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ABSTRACT

This document features a lesson plan in which genetic traits are identified and classified using a genetic wheel by playing several different games that introduce genetic diversity and highlight why it is important within populations. Samples of instruction and assessment are included. (KHR)

11 The Gene Scene

SUBJECTS

science

SKILLS

gathering (simulating), analyzing (identifying patterns), interpreting (identifying cause and effect, inferring)

FRAMEWORK LINKS

4, 19, 20, 22, 28

VOCABULARY

chromosome, **evolution, gene, genetic diversity,** *herd, inherit, nucleus, population,* **species, trait**

TIME

three sessions

MATERIALS

Part I—*copy of the "Human Genetic Wheel" (page 41) and "Checking Out Your Genetic Traits" (page 40)*
Part II—*15 to 20 index cards*
Part III—*scissors, copies of "All About Giraffes" (pages 42–43), "Giraffe Genetic Wheel" (page 45), "Giraffe Cards" (pages 46–50) on white paper and colored paper, "Spotting Giraffes" (page 44), "Event Cards" (page 52), and "Giraffe Calf Cards" (page 51) on white and colored paper (The copy pages for this activity are all included in the Student Book.)*

CONNECTIONS

For more on the importance of genetic diversity, follow up with "Diversity on Your Table" (pages 230–237) or "Biodiversity—It's Evolving" (pages 168–179). To investigate how the loss of genetic diversity affects species, try "The Case of the Florida Panther" (pages 246–251).

AT A GLANCE

Play several different games that introduce genetic diversity and highlight why it's important within populations.

OBJECTIVES

Identify and classify genetic traits using a genetic wheel. Explain why genetic diversity may be necessary for the long-term survival of a population of animals or plants. Explain that lack of genetic diversity is one of the reasons why small and fragmented populations are vulnerable to extinction.

From a scientific perspective, conserving biodiversity means more than just protecting the variety of different species on Earth. It also means preserving the natural variation that exists among the individuals of each species. Just as humans vary in their appearances and abilities, so, too, do individual fish, mushrooms, oak trees, and amoebae. Preserving variety within populations of species is essential for preserving the ability of that species to cope with environmental change.

An organism's ability to adapt to environmental change determines how well it will survive in the long run. The greater the diversity of genes in a population, the greater the chances that some individuals will possess the genes needed to survive under conditions of environmental stress. As wild populations of plants and animals become smaller and more fragmented, it becomes less likely that the remaining individuals will possess the genes needed to survive environmental changes. The individual—and the species—is subject to destruction.

This three-part activity will introduce your students to the concept of genetic diversity within a population. In Part I they will observe and compare human traits within their classroom population. This exercise should demonstrate that each individual has a variety of traits that make him or her unique and that create a diverse population within the classroom. In Part II they will discover through a quick, active demonstration that increased diversity contributes to greater survivability. And Part III will reinforce this idea as your students play a game in which they represent populations of giraffes coping with changes in the environment over time.

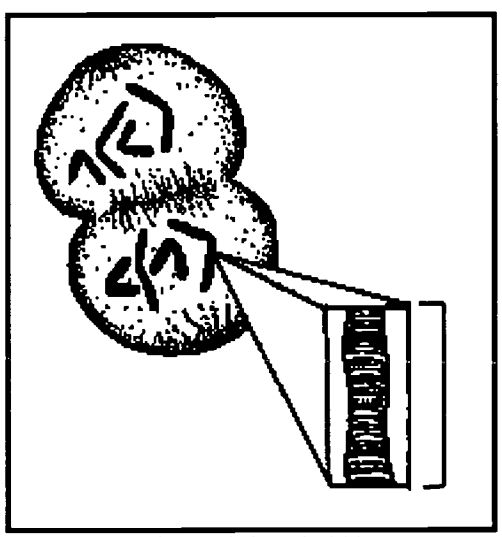
Before You Begin • Part I

For each student, make a copy of the "Human Genetic Wheel" (page 41 in the Student Book) and "Checking Out Your Genetic Traits" (page 40 in the Student Book).

What to Do • Part I

1. Introduce genes.

Your students may know that the physical characteristics of all creatures on Earth are determined by their genes. But what are genes and how do they work? Genes are sections of DNA that manifest themselves as visible traits, such as eye color and hair texture, and nonvisible traits, such as a susceptibility to a certain disease. Genes form visible bars on threadlike structures called *chromosomes,* which are inside the central part, or *nucleus,* of every plant and animal cell. Chromosomes contain the genetic material of each cell, made up mostly of DNA. Chromosomes become visible under a microsope when any animal or plant cell divides (see illustration below).



chromosomes and genes during cell division

In mammals, most healthy cells have two copies of each chromosome—one from each parent. Reproductive cells (eggs and sperm) have one copy of each chromosome. Different species have different numbers of chromosome pairs. In humans, for example, there are normally 23 pairs of chromosomes.

2. Discuss genetic diversity.

Explain that in a healthy population (a group of organisms of the same species living in a certain geographic area) there is a wide variety of genes that combine in many different ways to form a broad diversity of individuals. If the population is suddenly subjected to stress, such as disease or environmental change, the genetic variety makes it likely that at least some individuals will be adapted well enough to survive and continue the species.

Populations of some species have become so small or fragmented that they have lost much of their original genetic diversity. If these populations are suddenly subjected to a disease or other stress, there might not be any individuals with the genes that provide protection from the disease and enable the individuals to survive.

3. Determine the characteristics of the class population.

Give each student a copy of "Checking Out Your Genetic Traits." Go over the list of traits with your class. Have your students work in pairs to help each other determine their traits and check the traits off their worksheets. As you read the list, instruct your students to check the box that describes the trait they possess. They can also work in pairs to observe the traits in each other. For each trait, there are two possibilities:

1. Your ear lobes are either hanging loose or they are attached to the side of your head.
2. Your hair is either curly or straight.
3. You can either curl your tongue, or you cannot curl it. (This trait refers to whether you can or cannot roll the sides of your tongue to make it into a tube-like shape.)
4. You either have hair on your fingers, or you don't have it. (Look at the part of your finger between your knuckle and first joint.)
5. You either have light-colored eyes (blue or green), or you have dark eyes.
6. You either have a widow's peak, or you don't have one. (If your hairline comes to a point in the middle of your forehead, you have a widow's peak.)
7. Your little finger is either straight, or it is bent.

Point out to your students that their genes have determined each characteristic on the worksheet.

4. Use the "Human Genetic Wheel."

Pass out a copy of the "Human Genetic Wheel" to each student. Instruct each student to start at the inner band and find the appropriate letter code that describes his or her own ear lobe type (it will be either "L" for loose or "II" for attached). Instruct them to continue moving outward on the wheel, finding their characteristics for each trait, until they have located their little finger type in band seven. Each person should then find the number next to his or her finger type and record this number on the worksheet.

5. Pool the results.

There are 128 possible combinations of the seven traits. To find out how many different combinations are present in the class population, go around the room and have each student give his or her Genetic Wheel number. Record the numbers on the board. If there is more than one student with the same number, place a check next to that number.

6. Discuss your findings.

Are there any two students in the class who have the same seven traits? Then ask the students if they can think of an eighth trait that would set these two people apart. Are there any numbers that have clusters of classmates? Why?

Every individual in any population is different from every other individual. Have students look at the variations among the people in their class as an example. But these variations don't make any individual a different species. Everyone in the class, regardless of his or her differences, is still a human being.

DNA double helix

Before You Begin • Part II

You will need 15 to 20 index cards. On each card, write one characteristic that distinguishes one student from another. (See "Indexing Student Characteristics" on page 162.)

What to Do • Part II

1. Introduce the demonstration.

Divide the students into two teams and explain that they're going to do a demonstration that illustrates why genetic diversity is important. Show them your stack of index cards (see box on "Indexing Student Characteristics" on page 162), and explain that each one lists a characteristic that, for the purposes of the game, is going to represent a genetic trait. Tell them that once the game starts they are not allowed to change anything about themselves. Tell them that you're going to read several of these cards aloud and that if anyone on either team has the characteristic listed on that card, he or she will "die." Those students who are "dead" must sit down. The object of the game is to have at least one member of their team "alive" at the end.

2. Do the demonstration.

Have the students get into their teams and then stand facing you. Read one of the index cards you made earlier and ask all the students with the characteristic listed on the card to sit down. Repeat until you have gone through about three or four of the cards. (At least one of the teams should still have members standing.) Tell the students that if there's anyone still standing on their team, they can all regenerate and join back in. If both teams still have members standing, play another round, reading through three or four additional cards. Then go on to step 3.

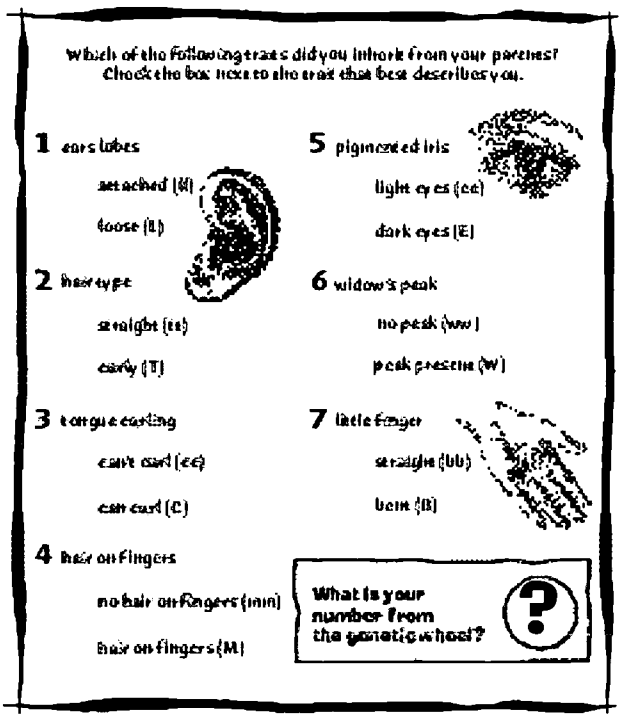
3. Discuss the demonstration.

Ask the students what happened. Did any "characteristics" wipe out more people on their team than others? Did one team do better than the other? Why? (Answers will vary depending on what happens with your group. However, students should be figuring out that their team has a better chance of surviving when the characteristics of the team members are more diverse.)

4. Do the demonstration again.

Restore each team to its full number of "live" members. Then tell the teams that they're going to try the demonstration again, but that before you start they are allowed to make any adjustments they want on their teams. (Students should do things that give the group a wider range of traits. For example, some team members may untie their shoes while others may leave them tied, and some may add layers of clothing.) Shuffle the stack of cards and then read through several of them, having students with any of the characteristics "die" and sit down.

Sample Student Sheet



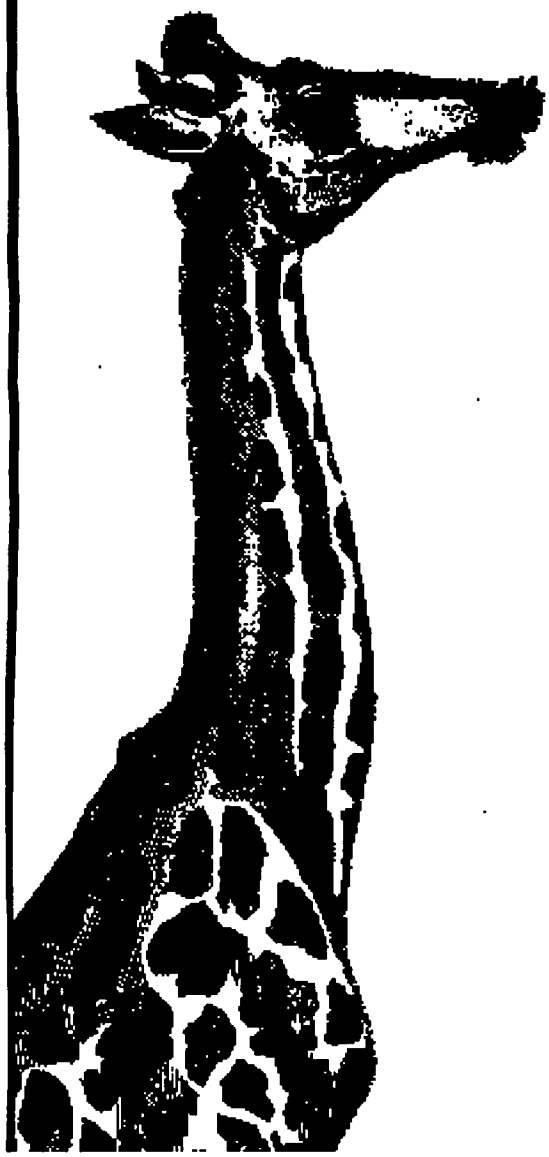
Indexing Student Characteristics

To do this demonstration you will need a stack of index cards, each of which has a "genetic" characteristic that can distinguish your students from one another. Because it may be difficult to come up with enough truly genetically-based traits, you should feel free to use traits, such as clothing color or type of shoes, in the demonstration. Below are some possibilities for the cards. You will need to choose characteristics that will weed out your group–but not wipe out the entire class all at once. During the demonstration, each time you read one of these traits, every student who has the trait will "die out" for the rest of the round.

- **Light-colored eyes**
- **Bent little finger**
- **Not wearing glasses**
- **Shoes laced and tied**
- **Shoes without laces**
- **Not wearing red**
- **Attached ear lobes**
- **Not able to curl tongue**
- **Wearing earring(s)**
- **Wearing a sweater**
- **Wearing hair clips of any kind**
- **Wearing a watch**
- **A widow's peak**
- **Wearing a hat**

5. Wrap up.

Have the students describe what happened. Did their team last longer or shorter this time? What helped them or hurt them? What can they say about how genetic diversity might help wild populations of animals or plants survive? (Students should understand that the more diverse their team was, the greater the chance it had of having at least one member left at the end of several rounds. They should also be able to generalize that the more genetically diverse a wild population is, the greater its chances of surviving over time. However, if the students can't quite make this leap yet, don't worry. They'll get a chance to apply these ideas in Part III.)



Before You Begin • Part III

Make several copies of the "Giraffe Genetic Wheel" (page 45 in the Student Book) for each group. Also make two copies of the "Giraffe Cards" (pages 46–50 in the Student Book) for each group (one copy on white paper and one copy on colored paper), as well as one copy of "Spotting Giraffes" (page 44 in the Student Book) for each group. You'll need to make two copies of the "Giraffe Calf Cards" (page 51 in the Student Book) on white paper and two copies on colored paper, cut the cards apart, and put them in a container. Then make one copy of the "Event Cards" (page 52 in the Student Book), cut them apart, and put them in another container. Have scissors for each group. (If "All About Giraffes" [pages 42–43 in the Student Book] is used as a homework assignment, copy one for each student.)

What to Do • Part III

1. Introduce the giraffe game.

Tell students that they will play a game that illustrates why genetic diversity is important. The game focuses on the giraffe. You may want to read "All About Giraffes" (pages 42–43 in the Student Book) to the class as an introduction to the activity or give it to the students to read for homework the night before. Also give the students a copy of "Spotting Giraffes" (page 44 in the Student Book) to illustrate the characteristics discussed in "All About Giraffes."

2. Set up for the game.

Divide the class into five groups and give each group its two sheets of "Giraffe Cards" (one on white paper, one on colored paper). Have the students cut the cards apart.

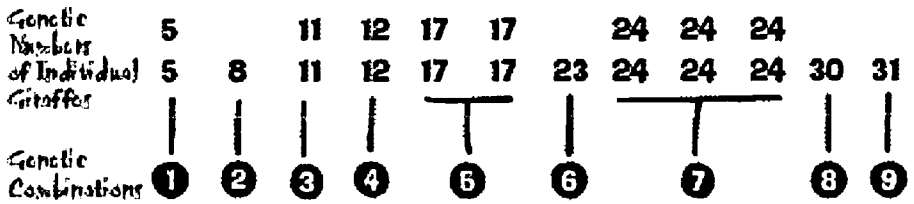
Explain that each group of students is "watching over" a small population of giraffes, represented by the giraffe cards. Each card identifies the characteristics (genetic traits) that each giraffe will have during the game. The genetic traits used in the game are as follows: sex, migratory behavior, resistance to plague, spot pattern, and leg length. Colored cards represent males and white ones represent females. The other genetic traits are written on each card.

3. Determine the genetic number of the giraffes.

Pass out several copies of the "Giraffe Genetic Wheel" (page 45 in the Student Book) to each group. Using the genetic traits provided on each giraffe card, tell the students to work together to determine the genetic number of each giraffe in their population. They should use the "Giraffe Genetic Wheel" to find the number of each giraffe in the same way they used the "Human Genetic Wheel" (Part I) to find their own numbers. Students should write the genetic number of each giraffe on each giraffe card.

4. Determine the genetic diversity of each group's population of giraffes.

Next ask the students to determine the genetic diversity of their group of giraffes. Ask the student groups to count how many different individual genetic numbers are exhibited by their 20 giraffes. This is the group's diversity number. Consider that a student group has a population of giraffes with the following genetic numbers:



Rules and Strategies

Before students begin the game, share the following information:

- *If a giraffe dies, the students should turn the card that represents that giraffe face down.*
- *Only the dominant male giraffe can mate with the females. If the dominant male dies, a new dominant male must be designated. If a group loses all its males or females, it cannot reproduce.*
- *Events usually affect half of a population. If you have an odd number of giraffes that are affected by an event, round down to find the number of giraffes affected.*
- *Female calves cannot reproduce.*
- *During reproduction events, each qualifying female will receive a calf card. Students must choose traits for each calf based only on the traits of that female and the dominant male. See the following example:*

Female	Dominant Male
Leafy-spotted	Reticulated
Resistant to plague	Resistant to plague
Migratory	Migratory
Long Legs	Short Legs

*Then the calf can be either leafy-spotted or reticulated and have either long legs or short legs, but the calf **must** be resistant to plague and migratory (because both parents are).*

Every time a female has a calf, the students will have to assign traits in this manner. Circle the traits on the calf cards.

In this case, the student group would have a total of **nine** different genetic combinations represented by their giraffe group so the diversity number is nine. Write a tally on the board, recording each student group's number of giraffes and diversity number. The larger a group's diversity number, the more genetically diverse the population of giraffes.

Each student group should start with 20 giraffes. The diversity number of group one should be 4, group two should be 8, group three should be 12, group four should be 14, and group five should be 20. Some students may realize that they have an advantage–or disadvantage–at this point.

5. Have each group select a dominant male.

Each group of students should select one male in its giraffe population to be the dominant male. Students should place a big letter "D" on the dominant male giraffe's card. This giraffe will be the only one that mates with the females in the population during the course of the game. If this male dies or joins another group of giraffes, the group will have to designate a new dominant male to take its place.

6. Have students choose cards from the "Event Cards" and read them to the class.

"Event Cards" depict scenarios of environmental change that the giraffe populations must confront. Bold text on the cards indicates the impact that the environmental change has on individuals in the population: (1) loss (death), (2) intermingling, and (3) reproduction. Remind your students that this exercise is a simulation of what *could* happen to a real giraffe population. While the events are not real, they do represent some of the many pressures exerted on populations by natural and human forces. Allow your students to take turns picking an event card at random and reading it aloud to the class. Tell your students to pay attention to the event being read and respond to that event based on the giraffes they have in their population. Every group follows the directions of each event card.

7. Record how many giraffes are left after the events have been read, and analyze the results.

After all the "Event Cards" have been read, record on the board the number of giraffes (adults and calves) surviving in each group's population. Compare different groups of giraffes and determine which ones were more successful. Did genetic diversity contribute to this success? How?

8. Discuss the results of the game.

After you finish the game, discuss genetic diversity using the following questions:

a. Why is genetic diversity important? *(Generally speaking, a more genetically diverse population is more likely to contain some individuals that have the traits necessary to survive and adapt to changes in the environment than populations that aren't as genetically diverse.)*

b. What is the relationship between the size of a population and its genetic diversity? *(As a population becomes smaller, some variation in traits is lost. Because there are fewer individuals in a smaller population, it is less likely that there will be individuals with the traits necessary to survive in times of environmental stress. This is one reason smaller populations are more vulnerable to extinction. Many species that once had large populations, such as the Florida panther, nene goose, and American bison, have lost a great deal of their genetic diversity in a short time because of habitat loss and overhunting.)*

c. What can be done to prevent the loss of genetic diversity? *(To preserve genetic diversity, it is important that wild populations of plants and animals do not become small or fragmented. This is becoming more and more challenging as human populations expand and increase their level of consumption as well as demand for space.)*

d. In the simulation, which events did humans cause? Which were caused by nature? Do you think humans can have both a positive and a negative role in influencing the survival of other animals? *(In the simulation, human actions had both positive consequences [the creation and protection of national parks] and negative consequences [poaching]. The better we are able to fulfill human needs while maintaining genetic diversity, the more a population will be able to withstand both natural and people-related pressures.)*

e. Did some traits seem to be favored over others? Were there any traits that were favored in one instance but selected against in another? How does this relate to the importance of genetic diversity? *(A trait that is advantageous under one set of environmental conditions may be detrimental under another. For example, migratory giraffes may do better in times of drought, but they will be more vulnerable to poaching because they're more likely to leave the safety of protected areas.)*

WRAPPING IT UP

Assessment

Have each student write a short response to the question: What does giraffe diversity (as represented in the "Giraffe Cards") have to do with the fate of a giraffe group (whether the group lives, dies, or successfully reproduces) in the game?

Unsatisfactory—The student is unable to make a connection between giraffe genetic diversity in a population and the fate of that group in the game.

Satisfactory—The student makes logical connections between giraffe population genetic diversity and the group's fate in the game.

Excellent—The student is able to incorporate the concepts of giraffe genetic diversity and the vulnerability of certain populations when confronted with environmental stresses ("Event Cards").

Portfolio

On the back of "Checking Out Your Genetic Traits," have students record their ideas about using a genetic wheel to compare human traits and their understanding of genetic diversity from the game.

Writing Ideas

- Students can compose creative stories that illustrate how genetic variety within species can help them survive over time. For example "Once upon a time, tigers were plain orange. Then a cub named Splasher was born. People called him Splasher because he was born with weird black stripes. Though everyone made fun of him, when he grew up, he found that he could stay hidden in the grass much longer than the ordinary, plain orange tigers. He caught more food and fathered many kittens. They had stripes, too."
- Pick a common animal or plant, and describe several distinct individuals, noting their physical traits. (Dogs and cats work especially well.) Students may illustrate their descriptions. How are the individuals different from one another? What sort of advantage or disadvantage might their characteristics provide?

Extension

Have students work individually or in groups to create displays focusing on how people have created genetic diversity in species to fill certain human needs and desires. They could highlight the dichotomy between the "original" species as they appear in the wild and the domesticated creatures they have become (e.g., wolves and chihuahuas, cougars and house cats.) Cattle and other livestock, crops, ornamental plants, and goldfish provide other dramatic examples. The students should also point out why the animal or plant was developed. After student presentations, ask how human manipulation of genes might help or hinder biodiversity.

Resources

The Cartoon Guide to Genetics by Larry Gonick and Mark Wheelis (Harper Perennial, 1991).

Giraffe by Caroline Arnold (William Morrow and Co., 1987).

The Giraffe, Its Biology, Behavior, and Ecology by A. I. Dagg and J. B. Foster (VanNostrand Reinhold Co., 1976).

Giraffes, the Sentinels of the Savannas by Helen Roney Sattler (Lothrop, Lee, and Sheppard Books, 1989).

Grizmek's Animal Life Encyclopedia by B. Grizmek (Van Nostrand Reinhold Co., 1972).

A Natural History of Giraffes by Dorcas MacClintock (Charles Scribner's Sons, 1973).

The genetic wheel approach was inspired by similar activities in *Losing Biodiversity* by Katherine Barrett, Global Systems Science, Lawrence Hall of Science, University of California at Berkeley (1996); and in *Biological Science: A Molecular Approach*, D. C. Heath and Co., (1985).

CHECKING OUT YOUR GENETIC TRAITS

Which of the following traits did you inherit from your parents?
Check the box next to the trait that best describes you.

1 ear lobes

- ☐ attached (ll)
- ☐ loose (L)

2 hair type

- ☐ straight (tt)
- ☐ curly (T)

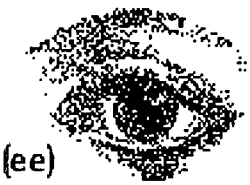
3 tongue curling

- ☐ can't curl (cc)
- ☐ can curl (C)

4 hair on fingers

- ☐ no hair on fingers (mm)
- ☐ hair on fingers (M)

5 pigmented iris



- ☐ light eyes (ee)
- ☐ dark eyes (E)

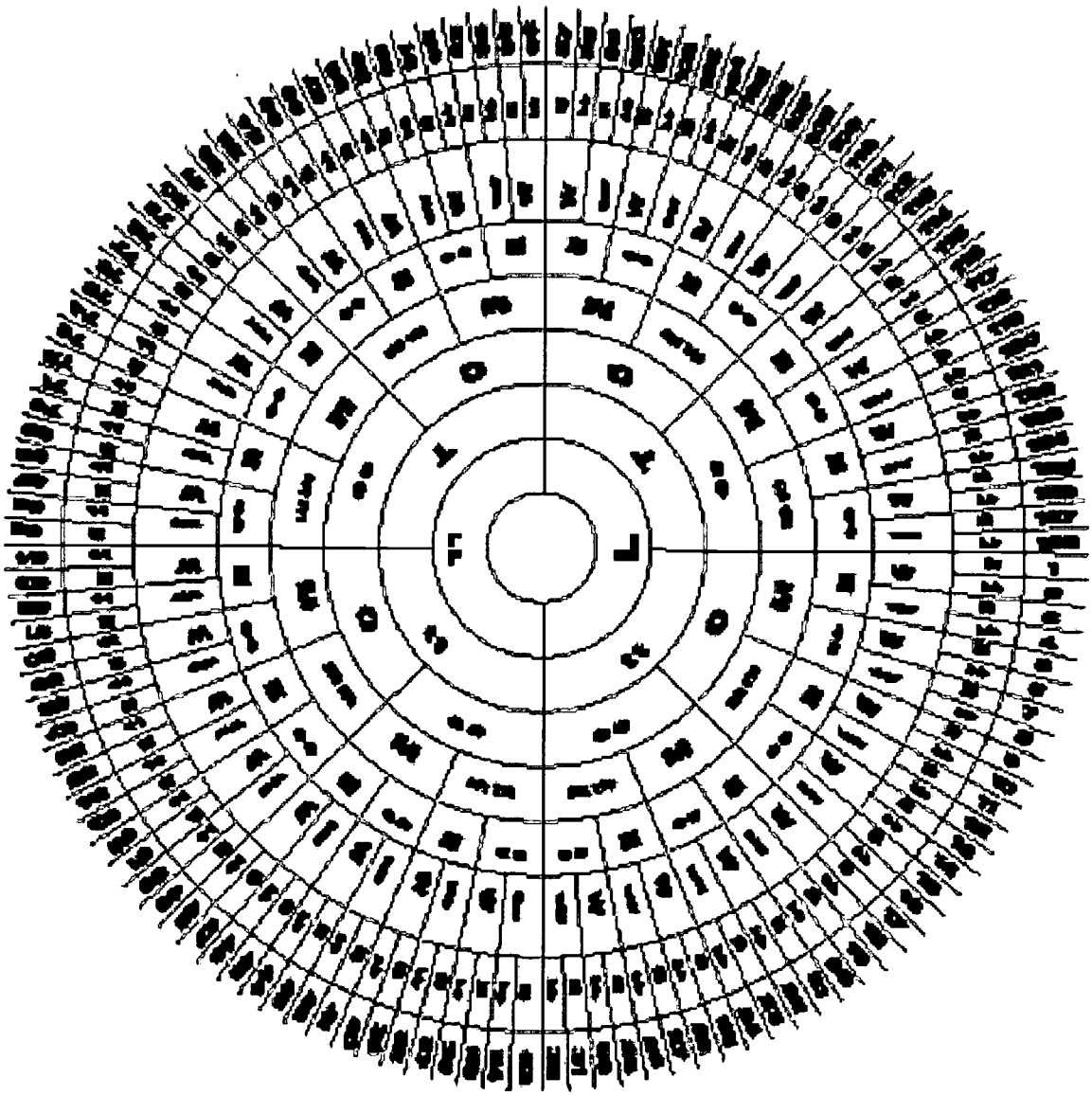
6 widow's peak

- ☐ no peak (ww)
- ☐ peak present (W)

7 little finger

- ☐ straight (bb)
- ☐ bent (B)

What is your number from the genetic wheel? ?



ALL ABOUT GIRAFFES

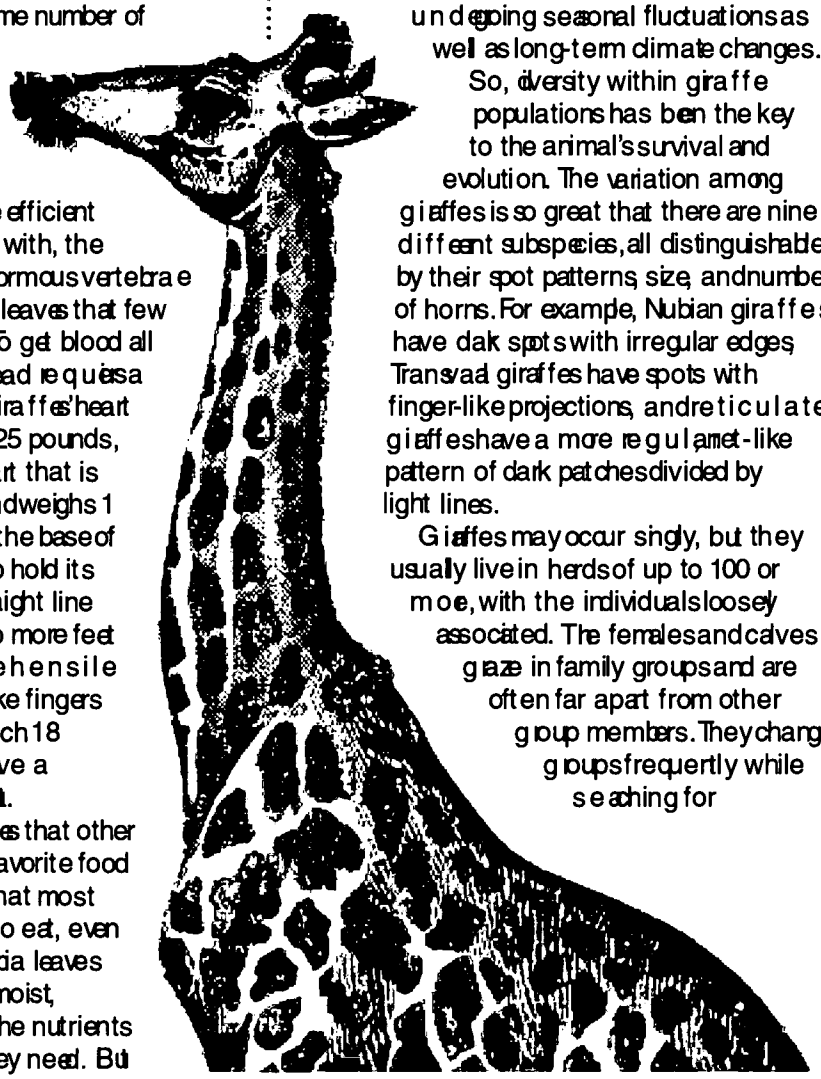
Giraffes really know how to draw a crowd! On a typical scorching day on the African plains, these gentle giants are surrounded by an amazing variety of grazers. Ostriches, kudu, impalas, wildebeests, and gazelles all gather near. No wonder—with their keen eyesight and unique vantage point, giraffes can easily spot a moving lion, hyena, or human predator from a mile away.

These sentinels of the savanna are certainly well known for their interesting bodies. Their necks are the longest of any living mammal, although they have the same number of vertebrae in their necks as humans do.

Giraffes are the ultimate tree browsers, their bodies providing marvelous evidence of the efficient design of nature. To begin with, the giraffe's long neck and enormous vertebrae allow it to browse on tree leaves that few other animals can reach. To get blood all the way to the animal's head requires a huge heart. The average giraffe's heart is 2 feet long and weighs 25 pounds, compared to a human heart that is only 4 to 5 inches long and weighs 1 pound. A special hinge at the base of its head allows a giraffe to hold its long slender head in a straight line with its neck, giving it two more feet of reach. Add to that a prehensile upper lip that can grasp like fingers and a tongue that can reach 18 inches farther, and you have a browser that's hard to beat.

Giraffes can reach leaves that other browsers can't, and their favorite food is the acacia tree—a tree that most animals wouldn't be able to eat, even if they could reach it. Acacia leaves are highly nutritious and moist, giving giraffes almost all the nutrients and much of the water they need. But acacia branches are covered with thick thorns. Giraffes have strong hairs and thick skin, which protect their faces from these sharp thorns. To top it all off, the giraffes' eyes are larger than those of any other land mammal, and they are situated on the sides of its head, enabling the giraffe to be alert to danger at any moment. Giraffes are able to keep watchful guard across the plains, as they never sleep for more than four to five minutes at a time.

Although they have many helpful adaptations, there is still no such thing as the perfect giraffe. Their environment is always changing, undergoing seasonal fluctuations as well as long-term climate changes. So, diversity within giraffe populations has been the key to the animal's survival and evolution. The variation among giraffes is so great that there are nine different subspecies, all distinguishable by their spot patterns, size, and number of horns. For example, Nubian giraffes have dark spots with irregular edges; Transvaal giraffes have spots with finger-like projections, and reticulated giraffes have a more regular, net-like pattern of dark patches divided by light lines.



Giraffes may occur singly, but they usually live in herds of up to 100 or more, with the individuals loosely associated. The females and calves graze in family groups and are often far apart from other group members. They change groups frequently while seaching for

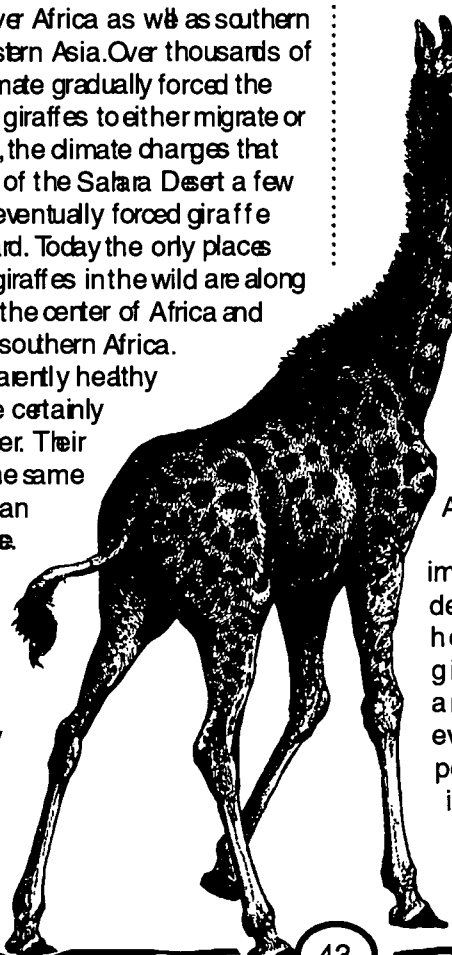
sity?

food. Giraffes are so tall that they can see other members of their herd from long distances. While grazing, giraffe calves and mothers are sometimes separated from each other by more than a mile and for several days at a time. The males move between herds, browsing and searching for mates. This constant flow and intermingling of giraffes within the larger population is important for maintaining genetic diversity. And because all the subspecies interbreed, there is an amazing variety of giraffes in the total population, so much so that no two giraffes have the same pattern of spots! This fact has enabled scientists to use the spot patterns of giraffe necks to distinguish individuals.

Although giraffes are not endangered, there is no doubt that their current populations are much smaller than they used to be. At one time, giraffes ranged all over Africa as well as southern Europe and southeastern Asia. Over thousands of years, changes in climate gradually forced the ancestors of modern giraffes to either migrate or die out. For example, the climate changes that led to the formation of the Sahara Desert a few thousand years ago eventually forced giraffe populations southward. Today the only places where you can find giraffes in the wild are along a narrow belt across the center of Africa and in a small section of southern Africa.

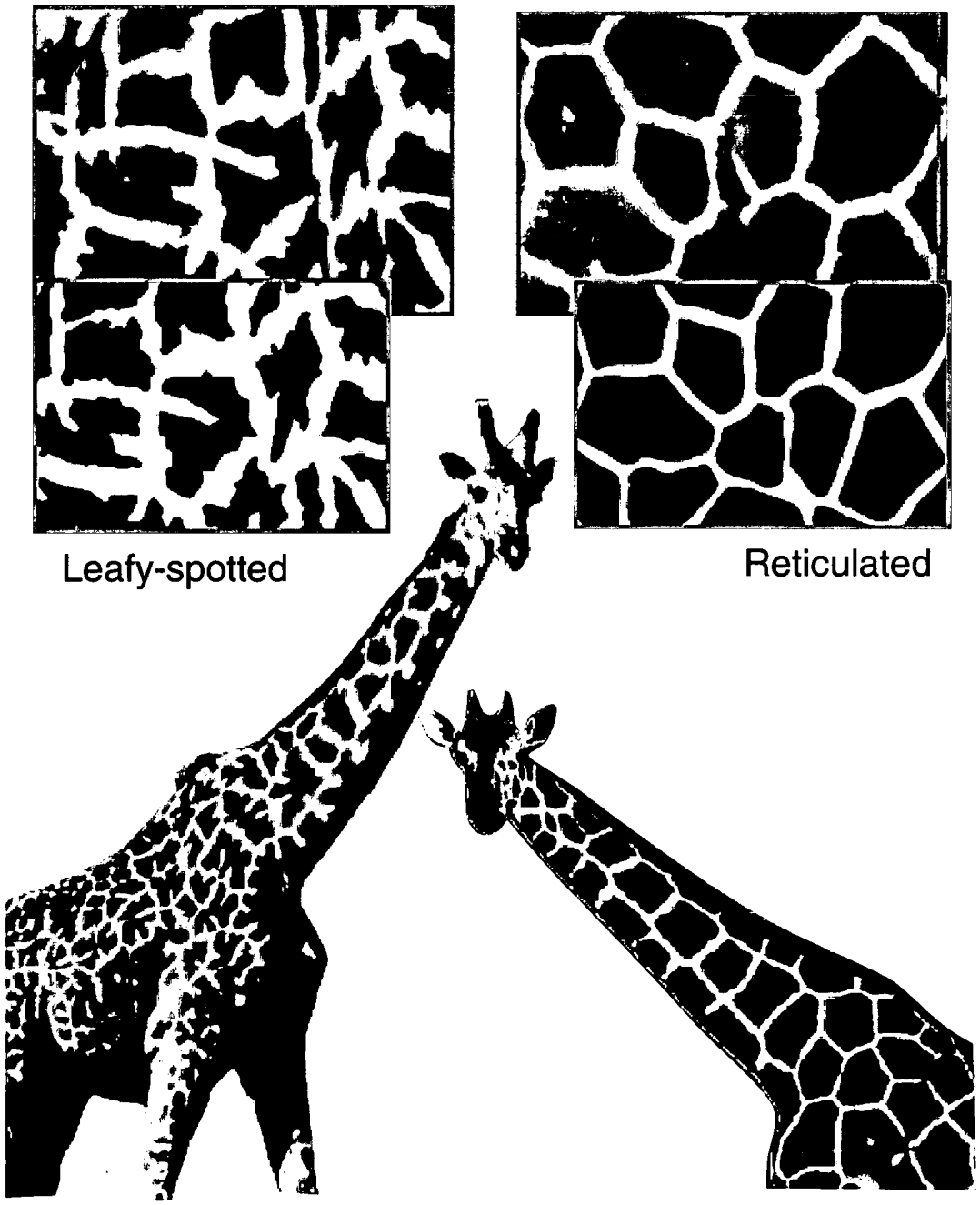
Despite their apparently healthy number, giraffes are certainly not immune to danger. Their biggest problem is the same as that of most African animals: lack of space. Expanding human populations mean shrinking habitats for wildlife, posing particular problems for large, migratory animals such as elephants and giraffes. During one 24-hour period, a large male giraffe can consume 75 pounds of food and may wander up to 20 miles in search of food and water. This wandering can become risky when giraffes leave the safety of national parks and protected areas.

It's no wonder that giraffes rarely allow people to get closer than 100 feet. Although lions and hyenas attack giraffe calves, humans are the only predator of adults. People throughout history have hunted giraffes for a variety of reasons. Although African governments have passed laws to make spot hunting illegal, giraffes are still killed for their meat, hides, and tails. Giraffe skins are used to make shoes, harnesses, whips, and shields. And their tails are popular for making amulets and bracelets. Some giraffes are killed simply because they wander into farmland or knock down power lines.



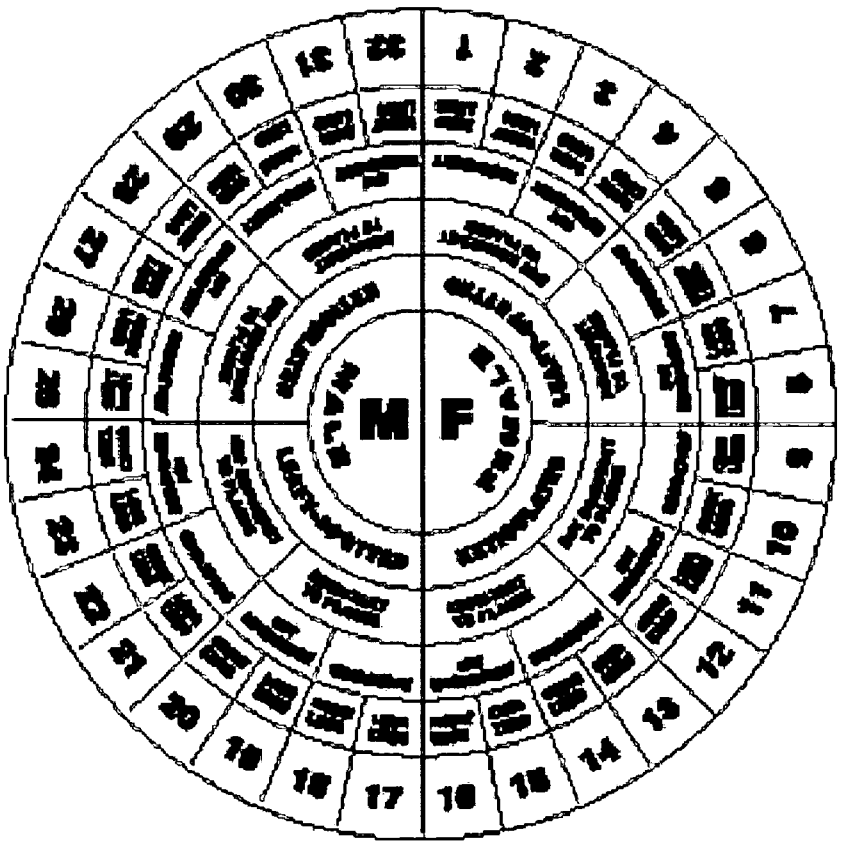
The future of giraffes is tied to the future of the people living around and among them. Some farmers have discovered that, by allowing giraffes to graze on the acacia trees on their farms or pastures, the giraffes actually perform a service by pruning the trees and keeping them from overgrowing. Giraffes are also a huge draw for tourists, who bring much-needed income to many African countries.

As you play the simulation game, it is important to keep in mind that the events described are fictional scenarios. They are, however, based on real events that face giraffes and other wildlife in Africa and around the world. Thinking about these events and how they might affect wild populations will help us to appreciate the importance of preserving genetic



GIRAFFE GENETIC WHEEL

BEGIN WITH THE CENTER CIRCLE AND MOVE OUTWARD, BASED ON YOUR GIRAFFE'S TRAITS.



For example, a female giraffe with the following characteristics:

Reticulated
Not Resistant to Plague
Not Migratory
Long Legs

would have a genetic number of 11.
A male with the same characteristics would have a genetic number of 27.

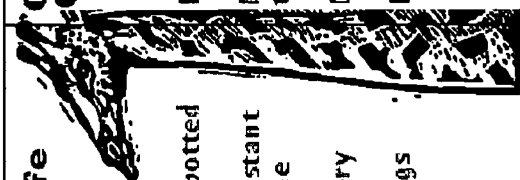
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Long legs



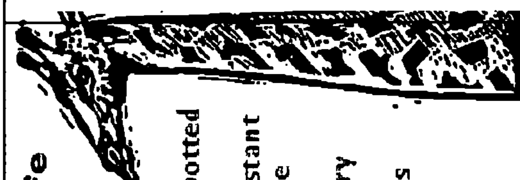
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Short legs



Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Long legs

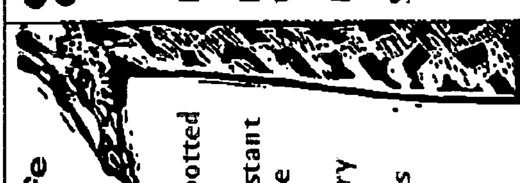
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Short legs



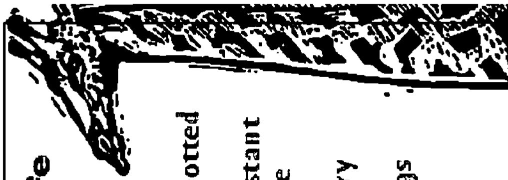
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Long legs



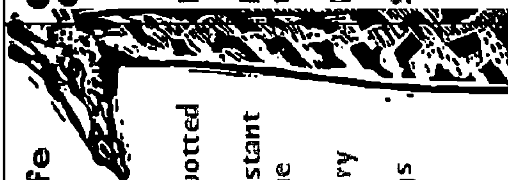
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Short legs



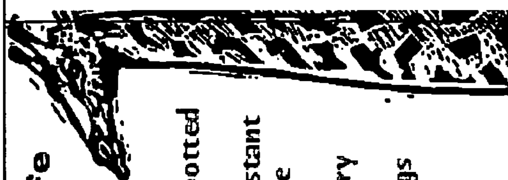
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Long legs



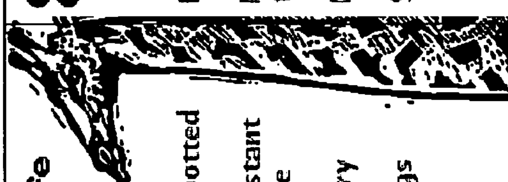
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Short legs



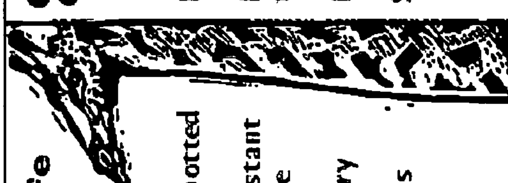
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Short legs



Giraffe Card

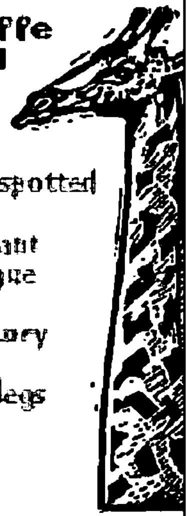
Leafy-spotted

Not resistant to plague

Migratory

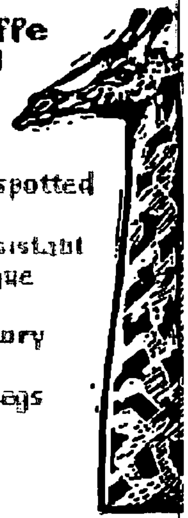
Long legs

Giraffe Card



Leafy-spotted
Resistant to plague
Migratory
Short legs

Giraffe Card

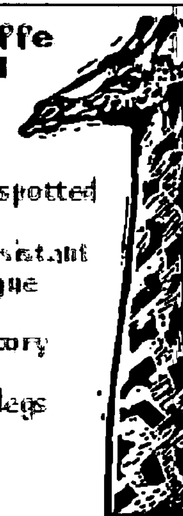


Leafy-spotted
Not resistant to plague
Migratory
Short legs

Giraffe Card

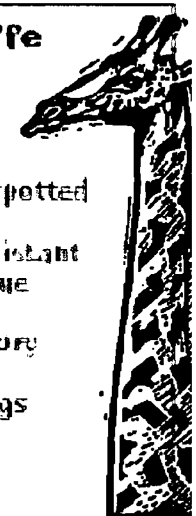
Leafy-spotted
Not resistant to plague
Migratory
Long legs

Giraffe Card



Leafy-spotted
Not resistant to plague
Migratory
Short legs

Giraffe Card

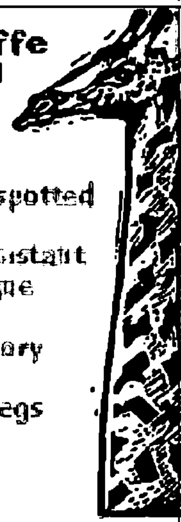


Leafy-spotted
Not resistant to plague
Migratory
Long legs

Giraffe Card

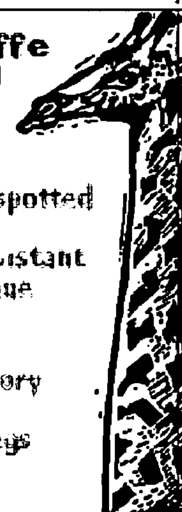
Leafy-spotted
Not resistant to plague
Not migratory
Long legs

Giraffe Card



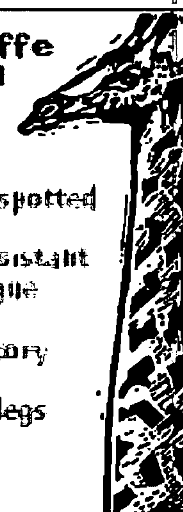
Leafy-spotted
Not resistant to plague
Migratory
Short legs

Giraffe Card



Leafy-spotted
Not resistant to plague
Not migratory
Long legs

Giraffe Card



Leafy-spotted
Not resistant to plague
Migratory
Short legs

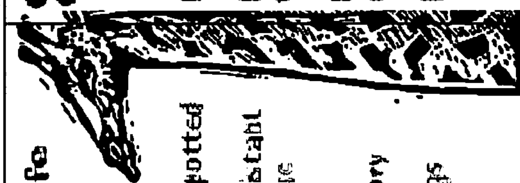
Giraffe Card

Leafy-spotted
Not resistant to plague
Not migratory
Long legs

GIRAFFE CARDS–GROUP 3

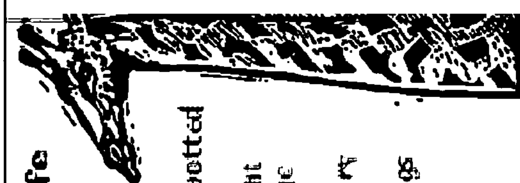
Giraffe Card

Leafy-spotted
Resistant to plague
Not migratory
Long legs



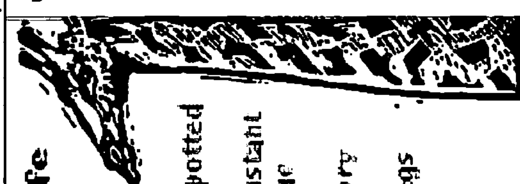
Giraffe Card

Leafy-spotted
Not resistant to plague
Not migratory
Long legs



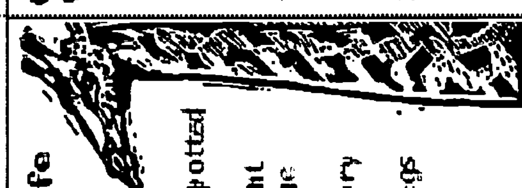
Giraffe Card

Leafy-spotted
Resistant to plague
Migratory
Short legs



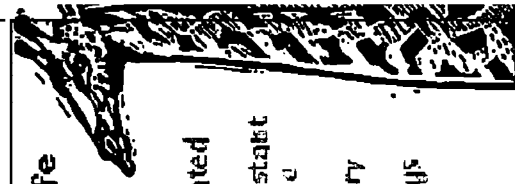
Giraffe Card

Leafy-spotted
Not resistant to plague
Migratory
Short legs



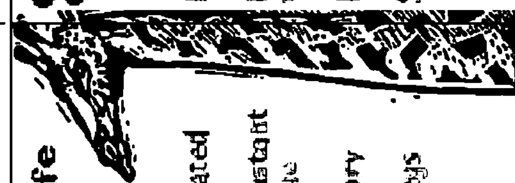
Giraffe Card

Leafy-spotted
Resistant to plague
Migratory
Short legs



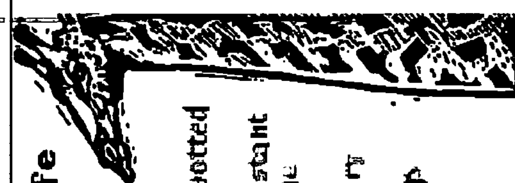
Giraffe Card

Reticulated
Not resistant to plague
Migratory
Short legs



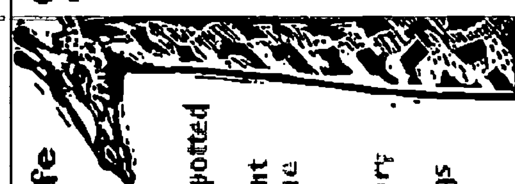
Giraffe Card

Reticulated
Not resistant to plague
Migratory
Short legs



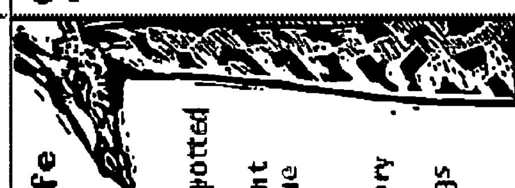
Giraffe Card

Leafy-spotted
Not resistant to plague
Migratory
Long legs



Giraffe Card

Leafy-spotted
Resistant to plague
Not migratory
Long legs



Giraffe Card

Leafy-spotted
Resistant to plague
Not migratory
Long legs

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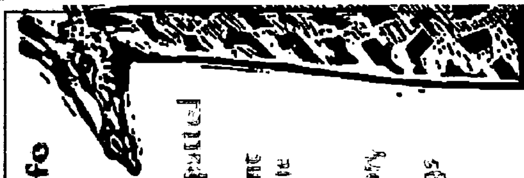
GIRAFFE CARDS–GROUP 4



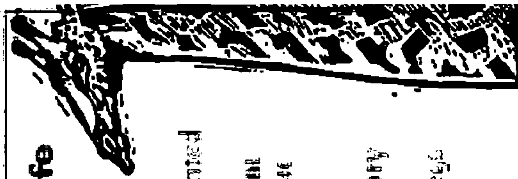
Giraffe Card

Leafy-spotted

Resistant to plague

Not migratory

Long legs



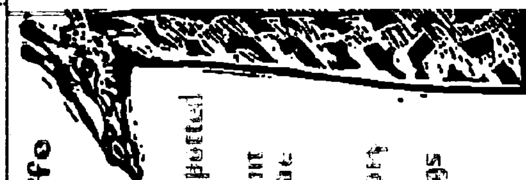
Giraffe Card

Reticulated

Resistant to plague

Not migratory

Short legs



Giraffe Card

Leafy-spotted

Resistant to plague

Not migratory

Long legs

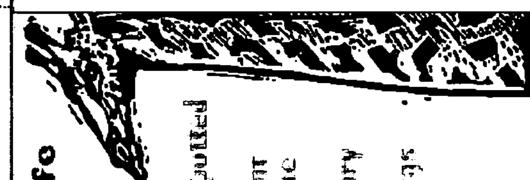
Giraffe Card

Reticulated

Not resistant to plague

Not migratory

Short legs



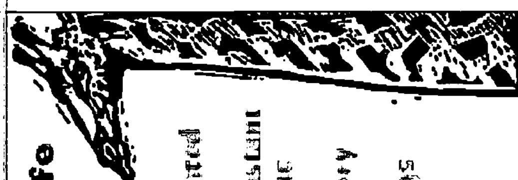
Giraffe Card

Leafy-spotted

Resistant to plague

Migratory

Short legs



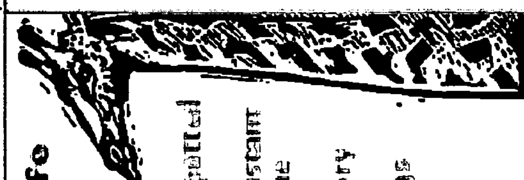
Giraffe Card

Reticulated

Not resistant to plague

Migratory

Long legs



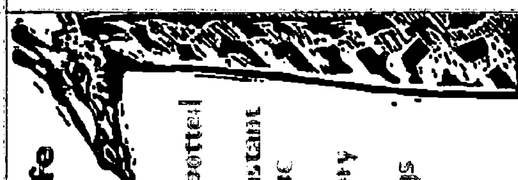
Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Long legs



Giraffe Card

Leafy-spotted

Not resistant to plague

Migratory

Long legs

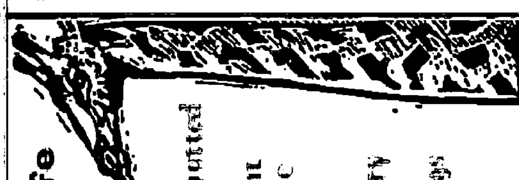
Giraffe Card

Leafy-spotted

Resistant to plague

Migratory

Short legs



Giraffe Card

Leafy-spotted

Resistant to plague

Not migratory

Short legs

GIRAFFE CARDS–GROUP 5

Giraffe Card

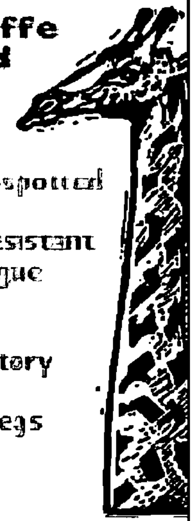
Leafy-spotted

Resistant to plague

Migratory

Long legs

Giraffe Card



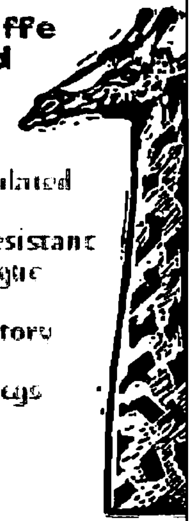
Leafy-spotted

Not resistant to plague

Not migratory

Long legs

Giraffe Card



Reticulated

Not resistant to plague

Migratory

Long legs

Giraffe Card

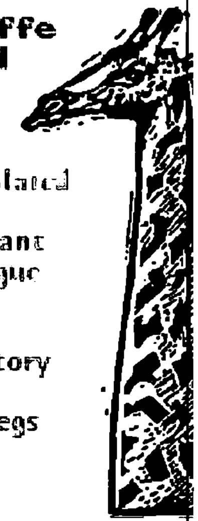
Reticulated

Resistant to plague

Migratory

Long legs

Giraffe Card



Reticulated

Resistant to plague

Not migratory

Long legs

Giraffe Card

Leafy-spotted

Resistant to plague

Not migratory

Short legs

Giraffe Card

Leafy-spotted

Not resistant to plague

Not migratory

Short legs

Giraffe Card

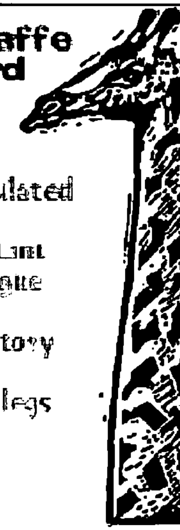
Reticulated

Not resistant to plague

Migratory

Short legs

Giraffe Card



Reticulated

Resistant to plague

Migratory

Short legs

Giraffe Card

Reticulated

Resistant to plague

Not migratory

Short legs

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Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

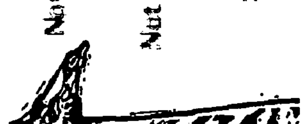
Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs



Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

Giraffe Calf Card
(circle the trait)

Leafy
Reticulated

Resistant
Not resistant

Migratory
Not migratory

Long legs
Short legs

The deadly "plains plague," a virus spread by ticks, is killing many animals. Giraffes with resistance to the virus are much more likely to survive and reproduce.

Lose half of your giraffes that are not resistant to the plains plague.

Your giraffes are in the safety of a well-protected national park right now, but when they migrate from this area, they might be killed by poachers for their meat or hides.

Lose half of your migratory male giraffes

Giraffes often switch herds, and isolated populations will intermingle if they come into contact with each other. Nondominant males will often wander from group to group.

Every group should give one nondominant male giraffe to the group to their left.

As tourism has increased in parts of Africa, so, too, has the demand for good luck bracelets made from giraffe tails. Reticulated giraffes are the easiest giraffes for the poachers to see and kill.

Lose one reticulated giraffe.

A severe drought has hit the plains. Because of dry conditions, giraffes must travel farther to find food and water.

Lose one giraffe that does not migrate.

Giraffe rugs have recently become fashionable. The most popular hides are from leafy-spotted giraffes, so poachers are hunting them.

Lose half of your leafy-spotted giraffes.

It's a very dry season and the top branches of the acacia trees are parched. The short-legged females are better able to reach in nooks and crannies to eat lush shrubs close to the ground. Because of good nutrition, all of your female giraffes with short legs give birth.

Add a calf for each short-legged female giraffe in your group, only if a male is present to mate with her.

Each group should pick the appropriate number of calf cards out of the calf card container.

Assign traits that are present in the parents (each short-legged female and the dominant male) to their calves.

There are many lions this year. Giraffes with short legs are less able to defend their newborn calves from lion attacks. As a result, only the calves of long-legged mothers survive.

Add a calf for each long-legged female giraffe in your group, only if a male is present to mate with her.

Each group should pick the appropriate number of calf cards out of the calf card container.

Assign traits that are present in the parents (each long-legged female and the dominant male) to their calves.

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