Matter

Physical Science | Lesson Guide

5th Grade

Photo Description

This image shows many old, rusty nails and metal objects scattered on weathered wooden boards. The metal pieces have different colors ranging from dark brown rust to lighter orange spots. Some nails are bent and twisted, while round metal discs are mixed throughout the collection.

Scientific Phenomena

The anchoring phenomenon shown here is oxidation and corrosion of iron-based metals. When iron in nails and metal objects is exposed to oxygen and moisture over time, it forms iron oxide (rust). This chemical reaction changes the metal's properties, making it weaker and changing its color from silver-gray to reddish-brown. The process is accelerated by exposure to water, salt, and acidic conditions.

Core Science Concepts

1. Chemical Changes vs. Physical Changes: Rusting is a chemical change because new substances (iron oxides) are formed that cannot be easily reversed, unlike physical changes such as melting or breaking.

2. Properties of Materials: The original properties of iron (strength, silver color, magnetic attraction) change during oxidation, demonstrating how chemical reactions alter material characteristics.

3. Environmental Factors: Temperature, moisture, and exposure to air affect the rate of chemical reactions, explaining why some nails show more rust than others.

4. Irreversible Reactions: Unlike melting ice or dissolving sugar, rust formation creates permanent changes to the metal's chemical structure.

Pedagogical Tip:

Use before/after photos of shiny new nails versus rusty ones to help students visualize the dramatic changes that occur during oxidation. This concrete comparison makes the abstract concept of chemical change more accessible.

UDL Suggestions:

Provide tactile experiences by letting students safely handle new nails, rusty nails (filed smooth), and iron filings to feel the different textures and weights. This multi-sensory approach supports learners who benefit from hands-on exploration.

Zoom In / Zoom Out

1. Zoom In: At the atomic level, iron atoms are losing electrons and bonding with oxygen atoms to form completely new compounds (iron oxides). This electron transfer creates new crystal structures that are more brittle and porous than the original iron.

2. Zoom Out: This oxidation process affects entire ecosystems and human infrastructure. Rusting bridges, buildings, and vehicles require constant maintenance and replacement, costing billions of dollars annually and affecting transportation, safety, and resource management globally.

Discussion Questions

1. What evidence do you see that tells you these nails have undergone a chemical change rather than just getting dirty? (Bloom's: Analyze | DOK: 3)

2. Why do you think some nails in the photo show more rust than others, even though they're all in the same location? (Bloom's: Evaluate | DOK: 2)

3. How might the environment where these nails were stored have affected the rusting process? (Bloom's: Apply | DOK: 2)

4. What could have been done to prevent or slow down the rusting of these metal objects? (Bloom's: Create | DOK: 3)

Potential Student Misconceptions

1. Misconception: "Rust is just dirty metal that can be washed off."
Clarification: Rust is a new chemical compound formed when iron combines with oxygen, creating a permanent change that cannot be reversed by washing.

2. Misconception: "All metals rust the same way."
Clarification: Only iron and iron-containing metals (steel) rust by forming iron oxide. Other metals like aluminum or copper oxidize differently, forming different compounds and colors.

3. Misconception: "Rust only happens to old things."
Clarification: Oxidation begins immediately when iron is exposed to oxygen and moisture, but it takes time to become visible depending on environmental conditions.

Cross-Curricular Ideas

1. Math - Data Collection and Graphing: Have students collect different types of metal objects (nails, screws, bolts) and measure the depth of rust on each one using rulers. Create a bar graph showing which objects rusted the most. Students can calculate averages and compare rates of rust formation across different metals.

2. ELA - Persuasive Writing: Ask students to write a persuasive letter to a city planner explaining why rust on bridges and buildings is a problem and what should be done about it. This connects the local relevance of oxidation to real-world infrastructure issues while practicing persuasive writing skills.

3. Social Studies - Historical Impact: Research how rust has affected historical structures and artifacts (like the Statue of Liberty, old ships, or ancient weapons). Create a timeline showing how communities have had to replace or repair corroded structures, demonstrating the economic and cultural impact of chemical weathering.

4. Art - Mixed Media Sculpture: Use safe, pre-rusted metal objects and wood to create mixed-media art installations. Students can arrange rusty items artistically while discussing how texture, color, and material decay can be beautiful and meaningful in art, similar to the aesthetic qualities visible in the photo.

STEM Career Connection

1. Materials Engineer: A materials engineer is a scientist who studies how different materials like metals, plastics, and ceramics behave and change over time. They figure out how to make metals last longer without rusting, or how to choose the right material for buildings and machines. Materials engineers work in factories, research labs, and construction companies. Average Annual Salary: $89,000 USD

2. Civil Engineer: Civil engineers design and build bridges, buildings, roads, and water systems. They have to think carefully about rust and corrosion because these structures need to last for many years without falling apart. They choose materials that won't rust easily and plan maintenance to keep everything safe and working. Average Annual Salary: $88,000 USD

3. Chemist: A chemist studies how substances change and interact with each other, including how iron reacts with oxygen to form rust. Chemists develop new coatings and treatments to protect metals from corrosion, create rust-resistant paints, and invent new materials that last longer. They work in laboratories and help many industries solve problems with material deterioration. Average Annual Salary: $79,000 USD

NGSS Connections

- Performance Expectation: 5-PS1-4 - Conduct an investigation to determine whether the mixing of two or more substances results in new substances
- Disciplinary Core Ideas:
  - 5-PS1.B - Chemical Reactions
  - 2-PS1.A - Structure and Properties of Matter
- Crosscutting Concepts:
  - Cause and Effect
  - Patterns
  - Structure and Function

Science Vocabulary

* Oxidation: A chemical reaction where a substance combines with oxygen to form a new compound
* Corrosion: The gradual destruction of materials by chemical reactions with their environment
* Chemical change: A process where substances combine to form new materials with different properties
* Iron oxide: The reddish-brown compound formed when iron reacts with oxygen, commonly called rust
* Irreversible: A change that cannot be easily undone or returned to its original state

External Resources

Children's Books:
- "Chemical and Physical Changes" by David Dreier
- "What Is Rust?" by Robin Johnson
- "Material Properties" by Angela Royston