

### Introduction

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.

### 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

### Readings, Lecture, and Practice

**Watch:** [Copper and Bronze Lecture \(19:33\)](#) [Copper and Bronze Lecture Transcript](#)

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

*To prepare for your quizzes and exams, take notes and think about how the lecture content relates to your readings as you watch the lecture.*

**Practice:** [Take the Copper and Bronze Quiz](#)

*The practice quiz has 10 questions. You will have 90 seconds to complete each question. You may only take the practice quiz one time and you must finish it once you open it so be sure you have adequately prepared by taking notes while you watched the lecture and by reading the chapter and studying before you begin.*

### Assignment: Application Video Analysis

**Key Concept:** The strong interest in decreasing our dependence on carbon emitting energy sources continues to drive the interest in photovoltaic or solar cells. Recent improvements in both inorganic and organic materials offer the potential to realize solar cells that could be cost competitive with fossil fuel sources. These new materials also have the potential to be flexible, opening up even more markets if, as we learned through our historic study of copper and bronze, we can maintain reliable trade routes to source their raw materials.

**Assignment Instructions:**

Before the video reflect on the lessons of this unit by considering the questions below. As you watch the video, think about how each question is answered.

- What are some of the many materials involved in making solar cells? Where do they come from?
- 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?

Watch: [Photovoltaics \(10:35\)](#)

**Write a 1 page essay** synthesizing the answers to the questions above with what you've learned in the lectures and readings. (full sentences in paragraphs, double-space, 11-12 pt. font). This assignment will be graded out of 10 points on effort, use of the lecture, video, reading materials, and thoughtful reflection. See the rubric attached to this assignment for grading criteria. Be sure your name is on the paper. A cover page is not necessary.

Refer to the due dates document for submission dates and the assignment rubric for grading criteria.

### Application Video Analysis Rubric

Criterion	9-10 points	6-8 points	3-5 points	0-2 points
Response Content (10 Points)	Responses are appropriate, thoughtful, and indicate engagement with the video.	Responses have minor inconsistencies with the video or are not supported by content.	Responses have major inconsistencies with the video or are not supported by content.	Responses are inaccurate, careless, and/or opinions not supported by content.
Mechanics (10 Points)	Grammar, sentence structure and punctuation are correct and paper is properly cited.	Minor issues with grammar, punctuation and/or sentence structure and citations.	Significant issues with grammar, punctuation and/or sentence structure and citations.	Major issues with grammar, punctuation and/or sentences and citations
Total				

### Assignment: Material Entanglement and Impact Paradigm Reflection

Think about your own and society's relationship with this module's material both in the past and present.

#### Part 1 Instructions:

1. **Open** to your Material Entanglement Reflection Document created in Module 2.
2. **Label** this new entry with this module's material and the date at the top of the page.  
(*Example: 1/23/16 Module 15: Diamonds*)
3. **Create** a tanglegram that illustrates your relationship with the material from this module.  
(\*If this module covered more than one material, then choose just one of the materials to explore your entanglement.)
  - Refer to the example tanglegram in the Module 2 reading, *Entanglement of Earth*. Make sure that this tanglegram demonstrates the new information about the relationship of materials to society that you learned in this lesson (e.g., our dependence on trade to acquire materials)
  - *Note that you may hand draw your tanglegram and take a picture to add to your document or use any other type of application that suits you. There are many free concept mapping applications found online. Just search mind-mapping applications.*
4. **Add your tanglegram** under your new entry.
5. **Source an image** that illustrates an aspect of your entanglement (or supports your lack of entanglement) with the material from this module. The image can be found, created, or photographed. If the image isn't yours, be sure to include a reference.
6. **Add your sourced image** under your tanglegram.
7. **Caption** the image telling what it is and its context.
8. **Discuss** your thoughts related to your personal relationship with this material and how that relates to society.  
Consider:
  - How do the social and cultural properties of this material affect you and society?
  - Based on what you've learned about this material what might be the consequences of the corrosion, degradation, or scarcity of this material?

*Note: Your entry should be no more than two paragraphs. Entries are evaluated for content, thoughtfully supported writing, and mechanics. Refer to the *Physical and Social Properties of Matter* document introduced in Module 1 to guide your discussions.*

#### Part 2 Instructions:

9. **Open** your Impact Paradigm Document
10. Add at least one question to any one of the categories. If you're having trouble coming up with a new question, think about the particular case studies of the material in this

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module, and the new information that you've learned about the relationships between materials and society. What is one new way to think about the social life of materials that you learned in this module?

11. Submit BOTH your Material Entanglement Reflection Document AND your Impact Paradigm Document

Refer to the DUE DATES document for submission dates and the rubric below for grading criteria.

### Material Entanglement and Impact Paradigm Reflection Grading Rubric

Criterion	9-10 points	6-8 points	3-5 points	0-2 points
Response Content (10 Points)	Responses are appropriate, comprehensive, and indicate thoughtful engagement with the information and concepts from the lecture, readings, and videos. Novel ideas, creativity, and attention to complexity are a plus. Tanglegram is fully supported by responses and image.	Good effort. Responses and arguments are not as clearly presented, or as comprehensive and thoughtful as in a full credit answer. Tanglegram is fully supported by responses and images.	Responses are less appropriate to the assignment, less thoughtful and engaged, with less complete information. Tanglegram is partially incomplete or unrelated to images and responses.	Responses are inaccurate, careless, and/or opinions not supported by content.  Tanglegram is incomplete.
Mechanics (10 Points)	Grammar, sentence structure and punctuation are correct. Works are cited properly when appropriate.	Occasional grammar or mechanics issue or works are cited incorrectly.	Some issues with grammar, punctuation and or sentence structure or chosen image or other works are not cited when appropriate.	Major issues with grammar, punctuation and or sentences. Chosen image or other works are not cited when appropriate.

### Additional Resources

- Nissim Amzallag (2009). "From Metallurgy to Bronze Age Civilizations: The Synthetic Theory." *American Journal of Archaeology*, Vol. 113, No. 4: pp. 497-519
- Naama Yahalom-Mack, Ehud Galilic, Irina Segald, Adi Eliyahu-Behara, Elisabetta Boarettoa, Sana Shilsteina, Israel Finkelstein. (2014) "New insights into Levantine copper trade:

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Analysis of ingots from the Bronze and Iron Ages in Israel.” *Journal of Archeological Science*, Vol. 45: pp. 159-177.

- Making History--the Bronze Age, by Andrew Sherratt