in the isolated midgut of the Cecropia silkworm. *Proc. Natl. Acad. Sci. U.S.A.* **51**, 731-735 (1964).

- ***Books:*** Author names follow the same citation style as above. For edited books, “Ed.” or “Eds.” should be added. Book titles should be italicized and followed by the publisher name, publisher location, edition number and year of publication in parentheses.

Examples: M. Lister, *Fundamentals of Operating Systems* (Springer-Verlag, New York, ed. 3, 1984), pp. 7-11.

J. B. Carroll, Ed., Language, Thought and Reality, Selected Writings of Benjamin Lee Whorf (MIT Press, Cambridge, MA, 1956).

A more exhaustive description of Science Reference Style is available online at Link 1: (https://www.sciencemag.org/authors/instructions-preparing-initial-manuscript).

Resources:

Paper Planner: The UCLA Undergraduate Science Journal (USJ) Paper Planner is a resource that breaks down the writing process into manageable pieces, and assigns deadlines for each piece to help authors stay on track with their writing. ***The paper planner can be found at Link 2***: (https://docs.google.com/spreadsheets/d/15cwDTiDNmZRcY_RtIrdNBGY2Qxb2MptUD9XP_4W08J0/edit#gid=986555058)

Reference Management Software: Recommended the use of bibliographic management tools such as Zotero and Endnote.

Remark: Zotero does not have the reference style for Science pre-installed, so authors should download the citation style from the Zotero Style Repository.

* ***Undergraduate Writing Center: The Undergraduate Writing Center at UCLA is a free service offered to UCLA students that provides assistance with a variety of writing-based tasks, including writing scientific articles. More information about the Undergraduate Writing Center, including their schedule, can be found on their website: Link 3: http://wp.ucla.edu/wc.***

Books:

A Student Handbook for Writing in Biology by Karen Knisely (ISBN: 9781429234917)

Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences by Janice R. Matthews and Robert W. Matthews (ISBN: 9780521699273)

How to Write and Publish a Scientific Paper by Barbara Gastel and Robert A. Day (ISBN: 9781440842801)

USJ Website: Examples of articles previously published in USJ can be found on our website: http://uclausj.weebly.com.

Links:

(The following is a list of all the links that were referred above):

Link 1 (Instructions for preparing an initial manuscript): http://www.sciencemag.org/authors/instructions-preparing-initial-manuscript

Link 2 (USJ Paper Planner): https://docs.google.com/spreadsheets/d/15cwDTiDNmZRcY_RtIrdNBGY2Qxb2MptUD9XP_4W08J0/edit#gid=986555058

Link 3 (Undergraduate Writing Center): http://wp.ucla.edu/wc

Library Resources:

UCLA library provides an online tutorial of how to use the library to assist your research at: http://www.sscnet.ucla.edu/library/

The following website provides a list of online libraries and documentation centers that can further assist your research in conservation. You are highly advised to use the online resources available.

Online Resources

Classic Chemistry (http://web.lemoyne.edu/~giunta/papers.html)

The American Institute for Conservation (https://www.culturalheritage.org/)

Canadian Conservation Institute (https://www.canada.ca/en/conservation-institute.html)

Getty Conservation Institute (http://www.getty.edu/conservation/)

(http://www.getty.edu/conservation/publications_resources/)

United Kingdom Institute for Conservation (http://www.ukic.org.uk/)

International Council on Monuments and Sites (ICOMOS) (http://www.icomos.org/)

US/ICOMOS at (http://www.icomos.org/usicomos/)

Smithsonian Center for Materials Research and Education (http://siarchives.si.edu/research/ah00289scmre.html)

The ICCROM's website (http://www.iccrom.org/index.shtml)

Databases

http://rruff.info/

http://www.irug.org/search-spectral-database

https://www.usgs.gov/labs/spec-lab/capabilities/spectral-library

https://speclib.jpl.nasa.gov/

http://fors.ifac.cnr.it/

Evaluation of Midterm I:

The written assignment will be evaluated based on criteria of peer review for research papers and will follow a rubric with scoring using generalizability theory as indicated below:

RUBRIC		**LEVEL**	
	0	1	2
THESIS/PROBLEM/RESEARCH QUESTION A statement why this is an interesting question.	Does not state a thesis/ problem/research question, or makes an inaccurate claim.	Makes an accurate but incomplete claim on the thesis/problem/research question.	Makes an accurate and complete claim on the thesis/problem/research question.
REFERENCES Appropriate and sufficient references.	Important references are missing. May include some relevant papers (references) but insufficient.	Provides relevant but insufficient references. May include some not relevant papers.	Provides appropriate and sufficient references to support the thesis/problem/ research question.
EVIDENCE/FACTS Appropriate and sufficient scientific data that supports the claim.	Does not provide evidence, or only provides inappropriate evidence.	Provides appropriate but insufficient evidence/facts to support the thesis/ problem/research question. May include some inappropriate evidence/ facts.	Provides appropriate and sufficient evidence/facts to support the thesis/problem/ research question.
CRITICAL ANALYSIS OF FACTS/ CONCLUSIONS Adding some commentary that explains what the data means in relationship to the thesis/problem/research question. It answers the questions, “So what?” “Why is this important or significant?	Does not add any commentary to explain what the data means in relationship to the thesis/ problem/research question.	Adds some commentary to explain “why” the data is important but comments are unclear or irrelevant to the thesis/problem/research question.	Adds commentary that explains ‘why” the data is important in relationship to the thesis/problem/research question.
STRUCTURE, FLOW AND PROSE This evaluates rhetorical and technical demands for writing a research paper, such as grammar, simple and short sentences, punctuations, organization and clarity.	Use of simple sentences, but many of them are incomplete or awkwardly written, which makes it very hard for people to understand what is written. Use some punctuation, but usually used incorrectly. Paper poorly organized, inappropriately laid out, and/or is messy.	Punctuation of most simple sentences correctly, using capital letters, full stops, question and exclamation marks and apostrophes. Some scientific prose. The paper is quite well organized, and is neatly presented and easy to read.	Punctuations such as capital letters, full stops, question and exclamation marks, commas, quotation marks, apostrophes, brackets, dashes and paragraphs are used correctly. The paper is well organized in the appropriate layout, and is neat, scientifically written and easy to read.

Research Scaffolding Process: Group Project/Presentation (MIDTERM II)

MIDTERM II (GROUP PROJECT/ PRESENTATION)	GROUP MEETINGS (6-8 STUDENTS/ PROJECT) WITH STUDENTS OF GROUP II	GROUP MEETINGS (6-8 STUDENTS/ PROJECT) WITH STUDENTS OF GROUP I
	WEEK 1	WEEK 6
SELECT TOPIC/DEFINE RESEARCH QUESTION; HOOK: WHAT IS INTERESTING ABOUT THIS QUESTION?	ASSIST STUDENTS SELECT THE TOPIC OF THEIR INDIVIDUAL RESEARCH AND IDENTIFY WHAT IS INTERESTING ABOUT THE RESEARCH QUESTION THEY HAVE CHOSEN (HOOK).	
HOW TO SEARCH FOR ARTICLES/USE SEARCH ENGINES & KEYWORDS AND HOW TO IDENTIFY AND COLLECT FACTS	REMIND AND SHOW STUDENTS THAT THEIR RESEARCH QUESTION CAN PROVIDE THE KEYWORDS FOR A TARGETED INTERNET SEARCH. ASSIST STUDENTS IDENTIFY THE BEST INTERNET SEARCH ENGINES FOR THE TOPIC. ASSIST STUDENTS SEARCH FOR RELEVANT PAPERS FOR THEIR GROUP PROJECT/ PRESENTATION. *Explain that information found in the articles may lead students to broaden their research question. Emphasize that students need to find articles from at least five different reliable sources that provide "clues" to answering their research question.*	
INSTRUCT STUDENTS HOW TO USE POWERPOINT FOR THEIR PRESENTATIONS	HELP STUDENTS CREATE DIFFERENT SLIDES TO PRESENT VARIOUS DATA. EXPLAIN CHARTS, DIAGRAMS AND OTHER TOOLS THAT CAN HELP THEM DEVELOP THEIR PRESENTATION	
	WEEK 2	WEEK 7
SUBMIT SELECTED BIBLIOGRAPHY (~15 ARTICLES) LISTING THE RELEVANT FACTS FROM EACH PAPER SUPPORTING THE RESEARCH QUESTION.	PROVIDE FEEDBACK ON THE BIBLIOGRAPHY SUBMITTED. ASSIST STUDENTS WITH IDENTIFYING FACTS, THE ANALYSIS OF FACTS AND THE DEVELOPMENT OF THE PRESENTATION. *Have students find the specific information (facts) in each article that helps answer their research question, and highlight the relevant passages. Check that students have correctly identified and marked relevant information before they proceed with the analysis.*	
ANALYSIS OF FACTS AND DEVELOPMENT OF PRESENTATION OUTLINE WITH VISUAL DATA	DISCUSS HOW THEY CAN ANALYZE FACTS. *Explain how they will compare the information they have gathered from various sources to identify themes.* *Explain the process of analysis. Show how making a numbered list of possible themes, drawn from the different perspectives proposed in the literature, can be useful for analysis.* DISCUSS THE OUTLINE (STRUCTURE) OF THE GROUP/PROJECT PRESENTATION AND HOW TO VISUALIZE IN A PRESENTATION THE FACTS AND ANALYSIS OF FACTS. DISCUSS HOW THE PRESENTATION CAN BE PRESENTED BY A GROUP OF STUDENTS (6-8 STUDENTS)	
	WEEK 3	WEEK 8
SUBMIT FIRST GROUP PROJECT/ PRESENTATION DRAFT AND PRESENT TO THE INSTRUCTOR	SUBMIT ELECTRONICALLY THE PRESENTATION (GROUP PROJECT) AND ALSO PRESENT TO THE INSTRUCTOR THE FIRST DRAFT OF THE GROUP PROJECT INSTRUCTOR WILL PROVIDE FEEDBACK ON THE STRUCTURE OF THE PRESENTATION, VISUAL AND TEXTUAL INFORMATION AND PRESENTATION STYLE AND TIMING.	
	WEEK 4	WEEK 9
SUBMIT SECOND GROUP PROJECT/ PRESENTATION DRAFT AND PRESENT TO THE INSTRUCTOR	SUBMIT/PRESENT SECOND DRAFT INSTRUCTOR AND TA WILL PROVIDE FEEDBACK	
	WEEK 5	WEEK 10
FINAL PRESENTATION	PRESENT THE GROUP PROJECT TO THE CLASS AND SUBMIT FINAL PRESENTATION (SUBMISSION ELECTRONICALLY VIA THE COURSEWEB)	

* *Use of Research Scaffold template provided - see Appendix 1*

Guide to Presenting a Group Project:

As with the individual written research papers, group projects are based on the presentation of a thesis based on literature review (read and evaluate studies done by others, instead of conducting a new research yourself), prepared by a small group of students. As authors, you will weave your research paper around a certain **thesis** (a statement or theory that is put forward as a premise to be maintained or proved) or problem/research question you wish to address, evaluate the quality and the meaning of the studies done before, and arrives at a conclusion about the problem based on the studies evaluated.

Presentation Guidelines:

Prepare your slides as a PowerPoint file or a PDF. You will need to load your presentation onto the computer before your stream, to facilitate a smooth transition between group presentations.

The time allocated for a presentation is 40 minutes, with a further 10 minutes allowed for discussion. Think in terms of the following slides:

A title slide – Name, Title and what the research is about

One slide to introduce (Introduction) the topic and the thesis/research question

6 or 8 slides covering the main Body (FACTS) of research. As with the individual research paper if you are describing three different methodologies, you might divide the body of the article into three sections, each discussing one of the methods. In these sections, authors must be sure to evaluate the studies.

6 or 8 slides for Discussion (ANALYSIS) and Conclusions. This section should contain a restatement of the thesis/research question and the purpose of the research, then discussing the conclusions that were drawn. Authors should also present the implications of their study and where they think research in this field should be directed.

One slide with the references cited.

You should not require any more than an absolute maximum of 20 slides – this would mean talking to each slide for only two minutes.

It is generally distracting to the audience to have too many slides in a short presentation.

Do not put too much text on a slide – you want the audience to listen to you and not to be reading your slides!

*Group Project/Presentation topics will be discussed with the instructor.

Lab Work Guidelines:

Students will participate in activities of examination, analysis and synthesis of materials and will need to complete lab work reports. Lab work will be in groups however assessment will be on an individual basis (completing reports).

*Report templates for each lab work (practical) will be available on the CourseWeb.

Paper Discussion Guidelines:

Students will need to discuss critically selected papers: whether the results met expectations and supported hypotheses; if findings were contextualized within previous research and theory; whether the figures and tables were necessary and useful. Students will also submit their review of papers (summarizing the paper with their own words) in writing. The instructor will provide feedback on these writing samples on a one-on-one basis and will discuss the submitted papers with the students. This exercise will provide additional support in writing quality papers.

The paper discussion will also help students structure and analyze their Individual Written Research Paper and Group Projects.

Final Exam:

This will be a one-hour exam that will include multiple choice questions with more than one correct answers.

Instruction

Instruction will be based on formal lectures/seminars that will also include presentations by visiting experts, supplemented with demos and hands-on object based learning through handling and reverse engineering of archaeological materials experience (handling museum objects relevant to the week's class); discussion, and site visits.

Weekly:

Seminar: 4 hours

Lab: 2 hours

Site visits: 4 hours

Outside Study/Research: 5 hours

Course Objectives

- Practice in materials science and engineering or a related field.
- Apply fundamental ideas of archaeological materials science integrating materials science and engineering principles and humanistic and social science methodologies.
- Develop problem solving and research skills.
- Exercise observation skills and methodical thinking.
- Understand diverse perspectives on human agency, and how people lived; how ancient/indigenous cultures selected the raw materials and what processes (technical and social) they used for the production of materials (utilitarian, ritual, artistic) and how they discovered new material knowledge.
- Assess information critically; how to deliver reasoned and convincing arguments both orally and in writing; and identify, acquire, and use the knowledge necessary to solve problems.
- Communicate effectively (writing and verbal).
- Collaborate effectively.

Student Learning Outcomes

Upon taking this course, students will develop:

- an ability to explain how scientists answer scientific questions, test a hypothesis, or solve a problem (FSI Goal #1)
- an ability to apply knowledge of science, technology and engineering (FSI Goals #1, 2, 6)
- an ability to design and conduct experiments, as well as to analyze and interpret data (FSI Goals #1, 3, 4, 5, 6)
- an ability to think critically and to identify, formulate, and solve engineering problems (FSI Goals #1, 2, 3, 4, 5, 7)
- an ability to function on multidisciplinary teams (FSI Goals #2, 3)
- an ability to conduct independent research (FSI Goals #1, 5, 6)
- leadership skills (FSI Goals #1, 5)
- an ability to communicate effectively (written and verbal communication skills) (FSI Goal #2)
- an understanding of professional and ethical responsibility (FSI Goals 1, 2, 4)
- a knowledge of past and contemporary issues (FSI Goal #6)

- an ability to use the techniques, skill, and modern engineering tools necessary for engineering practice (FSI Goals #1, 4, 5, 6)
- an ability to evaluate concepts and ideas from alternative perspectives (FSI Goals #3)
- broad knowledge, necessary to understand the impact of engineering solutions in a global and societal context (FSI Goals #1, 5, 7)

Textbook

There is no textbook for this course. Supplemental readings from technical journals will be provided, as well as lecture notes. (see reading list in weekly calendar below).

Center for Accessible Education

Students needing academic accommodations based on a disability must contact the Center for Accessible Education (CAE) at (310) 825-1501 or present in person at Murphy Hall A255. As the professionals delegated authority from campus to determine reasonable disability accommodations, CAE will assess all requested accommodations and communicate appropriately with faculty. In the event a student has approval for proctoring arrangements during exams, please inform your respective professors and/or Teaching Assistant(s) before date of exam(s). When possible, students should contact the CAE within the first two weeks of the term as reasonable notice is needed to coordinate accommodations. For more information visit, www.cae.ucla.edu.

Non-discrimination

UCLA, in accordance with applicable Federal and State law and University policy, does not discriminate on the basis of race, color, national origin, religion, sex, gender identity, pregnancy, physical or mental disability, medical condition (cancer related or genetic characteristics), ancestry, marital status, age, sexual orientation, citizenship, or service in the uniformed services. The University also prohibits sexual harassment. This nondiscrimination policy covers access and treatment in University programs and activities. Inquiries regarding UCLA's student-related nondiscrimination policies may be directed to the Office of the Dean of Students in 1206 Murphy Hall, or by email to: dean@saonet.ucla.edu.

Sexual Harassment

If you have experienced sexual harassment, you can file a report or complaint to the Title IX Coordinator at Murphy Hall, or by email to: TitleIX@conet.ucla.edu.

If you choose not to file a report, know that we have support services available for you. A confidential CARE Advocate can explain your options in detail and answer questions, so you can make the decision that's right for you. Talking to the CARE Advocate doesn't constitute filing an official report. The details of your experience won't be shared with anyone without your permission. Confidential advocacy and consultations can be reached by calling (310) 206–2465 or by writing to this email address advocate@careprogram.ucla.edu.

Course Calendar (Weekly)

Week 1

Introduction to the Course

Structure, Properties and Technology of Vitreous Materials I: ceramics

- Lecture/Seminar: Introduction to ancient vitreous materials with emphasis on ceramics. Raw material selection and production technology (processing).
- Demo/Lab (Hands-on, object-based learning): Examination of ancient ceramics and glass from museum collections.
- Discussion-critical review of papers.
- Site Visit: Getty Villa (focus on ancient Greek, Roman and Etruscan ceramics)
- Readings:

1. * Tite, Michael S. "Ceramic production, provenance and use—a review." *Archaeometry* 50, no. 2 (2008): 216-231. PAPER FOR DISCUSSION
2. Angelini, Ivana, Bernard Gratuze, and Gilberto Artioli. "Glass and other vitreous materials through history." EMU Notes Mineral 20 (2019): 87-150.
3. Rapp, George. "Ceramic Raw Materials." In Archaeomineralogy, pp. 183-200. Springer, Berlin, Heidelberg, 2009.

4. Roux, Valentine. "Introduction to Ceramic Technology." In Ceramics and Society, pp. 1-14. Springer, Cham, 2019.

5. Thér, Richard. "Ceramic technology. How to reconstruct and describe pottery-forming practices." Archaeological and Anthropological Sciences 12, no. 8 (2020): 1-22.

6. Marzec, Edyta, Evangelia Kiriatzi, Noémi S. Müller, and Anno Hein. "The provenance and technology of a group of Hellenistic colour-coated ware pottery from the excavations at Nea Paphos on Cyprus." Journal of Archaeological Science: Reports 21 (2018): 1035-1043.

Week 2

Structure, Properties and Technology of Vitreous Materials II: frits, glazed ceramics and glass

- Lecture/Seminar: Introduction to ancient frits glazed ceramics and glass; raw materials and production technology; chaînes opératoire (operational sequence).
- Demo/Lab (Hands-on, object-based learning): Create your own vitreous material (ceramic, frit, glass) based on ancient technology.
- Discussion-critical review of papers.
- Site Visit: Getty Villa (focus on glazed ceramics and glass artifacts)
- Readings:

1. * Gliozzo, Elisabetta. "The composition of colourless glass: a review." *Archaeological and Anthropological Sciences* 9, no. 4 (2017): 455-483. PAPER FOR DISCUSSION

2. Wang, Y., H. Ma, K. Chen, X. Huang, J. Cui, Z. Sun, and Q. Ma. "Identification of PbO (BaO) faience from an early and middle Warring States period cemetery at Zhaitouhe, northern Shaanxi, China." Archaeometry 61, no. 1 (2019): 43-54.

3. Hodgkinson, Anna K., Stefan Röhrs, Katharina Müller, and Ina Reiche. "The use of Cobalt in 18th Dynasty Blue Glass from Amarna: the results from an on-site analysis using portable XRF technology." STAR: Science & Technology of Archaeological Research (2019): 1-17.

4. Henderson, Julian. "Glass and glass production in the Near East during the Iron Age: evidence from objects, texts and chemical analysis. Oxford: Archaeopress; 978-1-78969-154-2£ 50." Antiquity 93, no. 372 (2019): 1687-1688.

5. Fischer, Christian, and Ellen Hsieh. "Export Chinese blue-and-white porcelain: compositional analysis and sourcing using non-invasive portable XRF and reflectance spectroscopy." Journal of Archaeological Science 80 (2017): 14-26.

6. Lin, Yuan, Tianchi Liu, Michael K. Toumazou, Derek B. Counts, and Ioanna Kakoulli. "Chemical analyses and production technology of archaeological glass from Athienou-Malloura, Cyprus." Journal of Archaeological Science: Reports 23 (2019): 700-713.

Week 3

Structure, Properties and Technology of Building Materials

- Lecture/Seminar: Introduction to building materials with emphasis on aerial lime-based mortars/plasters, natural and artificial hydraulic lime/cements and concretes, and the relationships that exist between the structural elements of these materials and their properties.

- Demo/Lab (Hands-on, object-based learning): Production of Roman cement (hydraulic) using aerial lime and natural and artificial pozzolanic materials.

- Discussion-critical review of papers.

- Site Visit: Getty Villa (focus on ancient Roman mosaics and wall paintings using hydraulic and aerial lime plasters)

- Readings:

1. * Siddall, Ruth. "The use of volcaniclastic material in Roman hydraulic concretes: a brief review." *Geological Society, London, Special Publications* 171, no. 1 (2000): 339-344. PAPER FOR DISCUSSION

2. Rapp, George. " Building, Monumental, and Statuary Materials." In Archaeomineralogy, pp. 247-280. Springer, Berlin, Heidelberg, 2009.Bonavetti, Viviana L., Viviana Fátima Rahhal, F. Locati, Edgardo F. Irassar, S. Marfil, and P. Maiza. "Pozzolanic activity of argentine vitreous breccia containing mordenite." Materiales de Construcción 70, no. 337 (2020): 208.

3. Lechtman, Heather N., and Linn W. Hobbs. "Roman concrete and the Roman architectural revolution." In High-Technology Ceramics: Past, Present, and Future-The Nature of Innovation and Change in Ceramic Technology, vol. 3, pp. 81-128. 1987.

4. Gotti, E., J. P. Oleson, L. Bottalico, C. Brandon, R. Cucitore, and R. L. Hohlfelder. "A comparison of the chemical and engineering characteristics of ancient Roman hydraulic concrete with a modern reproduction of Vitruvian hydraulic concrete." Archaeometry 50, no. 4 (2008): 576-590.

5. Brandon, Christopher J., Robert L. Hohlfelder, Marie D. Jackson, and John Peter Oleson. Building for eternity: the history and technology of Roman concrete engineering in the sea. Oxbow books, 2014.

6. Elsen, Jan, Ozlem Cizer, and Ruben Snellings. "Lessons from a lost technology: The secrets of Roman concrete." American Mineralogist 98, no. 11-12 (2013): 1917-1918.

Week 4

Structure, Properties and Technology of Wall Paintings

- Lecture/Seminar: Introduction to ancient wall paintings (binary systems composed of a paint layer and a plaster or plasters) and the fresco and secco painting techniques.
- Demo/Lab (Hands-on, object-based learning): Preparation of lime based plaster.
- Discussion-critical review of papers.
- Site Visit: Getty Villa (focus on ancient Roman wall paintings to discuss their technology)
- Readings:

1. * Kakoulli, Ioanna. "Late Classical and Hellenistic painting techniques and materials: a review of the technical literature." *Studies in Conservation* 47, no. sup1 (2002): 56-67. PAPER FOR DISCUSSION

2. Toschi, Francesco, Alessandra Paladini, Francesca Colosi, Patrizia Cafarelli, Veronica Valentini, Mauro Falconieri, Serena Gagliardi, and Paola Santoro. "A multi-technique approach for the characterization of Roman mural paintings." Applied surface science 284 (2013): 291-296.

3. Kakoulli, Ioanna, Sergey V. Prikhodko, Andrew King, and Christian Fischer. "Earliest evidence for asbestos composites linked to Byzantine wall paintings production." Journal of archaeological science 44 (2014): 148-153.

4. Kakoulli, Ioanna. Greek painting techniques and materials from the fourth to the first century BC. 2009.

5. Cline, Eric H., Assaf Yasur-Landau, and Nurith Goshen. "New fragments of Aegean-style painted plaster from Tel Kabri, Israel." American Journal of Archaeology 115, no. 2 (2011): 245-261.

6. Zanella, Elena, L. Gurioli, Giacomo Chiari, A. Ciarallo, R. Cioni, E. De Carolis, and Roberto Lanza. "Archaeomagnetic results from mural paintings and pyroclastic rocks in Pompeii and Herculaneum." Physics of the Earth and Planetary Interiors 118, no. 3-4 (2000): 227-240.

Week 5

Submission of Individual Written Research Paper (Student Group I) and Group Project/Presentation (Student Group II)

Week 6

Structure, Properties and Technology of Pigments and Colorants: natural pigments

- Lecture/Seminar: Analysis of the structure and chemical and physical properties of natural earth pigments. Compatibility with fresco application.
- Demo/Lab (Hands-on, object-based learning): Physical processing of earth pigments.
- Discussion-critical review of papers.
- Site Visit: Natural History Museum (focus on the collection of natural minerals)
- Readings:

1. * Colomban, Philippe. "Rocks as blue, green and black pigments/dyes of glazed pottery and enamelled glass artefacts–A review." *European Journal of Mineralogy* 25, no. 5 (2013): 863-879. PAPER FOR DISCUSSION
2. Rapp, George. "Pigments and Colorants." In Archaeomineralogy, pp. 201-221. Springer, Berlin, Heidelberg, 2009.
3. Orna, Mary Virginia. "Historic mineral pigments: colorful benchmarks of ancient civilizations." In Chemical Technology in Antiquity, pp. 17-69. American Chemical Society, 2015.
4. Feller, Robert L. Artist's pigments: a handbook of their history and characteristics. Vol. 1. Vol. 1. 1986.
5. Ospitali, Francesca, David C. Smith, and Michel Lorblanchet. "Preliminary investigations by Raman microscopy of prehistoric pigments in the wall-painted cave at Roucadour, Quercy, France." Journal of Raman Spectroscopy: An International Journal for Original Work in all Aspects of Raman Spectroscopy, Including Higher Order Processes, and also Brillouin and Rayleigh Scattering 37, no. 10 (2006): 1063-1071.

6. Scott, David A., and William D. Hyder. "A study of some Californian Indian rock art pigments." Studies in conservation 38, no. 3 (1993): 155-173.

Week 7

Structure, Properties and Technology of Pigments and Colorants: synthetic pigments

- Lecture/Seminar: Analysis of the structure and chemical and photophysical properties of synthetic inorganic and organic-inorganic hybrid pigments. Egyptian blue and Chinese blue (frit materials with high luminescent properties), Madder Lake (organic inorganic hybrid.
- Demo/Lab (Hands-on, object-based learning): Synthesis of Madder lake.
- Discussion-critical review of papers.
- Site Visit: Getty Villa (focus on south Italian painted terracotta artifacts)
- Readings:

1. *Daniels, V., T. Devièse, M. Hacke, and C. Higgitt. "Technological insights into madder pigment production in antiquity." *Br. Mus. Tech. Res. Bull* 8 (2014): 13-28. PAPER FOR DISCUSSION
2. Radpour, Roxanne, Christian Fischer, and Ioanna Kakoulli. "New Insight into Hellenistic and Roman Cypriot Wall Paintings: An Exploration of Artists' Materials, Production Technology, and Technical Style." In Arts, vol. 8, no. 2, p. 74. Multidisciplinary Digital Publishing Institute, 2019.
3. Grifa, Celestino, Laetitia Cavassa, Alberto De Bonis, Chiara Germinario, Vincenza Guarino, Francesco Izzo, Ioanna Kakoulli, Alessio Langella, Mariano Mercurio, and Vincenzo Morra. "Beyond Vitruvius: new insight in the technology of Egyptian blue and green frits." Journal of the American Ceramic Society 99, no. 10 (2016): 3467-3475.
4. Berke, Heinz. "The invention of blue and purple pigments in ancient times." Chemical Society Reviews 36, no. 1 (2007): 15-30.
5. Delaney, John K., Kathryn A. Dooley, Roxanne Radpour, and Ioanna Kakoulli. "Macroscale multimodal imaging reveals ancient painting production technology and the vogue in Greco-Roman Egypt." Scientific reports 7, no. 1 (2017): 1-12.
6. Chiari, Giacomo, Roberto Giustetto, J. Druzik, E. Doehne, and Gabriele Ricchiardi. "Pre-columbian nanotechnology: reconciling the mysteries of the maya blue pigment." Applied Physics A 90, no. 1 (2008): 3-7.

Week 8

Introduction to environmental degradation of archaeological ceramics, glass and building materials

- Lecture/Seminar: Examples of physical and chemical weathering, diagenetic processes and biological degradation of materials.
- Demo/Lab (Hands-on, object-based learning): Examination of weathered artifacts.
- Discussion-critical review of papers.
- Site Visit: Fowler Museum (examination of archaeological and ethnographic collections)
- Readings:

1. * Aze, Sebastien, J-M. Vallet, Vincent Detalle, Olivier Grauby, and Alain Baronnet. "Chromatic alterations of red lead pigments in artworks: a review." *Phase Transitions* 81, no. 2-3 (2008): 145-154. PAPER FOR DISCUSSION
2. Palamara, E., N. Zacharias, L. Papakosta, D. Palles, E. I. Kamitsos, and J. Pérez-Arantegui. "Studying a funerary Roman vessel glass collection from Patras, Greece: An interdisciplinary characterisation and use study." STAR: Science & Technology of Archaeological Research 2, no. 2 (2016): 203-216.
3. Smith, B. J., M. Gomez-Heras, and S. McCabe. "Understanding the decay of stone-built cultural heritage." Progress in Physical Geography 32, no. 4 (2008): 439-461.
4. Charola, A. Elena. "Salts in the deterioration of porous materials: an overview." Journal of the American institute for conservation 39, no. 3 (2000): 327-343.
5. Neiman, Madeleine Kegelman, Magdalena Balonis, and Ioanna Kakoulli. "Cinnabar alteration in archaeological wall paintings: an experimental and theoretical approach." Applied Physics A 121, no. 3 (2015): 915-938.
6. Cicinelli, Emanuela, Fabiola Benelli, Flavia Bartoli, Lorenzo Traversetti, and Giulia Caneva. "Trends of plant communities growing on the Etruscan tombs (Cerveteri, Italy) related to different management practices." Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology 154, no. 2 (2020): 158-164.

Week 9

Archaeomimetism and archaeoinspired novel materials' design for modern applications

- Lecture/Seminar: Archaeological materials surviving adverse conditions of terrestrial or underwater environments show promise for novel materials design with improved properties. Examples will include, ancient colorants and adhesives as well building materials such as Maya blue, Chinese blue birch bark adhesive and the Roman concrete.
- Demo/Lab (Hands-on, object-based learning): Synthesis of novel nanomaterials with luminescent properties based on the technology of Chinese blue.
- Discussion-critical review of papers.
- Site Visit: Molecular and Nano Archaeology Laboratory, UCLA
- Readings:

1. * Giulieri, Françoise, Sonia Ovarlez, and Anne–Marie Chaze. "Indigo/sepiolite nanohybrids: stability of natural pigments inspired by Maya blue." *International journal of nanotechnology* 9, no. 3-7 (2012): 605-617. PAPER FOR DISCUSSION
2. Jackson, Marie D., Juhyuk Moon, Emanuele Gotti, Rae Taylor, Sejung R. Chae, Martin Kunz, Abdul-Hamid Emwas et al. "Material and elastic properties of Al-tobermorite in ancient Roman seawater concrete." Journal of the American Ceramic Society 96, no. 8 (2013): 2598-2606.
3. Dejoie, Catherine, Eric Dooryhee, Pauline Martinetto, Sylvie Blanc, Patrice Bordat, Ross Brown, Florence Porcher et al. "Revisiting Maya Blue and Designing Hybrid Pigments by Archaeomimetism." arXiv preprint arXiv:1007.0818 (2010).
4. Lang, Johann, Benjamin Winkeljann, Oliver Lieleg, and Cordt Zollfrank. "Continuous Synthesis and Application of Novel, Archaeoinspired Tackifiers from Birch Bark Waste." ACS Sustainable Chemistry & Engineering 7, no. 15 (2019): 13157-13166.
5. Sciau, Philippe, and Philippe Goudeau. "Ceramics in art and archaeology: a review of the materials science aspects." The European physical journal B 88, no. 5 (2015): 132.
6. Walter, Philippe, Eléonore Welcomme, Philippe Hallégot, Nestor J. Zaluzec, Christopher Deeb, Jacques Castaing, Patrick Veyssière, René Bréniaux, Jean-Luc Lévêque, and Georges Tsoucaris. "Early use of PbS nanotechnology for an ancient hair dyeing formula." Nano letters 6, no. 10 (2006): 2215-2219.

Week 10

Submission of Individual Written Research Paper (Students Group II) and Group Project/Presentation (Students Group I)

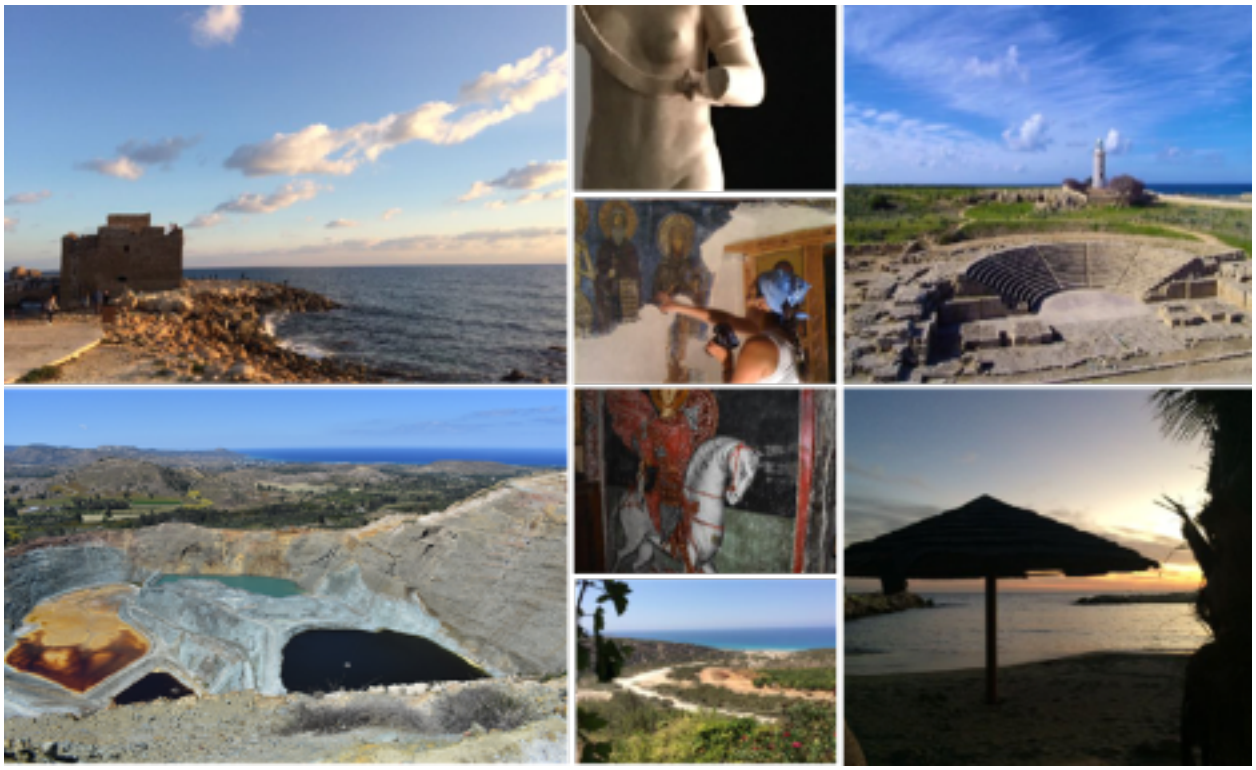
SUMMER COURSE MAT SCI 33

Materials Structure and Technology in Archaeology and Architecture (MST-A^2)

SUMMER COURSE to be offered through the UCLA Summer Abroad Program in Limassol, Cyprus, in collaboration with the Cyprus University of Technology

Duration/Period – Five-week program from July 4 to August 8, 2021

Enrolled # of students: 20 max - One TA



Instructor

PROF. IOANNA KAKOULLI, MATERIALS SCIENCE AND ENGINEERING DEPARTMENT
KAKOULLI@UCLA.EDU

COURSE SYLLABUS

*** The course syllabus will remain essentially the same (see regular course (10-week) above).** However, the weekly schedule (hours/week) will be modified as indicated below.

Instruction

Instruction will be based on formal lectures/seminars that will also include presentations by visiting experts, supplemented with demos and hands-on object based learning through handling and reverse engineering of archaeological materials experience (handling museum objects relevant to the week's class); discussion, and site visits.

Weekly:

Seminar: 8 hours

Lab: 4 hours

Site visits: 8 hours

Outside Study/Research: 10 hours

Assignment

Students will be evaluated in the same way as in the 10-week program: mainly based on the performance in an individual written Research Paper and Presentation based on a group project, lab work and paper discussion *A change in the assignments: No final exam; instead the % of each other assignment has increased.

The weighting of the final grade will be based on 100 points (for the conversion please see course above based on a 10-week program):

Individual Written Research Paper (Midterm I)	30%
Group Project & Presentation (Midterm II)	30%
Lab Work	30%
Paper Discussion	10%

Guidelines for each of these categories will be provided separately and posted on the CCLE website under the tag Guidelines.

Individual Written Research Paper (Midterm I) and Group Projects/ Presentations (Midterm II)

Half of the students (group I) enrolled in the summer course who will write the Individual Research Paper (Midterm I) on the first thematic of the course: i.e. on vitreous materials (ceramic, frit, glass) will have their Group Project/Presentation (Midterm II) on the second and third thematics that include: mortars, cements, wall paintings, pigments and colorants.

Examples of a research topics include: Biodegradation of archaeological glass; Egyptian blue: a high fired ceramic pigment (frit); Roman concrete inspires the design of modern eco-friendly constructions; alteration of copper-based pigments in ancient wall paintings and others.

*Subjects for the individual written research paper and group project/presentation will be discussed with the instructor.

Individual Written Research Paper (Writing Assignment)

To ensure good quality of the written paper and adequate supervision in the short period of 5 weeks please see research scaffolding procedure for the individual written research paper. The guidelines will remain the same as for 10-week program - see above.

MIDTERM I (INDIVIDUAL WRITTEN RESEARCH PAPER)	INDIVIDUAL MEETINGS WITH STUDENTS
	WEEK 1
SELECT TOPIC/DEFINE RESEARCH QUESTION; HOOK: WHAT IS INTERESTING ABOUT THIS QUESTION?	ASSIST STUDENTS SELECT THE TOPIC OF THEIR INDIVIDUAL RESEARCH AND IDENTIFY WHAT IS INTERESTING ABOUT THE RESEARCH QUESTION THEY HAVE CHOSEN (HOOK).
HOW TO SEARCH FOR ARTICLES/USE SEARCH ENGINES & KEYWORDS AND HOW TO IDENTIFY AND COLLECT FACTS	REMIND AND SHOW STUDENTS THAT THEIR RESEARCH QUESTION CAN PROVIDE THE KEYWORDS FOR A TARGETED INTERNET SEARCH. ASSIST STUDENTS IDENTIFY THE BEST INTERNET SEARCH ENGINES FOR THE TOPIC. ASSIST STUDENTS SEARCH FOR RELEVANT PAPERS FOR THEIR RESEARCH PAPER. *Explain that information found in the articles may lead students to broaden their research question. Emphasize that students need to find articles from at least five different reliable sources that provide "clues" to answering their research question.*

MIDTERM I (INDIVIDUAL WRITTEN RESEARCH PAPER)	INDIVIDUAL MEETINGS WITH STUDENTS
INSTRUCT STUDENTS HOW TO USE ENDNOTE OR OTHER BIBLIOGRAPHIC REFERENCE SOFTWARE AND HOW TO USE CAPTIONS AND CROSS REFERENCES	HELP STUDENTS WITH WORD PROCESSING AND HOW THEY CAN CITE AS THEY WRITE BY USING BIBLIOGRAPHIC SOFTWARE SUCH AS ENDNOTE. HELP STUDENTS USE CAPTIONS (FOR FIGURES, TABLES, EQUATIONS ETC) AND HOW TO CROSS REFERENCE IN THE TEXT.
	WEEK 2
SUBMIT SELECTED BIBLIOGRAPHY (~15 ARTICLES) LISTING THE RELEVANT FACTS FROM EACH PAPER SUPPORTING THE RESEARCH QUESTION.	PROVIDE FEEDBACK ON THE BIBLIOGRAPHY SUBMITTED. ASSIST STUDENTS WITH IDENTIFYING FACTS, THE ANALYSIS OF FACTS AND THE DEVELOPMENT OF A RESEARCH OUTLINE. *Have students find the specific information (facts) in each article that helps answer their research question, and highlight the relevant passages. Check that students have correctly identified and marked relevant information before they proceed with the analysis.*
ANALYSIS OF FACTS AND DEVELOPING A RESEARCH OUTLINE	DISCUSS HOW THEY CAN ANALYZE FACTS. *Explain how they will compare the information they have gathered from various sources to identify themes.* *Explain the process of analysis. Show how making a numbered list of possible themes, drawn from the different perspectives proposed in the literature, can be useful for analysis.* DISCUSS THE OUTLINE (STRUCTURE) OF THE PAPER.
	WEEK 3
SUBMIT FIRST DRAFT WITH ANALYSIS OF THE STUDIES/ PAPERS SELECTED	SUBMIT FIRST DRAFT AND PROVIDE FEEDBACK (ON THE STRUCTURE OF THE PAPER, FACTS, ANALYSIS AND CONCLUSIONS, ILLUSTRATIONS AND REFERENCES)
	WEEK 4
SUBMIT SECOND DRAFT OF WRITTEN PAPER AND FORMATTED ACCORDING TO GUIDELINES	SUBMIT SECOND DRAFT AND PROVIDE FEEDBACK
	WEEK 5
FINAL PAPER	SUBMIT FINAL PAPER (SUBMISSION ELECTRONICALLY VIA THE COURSEWEB)

* *Use of Research Scaffold template provided - Appendix 1*

Group Project (Presentation) (groups of 4 students/project)

To ensure good quality of the group project/presentation and adequate supervision in the short period of 5 weeks please see research scaffolding procedure for the group project. The guidelines will remain the same as for 10-week program - see above.

MIDTERM II (GROUP PROJECT/PRESENTATION)

	WEEK 1
SELECT TOPIC/DEFINE RESEARCH QUESTION; HOOK: WHAT IS INTERESTING ABOUT THIS QUESTION?	ASSIST STUDENTS (groups of 4) SELECT THE TOPIC OF THEIR INDIVIDUAL RESEARCH AND IDENTIFY WHAT IS INTERESTING ABOUT THE RESEARCH QUESTION THEY HAVE CHOSEN (HOOK).
HOW TO SEARCH FOR ARTICLES/USE SEARCH ENGINES & KEYWORDS AND HOW TO IDENTIFY AND COLLECT FACTS	REMIND AND SHOW STUDENTS THAT THEIR RESEARCH QUESTION CAN PROVIDE THE KEYWORDS FOR A TARGETED INTERNET SEARCH. ASSIST STUDENTS IDENTIFY THE BEST INTERNET SEARCH ENGINES FOR THE TOPIC. ASSIST STUDENTS SEARCH FOR RELEVANT PAPERS FOR THEIR GROUP PROJECT. *Explain that information found in the articles may lead students to broaden their research question. Emphasize that students need to find articles from at least five different reliable sources that provide "clues" to answering their research question.*
INSTRUCT STUDENTS HOW TO USE POWERPOINT FOR THEIR PRESENTATIONS	HELP STUDENTS CREATE DIFFERENT SLIDES TO PRESENT VARIOUS DATA. EXPLAIN CHARTS, DIAGRAMS AND OTHER TOOLS THAT CAN HELP THEM DEVELOP THEIR PRESENTATION
	WEEK 2
SUBMIT SELECTED BIBLIOGRAPHY (~15 ARTICLES) LISTING THE RELEVANT FACTS FROM EACH PAPER SUPPORTING THE RESEARCH QUESTION.	ASSIST STUDENTS WITH IDENTIFYING FACTS, THE ANALYSIS OF FACTS AND THE DEVELOPMENT OF THE PRESENTATION. *Have students find the specific information (facts) in each article that helps answer their research question, and highlight the relevant passages. Check that students have correctly identified and marked relevant information before they proceed with the analysis.*
ANALYSIS OF FACTS AND DEVELOPMENT OF PRESENTATION OUTLINE WITH VISUAL DATA	DISCUSS HOW THEY CAN ANALYZE FACTS. *Explain how they will compare the information they have gathered from various sources to identify themes.* *Explain the process of analysis. Show how making a numbered list of possible themes, drawn from the different perspectives proposed in the literature, can be useful for analysis.* DISCUSS THE OUTLINE (STRUCTURE) OF THE PRESENTATION AND HOW TO VISUALIZE IN A PRESENTATION THE FACTS AND ANALYSIS OF FACTS. DISCUSS HOW THE PRESENTATION CAN BE PRESENTED BY A GROUP OF STUDENTS (4 STUDENTS)
	WEEK 3
SUBMIT FIRST GROUP PROJECT/PRESENTATION DRAFT AND PRESENT TO THE INSTRUCTOR	SUBMIT ELECTRONICALLY THE PRESENTATION (GROUP PROJECT) AND ALSO PRESENT TO THE INSTRUCTOR THE FIRST DRAFT OF THE GROUP PROJECT/PRESENTATION INSTRUCTOR WILL PROVIDE FEEDBACK ON THE STRUCTURE OF THE PRESENTATION, VISUAL AND TEXTUAL INFORMATION AND PRESENTATION STYLE AND TIMING.

MIDTERM II (GROUP PROJECT/PRESENTATION)	
	WEEK 4
SUBMIT SECOND GROUP PROJECT/ PRESENTATION DRAFT AND PRESENT TO THE INSTRUCTOR	SUBMIT/PRESENT SECOND DRAFT INSTRUCTOR WILL PROVIDE FEEDBACK
	WEEK 5
FINAL PRESENTATION	PRESENT THE GROUP PROJECT TO THE CLASS AND SUBMIT FINAL PRESENTATION (SUBMISSION ELECTRONICALLY VIA THE COURSEWEB)

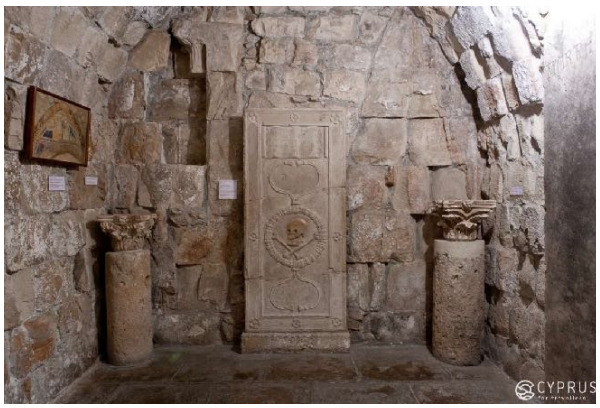
(Use of Research Scaffold template provided - Appendix 1)

Summer Course Calendar

Week 1

Structure, Properties and Technology of Vitreous Materials: ceramic, glazed ceramic, frit and glass

- Lecture/Seminar: General introduction to different types of ancient ceramics, frits and glass with emphasis on Hellenistic, Roman and Late Antique. Introduction to raw materials and production technology and processing as well as the relationships that exist between the structural elements of materials and their properties.
- Demo/Lab (Hands-on, object-based learning): Examination of ancient ceramics and vitreous materials from museum collections.
- Discussion-critical review of papers.
- Site Visit: Archaeological Museum of Limassol and Amathus archaeological site.





- Readings:

1. * Tite, Michael S. "Ceramic production, provenance and use—a review." *Archaeometry* 50, no. 2 (2008): 216-231. PAPER FOR DISCUSSION

2. * Gliozzo, Elisabetta. "The composition of colourless glass: a review." *Archaeological and Anthropological Sciences* 9, no. 4 (2017): 455-483. PAPER FOR DISCUSSION

3. Angelini, Ivana, Bernard Gratuze, and Gilberto Artioli. "Glass and other vitreous materials through history." EMU Notes Mineral 20 (2019): 87-150.

4. Rapp, George. "Ceramic Raw Materials." In Archaeomineralogy, pp. 183-200. Springer, Berlin, Heidelberg, 2009.

5. Roux, Valentine. "Introduction to Ceramic Technology." In Ceramics and Society, pp. 1-14. Springer, Cham, 2019.

6. Thér, Richard. "Ceramic technology. How to reconstruct and describe pottery-forming practices." Archaeological and Anthropological Sciences 12, no. 8 (2020): 1-22.

7. Marzec, Edyta, Evangelia Kiriatzi, Noémi S. Müller, and Anno Hein. "The provenance and technology of a group of Hellenistic colour-coated ware pottery from the excavations at Nea Paphos on Cyprus." Journal of Archaeological Science: Reports 21 (2018): 1035-1043.

8. Wang, Y., H. Ma, K. Chen, X. Huang, J. Cui, Z. Sun, and Q. Ma. "Identification of PbO (BaO) faience from an early and middle Warring States period cemetery at Zhaitouhe, northern Shaanxi, China." Archaeometry 61, no. 1 (2019): 43-54.

9. Hodgkinson, Anna K., Stefan Röhrs, Katharina Müller, and Ina Reiche. "The use of Cobalt in 18th Dynasty Blue Glass from Amarna: the results from an on-site analysis using portable XRF technology." STAR: Science & Technology of Archaeological Research (2019): 1-17.

10. Henderson, Julian. "Glass and glass production in the Near East during the Iron Age: evidence from objects, texts and chemical analysis. Oxford: Archaeopress; 978-1-78969-154-2£ 50." Antiquity 93, no. 372 (2019): 1687-1688.

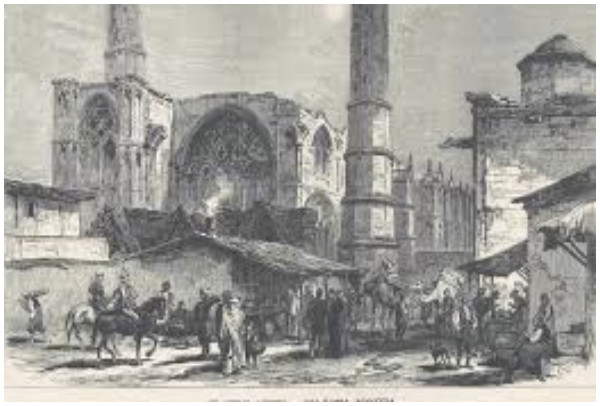
11. Fischer, Christian, and Ellen Hsieh. "Export Chinese blue-and-white porcelain: compositional analysis and sourcing using non-invasive portable XRF and reflectance spectroscopy." Journal of Archaeological Science 80 (2017): 14-26.

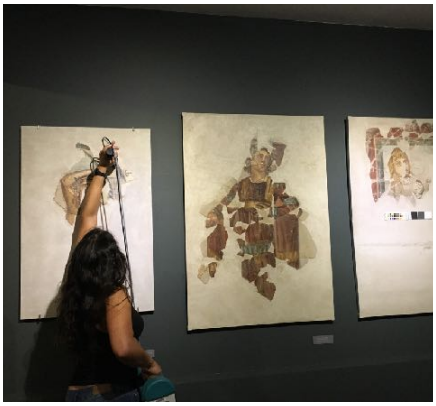
12. Lin, Yuan, Tianchi Liu, Michael K. Toumazou, Derek B. Counts, and Ioanna Kakoulli. "Chemical analyses and production technology of archaeological glass from Athienou-Malloura, Cyprus." Journal of Archaeological Science: Reports 23 (2019): 700-713.

Week 2

Structure, Properties and Technology of Ancient Building Materials and Wall Paintings: lime as a binder and fresco and secco wall painting techniques

- Lecture/Seminar: : Introduction to building materials with emphasis on aerial lime-based mortars/plasters, natural and artificial hydraulic lime/cements and concretes, and the relationships that exist between the structural elements of these materials and their properties. Introduction to wall paintings (binary systems composed of a paint layer and a plaster or plasters) with emphasis on Hellenistic and Roman painted architectural surfaces and their production technology: fresco and secco painting techniques, stratigraphy, chemical reactions, materials performance.
- Demo/Lab (Hands-on, object-based learning): Production of Roman cement (hydraulic) using aerial lime and natural and artificial pozzolanic materials.
- Demo/Lab (Hands-on, object-based learning): Preparation of lime based plaster.
- Discussion-critical review of papers.
- Site Visit: Discover the only divided capital in the world: Nicosia. Visit the city of Nicosia, capital of Cyprus. First stop is the national archaeological museum. Wandering the old streets, we will visit the house of Hatzigeorgakis Kornesios, dragoman in Cyprus (ethnological museum). Crossing the ‘green line’ (border of the divided city), we will first have lunch at the largest caravansarai on the island, the Buyuk Han built by the Ottomans in 1572. This is one of the most important Ottoman sites in the Eastern Mediterranean. After lunch, we will visit the Hagia (Saint) Sophia Cathedral now the Selimiye Mosque. We will cross back through the Ledra Street Checkpoint and head back to Limassol.





- Readings:

1. * Siddall, Ruth. "The use of volcaniclastic material in Roman hydraulic concretes: a brief review." *Geological Society, London, Special Publications* 171, no. 1 (2000): 339-344. PAPER FOR DISCUSSION

2. * Kakoulli, Ioanna. "Late Classical and Hellenistic painting techniques and materials: a review of the technical literature." *Studies in Conservation* 47, no. sup1 (2002): 56-67. PAPER FOR DISCUSSION

3. Rapp, George. " Building, Monumental, and Statuary Materials." In Archaeomineralogy, pp. 247-280. Springer, Berlin, Heidelberg, 2009.Bonavetti, Viviana L., Viviana Fátima Rahhal, F. Locati, Edgardo F. Irassar, S. Marfil, and P. Maiza. "Pozzolanic activity of argentine vitreous breccia containing mordenite." Materiales de Construcción 70, no. 337 (2020): 208.

4. Lechtman, Heather N., and Linn W. Hobbs. "Roman concrete and the Roman architectural revolution." In High-Technology Ceramics: Past, Present, and Future-The Nature of Innovation and Change in Ceramic Technology, vol. 3, pp. 81-128. 1987.

5. Gotti, E., J. P. Oleson, L. Bottalico, C. Brandon, R. Cucitore, and R. L. Hohlfelder. "A comparison of the chemical and engineering characteristics of ancient Roman hydraulic concrete with a modern reproduction of Vitruvian hydraulic concrete." Archaeometry 50, no. 4 (2008): 576-590.

6. Brandon, Christopher J., Robert L. Hohlfelder, Marie D. Jackson, and John Peter Oleson. Building for eternity: the history and technology of Roman concrete engineering in the sea. Oxbow books, 2014.

7. Elsen, Jan, Ozlem Cizer, and Ruben Snellings. "Lessons from a lost technology: The secrets of Roman concrete." American Mineralogist 98, no. 11-12 (2013): 1917-1918.

8. Toschi, Francesco, Alessandra Paladini, Francesca Colosi, Patrizia Cafarelli, Veronica Valentini, Mauro Falconieri, Serena Gagliardi, and Paola Santoro. "A multi-technique approach for the characterization of Roman mural paintings." Applied surface science 284 (2013): 291-296.

9. Kakoulli, Ioanna, Sergey V. Prikhodko, Andrew King, and Christian Fischer. "Earliest evidence for asbestos composites linked to Byzantine wall paintings production." Journal of archaeological science 44 (2014): 148-153.

10. Kakoulli, Ioanna. Greek painting techniques and materials from the fourth to the first century BC. 2009.

11. Cline, Eric H., Assaf Yasur-Landau, and Nurith Goshen. "New fragments of Aegean-style painted plaster from Tel Kabri, Israel." American Journal of Archaeology 115, no. 2 (2011): 245-261.

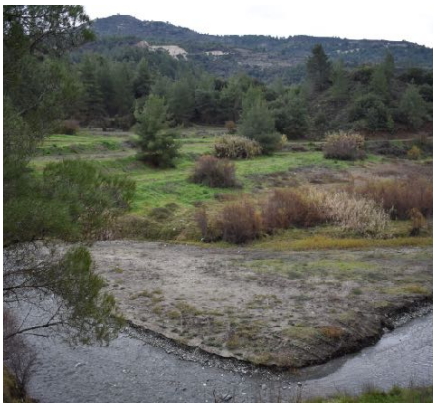
12. Zanella, Elena, L. Gurioli, Giacomo Chiari, A. Ciarallo, R. Cioni, E. De Carolis, and Roberto Lanza. "Archaeomagnetic results from mural paintings and pyroclastic rocks in Pompeii and Herculaneum." Physics of the Earth and Planetary Interiors 118, no. 3-4 (2000): 227-240.

Week 3

Structure, Properties and Technology of Pigments and Colorants

- Lecture/Seminar: Analysis of the structure and chemical and photophysical properties of pigments (natural and synthetic, organic, inorganic and organic/inorganic hybrid pigments) and the relationships that exist between the structural elements of these pigments/colorants and their properties. Compatibility with fresco application.
- Demo/Lab (Hands-on, object-based learning): Physical processing of earth pigments.
- Demo/Lab (Hands-on, object-based learning): Synthesis of Madder lake.
- Discussion-critical review of papers.
- Site visit: From Ocean Depths to Mountain tops. Visit of the Troodos mountains. Copper was known as ‘aes Cyprium’ (the ore of Cyprus) by the Romans and constituted one of the most important economic metals in antiquity. We will be visiting the Troodos mountains formed by an uplift of the earth’s crust forming a unique geomorphology on the island. There we will visit the mine of Skouriotissa which was known to Galen (Roman doctor) and where we can see metallurgical slags witnessing 4000 years of continuous exploitation of the copper minerals. At Troodos we will also visit a few of the Byzantine churches decorated with important wall paintings that are part of the UNESCO World Heritage List.



- Readings:

1. * Colomban, Philippe. "Rocks as blue, green and black pigments/dyes of glazed pottery and enamelled glass artefacts–A review." *European Journal of Mineralogy* 25, no. 5 (2013): 863-879. PAPER FOR DISCUSSION

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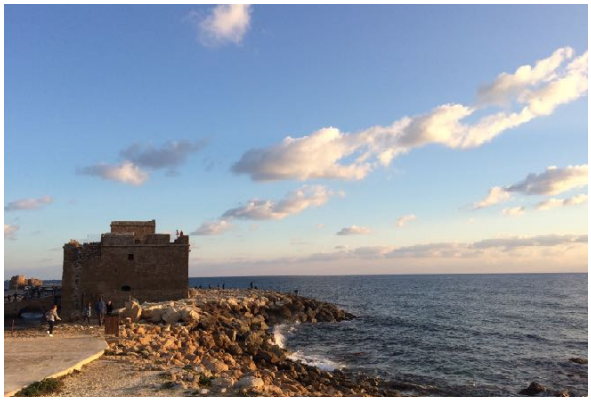
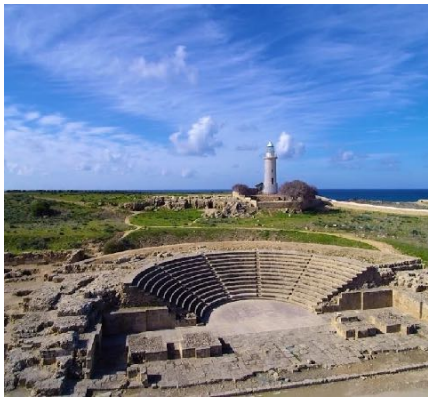
Week 4

Introduction to environmental degradation of archaeological ceramics, glass and building materials

Archaeomimetism and archaeoinspired novel materials' design for modern applications

- Lecture/Seminar 1: Examples of physical and chemical weathering, diagenetic processes and biological degradation of materials.
- Lecture/Seminar 2: Archaeological materials surviving adverse conditions of terrestrial or underwater environments show promise for novel materials design with improved properties. Examples will include, ancient colorants and adhesives as well building materials such as Maya blue, Chinese blue birch bark adhesive and the Roman concrete.
- Demo/Lab (Hands-on, object-based learning): Examination of weathered artifacts.
- Demo/Lab (Hands-on, object-based learning): Synthesis of novel nanomaterials with luminescent properties based on the technology of Chinese blue.
- Site visit: Discovering Paphos, the city of Goddess Aphrodite. Site visit to the archaeological park (Hellenistic/Roman city of Nea Paphos) with villas decorated with unique mosaics and wall paintings. We will then visit the Enkleistra (place of reclusion) of Saint Neophytos decorated with unique wall paintings from the 12th to the 18th century. On the outskirts of the city, we will visit the Sanctuary of Aphrodite at Palaepaphos (archaeological site of Kouklia), and the Palaepaphos museum housed in the medieval manor of Lusignan which exhibits interesting finds portraying how the Cult of the Goddess of Fertility developed into the Cult of Aphrodite.



- Readings:

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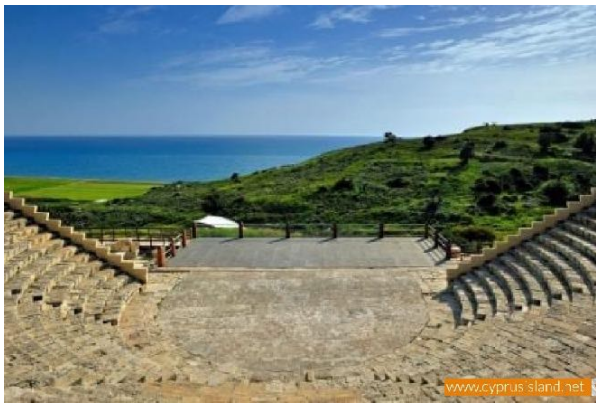
Week 5

Submission of Individual Written Research Paper and Group Project/Presentations

- Site Visit: In the footsteps of the Romans, the Order of Knights Hospitaller and the Crown. Site visit to Kourion archaeological site, the Akrotiri Environmental Educational Center and the Kolossi medieval castle.





* *The site visits to archaeological sites will help students emerged in the culture and also see examples of materials that will be learning during the course.*

APPENDIX 1: Research Scaffold Template

Name:_____ Date: _____

Research Scaffold

Research Question

_____

_____

_____

Hook

What is interesting about this question? Hook your readers with an interesting fact that might make them curious about this topic.

_____

_____

_____

_____

_____

(continued)

Research Scaffold (continued)

Literature Review

Find up to 15 articles about your topic and list the relevant facts from each one.

1. According to (*author/source*)_____(*date*_____) the main idea about this subject is

_____

_____ .

List facts from the source that support this idea

1. fact _____
2. fact _____
3. fact _____
4. fact _____
5. fact_____

(You can add more facts as you find them.)

In conclusion_____says _____

_____

_____ about the topic.

2. Another idea, by (*author/source*)_____(*date*_____) is _____

_____

_____ .

1. fact _____
2. fact _____
3. fact _____
4. fact _____
5. fact_____

(You can add more facts as you find them.)

In conclusion_____says _____

_____

3. A third writer,_____(*date*_____) states that _____

_____

_____ .

1. fact _____
2. fact _____
3. fact _____
4. fact _____
5. fact _____

(You can add more facts as you find them.)

(continued)

Literature Review (continued)

The third author concludes that _____

_____

_____.

4. A fourth source,_____(*date* _____) states that _____

_____

_____.

1. fact _____
2. fact _____
3. fact _____
4. fact _____
5. fact_____

(You can add more facts as you find them.)

This author concludes that_____

_____

_____.

5. Yet another idea, from_____(*date* _____) is that _____

_____

_____.

1. fact _____
2. fact _____
3. fact _____
4. fact _____
5. fact_____

(You can add more facts as you find them.)

This author concludes that_____

_____

_____

- Repeat this for all references

(continued)

Research Paper Scaffold (continued)

Analysis

I found (*how many*)_____main idea/s about (*name your topic*)_____:

List main idea/s _____

Explain how the ideas are different or the same.

Conclusion

What is your answer to the question? (*Give the facts that support your point.*)

The most likely explanation seems to be that _____

Research Paper Scaffold (continued)

References

Author last name, first initial. (date). title of article. date retrieved (if online publication), pages (if print publication) of the references cited.

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New Course Proposal

Materials Science & Engineering 33
Materials Structure and Technology in Archaeology and Architecture

Course Number Materials Science & Engineering 33

Title Materials Structure and Technology in Archaeology and Architecture

Short Title MAT STUC&TECH ARCH

Units Fixed: 5

Grading Basis Letter grade only

Instructional Format
Seminar - 4 hours per week
Laboratory - 2 hours per week
Other

Describe Other
Site visits, 4 hours
Outside study, 5 hours

TIE Code SEMR - Seminar (Research/Creative) [I]

GE Requirement No

Requisites None

Course Description Seminar, four hours; laboratory, two hours; site visits, four hours; outside study, five hours. Exploration of three classes of materials and composites, and relationships that exist between structural elements of materials and their properties: vitreous materials, building material binders, and pigments and colorants. Through study of ancient materials and technology in archaeology and architecture, exploration of relationships among processing, structure, properties, and performance for: vitreous materials--ceramics, frits, and glass; building material binders--aerial lime-based mortars, natural and artificial hydraulic lime/cements and concretes; and pigments and colorants (natural and synthetic organic, inorganic, and organic/inorganic hybrids). Through reverse engineering processing, exploration of ancient engineering materials (their micro/nano structure and physical, chemical, and mechanical properties), and their durability and sustainability as time-proven examples of technology innovation and/or invention. Letter grading.

Justification This course to be offered as part of a 5-week intensive summer study abroad program in Cyprus titled: Ancient Technology, Materials and Forensics (ATMF), is designed to provide students with an experience that blends STEM education and a rigorous scientific approach with social science and humanities theory and methodologies, turning STEM into STEAM (Science, Technology, Engineering, Arts and Mathematics) and preparing 21st century students for a global society. The course using archaeological materials as the vehicle aims introduces students to the basics of materials science and engineering and principles of chemistry, physics. This course complements existing courses in the department of materials science and engineering and introduces a new sub-discipline at undergraduate level, that of archaeological materials science. In addition to learning materials properties through reverse engineering students can also inspired by ancient technology and the properties of ancient materials for the design of novel materials for modern applications.

Syllabus File *SYLLABI.docx* was previously uploaded. You may view the file by clicking on the file name.

Supplemental Information n/a

Grading Structure
30% Midterm: Individual Research Paper
30% Final Presentation: Group Presentation
15% Site Visit
15 Lab Work
10% Paper Discussion

Effective Date Summer 1 2020

Instructor

Name	Title
Ioanna Kakoulli	Professor

Quarters Taught ☐ Fall ☐ Winter ☐ Spring ☑ Summer

Department **Materials Science & Engineering**

Contact	Name	E-mail
	PATTI BARRERA	**patti@seas.ucla.edu**

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Comments: Approved by Samueli Engineering FEC on 02/07/2020, FEC Chair is Tsu-Chin Tsao

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Changes: No Changes Made
Comments: n/a

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Status: Approved on 1/31/2020 11:10:00 AM
Changes: GE, Requisites
Comments: Changes made

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Status: Approved on 1/29/2020 1:40:29 PM
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Role: Department Chair or Designee - Dunn, Bruce S (bdunn@ucla.edu) - 51519, 55534
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