STEM Lesson Plan:

Accidental Science (Middle School)

Lesson Objectives: Student will be able to:

- Students will be able to describe how science discoveries can occur outside of the traditional science lab.
- Students will be able to describe how graphene has led to new discoveries and experiments at the Mag Lab.
- Students will replicate how graphene was discovered with tape.

STEM RATIONALE FOR LESSON:

In science, we are often taught that discoveries are made with systematic planning, multiple trials and detailed record keeping. However, some of the most prolific science discoveries happened, well, on accident. During this lesson, students will explore and learn about different scientific discoveries that were made outside of the traditional scientific method steps. In this lesson students will:

- Complete a card sort with discoveries and accident.
- Watch video on graphene's importance.
- Read about the MagLab's use of Graphene.
- Complete a graphic organizer.
- Demonstrate how graphene was discovered with tape.

Time: Each part can take 30-40 minutes.

Materials:

- Accident/Discovery Cards (included below)
- Paper
- Scotch Tape
- Pencils (specifically, pencil lead)
- Microscope (if available)

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Lesson Introduction:

This lesson highlights one of the fascinating aspects of science that often gets overlooked: the element of surprise. Many of the world's most significant discoveries didn't come from meticulous planning or careful experimentation, but rather from unexpected accidents and serendipitous moments. Think about how penicillin was discovered by Alexander Fleming when he noticed mold contaminating his petri dishes, or how microwave ovens came about thanks to Percy Spencer's unexpected encounter with radar technology.

These instances remind us that curiosity and openness to the unexpected can lead to incredible breakthroughs. Today, we're going to explore some of these surprising discoveries, examining the stories behind them and understanding how they changed our world.

But we won't stop at just learning about them. We'll also have the chance to replicate one of these discoveries ourselves! This hands-on experience will not only help solidify our understanding of the scientific method, but it will also highlight how a little bit of unpredictability can lead to remarkable results. So, get ready to embrace the unexpected and see where your curiosity takes you!

Lesson Instructions:

Part 1:

1. Begin the lesson by organizing students into small groups of 3-4. Hand out a set of cards to each group (refer to Attachment 1). Each card should detail a specific scientific accident and its corresponding discovery.
2. Instruct the students to take a few moments to read through each card carefully. Encourage them to discuss among themselves what they think the connections are between the accidents and the discoveries. This collaborative discussion will help stimulate critical thinking and allow students to engage with the material actively.
3. After about 10 minutes, reconvene the class and facilitate a discussion about some of the discoveries. Use the descriptions included in Attachment 1 to

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provide a brief overview of each accident and its resulting discovery. Ask groups to share their matches and reasoning. As you go over the discoveries, highlight the context and significance of each one, emphasizing how unexpected moments can lead to groundbreaking advancements.

4. Once you've reviewed the discoveries, instruct the students to update their cards with any new insights or corrections based on the discussion. Encourage them to write down key facts or interesting details they learned during the review. This will reinforce their understanding and ensure they leave with a clearer picture of each discovery.
5. Shift the focus to graphene. Introduce it by discussing its significance in the scientific community, mentioning its remarkable properties such as strength, conductivity, and flexibility.
6. Direct students to watch the video on graphene available at the following link: https://www.graphene.manchester.ac.uk/learn/discovery-of-graphene/ Encourage them to take notes on key points presented in the video, particularly about the importance of its isolation and the impact it could have on various fields. For those with one-to-one device access, provide the opportunity for students to explore the topic of graphene further. Direct them to the relevant sections of the website to enhance their understanding through interactive content and additional resources.
7. After watching the video and exploring the content, gather the class for a discussion based on the following guiding questions (these can also be found in the linked PowerPoint):
    a. Why is the discovery of graphene important? Encourage students to think about its applications in technology, medicine, and materials science.
    b. What properties does graphene have? Prompt students to discuss its unique characteristics and how they compare to other materials.
    c. What advancements could benefit from graphene? Foster a brainstorming session on potential innovations in various fields, including electronics, renewable energy, and healthcare.

    Allow ample time for students to share their thoughts and insights, promoting a collaborative learning environment. This discussion will not only solidify their understanding of graphene but also inspire them to think critically about the role of serendipity in scientific discovery.

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Part 2:

1. Begin by directing students to the MagLab article titled "Graphene Study: Step by Step" https://nationalmaglab.org/magnet-academy/read-science-stories/science-simplified/graphene-study-step-by-step/ Explain that this article will give them insight into the scientific process behind graphene research, specifically how high-power magnets play a crucial role in these studies. Ensure that students understand how to navigate the article, highlighting sections that discuss the application of magnets in graphene research. You may want to provide a brief overview of what high-power magnets are and their significance in scientific experimentation.
2. As students read through the article, instruct them to complete the graphic organizer provided. Emphasize that their focus should be on identifying key details about how the MagLab utilizes high-power magnets in graphene studies.
3. Encourage students to look for specific examples of experiments or applications mentioned in the article. They should fill in the sections of the graphic organizer with information such as:
    a. The role of high-power magnets in the isolation or study of graphene.
    b. Any notable experiments or findings that highlight the importance of these magnets.
    c. Key terms or concepts that are relevant to understanding the relationship between graphene research and magnet technology.
4. Remind students to refer back to the article as needed to ensure accuracy in their responses. This will not only help them retain the information but also develop their ability to extract and organize important details from scientific texts.
5. After students complete the graphic organizer, facilitate a brief discussion to share their findings. You can reference the answer key provided to clarify any points and address any misconceptions. This collaborative reflection will reinforce their learning and allow students to see the broader implications of using high-power magnets in graphene research.
6. To conclude this activity, ask students to reflect on what surprised them about the use of magnets in the study of graphene. This could lead to further discussion on the interdisciplinary nature of scientific research and how various tools and technologies contribute to groundbreaking discoveries.

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Part 3:

1. Begin this hands-on activity by briefly explaining the significance of the work done by Andre Geim and Konstantin Novoselov in isolating graphene using simple materials. Discuss how their groundbreaking method utilized everyday items, showcasing the beauty of scientific discovery through simplicity and creativity.
2. Distribute sheets of paper to each student or group. Instruct them to use a pencil to make a series of dense scribbles on the paper, ensuring the markings are dark and well-defined. Encourage students to press down firmly to deposit enough graphite on the paper, as this will be crucial for the next steps.
3. Provide each student or group with a roll of scotch tape, measuring 50 cm in length. Instruct them to cut a piece that is approximately 50 cm long and to carefully place it over the scribbled pencil markings, ensuring that about 5 cm of tape covers the graphite. Emphasize that they should align the tape carefully to maximize contact with the graphite.
4. Guide students to fold the end of the tape over so that the sticky side is facing out, effectively encapsulating the graphite. Instruct them to lift the tape gently and transfer it to a clean surface or a new piece of paper, making sure not to touch the sticky side to avoid contamination. Encourage them to smooth out the tape to ensure good adhesion and a clean transfer of graphite.
5. Instruct students to repeat the process of placing additional pieces of tape over the same area of pencil markings. Each time they place the tape, they should follow the same steps: pressing down firmly, folding over, and transferring. Continue this process until the tape is filled with multiple layers of transferred graphite. Emphasize that the goal is to build up the layers to eventually isolate a single layer of graphene.
6. Once students have completed the layering process, discuss how they should now have a piece of tape with a thin layer of graphite, resembling a single layer of graphene. Encourage them to examine the tape closely, discussing the properties of graphene and how it differs from bulk graphite.

Extension Activity: Microscopic Observation:

1. For an extended activity, provide students with access to a microscope or a digital microscope setup. Instruct them to place the tape under the microscope to observe the structure of the graphite more closely.

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2. Encourage students to look for patterns and characteristics that are indicative of graphene's unique properties. Ask guiding questions to prompt discussion, such as:
    a. What do you notice about the structure of the material?
    b. How does it compare to what you expected?
    c. Can you identify areas where the graphite appears to be layered or isolated?
3. Facilitate a class discussion afterward, allowing students to share their observations and insights. This will deepen their understanding of the experiment and highlight the relevance of Geim and Novoselov's work in the context of modern science.

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Attachment 1: Card Sort

Cut along the dotted lines to create a set of cards for card sort. Multiple can be made for small group work. This attachment can also serve as an answer key for the Card Sort activity.

Accident Dr. Alexander Fleming in 1928 returned from vacation to find a mold growing in a dish of Staphylococcus. This mold was preventing bacteria from growing around it.	**Discovery** Penicillin non-toxic antibiotic substance capable of killing many of the bacteria that cause minor and severe infections in humans and other animals.
Accident Swiss physicist Walter Jaeger in 1930 was trying to invent a sensor that could detect poison gas, instead it registered the smoke from this cigarette.	**Discovery** Smoke Detectors that help to save millions of lives each year.
Accident Physicist Wilhelm Conrad Röntgen when testing if cathode rays could pass through glass that there was a glow coming from a nearby chemically coated screen. He then noticed when he placed his hand in front of it that the rays would not pass through dense materials.	**Discovery** X rays that now are vital in the medical field.

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Accident In 2004 Andre Geim and Konstantin Novoselov with scotch tape and pencil on a Friday night, started to pull apart graphite. This resulted in the single layer of atoms, creating graphene.	**Discovery** Graphene materials that are strong and great conductors.
Accident During World War II, James Write was trying to create a synthetic rubber. When he dropped boric acid into silicone oil, the substance became bouncier and stretched more than the original rubber	**Discovery** Silly Putty was discovered that was market as a toy. It was even on the Apollo 8 Moon Mission.
Accident Arno Penzias and Robert Wilson were aggravated with this noise that kept appearing in their telescope. Come to find out, they discovered the earliest light.	**Discovery** Big Bang Theory evidence was found out of aggravation when trying to study other objects in space.

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Accident Wilson Greatbatch was tinkering with an oscilloscope (shows electronic waves) and he placed the wrong resistor, and what was created was a device that could make a heartbeat.	**Discovery** Pacemaker that saves lives every year by regulating the heartbeat.
Accident Henry Becquerel was investigated X-Rays in 1896 when he discovered that uranium salts were emitting a light without sunlight.	**Discovery** Radioactivity was discovered when researching another discovery.
Accident John H. Kellogg was working with his brother on a new time of wheat meal of patients. They rolled out thin wheat dough and forgot about it overnight. Instead of bread, they got thin flakes.	**Discovery** Corn Flakes was discovered to help patients with meals. In the first year, it sold over 100,000lbs of cereal.

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Accidental Science

Name: _____ Date: _____

Graphic Organizer for Graphene Article

What is the central idea of the article?		
Graphene conducts electricity better than which element?	**Why do scientist place graphene inside powerful magnetic fields?**	**Where is a common place that graphene is found?**
What is one reason why scientist want to know how graphene interacts with light?		

Describe the six steps scientists used to study Graphene at the MagLab?

1.

2.

3.

4.

5.

6.

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Accidental Science ANSWER KEY

Name: _____ Date: _____

Graphic Organizer for Graphene Article

What is the central idea of the article?

Graphene is being studied at the MagLab to understand how it may be used in future products.

Where is a common place that graphene is found?	Why do scientist place graphene inside powerful magnetic fields?	Graphene conducts electricity better than which element?
Flakes of your lead pencil.	Graphene is a one-atom thick layer of carbon atoms so scientists are wanting to study how light and magnetic fields interact with this material.	Copper

What is one reason why scientist want to know how graphene interacts with light?

Graphene could be used in televisions, computers and possibly billboards.

Describe the six steps scientists used to study Graphene at the MagLab?

1. The sample is mounted.
2. The probe that is placed into the magnet has the sample mounted.
3. The probe with the sample is inserted into the magnets bore, which is the strongest part of the magnet.
4. The magnet allows for light to be bent and shot through the sample.
5. The polarizer controls the laser beams inside of the magnet.
6. Data is collected from the experiment.

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