

“What effect do they have?”

### **Objectives**

Students will:

- read about large historical meteors and meteorite falls.
- discuss the effects the impacts have had on people.
- compare the responses recorded in history to their own responses.

### **Background**

**Part A: The Tunguska Meteor.** This reading describes the largest meteor and explosion in recorded history. Many effects of its explosion were like those of very large meteorite impacts. Yet, there is no agreement on what type of planetary material exploded in the Earth’s atmosphere to cause these effects.

**Part B: The Ensisheim Meteorite.** The story of the fall of the Ensisheim Meteorite focuses on how people reacted to a large meteorite fall in the year 1492.

**Part C: Fall of the Sikhote-Alin Meteorite.** This reading selection describes one of the largest meteorite showers in recorded history. The primary emphasis is on the physical events of the fall, with a secondary emphasis on the political context of the strategically sensitive area where the fall occurred.

#### **Part D: The Peekskill Fall.**

The story of the Peekskill fall, like that of Noblesville in Lesson 1, is a story of ordinary people in the 1990s. This meteorite crashed into a teenager’s car after the blazing meteor had been seen by many fans watching football games.

#### **Part E: The Fall of Allende.**

This reading describes a large meteorite shower and the subsequent scientific revolution. Allende is a special type of meteorite that generated extra excitement because it was studied by a large number of scientists testing their equipment in preparation for the imminent arrival of the Apollo Moon rocks. They discovered that this meteorite revealed new information about the early history of the solar system.

### **About This Lesson**

This lesson contains five reading selections and associated questions. The readings and questions are mostly about the responses of people to meteor and meteorite falls.

### **Materials**

- copies of readings (pgs. 15.3-15.12)
- reference materials
- writing materials
- maps

### **Procedure**

Give attached readings to students to read and discuss. Have students locate each event site on a map.

### **Vocabulary**

asteroid, meteorite, meteor, crater, comet, expedition, superstition, fireball

## Teacher Key - Questions

### Part A: The Tunguska Meteor

1. Why would an explosion blow down trees all around it?
2. Why might the trees nearest the explosion site still be standing?
3. Why might the Russian Academy of Sciences have waited 19 years to make an expedition to the Tunguska site? (**World War I, the Russian Revolution**)
4. How might the world react today to a Tunguska-type explosion at the same place? What if it happened in Texas?
5. What could you do today to find sand-sized grains from the asteroid or comet that hit at Tunguska? What types of material might have survived 85 years of weather? (**Metal, minerals**) The sand-sized grains from the meteor might have been propelled by the explosion; where might you find this sand separate from locally generated sand? Might any Tunguska material be preserved anywhere else?

### Part B: The Ensisheim Meteorite

1. How large was the stone, if its density was 3 grams per cubic centimeter? (**About the size of a cube 40 cm on an edge.**) How would you get a stone that heavy out of a hole in the ground?
2. After they found the stone, why do you suppose the townspeople argued? Why might the townspeople have thought the stone was good luck? What would you have thought?
3. Why didn't the person who owned the field claim the stone as his own? (**This is a difficult question. The concept of property ownership that we now accept was not known in 1492. Farmland around a village was considered "common land," to be used by the whole village.**)
4. Why might the mayor have taken the stone to the Church? Why didn't he take it inside the church? If a meteorite landed near your town, where would it be taken, or would it be moved at all?
5. Why was King Maximilian interested in the fall of the Ensisheim meteorite?
6. What other event happened in the year 1492?

### Part C: Fall of the Sikhote-Alin Meteorite

1. Where is Sikhote-Alin? Locate the area on a globe or a map. The towns nearest to the meteorite fall are Dainerecensk and Vostrecovo. Can you find these on a map? (**45.8°N, 134-135°E**)
2. Why might people not have rushed out immediately to find the meteorites?
3. Russia and Japan were fighting during World War II, just a few years before the Sikhote-Alin meteorite fall. What might people have thought about the fall if it had happened during the war?

4. China and the United States were fighting all across Korea during the Korean conflict, just a few years after the Sikhote-Alin meteorite fall. What might people have thought about the fall if it had happened during that conflict?

### Part D: The Peekskill Fall

1. Why would someone want to buy a meteorite?
2. Compare how the people in Peekskill responded to a meteorite fall with how those in Ensisheim responded five hundred years earlier.
3. How does the geography of the Earth affect how many meteorites are found?
4. How do you think population density affects recovery rates of meteorite falls?
5. Using the many videos of the meteor streak, how could you determine the direction of flight and the speed of the meteor?

### Part E: The Fall of Allende

1. In February 1969, many scientists:
  - a. **had developed ways to study moon rocks, but didn't have any samples yet.**
  - b. were studying lunar samples that had been brought back from the moon the previous summer.
  - c. believed that life existed on the Moon.
  - d. were in Pueblito de Allende when the meteorite shower occurred.
2. In this passage, it seems:
  - a. seeing a fireball in the sky in central Mexico is a normal event.
  - b. Pueblito de Allende is a large, busy town.
  - c. **meteorite fragments are interesting to villagers and farmers as well as scientists.**
  - d. after several days, people lost interest in the meteorite fragments.
3. The statement "The meteorite proved to be most unusual." means:
  - a. the meteorite was average.
  - b. the scientists did not like the meteorite.
  - c. **the meteorite was special.**
  - d. the meteorite was from the Moon.
4. Which of these statements best summarizes the passage?
  - a. **The Allende meteorite shower gave scientists a very unusual meteorite to study and an opportunity to practice using labs and procedures that would be used later with the lunar samples.**
  - b. The Mexican government was very cooperative as scientists looked for meteorites in 1969.
  - c. Although meteoriticists were very interested in the Allende shower in early 1969, they soon turned their attention to the lunar samples and forgot this wonderful event and the important information it revealed.
  - d. The Allende meteorite shower was an important scientific event because it happened near NASA JSC.

Lesson 15 — Historical Meteorite Falls  
Part A: The Tunguska Meteor

The biggest meteor in recorded history shot across the Tunguska River in Russia in 1908, and exploded like a nuclear bomb. The Tunguska meteor did not make an impact crater, but some of the effects of its explosion are similar to what could happen in a large meteorite impact.

At seven in the morning on June 30, 1908, a blazing meteor streaked across the sky in central Russia. It sped northwest from Lake Baikal toward the trading post of Baikit in central Siberia, an area of dense forests, wide swamps, and meandering rivers. Before reaching Baikit, the meteor exploded in a gigantic column of fire near the Tunguska River (61°N, 101.5°E).

The effects of the explosion were felt worldwide. Around the globe scientists wondered at the rapid changes in atmospheric pressure and unusual vibrations in the Earth. People within a thousand kilometers of the explosion saw both the meteor and the fire column. They also heard the explosion like a series of bombs. Closer to the explosion, people felt the ground rumble and shake. At about a hundred kilometers from the explosion, people, animals and houses were scorched and thrown by a hot blast of air. Only a few people were nearer to the blast, and they reported fires, houses being blown down and burnt, and reindeer being killed by falling trees. For 20 kilometers around the center of the explosion, the forest was flattened, with the downed trees pointing away from the explosion. At the center of the blown down area, tree trunks still stood, but all their limbs had been stripped off. Everything was



*Courtesy of the Smithsonian Institution.*

scorched from the heat.

The Tunguska meteor and explosion were widely reported in newspapers and magazines. However, there was little scientific interest until 1927, when the Russian Academy of Sciences organized an expedition to map the area and find meteorites. The expedition had to battle deep swamps, thick forests, and

hungry insects. Almost 20 years had passed since the explosion, and the explorers were not sure what would be left. At the explosion site, they found the blown down tree trunks and traces of fire among the new growth that had developed during those years. The explorers did not find meteorite craters, but guessed that some bogs were the remains of craters. After working very hard to drain and dig out the most promising bogs, they found no meteorites at all and finally realized that bogs were common all over the region, not only near the explosion. Later expeditions found tiny traces of melted rock in the soil, but never any meteorites.

Scientists have debated for years about what hit the Earth at Tunguska in 1908, especially since it left no meteorites behind. Some people have claimed that an alien spacecraft or a black hole hit the Earth. Most scientists think it was a comet because comets are made mostly of ice and would leave no meteorites. But it may have been a small rocky asteroid, which completely exploded in the air so that no rocks were left. Now, over 85 years later, it may be impossible to learn any more about the Earth's largest meteor explosion in modern history.

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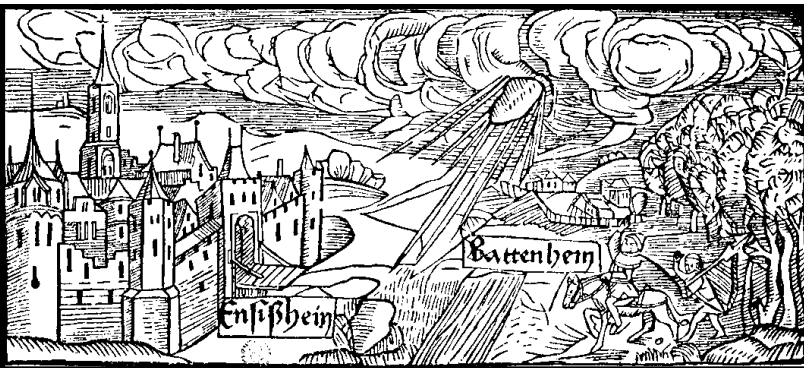
## **Questions**

1. Why would an explosion blow down trees all around it?
2. Why might the trees nearest the explosion site still be standing?
3. Why might the Russian Academy of Sciences have waited 19 years to make an expedition to the Tunguska site?
4. How might the world today react to a Tunguska-type explosion at the same place? What if it happened in Texas?
5. What could you do today to find sand-sized grains from the asteroid or comet that hit at Tunguska? What types of material might have survived 85 years of weather? The sand-sized grains from the meteor might have been propelled by the explosion; where might you find this sand separate from indigenous sand? Might any Tunguska material be preserved anywhere else?

Lesson 15 — Historical Meteorite Falls  
Part B: The Ensisheim Meteorite

In early November of 1492, the people of central France were astonished to hear a thunderclap from a clear sky rumble across their hills and farms. Today, a sound like that would probably be ignored as an airplane’s sonic boom or an industrial accident. But no one in 1492 had ever heard such a loud explosion. They must have thought it was a “sign.”

As the sound of the thunderclap died out, the people searched for its cause and meaning. Their world was apparently unchanged, except in the small town of Ensisheim, near the border of what are now France and Germany. There, a young boy saw a very large stone fall from the sky and land in a wheat field. He must have told his parents, and a crowd soon gathered where the stone had fallen. It sat at the bottom of a hole, one meter deep in the field. After arguing about what to do, the crowd finally pulled the 150 kilogram stone out of its hole and began breaking pieces off for good-luck charms. The mayor ordered them to stop and had the stone carried into the town and placed in front of the church.



*Brant, 1492; courtesy of Zentralbibliothek, Zurich.*

News of this marvelous stone traveled quickly to King Maximilian of Austria, heir to the Holy Roman Empire. He arrived in Ensisheim two weeks later, on his way to battle with the French. The King examined the stone, consulted with his advisors,

and decided that it was a sign from God foretelling victory in his upcoming battles. After taking his own piece of the stone from Heaven, the King ordered that it be kept forever in the town church. King Maximilian and his soldiers then marched off to battle and managed to defeat a much larger French army in the battle of Salins. The stone was preserved in the Ensisheim church, where it hangs today. The stone from Heaven got as much credit for the victory as did Maximilian.

## Questions

1. How large was the stone, if its density was 3 grams per cubic centimeter?  
How would you get a stone that heavy out of a hole in the ground?
2. After they found the stone, why do you suppose the townspeople argued?  
Why might the townspeople have thought the stone was good luck? What would you have thought?
3. Why didn't the person who owned the field claim the stone as his own?
4. Why might the mayor have taken the stone to the Church? Why didn't he take it inside the church? If a meteorite landed near your town, where would it be taken, or would it be moved at all?
5. Why was King Maximilian interested in the fall of the Ensisheim meteorite?
6. What other event happened in the year 1492?

*Lesson 15 — Historical Meteorite Falls*

**Part C: The Fall of the Sikhote-Alin  
Meteorite**

An area of Russia called the Sikhote-Alin hills, north of Vladivostok along the Sea of Japan, was enjoying a quiet, cold morning in February, 1947. Although Sikhote-Alin lies next to China and near Japan, two of Russia's traditional enemies, all was peaceful in 1947. World War II had ended a year and a half earlier, and the Korean conflict was years in the future. The few people in Sikhote-Alin went about their business, mostly surviving the long winter and preparing for spring.

At 10:30 in the morning on February 12, the mid-morning calm was shattered as a huge red and yellow meteor streaked across the sky. The fireball, with its trail of smoke and sparks, was visible for more than 300 kilometers. As it roared over the hills, it broke apart with a thunderous explosion, and the burning fragments flew downward and crashed into the forest.

Apparently no one rushed to investigate the fall. The next day two airmen discovered where the meteorite had landed when they happened to fly over the site. Where there had been unbroken forest, the airmen saw downed trees, craters, and open clearings. The airmen reported what they had seen to the Soviet government, and a scientific expedition was organized immediately. After slogging through the dense forest, the expedition arrived at the fall site on February 24, 1947.



There, scientists found more than 100 holes and craters in the rocky soil. The largest crater was 26 meters across and 6 meters deep; in the crater were many pieces of iron meteorite, together weighing 150 kilograms. The force of the meteorite's impact had twisted the meteorite pieces like taffy candy, blasted trees apart, and thrown rocks a kilometer from the crater. More than 23,000 kilograms of meteorites were found, equal to an iron ball 1.6 meters in diameter.

## Questions

1. Where is Sikhote-Alin? Locate the area on a globe or a map. The towns nearest to the meteorite fall are Dainerecensk and Vostrecovo. Can you find these on a map?
2. Why might people not have rushed out immediately to find the meteorites?
3. Russia and Japan were fighting during World War II, just a few years before the Sikhote-Alin meteorite fall? What might people have thought about the fall if it had happened during the war?
4. China and the United States were fighting all across Korea during the Korean conflict, just a few years after the Sikhote-Alin meteorite fall. What might people have thought about the fall if it had happened during that conflict?

Lesson 15 — Historical Meteorite Falls  
Part D: The Peekskill Fall

### Crash! Boom! Pow!

No, it wasn't Batman, Superman or an automobile accident. Michelle Knapp, a typical eighteen year old high school senior from Peekskill, NY, was home watching television at 7:50 Friday evening October 9, 1992, when she heard a loud crash. She rushed out of her house to investigate and found that her 1980 red Malibu had a demolished trunk.

In other parts of eastern United States, video cameras that had been focused on high school football games shifted upward and caught glimpses of an object streaking across the night sky. Later that evening, local television stations broadcast the videos of this spectacular meteor. Once a meteor makes it through the Earth's atmosphere and strikes the ground, it is called a meteorite.

Under her mangled car, Michelle found a 11.8 kg, football-sized rock from space. The first clue that suggested this rock might be a meteorite was the melted appearance of the front or leading edge. This exterior texture, called fusion crust, is produced by the friction of the speeding meteorite with the atmosphere. When Michelle touched the rock it was still warm, another good clue. The rock fell with such a great force that the red paint from the car was imbedded in the meteorite. Also, after passing through the car's trunk, the rock made a 15 cm deep crater in the driveway.

The Peekskill Police Department transported the meteorite to the American Museum of Natural History in Manhattan to be classified. Scientists identified it as an ordinary chondrite, the most common type of meteorite found. Meteorite falls are



*Credit: Dr. Dimitri Mihalas, courtesy of Science Graphics.*

a regular occurrence; thousands of kilograms are distributed onto Earth's surface each year. Even so, the odds against a meteorite hitting Michelle's car were extremely high. There have only been a few recorded instances of meteorites striking anything but the ground or the ocean. A dog was reportedly killed in Egypt in 1911 by the impact of a meteorite. In Alabama a meteorite passed through the roof of a house and injured a woman.

The Peekskill meteorite sold for about \$ 69,000. What about Michelle's car? Would insurance cover it? Would you believe someone bought it for \$10,000 so they could put it on display?

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### **Questions**

1. Why would someone want to buy a meteorite?
2. Compare how the people in Peekskill responded to a meteorite fall with how those in Ensisheim responded five hundred years earlier.
3. How does the geography of the Earth affect how many meteorites are found?
4. How do you think population density affects recovery rates of meteorite falls?
5. Using the many videos of the meteor streak, how could you determine the direction of flight and the speed of the meteor?

## Part E: The Fall of Allende

### The Allende Meteorite Shower — A Scientific Revolution

Early on the morning of February 8, 1969, the peaceful sleep of villagers in central Mexico was disturbed by a brilliant fireball and loud explosions. The fireball came from the south-southwest and scattered thousands of meteorite fragments over a huge area around the town of Pueblito de Allende. The villagers and farmers collected many pieces of meteorite. One of the pieces was taken to the nearest city and reported in the newspaper. Within days scientists from NASA and the Smithsonian Institution were at the site in Mexico, collecting specimens and describing their distribution. Over the following months many other collectors visited the area. Altogether the Mexican and foreign collectors recovered thousands of fragments weighing a total of 1,000 kg!

The earliest samples collected by U.S. meteoriticists were rapidly distributed to many other scientists who were preparing their labs for the imminent return of Apollo lunar samples. The scientists welcomed the chance to study a new meteorite and test their new procedures. The meteorite proved to be anything but ordinary. It was a very primitive carbonaceous chondrite containing evidence of the earliest history of the solar system. This special meteorite fell at the right place and the right time. The right place was in Mexico only a day's drive from NASA's Johnson Space Center in Houston. The right time was early 1969, five months before the return of the first Apollo Moon rocks. The information about the early solar system revealed in the Allende meteorite created a revolution in meteorite science that is still felt today.



## Questions

1. In February 1969, many scientists:
  - a. had developed ways to study moon rocks, but didn't have any samples yet.
  - b. were studying lunar samples that had been brought back from the moon the previous summer.
  - c. believed that life existed on the Moon.
  - d. were in Pueblito de Allende when the meteorite shower occurred.
  
2. In this passage, it seems:
  - a. seeing a fireball in the sky in central Mexico is a normal event.
  - b. Pueblito de Allende is a large, busy town.
  - c. meteorite fragments are interesting to villagers and farmers as well as scientists.
  - d. after several days, people lost interest in the meteorite fragments.
  
3. The statement "The meteorite proved to be most unusual." means:
  - a. the meteorite was average.
  - b. the scientists did not like the meteorite.
  - c. the meteorite was special.
  - d. the meteorite was from the moon.
  
4. Which of these statements best summarizes the passage?
  - a. The Allende meteorite shower gave scientists a very unusual meteorite to study and an opportunity to practice using labs and procedures that would be used later with the lunar samples.
  - b. The Mexican government was very cooperative as scientists looked for meteorites in 1969.
  - c. Although meteoriticists were very interested in the Allende shower in early 1969, they soon turned their attention to the lunar samples and forgot this wonderful event and the important information it revealed.
  - d. The Allende meteorite shower was an important scientific event because it happened near NASA JSC.