

## Lesson Summary

In this activity, students apply the methods developed to identify and interpret patterns to the identification of fingerprints. They look at fingerprints of their classmates, snowflakes, and finally “spectral fingerprints” of elements. They learn to identify each image as unique, yet part of a group containing recognizable similarities.

## Prior Knowledge & Skills

- Ability to recognize and describe patterns
- Experience interpreting data
- Visible light represents only a small portion of all light
- General understanding of energy

## AAAS Science Benchmarks

### **The Nature of Mathematics**

*Patterns and Relationships*

## NSES Science Standards

- **Life Science:** Structure and function in living systems

## NCTM Mathematics Standards

- **Geometry:** Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships
- **Algebra:** Understand patterns, relations, and functions

## Colorado State Standards

- Mathematics Standards 1.1, 1.2, 2.1, 4.2
- Science Standard 3, 5

## Suggested background reading

*Fingerprint Identification*

**Teaching Time:** One 60-minute period

## Materials

Each group needs:

- Pencil or pen
- Index cards (1 per student)

To share with the class:

- Photocopier
- Ink pad (2)
- Overhead copy of Fingerprint Field guide
- Master of Finger Print Field Guide
- PowerPoint (Included on CDrom)

### **OR**

- Overhead copies of the student pages: Patterns In Nature, Numbers and Patterns, Sample Spectra
- Answer key for student pages, Patterns In Nature, Numbers and Patterns

## Advanced Planning

**Preparation Time:** 30 minutes

1. The day before the activity, create the Fingerprint Field Guide page and a set of anonymous fingerprints. Have each student make a thumbprint on the Fingerprint Field Guide page and write his or her name under the print. Create a set of anonymous fingerprints on index cards by having students imprint an index card when they add their print to the Fingerprint Field Guide. Number the index cards randomly.
2. Make one copy of the Fingerprint Field Guide for each student.
3. Copy the Fingerprint Field Guide and the anonymous prints on to overhead transparencies.
4. Copy Patterns in Nature, Numbers and Patterns, and Sample Spectra sheets on to overhead transparencies.

## Why Do We Care?

A spectrum is the unique light signature produced by every element and molecule. Astronomers analyze spectra (spectroscopy) to figure out what stars, planets, moons and other astronomical objects are made of. In this activity, students practice identifying fingerprints using recognizable features (they may refer to the *Fingerprint Identification* reading for tips on how the pros do it, or develop their own system). This is analogous to how scientists analyze spectra.



# Patterns and Fingerprints

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## Group Size 1 or 2

**Expendable Cost per Group** \$0.20

## Engineering Connection

Understanding patterns is crucial to any engineer, whether it be the electrical engineer who needs to understand patterns involved in circuitry or the aerospace engineer fitting pieces of a spacecraft together. In the context of this unit, however, engineers need to understand the patterns in the physical world that help them build the tools to expand our knowledge of that world.

## Learning Objectives

After this activity, students should be able to:

- Describe the differences and similarities between patterns and fingerprints
- Identify fingerprints using pattern-identifying strategies
- Extend a numerical and alpha-numerical pattern
- Recognize patterns present in the natural world
- Identify some patterns engineers use

## Introduction / Motivation

*Display “Patterns in Nature” transparency on the overhead or use the PowerPoint presentation. What do you think this image could be? Have the class discuss the clues they used to identify the images. What clues did you use to decide what the images could be? Reveal the answer key on the overhead. Natural processes create organized geometrical patterns. These patterns can be found in a variety of places in nature. Have you ever looked closely at a leaf or a butterfly? Patterns exist all around us. Humans have created some tools to help us understand patterns better. Mathematical concepts, such as geometry, were created to explain the physical world and to help us decipher some of these patterns. Engineers use patterns to help them design better instruments. Engineers also create new instruments to study these patterns so that we can understand them better. Let’s look at some more patterns and see if you can figure out what is going on. Hand out the “Numbers and Patterns” sheet. Give students a few minutes to figure out the puzzles, and then ask members of the class for their answers.*

## Procedure

### Background

The light patterns in this activity are emission spectra produced by hydrogen and helium gas. Every gas has a unique pattern, so we can identify the gas based on the lines that appear in the spectrum. An emission spectrum is seen as bright lines against a dark background, and is produced by light (or energy) passing through hot gas, and the gas emitting photons. The pattern depends on the type of gas.

**Before the Activity**

The day before the activity, create the “Fingerprint Field Guide” page and a set of anonymous fingerprints.

- a. Using the inkpad, have each student make a thumbprint on the “Fingerprint Field Guide” page and write his or her name under the print.
- b. Next, have students make an identical thumbprint on an index card when they add their print to the “Fingerprint Field Guide.” (Note: it helps to keep the index cards in order of the prints on the Field Guide so you can number them accurately after the students are gone.)
- c. Lastly, give a number to the fingerprint on the Field Guide and its corresponding index card. It is best to number these randomly so that students do not see a pattern on the Field Guide while they are trying to match the cards later.



**Figure 1**  
Copy of the fingerprints field guide worksheet, showing students’ fingerprints with names and numbers.  
**Source/Rights: LASP**

- 2. Copy the “Fingerprint Field Guide” onto two transparencies, one with students’ names and one with names removed.
- 3. Hand out copies of the anonymous prints.
- 4. Copy “Patterns in Nature,” “Numbers and Patterns,” and “Sample Spectra” sheets on to overhead transparencies or use the PowerPoint presentation.

## With the Students

### *Part 1: Fingerprint detectives*

1. Have the class place their desks in a large circle.
2. Divide students into pairs and distribute to each team a copy of the “Fingerprint Field Guide.”
3. Explain that you will pass out one index card to each pair.
4. Explain that students will try to match the numbered fingerprint to one of the prints on the “Fingerprint Field Guide.”
5. Explain that students will have 1 minute (or choose another limit you think is appropriate) to make the identification and then they will pass the card to the team on their right. In this way, each team will have the same amount of time to identify each fingerprint on the index card.
6. Circulate around the room as students work. Listen to their conversations and observe them work to understand the processes they use to identify the numbered fingerprints.
7. Ask students to explain the processes that they used to match known and unknown prints. Make a list of methods and solutions students developed while trying to match numbered prints to named prints.
8. Review the list and ask students to discuss or expand on the processes and identify which methods were most successful.
9. As a class, review the prints and identify the owner of each numbered print. (Use the overhead transparency of the “Fingerprint Field Guide” to enlarge the images and look for details.)
10. Ask students to compare the processes used identify patterns and fingerprints. What were the similarities and differences? How does recognizing a pattern compare to looking for unique characteristics? How are fingerprints alike and at the same time unique?

### *Part 2: Spectral fingerprints*

11. Place the sample spectra overhead up for the students to see.
12. For each image set, ask the students the following questions:
  - Do you recognize these images?
  - What can you tell me about the patterns?
  - Compare and contrast the images, what are some of the similarities and differences?
  - Are these examples of fingerprints or patterns?
13. Point out that the images of colored bands are known as “spectral fingerprints” and that they represent the absorption and emission of energy by individual elements.
14. Explain that like human fingerprints, spectral fingerprints are unique to each element and help scientists to identify the composition of many substances including mineral and gases.
15. Bring closure to the activity by asking students to summarize the similarities and differences between patterns and fingerprints in a graphic organizer such as a “T-chart” or Venn diagram.



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16. Encourage students to list how patterns and fingerprints appear and how they are used to help us understand the world around us.

## Troubleshooting Tips

Severely vision-impaired and blind children will have difficulty with portions of this activity. Students with corrective lenses will not have difficulty.

It may be good to have an extra set of brainteasers available if students are interested.

## Assessment

### Pre-Activity Assessment

Accessing prior knowledge: Ask students to draw or write what they think of when they hear the word “pattern.”

### Activity Embedded Assessment

Class discussion: Ask students why it is important for engineers to understand the patterns in the natural world. To begin the discussion, you can ask about patterns they are familiar with like the lines on a CD-rom (connected to sound patterns, a natural pattern). Some examples (if students are having difficulty) are: engineers can send a spacecraft to a planet because the planets move around the Sun in a specific pattern that repeats, engineers can use sonograms and other technology to create underground maps (patterns) which help establish where bridges and buildings can be safely built; some structures, like the honeycomb pattern in a beehive, are strong structures that help engineers build stronger structures etc.

### Post-Activity Assessment

Compare and contrast: Have students summarize the similarities and differences between patterns and fingerprints in a graphic organizer such as a “T-chart” or Venn diagram. Encourage students to list how patterns and fingerprints appear and how engineers use them to help us understand the world around us.

Crime scene investigators and engineering: Engineers help create technologies to help us identify fingerprints for criminal investigations. For example, they develop the computer programs that recognize specific fingerprint patterns. They also help develop the techniques to retrieve fingerprints from different surfaces, such as metals. Have the students think about the different ways they identified the fingerprints in the “Fingerprint Field Guide.” Using the methods they discovered, have them pretend to be engineers and create a written procedure for identification of fingerprints that could be converted into a computer program for their local police department.

### Activity Extensions

Continue the spectroscopy unit by completing the associated activity, “Graphing the Rainbow.”

Have students create a list of other patterns they have seen in nature.

Have students create their own alpha numeric brainteaser to share with the class.

Engineering connection: Biomimicry: Engineers often use the natural world as inspiration for design. Biomimicry means to study nature’s ideas and patterns and imitate them to solve human problems.



# *Patterns and Fingerprints*

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Some of these designs include air- and sea-going vessels, medical imaging devices, and water and pollution treatment processes. Have students think of and discuss technologies that mimic patterns in nature, such as solar cells that mimic cell patterns in leaves.

## **References**

“NIEHS Kids Page: Brainteasers, Puzzles & Riddles.” April 27, 2004. The NIEHS Office of Management. March 4, 2005.

<<http://www.niehs.nih.gov/kids/braint.htm>>

“Absorption Spectra.” Physics2000/University of Colorado. March 4, 2005.

<<http://www.colorado.edu/physics/2000/quantumzone/fraunhofer.html>>

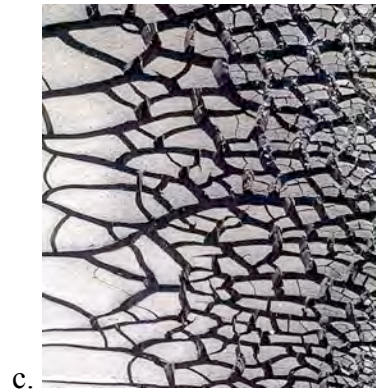
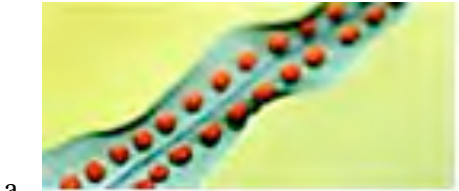
## **Owner**

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Patterns In Nature





# Patterns and Fingerprints

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## Answer Key and Sources Part I: Patterns in Nature



Leaf with seeds

<http://www.drellenrudolph.com/patterns%20A/patternsA.html>

Summary of a talk presented at the 13th International Congress of the International Union for the Study of Social Insects, Adelaide, Australia, January 1999.



Sand Dunes <http://www.drellenrudolph.com/patterns%20A/patternsA.html>

Summary of a talk presented at the 13th International Congress of the International Union for the Study of Social Insects, Adelaide, Australia, January 1999.



Mud cracks <http://www.drellenrudolph.com/patterns%20A/patternsA.html>

Summary of a talk presented at the 13th International Congress of the International Union for the Study of Social Insects, Adelaide, Australia, January 1999.



Olive Shell

<http://www.drellenrudolph.com/patterns%20A/patternsA.html>

Summary of a talk presented at the 13th International Congress of the International Union for the Study of Social Insects, Adelaide, Australia, January 1999.

Student hand-out: Numbers and Patterns





# Patterns and Fingerprints

Like the barcodes that identify the items you buy almost anywhere—grocery stores, bookstores, department stores—these spectra can be “read.” Before you learn how to read spectra, get your pattern identification skills in shape by matching each barcode in the left column with the identical barcode on the right. Draw a line between matching barcodes.



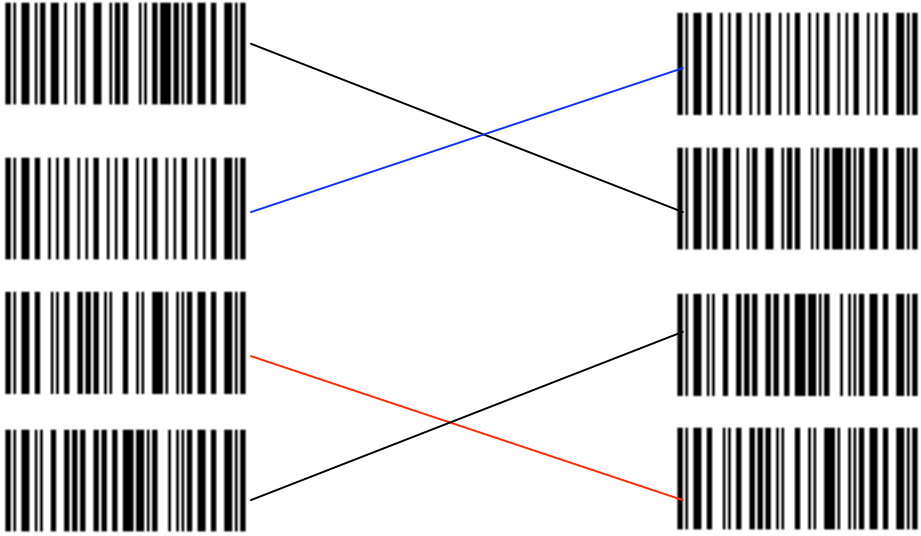
1) What is the next number in this sequence? \_\_\_\_\_  
1, 1, 2, 3, 5,

2) What is the next, bottom, row in this triangle? \_\_\_\_\_  
1  
1 1  
1 2 1  
1 3 3 1  
1 4 6 4 1  
1 5 10 10 5 1

3) What is the next number in this sequence? \_\_\_\_\_  
14, 91, 62, 53, 64,

4) Which letter comes next in the following sequence? \_\_\_\_\_  
S, N, E, P, O, H, C

Key: Numbers and Patterns



1) What is the next number in this sequence? \_\_\_\_\_  
 1, 1, 2, 3, 5, 8 Fibonacci Sequence

2) What is the next, bottom, row in this triangle? \_\_\_\_\_

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    1
   1 1
  1 2 1
 1 3 3 1
1 4 6 4 1
1 5 10 10 5 1
1 6 15 20 15 6 1
    
```

Pascal's Triangle

3) What is the next number in this sequence? 14, 91, 62, 53, 64, ? 96  
 Answer: 96. They are the first few square number separated into sets of two digits, ie. 1 4 9 16 25 36 49 64... becomes 14 91 62 53 64 96...

Source: <http://www.braingle.com/brainteasers/index.php>

4) Which letter comes next in the following sequence? \_\_\_\_\_  
 S, N, E, P, O, H, C, Answer: E. Why? Each group of four consecutive letters, when read in reverse, forms a word:

- SNEP - pens
- NEPO - open
- EPOH - hope
- POHC - chop
- OHCE - echo

Source: <http://www.braingle.com/brainteasers/index.php>





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Sample Spectra





# *Patterns and Fingerprints*

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## Sample Spectra



Emission spectra for hydrogen

<http://www-astronomy.mps.ohio-state.edu/~pogge/Ast162/Intro/Spectra/>



Emission spectra for helium

<http://www-astronomy.mps.ohio-state.edu/~pogge/Ast162/Intro/Spectra/>