

### The Impact of Materials on Society

#### Module 4 –Copper and Bronze – Outline of Instruction for Faculty

The discovery of the metals and the invention of metallurgy was both a technical and a social revolution. This module examines the economic and social dimensions of smelting and casting copper in the Bronze Age, and uses these lessons to predict the intensive sourcing and production needs of new photovoltaics. Understanding the relationships of trade, social class, and expertise is crucial to creating enduring materials for tomorrow's world.

Copper's applications involve intensive sourcing and production processes. Where are we going to get the supply to make all of these materials? How do our uses for copper require creating trade routes, public policies, anti-theft considerations, etc.?

#### Module Objectives

Students will:

- identify the properties of copper and its alloys
- identify the properties of photovoltaics
- explore the uses and applications of copper, both historically and in modern times
- examine the relationship of trade routes to materials innovation
- explore the importance of codifying expertise in materials engineering

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#### Student Reading Assignment before Day 1

Read excerpt (pp. 49-67) from **Sass, Stephen L.** (1998/2011) *The Substance of Civilization*. New York: Arcade Publishing.

#### Day 1 Class - Material Science & Engineering Lecture on Copper and Bronze

Material Science Professor presents background on Copper and Bronze: Properties of copper and bronze, natural abundance structure and location, history, native vs smelted, arsenic as an impurity, medical implications

#### Day 1 Lecture Development Resources:

**Lecture:** [Copper and Bronze](#) PPT slides

**Sample Lecture Video:** [Copper and Bronze video](#) (19:34) ([Transcript](#))

*Excerpts from Kevin Jones' lecture*

**Classroom Demo:** Make Copper from Malachite using torch and piece of charcoal

**Demo Video:** [Demonstration of Smelting Bronze](#) (4:01)

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#### Student Reading Assignment before Day 2

Read [Copper and Bronze: The Far-Reaching Consequences of Metallurgy](#) by Florin Curta.

*Abstract: The discovery of the metals and the invention of metallurgy has long been viewed as a revolutionary step in the history of humanity. But metallurgy was more than a technical revolution; its invention in the Bronze Ages was primarily a social revolution. This week's lectures look at the economic and social problems created by the technological innovations associated with smelting and casting. At the same time, the role of trade will be highlighted, and its connection to the rise of metallurgical, proto-industrial centers. The ensuing social and political complexity, disparities, and military conflict are a direct result of that connection and of the competition for resources inherent for metallurgy. Finally, we will look at the rise of a class of specialists in society, forerunners to modern engineers.*

**Read Article:** Nissim Amzallag (2009). "[From Metallurgy to Bronze Age Civilizations: The Synthetic Theory.](#)" *American Journal of Archaeology*, Vol. 113, No. 4: pp. 497-519

*Recommended Reading to learn more about the most current research on this topic:*

Naama Yahalom-Mack, Ehud Galilic, Irina Segald, Adi Eliyahu-Behara, Elisabetta Boaretto, Sana Shilsteina, Israel Finkelstein. (2014) "[New insights into Levantine copper trade: Analysis of ingots from the Bronze and Iron Ages in Israel.](#)" *Journal of Archeological Science*, Vol. 45: pp. 159-177.

### **Day 2 Class: Lecture on Trading Material Resources and Knowledge**

Guest Humanities/Archaeology Professor presents Copper and Bronze: Trading Materials Resources and Knowledge

The lecture highlights the importance of the invention and practice of metallurgy, with special emphasis on the extraction and smelting of copper, as well as the production of alloys (bronze). Because of the choice of alloys is a key component in producing different artifacts, the lecture also plays an emphasis on how metallurgy encouraged the development of long-distance exchanges and trade. Another key point of the lecture is the development of mould technology, with intricate forms being cast by the "lost wax" technique. Technological, economic, and social consequences of the invention of metallurgy are the focus of the last part of the lecture.

**Watch:** [Making History--the Bronze Age](#) (2:43) video at start of lecture

### **Day 2 Lecture Development Resources:**

**Lecture:** [Copper and Bronze](#) (PPT) slides by Prof. Florin Curta (UF)

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### **Student Video and Homework Assignments before Day 3**

**Watch Video:** [Photovoltaics](#) video (10:34) ([Transcript](#))

## Module 4: Copper and Bronze

As you watch this video, think about the answers to these questions:

- What are some of the many materials involved in making solar cells?
- Why is generating sustainable energy important to different societies?
- How efficient are Photovoltaics? Does their efficiency make them sustainable?
- What are some of the disadvantages and challenges to making Photovoltaics?
- What are the most important usage issues to be addressed in weighing the advantages and disadvantages of Photovoltaics?

**Assignment:** [Module 4 – Individual Homework Assignment](#) (WORD)

Photovoltaic Homework due start of class Day 3.

Please answer these questions in either bullet points or full sentences. Your responses will probably take ½ to 1 page. Assignment will be graded on effort, use of the lecture, video, and reading materials, and thoughtful reflection. Be sure your name is on the paper. A cover page is not necessary. See grading rubric below:

**Your grade will be based on the following criteria:**

Grading Rubric.

2= Responses are appropriate, thoughtful, and indicate engagement with the video and any other required viewing/reading materials. Grammar, sentence structure and punctuation are correct.

1= Responses and arguments are incomplete and/or inconsistent with the required viewing/reading material. Some issues with grammar, punctuation and or sentence structure.

0= Responses are not appropriate to the assignment or missing entirely. Major issues with grammar, punctuation and or sentence structure.

**Day 3 Class: Flipped Classroom Activity on Photovoltaics and Trade**

**Key Concepts:** The availability of materials impacts their utilization. Thus social constructs like trade and conflict can influence the use and acceptance of certain materials and one needs to be aware of such issues.

**Day 3 Classroom Activity: Photovoltaics**

This week's topic—copper and bronze—brings up some interesting points about the links between materials and long-distance trade/exchange. We are learning about challenges ancient artisans faced when they needed the key ingredients for certain alloy recipes, or the technological solutions for smelting metals. The response to the former problem is trade; the solution to the latter problem is the diffusion of (good) ideas. Let's now take that aspect of the relation between materials and long-distance exchange one step further by answering some questions about Photovoltaics:

## Module 4: Copper and Bronze

1. What do you need to make Photovoltaics?
  2. Where will you source the materials you listed in question #1? (Are there existing markets on which you can buy the materials?)
  3. Are there any particular challenges (logistical, social, religious, etc.) to extracting, mining, or moving any of the key materials involved in making Photovoltaics?
  4. Who has the know-how in how to make and use Photovoltaics? (Where are these people located? Are they located in different places than their potential users?)
  5. Is recycling possible for Photovoltaics? If so, where could the recycling be done? What technological and environmental problems may be raised by recycling Photovoltaics?
- Refer to [Day 3 In-Class Activity: Photovoltaics](#) worksheet for specific instructions.
  - Refer to the rubric for grading criteria.

### Your grade will be determined from the following criteria.

#### Grading Rubric.

5= Responses are appropriate and indicate engagement with the preparatory material. Grammar, sentence structure and punctuation are correct.

4= Responses and arguments are not as clearly presented. Some minor issues with grammar, punctuation and or sentence structure.

3= Responses are not appropriate to the assignment and do not reinforce the physical and cultural properties of materials. Mistakes in grammar, punctuation and or sentence structure.

2= Responses are incomplete. Major problems with grammar, punctuation and or sentence structure.

1= Responses are inconsistent with material covered in class, videos, and readings. Missing elements of assignment. Poor grammar, punctuation and or sentence structure.

### Day 3 Lecture Development Resources:

1. **Assignment:** [Day 3 In-Class Activity: Photovoltaics handout](#) (WORD)

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### Complete Impact Paradigm Assignment:

Thinking about the material that we covered in this week's unit, add another question to the impact paradigm.

- **Assignment:** [Module 4—Impact Paradigm Individual Homework Assignment](#) (Word)

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### Additional Resources

**Online Course Module**

- View the online Module 4 in [Word](#) or [PDF](#) format
- Available soon: The full online course to upload to your Learning Management System. Contact Kevin Jones at [kjones@eng.ufl.edu](mailto:kjones@eng.ufl.edu) or Pamela Hupp at [hupp@mrs.org](mailto:hupp@mrs.org) for more information.

**Articles:**

- a. Nissim Amzallag (2009). "[From Metallurgy to Bronze Age Civilizations: The Synthetic Theory.](#)" *American Journal of Archaeology*, Vol. 113, No. 4: pp. 497-519
- b. Naama Yahalom-Mack, Ehud Galilic, Irina Segald, Adi Eliyahu-Behara, Elisabetta Boarettoa, Sana Shilsteina, Israel Finkelstein. (2014) "[New insights into Levantine copper trade: Analysis of ingots from the Bronze and Iron Ages in Israel.](#)" *Journal of Archeological Science*, Vol. 45: pp. 159-177.

**Videos:**

- a. National Science Foundation and NBC Learn. "[Nanotechnology: Super Small Science—Powerful Solution.](#)" Video. National Science Foundation.
- b. Andrew Sheratt. [Making History--the Bronze Age](#) (2:43) video.
- c. Andrew Shreve. [Photovoltaics](#) (10:34) video.