

Research Topic- Kevlar

Research Topic	Kevlar and its use in the military
Grade Level	Grades 6-8
Time Required	1 class period (60 Minutes)
Ohio's Learning Standards S.T.E.M.	<p>Grade 6 Early civilizations (India, Egypt, China and Mesopotamia) had unique governments, economic systems, social structures, religious, technologies and agricultural practices and products. The cultural practices and products of these early civilizations can be used to help understand the Eastern Hemisphere today.</p> <p>Grade 7 The civilizations that developed in Greece and Rome had an enduring impact on later civilizations. This legacy includes governance and law, engineering and technology, art and architecture, as well as literature and history. The Roman Empire also played an instrumental role in the spread of Christianity.</p> <p>Grade 8 The Industrial Revolution fundamentally changed the means of production as a result of improvements in technology, use of new power resources, the advent of interchangeable parts and the shift from craftwork to factory work.</p>
Common Core Standards	<p><u>CCSS.ELA-LITERACY.RH.6-8.7</u> Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.</p>
Objectives	Students will be able to examine various types of body armors throughout history and compare ancient protective gear to modern gear using Kevlar.
Research Statement	Protective clothing or body armor dates back to the Bronze Age in Ancient Greece with the Dendra panoply, designed for the safety of an individual under physical attack. Over time technology and engineering was allowed safety gear to evolve using materials that are more flexible, light weight, heat and water resistance. Kevlar provides the qualities in protective armor used to keep our service men and women safe.
Introduction	Kevlar is a heat-resistant and strong synthetic fiber developed in 1965 by Stephanie Kwolek at Dupont. At Dupont, Kwolek was tasked with finding a fiber that could be spun at a lower temperature. During one attempt, a batch dissolved into a milky white, runny liquid solution instead of the usual clear, syrup-thick solution. Instead of throwing it out, Kwolek salvaged the solution. The result was the strongest, stiffest fiber that has ever been created.
Supporting Idea I	<p>Kevlar is made from a synthetic plastic made from the chemical called poly-para-phenylene-terephthalamide which is turned into strong fibers. The reason that Kevlar works is because, under the right conditions, the molecules arrange themselves end to end, parallel to the length of the fiber and form strong hydrogen bonds between its molecular chains. During the formation of Kevlar fiber (a polyamide solution):</p> <ul style="list-style-type: none"> • The amide groups are separated by para phenylene groups. This causes the amide groups to attach to each other on opposite side of the phenyl group. • The separation of amide groups by large phenyl groups causes polymers to nearly always form a trans conformation which causes the groups to become too large to fit on the same side of a bond. • When all monomers connect in a trans conformation, a long straight chain is formed creating an ideal fiber. <p>The reason Kevlar is so strong is because it forms an unusually regular structure created from Hydrogen bonding. Even the weakest form of Kevlar is stronger than steel and only half as dense.</p>

Supporting Idea II	Kevlar is a well-known component of personal armor such as combat helmets, ballistic face masks, and ballistic vests. The PASGT helmet and vest used by United States military forces, use Kevlar as a key component in their construction. Other military uses include bulletproof face masks and spall liners used to protect the crews of armored fighting vehicles. Nimitz-class aircraft carriers use Kevlar reinforcement in vital areas. Civilian applications include: high heat resistance uniforms worn by firefighters, body armor worn by police officers, security, and police tactical teams such as SWAT.
Supporting Idea III	Kevlar is not like cotton—it's not something anyone can make from the right raw materials. It's a proprietary material made only by the DuPont™ chemical company and it comes in two main varieties called Kevlar 29 and Kevlar 49. Kevlar 29 is used in the manufacture of body armor for lightweight military vehicles. It was selected because it is lightweight and withstands attack from RPGs. Kevlar 49 is used for specialist boat hulls and in the aerospace industry. It is popular for boats because it is lightweight and can withstand a considerable amount of force, tensile stress and impact. Hulls manufactured from traditional materials, such as fiberglass, are limited in their resistance to forces and stress.
Conclusion	It is important to keep our servicemen and women safe when they are in uniform. Kevlar is one of the strongest materials in the world that will protect them against enemy fire. Advancement in the production of materials is critical to our military and their safety.
Resources	https://www.youtube.com/watch?v=bizSWjzi4jg https://www.youtube.com/watch?v=L1pepaAdkWA&t=117s https://www.explainthatstuff.com/kevlar.html
Visual Thinking Strategies	Visual Thinking Strategies transforms the way students think and learn by providing training and curriculum for people to facilitate discussions of visual art that significantly increase student engagement, performance and enjoyment of learning. https://vtshome.org/about/
Assignment	Have students take 3-5 minutes to look at the images. <ol style="list-style-type: none"> 1. Ask students to describe what they see in the images. 2. Ask students what more can they tell you about the images. 3. Ask why?
Assessment	Using visual cues, student should observe and discuss people, the way individuals are dressed, the activity of individuals, if individuals look familiar landscapes, backgrounds, etc. Students should be able to articulate what they see in each image using visual thinking strategies.
Critical Thinking Questions	<ol style="list-style-type: none"> 1. How has technology in body armor evolved over time to keep soldiers safe? 2. Are there any other scientific discoveries that you can think of which were discovered by accident?



Golden yellow aramid fiber (Kevlar). The diameter of the filaments is about 10 μm . Melting point: none (does not melt). Decomposition temperature: 500-550 $^{\circ}\text{C}$. Decomposition temperature in air: 427-482 $^{\circ}\text{C}$ (800-900 $^{\circ}\text{F}$).



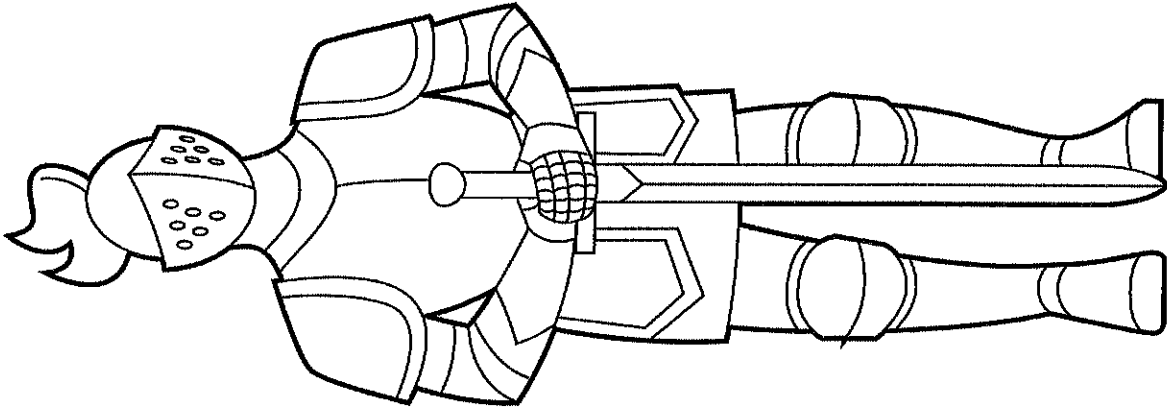
Photograph by JJ Miller. Hair and Makeup by Laura Dillon/Team

1. A notch in the back collar of the vest can accommodate a woman's ponytail or bun, keeping her helmet securely in place.
2. Narrowed shoulders and armholes allow a better range of motion.
3. Darting that's built into several sections of the vest provides a snugger fit.
4. Two inches were removed from the waistline of the vest. The new version is slightly shorter as well, making the "turtling" issues and hip bruises less likely.
5. The waistline, built for the female form, has fewer Kevlar plates and weighs 25 pounds—five pounds lighter than the original model.

<https://www.bostonmagazine.com/news/2013/09/26/new-body-armor-women-military/>

Armor designed for battle

Technological advances have helped military forces over time.

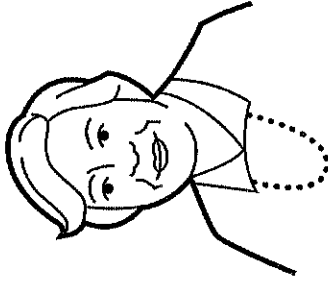
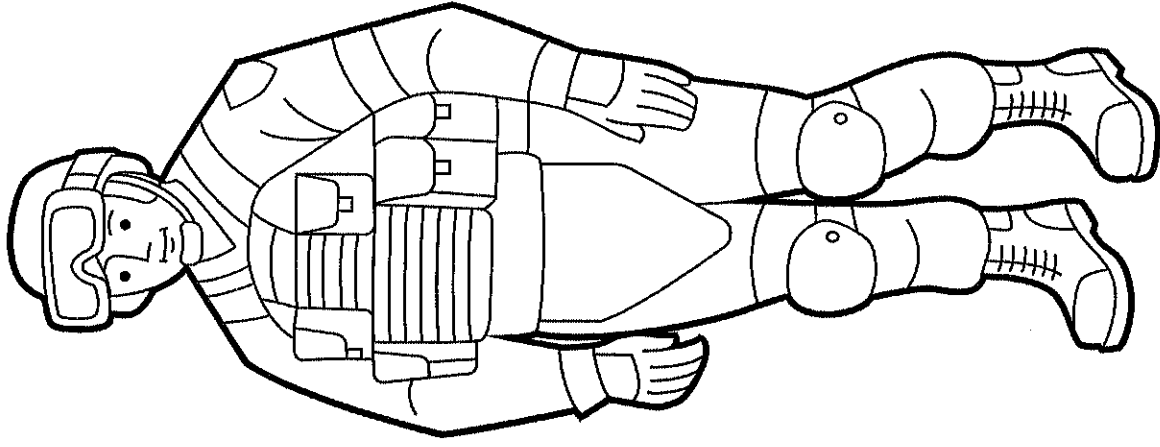


◀ Medieval Armor

Body armor dating back to the 5th century was used to protect the body during combat against weapons and projectiles. Plate armor protected the body core while helmets protected the head. Materials used to make armor during this period include leather,

▶ Modern Armor

Today, body armor or personal armor is used by military personnel as well as police, fire fighters and security guards. Advancement in technology allow armor to be light weight, bullet resistant, cold and fire resistant. Bullet resistant vests are made with metal or



Stephanie Kwolek

American chemist who invented Kevlar.
She certainly represents women in S.T.E.M.
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What's so good about Kevlar?

- It's strong but relatively light
- It does not melt
- Very low temperatures have no effect on Kevlar
- Resistant to attacks from many different chemicals
- In DuPont's tests, Kevlar remained "virtually unchanged" after exposure to hot water for more than 200 days and its super-strong properties are "virtually unaffected" by moisture