Educational Product	
Educators	Grades 9–12

The Potential Consequences of Climate Variability and Change

HUMAN HEALTH

Climate & Disease: A Critical Connection

2001 APPROVED by NASA Earth Science Enterprise

AN ACTIVITY RESOURCE FOR TEACHERS

Responding to National Education Standards in:

- ***English Language Arts***
- ***Geography***
- ***Mathematics***
- ***Science***
- ***Social Studies***

This learning activity was developed to examine the potential impacts of climate variability and change. Each activity is part of an overall series entitled ***The Potential Consequences of Climate Variability and Change,*** which includes 1–12 teacher resources. Twelve modules (10 printed and 2 online resources) comprise the set and are presented below:

OVERVIEW

- Too Many Blankets (Grades 1–4)
- Global Balance (Grades 5–12)

AGRICULTURE

- El Niño (Grades 5–8)
  This activity is provided in an online format only and is available at *http://ois.unomaha.edu/casde/casde/lessons/Nino/teacherp.htm.*
- The Great American Desert? (Grades 9–12)
  This activity is provided in an online format only and is available at *http://ois.unomaha.edu/casde/casde/lessons/grass/teacherp.htm.*

COASTAL AREAS

- What Could a Hurricane Do to My Home? (Grades 5–8)
- What Is El Niño? (Grades 5–8, 9–12)
- Coral Reefs in Hot Water (Grades 9–12)

FORESTS

- A Sticky Situation (Grades 5–8)
- Planet Watch (Grades 9–12)

HUMAN HEALTH

- Beyond the Bite: Mosquitoes and Malaria (Grades 5–8, 9–12)
- Climate and Disease: A Critical Connection (Grades 9–12)

WATER

- Here, There, Everywhere (Grades 7–8, 9–12)

The development of the activities was sponsored by the National Aeronautics and Space Administration and the Environmental Protection Agency, in support of the US Global Change Research Program. The Institute for Global Environmental Strategies implemented the effort. For more information, see *http://www.strategies.org.* For additional resources, please visit *http://teach earth.com*—Resources for Teaching and Learning about Earth System Science.

Climate Variability & Change
HUMAN HEALTH

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TWO ACTIVITIES
Climate & Disease: A Critical Connection

CONTENTS

Climate & Disease: A Critical Connection

Although the following activities are designed to tap specific skills and knowledge through scientific inquiry, their broader intent is to stimulate thought about the long-term impacts of a warmer planet.

GRADE LEVELS

Grades 9–12

TIME REQUIRED

Two to three class periods

OBJECTIVES

This activity is designed to help students:

- Analyze how climate variability can affect the food chain.
- Predict changes in animal population due to climate variability.
- Interpret the relationship between climate variability, and diseases as explained by basic concepts of ecology and genetics.

DISCIPLINES ENCOMPASSED

- Biology
- Earth System Science
- Ecology
- Geography
- Language Arts
- Mathematics
- Social Studies

PREREQUISITE KNOWLEDGE: TEACHER

- Some climate change models suggest that erratic weather is an early effect of climate variability.
- A deadly disease—hantavirus pulmonary syndrome—appears to be harming human health as a result of variable weather. Recent research indicates that this is an old disease that has been newly identified.
- Hantaviruses have been identified in various rodent populations. It appears they have little effect on the rodents but may be picked up by humans from rodent saliva, urine, and feces.
- Hantaviruses may cause various severe diseases in humans that usually affect their kidney function.
- In 1993, hantavirus infection was confirmed in the southwestern United States in 94 people, 48 percent of whom died.

PREREQUISITE KNOWLEDGE: STUDENTS

The following skills and knowledge will enhance students' participation in these activities:

- Knowledge of food chains; and
- Basic understanding of genetics.
- This case study involving cause and effect is greatly simplified to demonstrate the link between climate variations and the spread of disease. Connections within systems found in nature are much more involved.
- **An introduction to genetics**

  Biological human traits, such as height and eye color, are inherited from parent to child by discrete units called genes. These genes provide the information that makes each individual unique.

  The first person to study genes was Gregor Mendel, an Austrian monk. In 1866, Mendel published his findings for his studies of the pea plant. He found that by making hybrids, he could keep track of the traits displayed by progeny plants (offspring). After studying many generations of these plants he concluded that discrete "units of inheritance" are what determined the traits he was observing. Each trait was in turn determined by

two units of inheritance, or genes, one coming from each parent plant.

In his studies Mendel also found that each trait can be expressed differently. He determined this to be due to alleles, or alternative gene information for a trait. For example, a flower for the same type of plant can be pink or white, each color being the representation of an allele. His experiments further determined that some of these alleles were dominant over others. For example, if two plants were crossed, one with two genes for a pink flower (let's designate this to be the dominant gene), the other with two genes for a white flower (let's designate this to be the recessive gene), the resulting flower will have both a gene for pink flowers and a gene for white flowers. Because the pink gene is dominant over the white gene, the resulting flower will be pink.

KEY TERMS AND CONCEPTS

The following terms and concepts will be presented in the following text and activities:

Climate
Climate variability and change
Dominant gene
Ecology
Genetic variation
Genetics
Hantavirus pulmonary syndrome
Recessive gene
Trophic

SUGGESTED READING/RESOURCES

■ *PUBLICATIONS*

Epstein, Paul R. 1998. ***Climate Changes: An Issue Summary of Health and Climate Change.*** World Wildlife Fund. Washington, DC.

High-school biology texts that provide basic instruction in genetics and viral diseases would be helpful.

■ *WEB SITES*

All About Hantavirus: El Niño
http://www.cdc.gov/ncidod/diseases/hanta/hps/noframs/elnino.htm

Basic Facts about HPS and the Hantavirus
http://www.hantavirus.net/info1.html

The Biology Project: Mendelian Genetics
http://www.biology.arizona.edu/mendelian_genetics/mendelian_genetics.html

The Climate Change and Human Health Integrated Assessment Web: Public Health Impacts
http://www.jhu.edu/~climate/health.html

Frequently Asked Questions About Ecology
http://advlifesupport.jsc.nasa.gov/

Genetic Science Learning Center
http://gslc.genetics.utah.edu/

Harmon Science Center
Splice of Life Teachers Guide
Activity One—Punnett Squares
http://www.sciencecenter.org/splicpg1.htm

Mendel Web
http://www.netspace.org/MendelWeb/

NASA Facts: Science Issues
http://trmm.gsfc.nasa.gov/climate_disease.html

Public Health Impacts
http://www.jhu.edu/~climate/health.html

Science of the Earth System
http://earth.nasa.gov/science/index.html

Tracking the mouse in the house
http://www.enn.com/news/ennstories/1999/05/052599/hantavirus_3317.asp

ACTIVITY ONE
The Chain Game

Activities One and **Two** are designed to help you understand how erratic weather and/or genetic variation may have played a part in the outbreak of hantavirus.

MATERIALS

- Food chain game board (Appendix D)
- Game pieces representing organisms of the trophic levels—plants, grasshoppers, deer mice, and owls (Appendix D)
- Three sets of game pieces, as follows:
  Set A—has only a single organism on each piece
  Set B—has pieces with a few of the same organism on each piece and pieces with many of the same organism on each piece
  Set C—has four pieces depicting hantavirus, a human, the sun, and rain (Appendix D)
- Internet access

PROCEDURE

Step 1
Distribute the materials from Appendix D and the ***Activity One Student Worksheet: The Chain Game.***

Step 2
Place students into groups of three or four and work though to Part 4.

Step 3
When students have completed Part 4, discuss with the class the following topics:

- The temperature and moisture effects on the food chain;
- How diseases are passed through the food chain; and
- How climate change can affect the spread of diseases through the food chain.

CONCLUSION

- Ask the students to share their food chains for Parts 1–4.
- Discuss with the students possible reasons for differences.
- Discuss with students their answers to the question from Part 4.

EXTENSIONS

1. Have students research areas in the U.S that have gone through drought and heavy rains. Were their food chain predictions accurate? Why or why not?
2. Research other climactic factors (i.e. temperature) that can influence the food chain. Repeat the activity using these factors.

Student Activity One Worksheet: THE CHAIN GAME

Part 1

Hantavirus lives in the white-footed deer mouse. The virus probably is not helpful to the mice, but it does not seem to make them sick or die.

- Use Set A pieces and the food chain game board to arrange a food chain for the deer mouse.
- Record the food chain to the right. Discuss your arrangement with other groups, and see if they agree.

Part 2

The "Four Corners" area of the United States—where Colorado, Utah, Arizona, and New Mexico meet—had undergone six years of severe drought, when in Spring of 1993, a period of heavy rains began.

- With Sets A and B and the game board, show the food chain as it might have been just before the heavy rains started.
- Consider adding pieces from Set C (they may be placed on the board outside of the squares).
- Record the food chain to the right and discuss your arrangement with other groups.

Part 3

- With Sets A and B, the game board, and the same pieces as in Part 2, show the food chain as it might have been shortly after the heavy rain started.
- Consider adding the pieces from Set C to the food chain board.
- Record the food chain to the right and discuss your arrangement with other groups .

NOTE: It may be helpful to remember that owls have only one family of young per year and mice often have several.

Part 4

- With Sets A and B and the game board, show the food chain as it might have been about a year *after* the heavy rains began.
- Consider adding the pieces from Set C to the food chain board.
- Record the food chain to the right and discuss your arrangement with other groups.

It has been suggested that the top predators were still not abundant after a year of heavy rains. What could explain this?

ACTIVITY TWO
Genes & Germs

Activities One and **Two** are designed to help you understand how erratic weather and/or genetic variation may have played a part in the outbreak of hantavirus.

MATERIALS

- A coin
- Internet access

PROCEDURE

Step 1
Read and review with the students the opening paragraphs for the ***Student Activity Two Worksheet: Genes and Germs*** (see p. 8). Be sure all students understand the activity before they begin.

Step 2
Explain that they will each become a member of an owl population. By studying genetics and reproduction, they will determine how climate variability will alter this population. Assign each student a pair of genes ("EE", "Ee", or "ee"), being sure to have a 1:2:1 ratio for the entire class.

Step 3
Complete the ***Student Activity Two Worksheets.***

CONCLUSION

- Discuss how offspring genetics differed due to changing climatic conditions.
- Discuss how and why offspring genetics differed between students.
- Ask the students how climactic conditions affected the spread of hantavirus to people.

EXTENSIONS

1. Identify another disease affected by climate. What are the climate factors that affect this disease?
2. Discuss with the students what heterozygous and homozygous mean. Then have the students practice using punnett squares.

Student Activity Two Worksheet: GENES & GERMS

New research is indicating that changes in the spread of diseases may be correlated with changes in weather patterns. These changes can occur worldwide. For example:

- Global warming can cause increased precipitation. With this increase in precipitation comes increased runoff of the tiny Cryptosporidium oocysts into public water supplies. The Cryptosporidium is a protozoa that can be found in livestock and wildlife, such as cattle and deer. Standard purification processes for drinking water in the United States involve chlorination, which has little effect on the organism, and filtration, which can only remove the tiny protozoan if properly monitored and managed.
- Schistosomiosis is a devastating disease found in parasites of the Nile River Delta. The parasites, using snails as their hosts, are found in areas with high soil moisture. The snails have a better chance of survival as the amount of moisture in the area increases, which increases the chances of spreading the disease to humans.

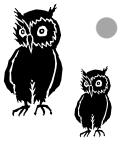
This activity will build on what you have discovered in **Activity One.** Let's see how a pair of genes with a simple dominant and recessive relationship might play a part in the following scenario.

Assume the owls in this food chain have a pair of genes that allow them to live a healthy life if the climate remains moderately wet, but have an unhealthy life if it is extremely wet or dry. These genes originally came from the parents—one gene from the female and the other from the male. The letter "e" will represent each gene; it may be a capital "E" for dominant, or a lower case "e" for recessive. As long as an owl has at least one "E" gene, it can survive in extreme wet or dry weather; however, if it has two "e" genes, it cannot.

We will assume that the usual owl population has a 1:2:1 ratio for this trait—that is, for every one owl that is "EE," there are two that are "Ee," and one that is "ee." Let's find out what will happen to this owl population in moderate weather by doing the following activity.

Part 1

Each participant, or owl, in this activity has two genes (that is, either "EE," "ee," or "Ee") assigned by the teacher, with only one of the genes available for any particular mating. On your genetics worksheet write an "E" if you were assigned "EE", or an "e" if you were assigned "ee" under the words "YOUR GENE." If you were assigned "Ee," flip a coin to determine which to write.



- Why should half the class have a capital letter (dominant) and half the class have a lowercase letter (recessive)?

Owls mate, and therefore produce young once a year. We will assume only one young survives to reproduce the following year. Mating is done at random within the population, or class. For each generation you will pick a mate from the population. You and your mate will then determine the genes that are passed on to your offspring. Remember, if you or your mate is an "Ee," you must flip a coin to determine which gene is involved in the mating. Then, you are to assume the genes of the offspring for mating for the following year—that is, you will play the role of the new offspring.

Part 2

Use the worksheet to follow the mating pattern for six years and tabulate the genetic makeup for all the young owls produced. Assume the weather has been normal during this period (that is, not extremely wet or dry).

- What is the total number of young produced from all the matings?
- What is the genetic ratio of this population?
- How will this owl population affect its food chain (refer back to Activity One)?
- Predict the spread of hantavirus to people (think about the food chain).

Part 3

Repeat parts one and two for a six-year dry period, during which all "ee" owls die. Once "dead" you will no longer be able to mate, and must take your seat.

- What is the total number of young produced from all the matings?
- What is the genetic ratio of this population?
- How will this owl population affect its food chain?
- Predict the spread of hantavirus to people.

Part 4

The genetic data for a 6-week wet period will be the same as for a dry period.

- How was the population affected?

- How will this affect the food chain?

- Predict the spread of hantavirus to people.

Student Activity Two Genetics Worksheet: GENES & GERMS

Your genetic makeup:

NORMAL PRECIPITATION

	Your Gene	x	Mate's Gene	=	Offspring's Gene
Generation 1					
Generation 2					
Generation 3					
Generation 4					
Generation 5					
Generation 6					

Student Activity Two Genetics Worksheet: GENES & GERMS

Your genetic makeup:

6 YEAR DROUGHT/WET

	Your Gene	x	Mate's Gene	=	Offspring's Gene
Generation 1					
Generation 2					
Generation 3					
Generation 4					
Generation 5					
Generation 6					

Appendix A
Bibliography

Epstein, Paul R. 1995. "Emerging Diseases and Ecosystem Instability: New Threats to Public Health." ***American Journal of Public Health.*** 85(2): 168–172

Climate Change May Impact Waterborne Diseases
http://www.psu.edu/ur/NEWS/news/crypto.html

Encarta Encyclopedia: Mendel, Gregor Johann
http://encarta.msn.com/index/conciseindex/2A/02A8A000.htm?z=1&pg=2&br=1

Genetic Science Learning Center
http://gslc.genetics.utah.edu/basic/concepts/inheritance/index.html

NASA Facts: Science Issues
http://trmm.gsfc.nasa.gov/climate_disease.html

Appendix B

Assessment Rubric & Answer Key

Assessment Rubric

To be used after completion of both Human Health activities:
Beyond the Bite: Mosquitoes & Malaria and ***Climate & Disease: A Critical Connection.***

SKILL	Excellent (4)	Good (3)	Satisfactory (2)	Poor (1)
Data	Able to manipulate (use) limiting factors data: temperature, genetics, and food chain population.	Able to manipulate (use) two of the proceeding sets of data.	Able to manipulate (use) one of the proceeding sets of data.	Not able to manipulate (use) the data sets.
Presentation	Able to clearly show* limiting factors of food chains, genetic factors, and geographic distribution.	Able to show* two of the limiting factors.	Able to show* one of the limiting factors.	Unable to show* limiting factors.
Concept	Able to explain* that temperature, rainfall, and genetic composition are limiting factors.	Able to explain* two of the preceding as limiting factors.	Able to explain* one of the preceding as limiting factors.	Not able to explain* the preceding as limiting factors.
Relationships	Able to clearly communicate* how the interaction of temperature, precipitation, and genetics control the spread of disease.	Able to communicate* how the interaction of two of the preceding control the spread of disease.	Able to communicate* how one of the preceding controls the spread of disease.	Not able to communicate* how the preceding factors control the spread of disease.
Applications	Able to apply the understanding of relationships of the three limiting factors to another climate related health problem.	Able to apply the understanding of relationships of two limiting factors to another climate related health problem.	Able to apply the understanding of one limiting factor to another climate related health problem.	Unable to apply the understanding of a limiting factor to another climate related health problem.

** Students may use any form of appropriate communication, language arts, mathematics, fine arts, etc.*

Students' answers should be in their own words and in complete sentences.

ANSWER KEY Student Activity One Worksheet–THE CHAIN GAME

Part 1
The sequence should be owl-mouse-grasshopper-plant. Owl should be on top, but some could run in the opposite direction with an explanation.

Part 2
There will be few plants because of the lack of rain, and other levels will not be very large because of lack of food supply.

Part 3
More rain brings more plants and some increases in population up the food chain.

Part 4
Rains continue and all populations increase. Hantavirus becomes more widely distributed.

ANSWER KEY Student Activity Two Worksheet–GENES & GERMS

Part 1
Half the class should have a capital letter (dominant) and half the class have a lowercase letter (recessive), as long as the initial ration is 1:2:1. The homozygous dominant pair of genes "EE" will pass on a dominant "E" gene. The homozygous recessive pair of genes "ee" will pass on a recessive "e" gene. The heterozygous pair of genes will pass on a dominant "E" 50% of the time and a recessive "e" 50% of the time.

Part 2
- The total number of young produced from all the matings is 6 x the number of mating pairs.
- The genetic ratio of this population should be at or near 1:2:1.
- All populations remain rather stable.
- Mouse populations remain stable and the spread of hantavirus is moderate.

Part 3
- The owl population decreased. The ratio will show a decrease in the recessive gene ("e").
- The number of mice increases.
- More mice means more mouse droppings, which increases the spread of hantavirus.

Part 4
- This causes the owl population to decrease.
- Answers to how this will affect the food chain can vary, as long as they are scientifically accurate.
- Predictions of how this will cause the spread of hantavirus to people can vary, as long as they are scientifically accurate.

Appendix C
National Education Standards

This activity responds to the following National Education Standards:

STANDARDS FOR THE ENGLISH LANGUAGE ARTS

Standard 3: Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound- letter correspondence, sentence structure, context, graphics).

Standard 4: Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Standard 5: Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

Standard 6: Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss different print and nonprint texts.

Standard 7: Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

Standard 8: Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Standard 12: Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

National Council of Teachers of English and International Reading Association. 1996. ***Standards for the English Language Arts*** *p. 24–46. Urbana, Illinois and Newark, Delaware: National Council of Teachers of English and International Reading Association.*

NATIONAL GEOGRAPHY STANDARDS GEOGRAPHY FOR LIFE (9–12)

Geography Standard 3: *The World in Spatial Terms.* How to analyze the spatial organization of people, places, and environments on Earth's surface.

Geography Standard 4: *Places and Regions.* The physical and human characteristics of places.

Geography Standard 7: *Physical Systems.* The physical processes that shape the patterns of Earth's surface.

Geography Standard 8: *Physical Systems.* The characteristics and spatial distribution of ecosystems on Earth's surface.

Geography Standard 15: *Environment and Society.* How physical systems affect human systems.

American Geographical Society, Association of American Geographers, National Council for Geographic Education, and National Geographic Society. 1994. ***Geography for Life: National Geography Standards*** *p. 183–222. Washington, DC: National Geographic Research and Exploration.*

CURRICULUM AND EVALUATION STANDARDS FOR SCHOOL MATHEMATICS (9–12)

Standard 1: Mathematics as problem solving.

Standard 3: Mathematics as reasoning.

Standard 4: Mathematical connections.

National Council of Teachers of Mathematics. 1989. ***Curriculum and Evaluation Standards for School Mathematics*** *p. 123–186. Reston, VA: The National Council of Teachers of Mathematics, Inc.*

NATIONAL SCIENCE EDUCATION STANDARDS

CONTENT STANDARD: K–12

Unifying Concepts and Processes

Standard: As a result of activities in grades K–12, all students should develop understanding and abilities aligned with the following concepts and processes:

- Systems, orders, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement

National Research Council. 1996. ***National Science Education Standards*** *p. 115–119. Washington, DC: National Academy Press.*

CONTENT STANDARDS: 9–12

Science as Inquiry

Content Standard A: As a result of activities in grades 9–12, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science

Content Standard C: As a result of activities in grades 9–12, all students should develop an understanding of:

- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

Earth and Space Science

Content Standard D: As a result of activities in grades 9–12, all students should develop an understanding of:

- Energy in the Earth system

Science and Technology

Content Standard E: As a result of activities in grades 9–12, all students should develop:

- Understandings about science and technology

Science in Personal and Social Perspectives

Content Standard F: As a result of activities in grades 9–12, all students should develop an understanding of:

- Personal and community health
- Population growth
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

National Research Council. 1996. ***National Science Education Standards*** *p. 173–204. Washington, DC: National Academy Press.*

CURRICULUM STANDARDS FOR SOCIAL STUDIES

Strand 3: *People, Places, & Environments.* Social studies programs should include experiences that provide for the study of people, places, and environments.

Strand 8: *Science, Technology, & Society.* Social studies programs should include experiences that provide for the study of relationships among science, technology, and society.

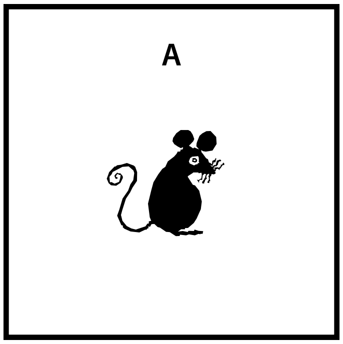
Strand 9: *Global Connections.* Social studies programs should include experiences that provide for the study of global connections and interdependence.

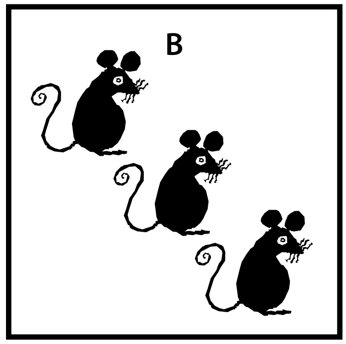
National Council for the Social Studies. 1994. ***Expectations of Excellence: Curriculum Standards for the Social Studies*** *p. 21–30. Washington, DC: National Council for the Social Studies.*

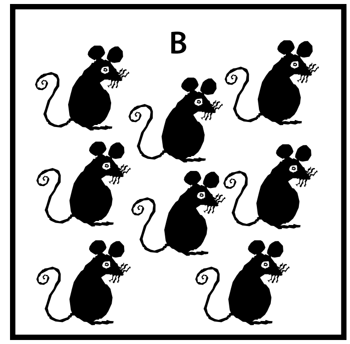
Materials

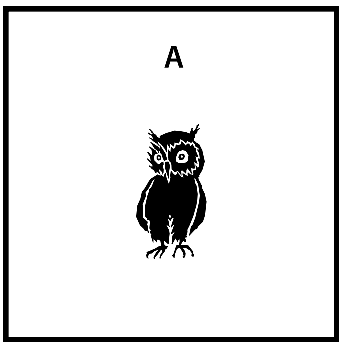
THE CHAIN GAME: Game Pieces

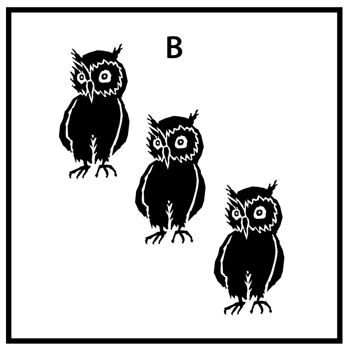
Set A | **Set B** | **Set B**

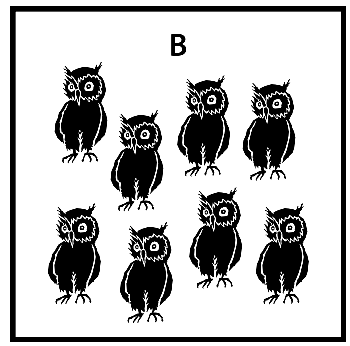


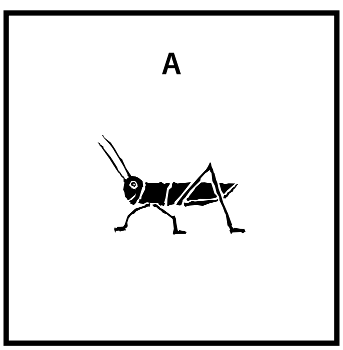


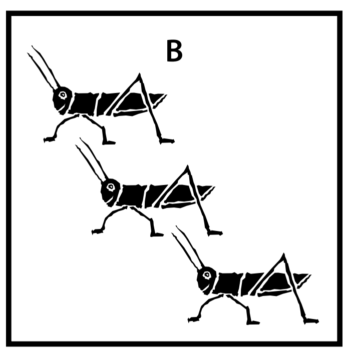


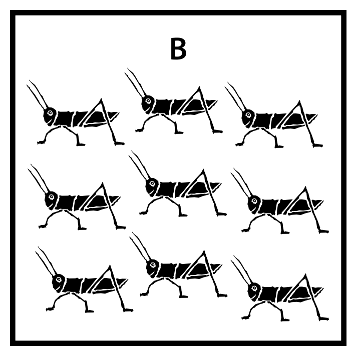


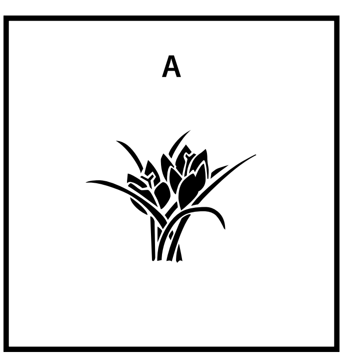


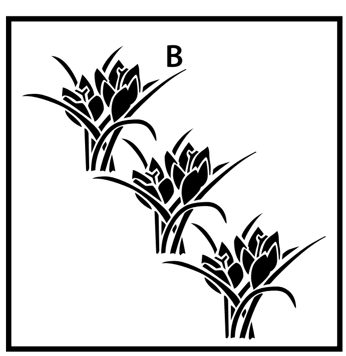


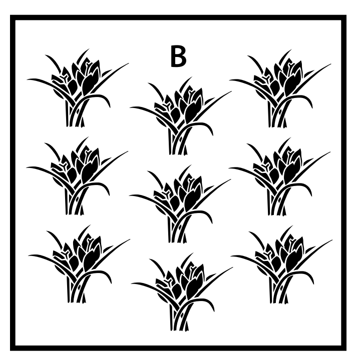








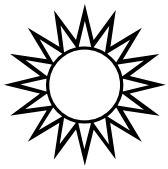




THE CHAIN GAME: Game Pieces

Set C

C



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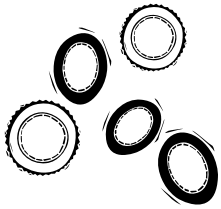
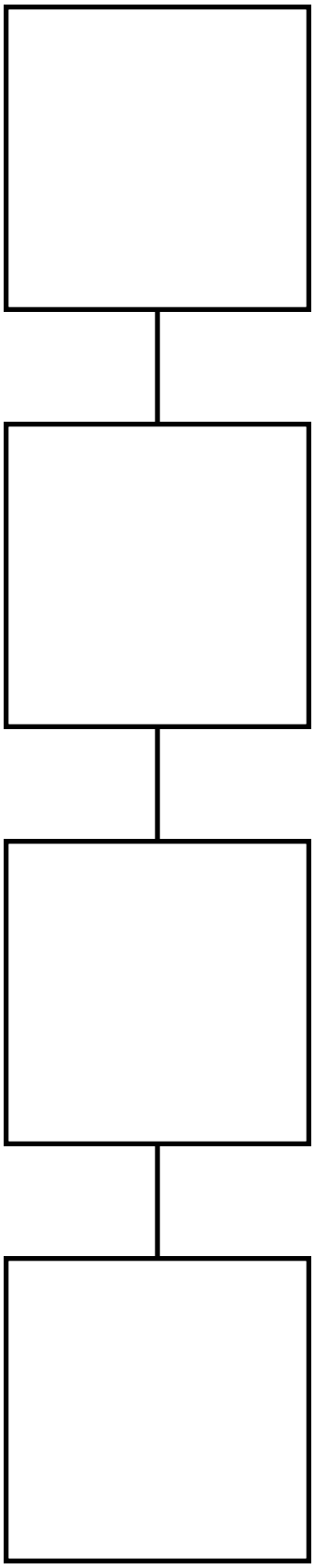


THE CHAIN GAME: Game Board



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