Periodic Table of the Elements
Transition Metals II
Teacher's Guide

Grade Level: 6–8	**Curriculum Focus:** Physical Science	**Lesson Duration:** One class period

Program Description

The transition metals provide both strength and beauty. Chromium protects against corrosion, copper is common in coins and ancient artifacts, and silver made possible the development of photography and motion pictures. Learn the value of different metals during a tour of the U.S. Mint.

Lesson Summary

Students discuss examples and common properties of transition metals. Then they conduct an experiment in which copper is transferred from pennies to an iron nail in a vinegar-salt solution. They'll discuss the use of transition metals in coins, as well as how pennies oxidize when they come in contact with oxygen.

Onscreen Questions

Part 1, "Exploring Transition Metals," "Chromium: Strengthening Steel," "Copper: Bells of the Bronze Age," and "Silver: A Lode of Treasure"

- What are alloys and why are they useful?
- What effect did copper and silver have on history?

Part 2, "Inside the U.S. Mint"

- What metals are in our coins?
- Why is gold so valuable?

Lesson Plan

Student Objectives

- Explore transition metals.
- Explain why transition metals are used in coins.
- Describe why oxides such as rust and tarnish form on metals.

Materials

- *Periodic Table of the Elements: Transition Metals II* video

For each team:

- Measuring cup
- 1/4 cup vinegar
- Pinch of salt
- Clean glass jar
- 10 dirty pennies (from before 1982)
- Paper towels
- Two new, untarnished iron nails
- Small bowl of water

Procedures

1. After watching the video, ask students to name examples of transition metals. (*iron, nickel, titanium, copper, silver, gold, chromium, iron, zinc*) Point out the transition metals on a periodic table. Ask students to identify some properties of most transition metals. (*hard, dense, shiny, high melting and boiling points, good conductors of heat and electricity, malleable, and ductile*)
2. Tell the class that they're going to conduct an experiment with the transition metal copper in the form of old pennies. Explain that today pennies contain just a coating with 2.5 percent copper, but pennies made before 1982 contain 95 percent copper. Divide students into teams of three or four and give each team the materials listed above.
3. Have each team pour 1/4 cup of vinegar into a glass jar. Add a pinch of salt and stir. Put 10 dirty pennies and one of the nails into the jar. Let sit for 10 minutes.
4. While waiting, explain that copper isn't the only transition metal in coins. In fact, all metals tin U.S. coins are transition metals. Challenge students to name the three transition metals that are found in all current U.S. coins. (*copper, zinc, nickel*) What additional metal is found in the new golden dollar? (*manganese*) Which three coins have the exact same composition, including the percentage of each metal? (*dime, quarter, half dollar*) You may want to share and discuss the chart below about the composition of today's U.S. coins.

Penny	Nickel	Dime	Quarter	Half Dollar	Dollar (Susan B. Anthony)	Golden Dollar (Sacagawea)
2.5% Cu Balance Zn	25% Ni Balance Cu	8.33% Ni Balance Cu	8.33% Ni Balance Cu	8.33% Ni Balance Cu	12.5% Ni Balance Cu	88.5% Cu 6% Zn 3.5% Mn 2% Ni

(Students can find other coin specifications from the U.S. Mint at: http://www.usmint.gov/about_the_mint/index.cfm?action=coin_specifications.)

5. Talk about why transition metals are ideal for coins. (*They are malleable; they can be shaped or imprinted without breaking. Other materials might be crushed or shattered under the pressure. Also, they are strong enough to resist the wear of everyday use*.)
6. After 10 minutes, have teams remove five pennies and place them on a paper towel. Then have them remove the other five pennies, rinse them in the bowl of water, dry them, and place them on another paper towel. Explain that the nail stays in the vinegar mixture for 10 more minutes.
7. Ask students to describe the pennies. (*They look bright and shiny.)* To understand why this happens, talk about what causes pennies to tarnish. *(A chemical reaction takes place between the copper and oxygen. The copper atoms and oxygen atoms form molecules called copper oxide. An oxide is a compound that forms when oxygen reacts with a metal. The copper oxide is the tarnish on the penny.)* Other examples of oxide are the rust on an iron gate or the tarnish on a silver cup; these oxides occur because oxygen reacts with iron and silver just as it does with copper.
8. Using what they've just learned, students should describe what happened to the pennies in the vinegar. (*The salt and vinegar wore away the oxide layer, or tarnish, on the pennies*.)
9. If time permits, talk about the harmful affects of oxidation. For example, over time rust or tarnish can cause metals to corrode. What are some ways that people prevent oxidation?
10. After the 10 additional minutes, remove the iron nail and place it on a paper towel. Compare it to the nail left out of the vinegar solution. What happened to the nail? (*It should have a sticky brown coating*.) What is the brown substance? (*copper*) Where did the copper come from? (*copper oxide from the pennies*) Explain that when the copper ions from the pennies were released into the vinegar, they reacted with the iron in the nail to produce the copper coating.
11. Have students hypothesize what the nail might have looked like if they had used pennies made after 1982.
12. Now observe and compare the two sets of pennies. Ask students to turn the pennies over and observe both sides. How do the two sets look different? (*Those rinsed and dried should look bright and shiny. A faint, blue-green coating will be visible on the others*.) The blue-green coating is a compound called malachite that formed from a reaction between the copper, salt, and oxygen. The vinegar solution on the pennies promotes this reaction. (NOTE: Some malachite will begin to appear by the end of the class period, and it will be much more noticeable the following day. If possible, leave the pennies out and observe them again.)
13. To conclude the lesson, have students write a short paragraph to describe an example of where to find an oxide, including an explanation of why it formed.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: Students shared several examples and properties of transition metals; identified the transition metals used in coins and explained why these metals are used; wrote a clear and accurate explanation of why oxides such as rust and tarnish form on metals.
- 2 points: Students shared a few examples and properties of transition metals; identified at least one transition metal used in coins and explained why these metals are used; wrote a satisfactory explanation of why oxides such as rust and tarnish form on metals.
- 1 point: Students shared few or no examples and properties of transition metals; could not identify the transition metals used in coins or explain why these metals are used; wrote an unclear or inaccurate explanation of why oxides such as rust and tarnish form on metals.

Vocabulary

alloy
Definition: A solid substance made by mixing a metal with another substance, usually another metal
Context: The U.S. Mint's a new dollar coin is made with an alloy of copper, nickel, zinc, and manganese.

conductor
Definition: A material through which electric current flows easily
Context: Copper is an excellent conductor of electricity and heat, making it useful for electrical equipment and cookware.

ductile
Definition: Able to be drawn into a wire
Context: Like most transition metals, gold is ductile and can be flattened.

malleable
Definition: Able to be hammered or pressed without breaking
Context: The malleable nature of the transition metals makes them ideal for coins.

metal
Definition: An element that is a good conductor of heat and electricity and is usually shiny and hard at normal temperature
Context: Silver is a popular metal for use as jewelry, coinage, and household objects.

Academic Standards

Mid-continent Research for Education and Learning (McREL)
McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K–12 Education addresses 14 content areas. To view the standards and benchmarks, visit

http://www.mcrel.org/compendium/browse.asp.

This lesson plan addresses the following national standards:

- Science—Physical Sciences: Understands the structure and properties of matter
- Technology: Understands the nature of technological design

National Academy of Sciences

The National Academy of Sciences provides guidelines for teaching science in grades K–12 to promote scientific literacy. To view the standards, visit this Web site:
http://books.nap.edu/html/nses/html/overview.html#content.

This lesson plan addresses the following science standards:

- Physical Science
- Science and Technology

Support Materials

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- http://school.discovery.com/teachingtools/teachingtools.html

DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

How To Use the DVD

The DVD starting screen has the following options:

Play Video—This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

Video Index—Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

Curriculum Units—These are specially edited video segments pulled from different sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

Standards Link—Selecting this option displays a single screen that lists the national academic standards the video addresses.

Teacher Resources—This screen gives the technical support number and Web site address.

Video Index

I. Exploring Transition Metals (5 min.)
The transition metals include most of metals commonly used for making tools. Learn about the common traits and unique properties of this large group of elements.

II. Chromium: Strengthening Steel (6 min.)
Adding chromium to steel creates stainless steel, which is a corrosion-resistant steel alloy used in shipbuilding and many everyday objects. Learn about the properties and uses of chromium.

III. Copper: Bells of the Bronze Age (7 min.)
Copper often goes into the manufacture of electrical equipment and cookware; combined with tin, it creates bronze. Examine the properties and uses of copper and explore Bronze Age China.

IV. Silver: A Lode of Treasure (5 min.)
Discover silver, its many applications, and all about the Comstock Lode that made millionaires, sparked the industrial mining industry, and helped the North win the Civil War.

V. Inside the U.S. Mint (21 min.)
Strong and malleable, transition metals are ideal for producing coins. Observe a variety of coins being minted in the U.S. and Canada.

Curriculum Units

1. Transition Metals: Traits and Properties
Pre-viewing question
Q: What metal tools and objects do you use every day?
A: Answers will vary.

Post-viewing question
Q: Which transition metals are usually found in their pure metallic state?
A: Only copper, silver, and gold are found in their pure metallic state. All other transition metals interact with oxygen so they are usually found only as compounds.

2. Chromium: Properties and Uses
Pre-viewing question
Q: What do you know about chromium and its uses?
A: Answers will vary.

Post-viewing question
Q: What are the physical characteristics of chromium?
A: Chromium is a shiny, bluish metal that is brittle and noncorrosive. It is never found uncombined in nature.

3. Building Steel Aircraft Carriers
Pre-viewing question
Q: How is steel used?
A: Answers will vary.

Post-viewing question
Q: How does adding chromium to steel change the metal?
A: Chromium added to steel creates stainless steel. It binds with the carbon and makes steel harder, less brittle, and more resistant to corrosion.

4. Copper: Properties and Uses
Pre-viewing question
Q: Where might you find copper at home, at school, or in your community?
A: Answers will vary.

Post-viewing question
Q: What are some common uses of copper?
A: An excellent conductor of electricity and heat, copper is useful for electrical equipment and cookware. It is also used in coins and as a component in alloys such as bronze alloys (for knives and swords) and brass alloys (for plumbing).

5. China's Bronze Age
Pre-viewing question
Q: What is bronze made of? What are its modern uses?
A: Answers will vary.

Post-viewing question
Q: How was bronze used in China during the Bronze Age?
A: By the 5th century B.C., the Chinese were using bronze for weaponry and important ritual objects. An alloy made of copper and tin, the metal is stronger than copper.

6. Silver: Properties and Uses

Pre-viewing question
Q: What are some uses for silver?
A: Answers may include mirrors, jewelry, decorative household items, solder, and electrical contacts. Silver compounds are used in photography and high-capacity batteries.

Post-viewing question
Q: Describe an atom of silver in its most common form.
A: In its most common form, an atom of silver has 47 positively charged protons and 61 uncharged neutrons in its nucleus. Its 47 negatively charged electrons balance the protons; they are found in five orbital shells surrounding the nucleus.

7. The Comstock Lode

Pre-viewing question
Q: What do you know about mining in the United States during the 19th century?
A: Answers will vary.

Post-viewing question
Q: Why did the U.S. government want Nevada to be a Union territory?
A: With the Civil War looming in early 1861, the U.S. government wanted Nevada as a Union territory to secure its silver and other mineral riches.

8. Minting Nickels

Pre-viewing question
Q: How do you think coins and dollar bills are produced?
A: Answers will vary.

Post-viewing question
Q: What takes place at the Philadelphia Mint?
A: The Philadelphia Mint produces some 10 to 11 billion U.S. coins in a year.
Half of all U.S. coins, one-sixth of all the coins in the world, are minted there, including 20 million pennies a day.

9. Using the Coining Press, Inspecting Coins

Pre-viewing question
Q: How does a printing or metal press work?
A: Answers will vary.

Post-viewing question
Q: Why are transition metals ideal for coining?
A: The malleable nature of the transition metals is ideal for coining. Unlike other elements, the transition metals can be shaped and imprinted without destroying their crystalline structure. They are flexible enough to be shaped by the coining press but strong enough to resist wear in everyday situations.

10. Designing a New Coin
Pre-viewing question
Q: What might be considered in designing a new coin?
A: Answers will vary.

Post-viewing question
Q: What went into choosing the metal for the new U.S. dollar coin?
A: Scientists tested potential metals and recorded all visible changes to the samples because Congress mandated that the new coin had to be a shade of gold. It also had to last 30 years without tarnishing, share some properties (weight, shape, size, electromagnetism) with the Susan B. Anthony dollar coin so vending machines would recognize it, and be economical to make.

11.Manufacturing Coin Dies
Pre-viewing question
Q: What might be difficult in making coins?
A: Answers will vary.

Post-viewing question
Q: How is a coin die manufactured?
A: A die blank is placed in the coin press with a collar around it. The master hub is placed on top, face down. While coins are struck in a fraction of a second, the dies must be pressed for 15 seconds at 85 tons of pressure. The slow speed imprints the design into a die face as an inverted mirror image, so the low points on the die will imprint the high points on a coin.

12. Canada's Gold Coins
Pre-viewing question
Q: Have you ever handled a gold coin?
A: Answers will vary.

Post-viewing question
Q: How are Canada's gold coins manufactured?
A: The Royal Canadian Mint in Ottawa refines some of the purest gold in the world, 999.9 thousandths pure. The raw gold's impurities are skimmed off, and the pure gold is made into bars and further refined. Most of it is melted and cast into ingots that are slowly rolled to the thickness of a coin. The long gold strip is stamped into blanks and sent through the coining press. The coins are large and the design is intricate, so they must be struck at 133 tons, about twice the tonnage needed to strike a U.S. quarter.