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| **Lesson Title:** Materials Safe in the Body for Implant Use | **Unit #:** | **Lesson #:** | **Activity #:** |
| **Activity Title:** Exploring and Researching Materials Used for Implants |

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| **Estimated Lesson Duration:** | 3 periods, 45 minutes each |
| **Estimated Activity Duration:** | 3 periods, 45 minutes each |

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| **Setting:** | **Classroom** |

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| **Activity Objectives:** |

1. Student will be able to identify what is considered to be a “safe” material, when introduced to the body.
2. Student will be able to test different materials (when introduced to the body) for their “safe” qualities.
3. Student will be able to identify what materials (when introduced to the body) are suited for specific purposes because of their special properties.
4. Students will research possible failures with materials.

**Activity Guiding Questions:**

1. How is an implant different from a transplant?
2. What are available types of implants?
3. Why are metals, ceramics, and polymers suitable for implants?
4. What possible failures are associated with implants?

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| **NGSS Practices of Science and Engineering / Crosscutting Concepts** |

| **Practices of Science and Engineers (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
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| ☒ Asking questions (for science) and defining problems (for engineering) | ☐Patterns |
| ☐ Developing and using models | ☒ Cause and effect |
| ☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | ☐ Systems and system models |
| ☐ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation. |
| ☐ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function. |
| ☐ Engaging in argument from evidence | ☐ Stability and change. |
| ☒ Obtaining, evaluating, and communicating information |  |

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| **Unit Academic Standards (Ohio State Revised Science Education Standards and/or NGSS Content, Common Core etc.):** |

**Cognitive Demands (Ohio State Revised Science Education Standards)**

| **Expectations for Learning Cognitive Demands (Check all that apply)** |
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| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☐ Demonstrating Science Knowledge **(D)** |
| ☐ Interpreting and Communicating Science Concepts **(C)** |
| ☐ Recalling Accurate Science **(R)** |

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| **Materials**: |

Computers

Personal whiteboards and markers

Activity.pptx

Pre-assessment.docx

Post-assessment.docx

Hook.pptx

1\_research.docx

1\_research\_discussion.docx

1\_Oxidation\_Experiment.docx

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| **Teacher Advance Preparation:** |

Obtain salt water, RO/DI water, and white vinegar for experimental use. Request classroom computers or have students research using smart phones and tablets.

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| **Activity Procedures:** |

**Day One**

1. Pass out pre-test. Give them 10-15 minutes to complete it. If students finish early, give them plain paper and tell them to write down as many examples of implants that they know. If they are not sure, they can guess.
2. Write the words, "Medical Implants" in the center of the board. Turn on a PowerPoint cycling through photos of actual implants.
3. Ask the students if they have ever had any experience or know someone with some type of medical implant device.  Have them write down their answers on their own personal white boards. (Examples here are hip, knee, breast, dental, pacemaker, cochlear implant, etc.)
4. Tell them the definition of an implant.  It is a medical device made to replace a biological stricture or to enhance a biological structure.  Ask them, "How is a medical implant different from a transplant?   Write something on your white board.” (Answer: A transplant is biomedical tissue from a donor.)
5. Tell them medical implants are often made from titanium, silicone, apatite, and some implants contain electronics such as artificial pacemakers, and cochlear implants.  Some implants actually dispense drugs.
6. Set up experiment. Refer to the experiment document for in-depth information.
7. Ask them to get into groups of two and write down properties that they think an implant needs to have to be acceptable in the body or any complications they think could arise from an implant.  Then discuss. (Answer: The most common medicals implants are pins, rods, and screws. All implants have to be FDA approved. They must be made of materials that will not cause a bad reaction to the neighboring tissues. Invasive materials can cause infections, pain, inflammation, and rejection)
8. Tell them implants can fail, "What can happen if a hip replacement fails? A breast implant? An artificial heart valve?” Stress how the hip and breast failure can be fixed but the heart valve failure can be life threatening.

**Day Two**

1. Review from the day before. Ask 1) who can tell me what a medical implant is? 2) who can tell me how an implant is different from a transplant? 3) who can name any of the materials that we talked about previously that an implant can be made out of? 4) who can tell me any problems that could occur with an implant.
2. Observe experiment. Note any changes. Has any rust begun to occur?
3. Put the students into groups of two or three for research. Assign each group a specific type of implant to research (polymer, metal, ceramic). Specifically, what type of implant can be made from this material, and what possible failures or side effects it can have on the body. After 20 minutes have each group report on their findings.
4. Put the students back into their groups and have them discuss the other groups’ presentations and share two new and exciting things that didn’t know before.
5. Therefore it is very important that implants be made to be as safe and long lasting as possible. This is why the field of biomedical engineering is so important. Biomedical engineering is a relatively new field combining engineering skills with medical and biological sciences.
6. \*Start PowerPoint, go to slide 2\* Implants work well in the body only if they are biologically compatible. This means they must be resistant to corrosion and able to withstand the harsh environment inside the body.
7. \*slide 3\* Yesterday we learned that the three main materials used to manufacture implants are ceramics, polymers, and metals. Ceramic implants are known as the implants of the future! Because of their properties they can last much longer than other implants, about 20 years. Metal implants are not used as much now as they may corrode and release harmful ions into the body. Polymers can be used in the body as well, such as in hernia repair surgeries and other types of tissue repairs. They can be either permanent or temporary depending on their usage, we’ll talk more about this one later.
8. \*slide 4\* Now let’s talk about metal implants. Metal implants are commonly used for ball and socket replacements, such as the hip or shoulder. Because metal is so dense, it is more stable than a ceramic implant in this respect. That does not make it better, however. Metal implants only have a lifespan of about 10 years, so once that time is up you have to get the implant taken out and a new one put in. When the metal corrodes in the body it will release metal ions which may cause pain and inflammation. Typically, metal implants are made from vitallium (cobalt-chromium alloy) or titanium. These metals are resistant to corrosion in the body- but still can’t last longer than 10 years.

**Day Three**

1. Review from the day before.
2. Observe experiments. Hopefully rust has occurred by now. Discuss with students about what is happening and why. Ask them what they think is happening and ask them to explain.
3. \*slide 5\* One of the main causes of an implant to fail is oxidation. Oxidation occurs in nearly every material out there! It’s essentially just the loss of electrons which results in a net positive charge. The product includes free radicals with unpaired electrons. These free radicals are what can cause pain or discomfort in the body when an implant starts to oxidize. Reduction is the opposite of oxidation- the gain of electrons which results in a net negative charge.
4. \*slide 6\* Here is an example of an oxidation reaction. The second equation is the iron and water equation. What happens when you add iron to water? We’ll find out as we keep observing the experiment!
5. \*slide 7\* This is just an example of the mechanism of an oxidation reaction. As you can see, sodium loses electrons and fluorine gains them. Sodium has become oxidized and fluorine is reduced.
6. \*slide 8\* Like I said, oxidation occurs in nearly everything.. including fruit!! Here you can see an apple turning brown. Well, the apple is actually becoming oxidized! What happens is the oxygen is used by the cells on the fruit surface forming the reaction byproduct of free radicals. These free radicals are so reactive that they attack other nearby cells to steal their electrons, which causes eventual cell damage, and leaves the apple looking brown.
7. \*slide 9\* In metal, oxidation occurs as rust. We’ll be observing this in our experiment as well. However, you can protect some types of metal by coating them with another type of material that will not corrode. An example of this is stainless steel, which has the addition of chromium. Also, galvanized steel is coated with a layer of zinc to prevent metal.
8. \*slide 10\* Ceramic implants are different from metal implants by the fact that they are completely inert in the body. They don’t react with anything and there is no chance of corrosion. Ceramic implants can be used in electronic devices as well, such as pacemakers and hearing implants. A variety of surface treatments may be used to increase the longevity and overall use of the implants. Friction can be reduced, along with increasing surface hardness and ion transfer prevention. Since these are the implants of the future, technology is constantly growing and improving. Perhaps someday these implants will have a lifespan of 40 years!
9. \*slide 11\* Polymeric implants are pretty interesting because of the variety of things you can do with them. They can be used as permanent or bioresorbable- which means it will eventually dissolve in your body. The most interesting thing about polymeric implants is definitely their bioresorbable properties. If someone has an injured artery, they can place a stent in the artery to keep it open and allow blood to flow normally. As the artery heals, the stent will slowly start to dissolve so the artery can fully heal and not have to be cut open again for stent removal. It’s also similar if you get stitches and they eventually dissolve in your body.
10. \*slide 12\* Aroldis Chapman was hit in the face by a line drive and has now had a titanium plate inserted above his left eye to stabilize the fracture. However, Doctors say he can begin throwing again in just 10-14 days! Plates such as this one are typically used in places where a cast cannot be used. The plate is fastened on both sides of the fracture and held in place with screws. This holds the broken bone in place, allowing it to heal.
11. \*slide 13\* Implants may also be necessary in broken bones. If part of your bone breaks, chips off, or does not fit back together perfectly, you may need an implant. These can include plates, screws, nails or rods, and wires or pins. These implants will hold the bone in place, allowing it to heal properly. You still wear an external cast as well.
12. \*slide 14\* In bigger bones such as the femur and hip, screws and plates may be used simply to stabilize the bone and attempt to strengthen it. After a bone has broken, it is not quite as strong as it was once before. The extra added support is critical in regaining mobility and strength in your body.
13. \*slide 15\* Here are a few reasons why people may need to get an implant. Sports related accidents happen, and sometimes teeth are lost. Dental implants have 99% success rate and have very low risk of infection. The only failure that could occur in a dental implant is non-integration. This means the implant did not integrate into the surrounding bone as bone cells grow into the surface of the implant. If soft tissue cells manage to get between the implant and the bone, the implant could be rejected. After an implant fails, you must wait 3-5 months to heal before having another put in.
14. \*slide 16\* Athletes with family history of arthritis may eventually need a knee replacement. Over time, the cartilage in your knee can wear down and lose its sponginess, and thus not absorb as much shock. The bones pound on each other harder, and from friction, arthritis worsens. This also depends on your stride, how you land on the ground, and how well your knees bend. Getting a knee replacement early in life almost ensures you will need to get another one sometime during your life. People over age 60 usually will have the implant for the rest of their lives.
15. \*slide 17\* Implants can be used to enhance as well as fix major medical problems. You can get many different types of implants just for aesthetics reasons! You can even get teeth if you don’t like how yours look.
16. Now you’ve learned about all of the different types of implant materials out there. Are there any questions?
17. Tell them, you now have a base of information to help them understand and make informed decisions about any implants they may need or want in the future. You now have been exposed to areas of study for engineers that you may not have known about before. Maybe some of this interests you and you may be interested in learning more about it or perhaps using it as a career choice.
18. Give post assessment

**Formative Assessments:**

Pre-assessment.docx

**Summative Assessments:**

Post-assessment.docx

1\_research.docx

1\_research\_discussion.docx

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| **Differentiation:** |

Different learners may be given more time to research, or take home research to do as homework. As I looked at the pre-assessment results, I was able to gauge what I needed to put more emphasis on with this particular group of students.

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| **Reflection:** |

The lesson simply needed more time to be executed. The students did not quite get enough time to research due to other formalities that needed to happen during the class period. The unit went well, the students were very interested in the content and the post-assessment results were much higher than the pre-assessment.