LESSON 21

# Examining and Grouping Elements

© GRAZIA NERI/WOODFIN CAMP & ASSOCIATES

*Marie Curie, working with her husband Pierre, discovered two elements in 1898 while investigating the radioactive element uranium. They named the first element polonium after her home country, Poland. They named the second one radium because it was very radioactive. In 1903, Marie was awarded the Nobel Prize for her work. She was also awarded a Nobel Prize in 1911 for her work on radioactive elements. Marie Curie was the first person to receive two Nobel Prizes.*

## INTRODUCTION

More than 100 different elements exist. They make up all matter. How many elements have you seen or could you recognize? In the last lesson, you obtained two elements, hydrogen and oxygen, by splitting water, a compound. You have come across some others in this module. Sulfur and iron are two. You probably know what some other elements look like, such as gold, silver, and aluminum. But what about silicon, the second most common element in Earth's crust? (Oxygen is the most common.) Or what about calcium, which is found combined with other elements as a compound in bones and teeth? Did you know that each time you take a breath you inhale the elements argon and neon? What are their characteristic properties?

Do not be surprised if you do not recognize many elements in your daily life. Identifying the elements took scientists hundreds of years. Most elements have been recognized only during the past 200 years. The reason chemists had to work so hard to identify all the elements known today is that most elements are reactive. That

### OBJECTIVES FOR THIS LESSON

**Describe the appearance of several elements.**

**Perform tests and make observations to determine some physical properties of elements.**

**Collect information on elements and organize it into a table.**

**Use the information collected to classify elements into groups.**

**Compare your classification system with one used by chemists.**

is, they tend to combine with other elements to form compounds. Therefore, they usually exist in chemical compounds rather than by themselves. Water, for example, is produced when hydrogen combines with oxygen in a chemical reaction. You observed that reaction in Lesson 20 when you heard hydrogen burn with a squeaky pop, although you probably did not notice that water vapor was being produced!

When you have a large collection of different items, it is often useful to put them into groups. Think of your kitchen at home. You probably have a drawer that contains silverware (probably divided into knives, forks, and spoons). You may also have several cupboards: one for pans, one for plates, and one for glasses. These items are often classified according to their use and sometimes according to their appearance.

After scientists discovered many elements, they began to classify them according to their characteristic properties. By placing elements in groups, scientists could predict how they would behave or react with other elements, what their physical properties would be, and how they could be used. Scientists could even use this classification system to predict the existence of other elements that had not yet been discovered. In this lesson, you will try your hand at classifying some elements.

## MATERIALS FOR LESSON 21

**For you**

- 1 copy of Student Sheet 21.1a: Examining and Grouping Elements
- 1 copy of Student Sheet 21.1b: The Periodic Table

**For your group**

- 1 black marker
- 1 sheet of newsprint
- Masking tape

## Getting Started

1. Your teacher will refer to Lesson 20 while reviewing the terms "element" and "compound."

2. Participate in a brainstorming session on elements and their characteristic properties.

3. Your teacher will construct a list of your ideas about elements and their characteristic properties. At the end of the lesson, you will look at this list again to discover how much you have learned about elements.

## Inquiry 21.1
## Investigating and Classifying Elements

### PROCEDURE

1. Look carefully at Table 1 on Student Sheet 21.1a. You are going to use this table to collect data on 25 different elements. Your teacher will demonstrate how to collect information and will help you complete the table for the elements shown in Figures 21.1 and 21.2. (Use Figure 21.3 when your teacher instructs you to do so.)

# Zinc

**Zn**

| | |
|---|---|
| **Melting point** | **416 °C** |
| **Boiling point** | **907 °C** |
| **Density** | **7.1 g/cm³** |
| **Appearance** | |
| **Other physical properties** | **Zinc is ductile and malleable at temperature higher than 100 °C.** |
| **Chemical properties** | **Zinc reacts with acid, releasing hydrogen gas.** |
| **Compounds** | **Compounds of zinc are white in color.** |
| **Uses** | **Zinc is used to coat steel (galvanizing to stop rusting), in car parts, in electrical equipment, and in batteries. Zinc oxide is used in paints and some sun tan lotions.** |
| **Notes** | **Zinc is obtained from its ores by roasting them to turn them into zinc oxide. The zinc oxide is then smelted to produce the metal.** |

CORBIS/THE PURCELL TEAM

*Tin roofs like this one are not made from the element tin. They are made from sheets of steel covered in a protective layer of zinc. The zinc is applied to the steel by galvanizing.*


CORBIS/CHRISTINE OSBORNE

*This lifeguard is using a cream that contains zinc oxide. Its bright white color reflects sunlight and protects the skin.*

**Figure 21.1** *Use the facts and photos shown here and the tests demonstrated by your teacher to complete the information for zinc in Table 1 on Student Sheet 21.1a.*

# Uranium

U

| | |
|---|---|
| Melting point | 1132 °C |
| Boiling point | 3818 °C |
| Density | 19.1 g/cm³ |
| Appearance | |
| Other physical properties | Uranium is radioactive and malleable, but it is not a very good conductor of electricity. |
| Chemical properties | Uranium gets a thin coat of oxide when left in the air, and it reacts with water. Uranium powder or chips react violently with air. |
| Compounds | Uranium compounds come in a variety of colors (uranium dioxide, dark brown; uranium trioxide, orange; uranium fluoride, white). |
| Uses | Uranium is used in nuclear weapons and nuclear reactors. |
| Notes | Uranium is highly radioactive, and even small amounts can be a health hazard. |

U.S. DEPT. OF ENERGY/PHOTO RESEARCHERS, INC.

*Uranium is used inside nuclear reactors and nuclear weapons.*

COURTESY OF THE NATIONAL ARCHIVES

*A nuclear bomb containing uranium was dropped by the United States on Hiroshima, Japan, toward the end of World War II. Because of their terrifying destructiveness, only two nuclear bombs have ever been used in war. The other, dropped on the Japanese city of Nagasaki, contained a different radioactive metal, called plutonium.*

**Figure 21.2** *Use the facts and photos shown here to help you complete the information for uranium in Table 1 on Student Sheet 21.1a.*

# Helium

**He**

| | |
|---|---|
| **Melting point** | **–272 °C** |
| **Boiling point** | **–269 °C** |
| **Density** | **0.00018 g/cm³** |
| **Appearance** | **Helium is colorless.** |
| **Other physical properties** | **Helium is the second least dense element.** |
| **Chemical properties** | **Helium is odorless and does not react easily with other elements.** |
| **Compounds** | |
| **Uses** | **Helium is used to inflate weather and party balloons as well as modern airships and blimps. It is mixed with oxygen for use by divers.** |
| **Notes** | **Helium is the second most abundant gas in the universe. It was discovered in the sun by a technique known as spectroscopy before it was found on Earth. It gets its name from Helios, the god of the sun in Greek mythology.** |

NASA

*Only hydrogen is less dense than helium. Helium is used to fill balloons such as this NASA research balloon. Why is helium used for this purpose instead of hydrogen?*

© JOEL SILVERSTEIN

*Helium/oxygen mixtures are used by divers who descend to great depths. When breathed under pressure, helium has less toxic effects than nitrogen, the major component of air. When nitrogen is breathed under pressure, it can cause symptoms of nitrogen narcosis, a condition that can disorient divers.*

**Figure 21.3** *When instructed by your teacher, use the facts and photos shown here to enter the information for helium in Table 1 on Student Sheet 21.1a.*

2. Using your observations from Lesson 20 and your own knowledge, complete the rows in Table 1 for hydrogen and oxygen.

3. Participate in a class discussion of your information on hydrogen and oxygen in Table 1. If additional information about these elements arises during the discussion, add it to your table.

4. Your teacher will explain how you should investigate some other elements. Follow along as your teacher reviews Steps 5 through 9 of this procedure.

5. The elements are arranged in stations around the room. For each element, there is a card that looks similar to Figure 21.1, 21.2, or 21.3. Some of these cards have missing information. You will need to examine and test the elements to determine what some of their properties are.

6. For some elements, you must determine whether they conduct electricity (allow electricity to pass through them) or whether they are insulators (do not allow electricity to pass through them). See Figure 21.4 for information on how to perform this test.

7. If a paper clip is at the station, you should investigate the hardness of the element (see Figure 21.5). First, try scratching the element with your fingernail. If this has no effect, try using the end of the paper clip. Is the element hard or soft compared with your fingernail and the paper clip? What does the scratched surface of the element look like?

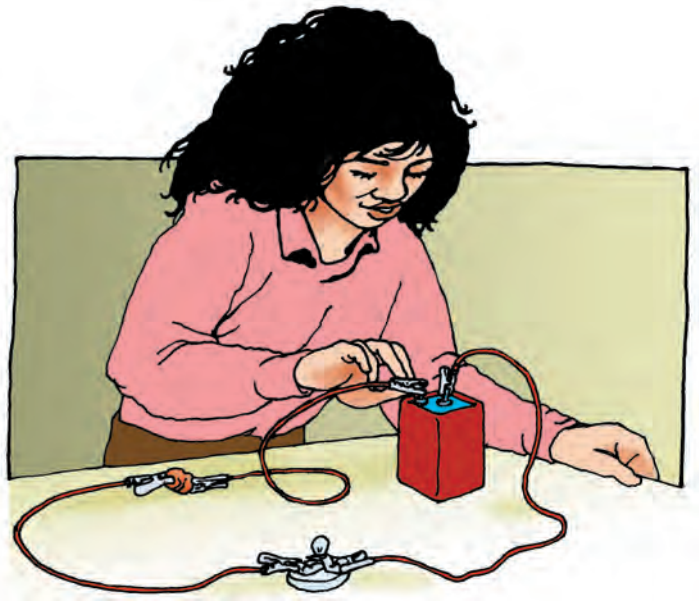


**Figure 21.4** *For some elements, you will perform a test to determine whether they conduct electricity. Make a conductivity-testing apparatus. Test the element as shown. If the bulb lights, the element conducts electricity. The brighter the bulb, the better the element conducts electricity.*

**Figure 21.5** *Use your fingernail and the paper clip to determine how hard the element is. Also observe how the surface of the element looks after it has been scratched.*

8. Use the magnet to determine whether an element is magnetic.

9. You and your partner will be assigned to a numbered station. Go to that station and start collecting the information you need to complete Table 1. Do not transfer all of the information on the card to the table. Select only the information that you think you need. (Remember that the photographs and their captions contain useful information.) You have 5 minutes to investigate each element.

10. When your teacher calls time, leave the card, element, and any apparatus where you found it. Move to the next station. (If you are at station 20, move to station 1.)

11. When you have collected information on all of the elements at the stations, return to your place. Your teacher will outline how you should place your elements in groups and will ask for your ideas on grouping the elements.

12. Working with the other pair in your group, try to identify at least five groups of elements. Place the elements in these groups. Remember that most elements will fit into more than one group.

13. Write your ideas in your science notebook. When you think you have useful groups of elements, transfer the information from your notebook to the newsprint (see Figure 21.6). When you have finished writing all five groups, attach the sheet of newsprint to the wall.


**Figure 21.6** *Record your groups of elements on the newsprint. Make sure the lettering is easily read from the other side of your classroom.*

## REFLECTING ON WHAT YOU'VE DONE

1. Participate in a class discussion about how you decided on groupings of elements.

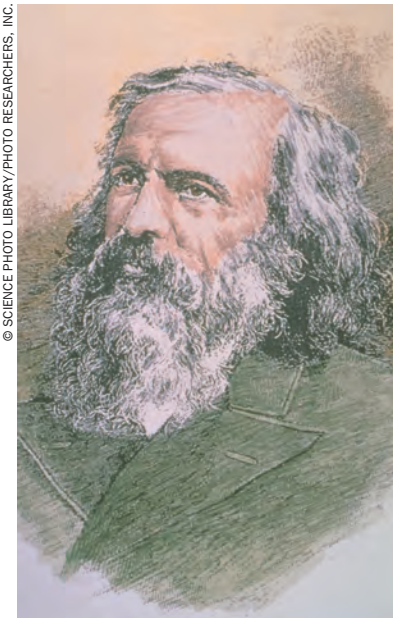
2. Your teacher will compare your classification with an existing one called the periodic table. This table uses the symbols you copied from the Element Cards. Mark where some of the different groups are on your copy of the periodic table (Student Sheet 21.1b). You will notice there are many more elements than the ones you investigated in the inquiry. Some of them fall under the groups you chose.

3. Refer to the list of elements and characteristic properties compiled by the class at the start of the lesson. Discuss the following questions with other members of your group:

   *A. How correct were the original examples and characteristic properties of elements you suggested in "Getting Started"?*

   *B. What changes would you now make to this list?*

# Dmitry's Card Game



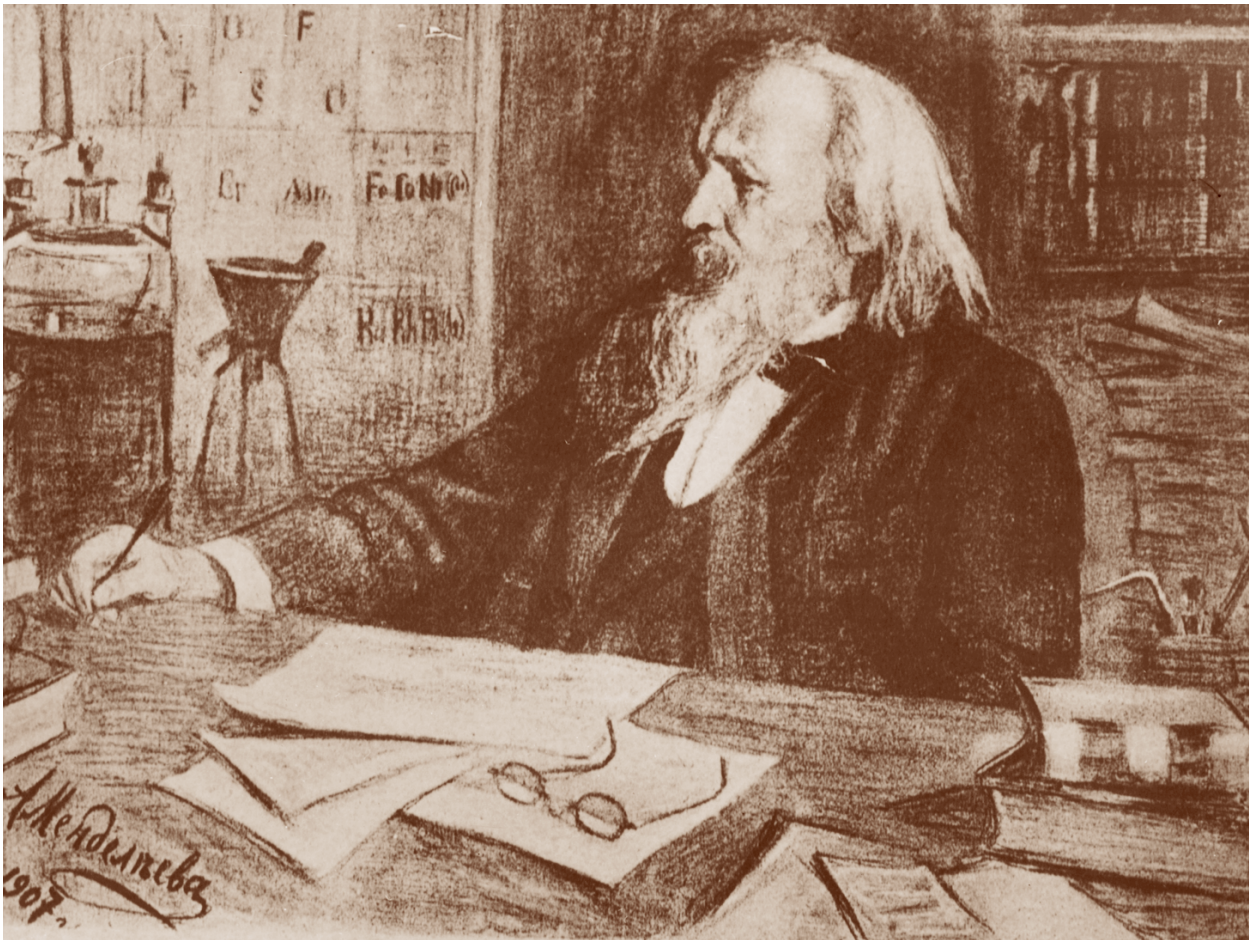


*Dmitry Mendeleyev devised the forerunner to today's periodic table. Initially a poor student, he eventually graduated from college at the top of his class.*

It's interesting how different skills can be brought together to contribute to scientific discovery. Consider the story of Dmitry Mendeleyev and his card game that changed the face of chemistry.

Mendeleyev was a Russian college professor who loved to play cards. He was also looking for a way to organize the elements. To accomplish this, he wrote the symbols, characteristic properties, and other information for 63 elements on cards (only 63 elements had been discov-





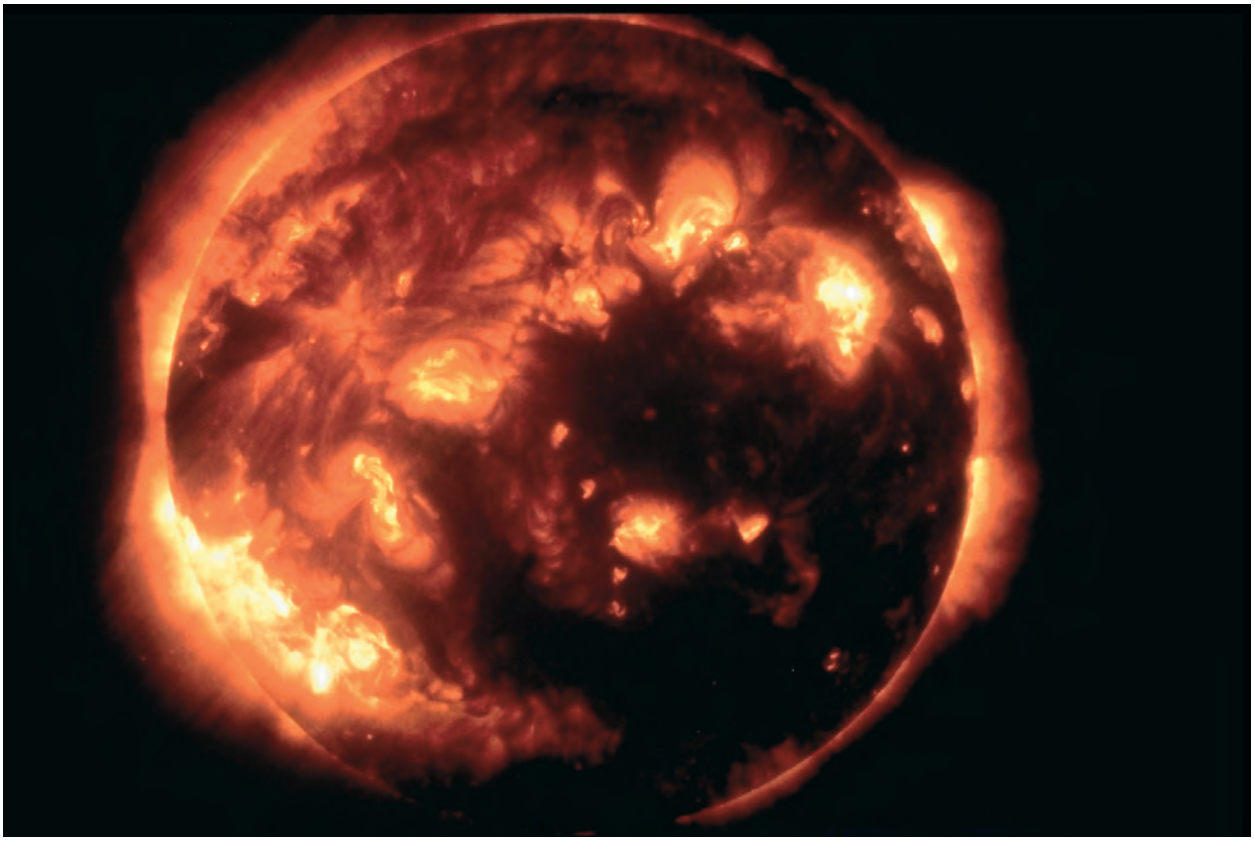
*Mendeleyev was 35 years old when he published his "Periodic Table of the Elements." This charcoal drawing, done by his wife, shows him in his later years, working in his laboratory. Part of his periodic table can be seen in the background of this picture.*

CORBIS/STEVE REYMER


*Mendeleyev's early "Periodic Table" adorns the wall of the school where he worked in St. Petersburg, Russia. Mendeleyev's original table contained the 63 elements known at that time. He correctly predicted that the gaps would be filled with elements that had yet to be discovered.*

ered by 1869, the year he developed the card game). He then placed the cards face up on a table and began moving them around. He put the elements into groups according to the information he had about each one and how one element compared with another. For example, the elements sodium and potassium are soft, shiny, and highly reactive metals. Mendel-eyev placed the cards for these elements in a column. He noticed that the elements calcium and magnesium had properties similar to one another, so he placed them together in another column. He did this with other elements and then moved the columns around so that the columns with similarities were next to one another. He discovered that when he did this, he could see patterns emerging. As he examined the rows of the table, he noticed that the pattern of properties periodically repeated itself. Thus, he called this classification system the "Periodic Table of the Elements."

Over a period of 20 years, Mendeleyev improved his classification system. There were some gaps in the table—missing cards. He predicted that elements yet to be discovered would fill these gaps. He was able to suggest some of the characteristic properties they would have. As scientists became more knowledgeable about the physics and chemistry of matter, they helped refine the table, and the missing elements were discovered. □



*The periodic table is the "list of ingredients" for our entire universe. Most of the elements were formed in nuclear reactions, which took place inside stars or exploding stars called super nova. Some of these nuclear reactions continue to take place inside our sun (shown in this X-ray photograph), which releases energy when the element hydrogen undergoes fusion and is converted to the element helium.*

## QUESTION

The periodic table was not the work of one person. As with most discoveries, evidence was collected over many years and scientists in many different countries were involved. Use the Internet and other resources to find out about the most famous scientists involved in developing the periodic table.