



Drexel-SDP GK-12 LESSON

Send in Reinforcements!

Subject Area(s) Physical Science, Problem Solving, Science and Technology

Lesson Title Send in Reinforcements!

Grade Level 7 (6-12)

Time Required 30 minutes

Summary

This lesson introduces the topic of composite materials, some of which seem mundane – roads, parking garages, plywood – and others which require further inspection, such as plants and biological tissues.

Engineering Connection

Composite materials (as pertaining to this lesson and the associated activity, **Ice Breakers**) are formed from two distinct materials which may be embedded in each other or layered. Unlike metal alloys, the constituent materials retain their original characteristics while contributing to the overall properties of the composite, which may not be similar to properties of the constituent materials. Typically, composites are used to combine favorable characteristics. Some materials perform better in tension than compression, which the reverse is true for others. A combination of materials and their properties, such as reinforcing the compressive strength of concrete with the tensile strength of steel, is the basis for many structural applications.

Though the idea of structural strength and behavior resulting from composite materials can be readily evidenced in any city's buildings, there is an increasing need among biomedical engineers to understand biological functions. Interestingly, many biological tissues (this includes plant cell walls) have features that relate to some biological mechanical forces (biomechanics). A plant cell wall supports its growth and weight; our bones have different regions that do the same. Among biological soft and hard tissues, cartilage and vascular tissue respond to mechanical stimuli and grow, atrophy, or remodel in response.

Engineers design objects and systems based on how the component materials are predicted to respond. This requires knowledge of the materials' behavior, which requires

experimental testing. An understanding of composite materials, particularly those whose material properties may change in certain environments (temperature, electric fields, force and pressure loads), present a challenge, which in turn present design challenges.

Keywords

composite, fiber, reinforce, materials testing, biological tissue

Educational Standards

- PA Science:
 - 3.1.7 – Unifying themes
 - 3.2.7.B – Apply process knowledge to make and interpret observations
 - 3.2.7.D – Know and use the technological design process to solve problems
- PA Math:
 - 2.1.8.D – Apply ratio and proportion to mathematical problem situations involving distance, rate, time, and similar triangles
 - 2.4.5.B – Use models, number facts, properties, and relationships to check and verify predictions and explain reasoning

Learning Objectives

After this lesson, students should be able to:

- Define a composite object
- Identify composite objects
- Relate the shape or constitutive materials of a composite to its function(s)

Introduction / Motivation

As a class, read the *Popular Mechanics* article, “Can you Build Ships Out of Ice? The Mythbusters Investigate.” The article gives a fair introduction to the idea behind composites and a direct relation to the associated activity, **Ice Breakers**.

In the *Popular Mechanics* article, Adam Savage makes several comparisons to plywood, which itself is a composite made of thin sheets of wood that are glued together (a “How It’s Made” covered plywood). The orientations of the wood fibers in the sheets are staggered and overlaid, and this pattern contributes to its structural strength. Similarly, veneered wood (found in IKEA products) uses a particleboard core, which is glued-up sawdust. A thin sheet of veneer, like that used in plywood, covers its face for a finished look.

In the frozen newspaper block tested by the Mythbusters, the wood pulp is bonded together with frozen water as its “glue.” This is the definition of a fiber-reinforced composite, wherein the saturated, frozen newspaper lends tensile strength to the overall composite and the ice provides a compressive component.

Composite materials and construction methods allow buildings to be designed with more strength. A masonry building supports all of its weight on its exterior, so the overall aesthetic is determined by the masonry materials. In contrast, a glass-faced building cannot rely on its exterior for support. Construction of glass-faced buildings may utilize a central concrete core, which may not be visible when the glass is highly reflective. In this design, the central core supports the building load.

Composite materials have revolutionized the aerospace industry. Steel and aluminum parts that used to be machined are being replaced by composite parts that are lightweight and less expensive to manufacture. This reduces manual labor cost and allows aircraft to be more efficient while pushing new boundaries.

Though we may not immediately associate biological tissues with the word “composite,” certain tissues’ composition certainly puts them in this category. As we’ve learned (or the students will learn...) in biology, plants are supported by stems, and stems consist of an arrangement of rectangular cells that are stiff but hollow to allow passage of water to other cells (necessary for photosynthesis). Layers of plant cells make up its xylum and accomplish structural and transport functions. Similarly, bones provide support for the weight of animals and reptiles. Regions of bone vary in density and composition: mechanical loads are distributed at the ends of the bone through a “hollow” center. Bone is also multifunctional: growth is regulated at the ends of the bone, while the marrow resides in the hollow center to produce blood cells. Arteries are another example of a functionally-motivated tissue: the three distinct layers of an artery provide biochemical, biological, and mechanical responses to the circulatory environment. Biological tissues will also respond to biochemical and mechanical stimuli by remodeling themselves, adapting to biological need by growing or atrophying.

Vocabulary / Definitions

Word	Definition
composite	two distinct materials that are embedded in each other or layered
tension	the internal forces that develop in a material when it is stretched
compression	the internal forces that develop in a material when it is pushed together, or compressed

Associated Activities

Ice Breakers

Lesson Closure

Segue into **Ice Breakers**, activity should end with video clip of newspaper-ice boat and investigative questions

Assessment

Pre-Lesson Assessment

KWL Chart on attached worksheet

Post-Introduction Assessment

Reading comprehension / follow along questions on attached worksheet

Lesson Extension Activities

Read the *Popular Mechanics* article, “Can you Build Ships Out of Ice? The Mythbusters Investigate.”

Additional Multimedia Support

Mythbusters_Ice_Ships.pdf, the *Popular Mechanics* article, “Can you Build Ships Out of Ice? The Mythbusters Investigate.”

Lesson_SendReinforcements.ppt, slides relating to composite materials and usage

Owner

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Name: _____

Ice Breakers

- List what you know (K) and what you want to learn (W) from the blocks on your desk.

K	W	L

1. How does Jamie Hyneman compare pykrete made of newsprint to plywood?

2. In lab tests, the strength of 2-inch-thick newsprint compares with 2-inch-thick _____.

3. To test the idea pykrete skiff idea, the Mythbusters team:

- i. traveled to _____,
- ii. recruited high school students to unfold and soak _____-plus pounds of newspaper,
- iii. build a boat of wet newspaper laying sheets starting at the _____ and moving _____, which is like the _____ on a house.

4. Did the Mythbusters prove that an operable skiff could be constructed from frozen newspaper? Why didn't the Mythbusters choose to try this in the Chesapeake?
