May 2002

SeaWorld/Busch Gardens

Physics

4-8 Classroom Activities

Newton Laws of Motion

OBJECTIVE

The student will correlate Newton's Laws to various animal behaviors.

ACTION

1. Begin the activity by introducing the study of physics and Newton's Laws. (See Background Information, next page.) Newton's Laws surround us everyday and are even found in the animal kingdom.
2. Explain that in this activity, students will have an opportunity to match animal behaviors with Newton's Laws.
3. Divide the class into two equal groups, Group A and Group B.
4. Give each student in Group A an Animal Physics card. Give each student in Group B a Newton's Law card. Since there are only three Laws, several students in group B will have the same law listed on their card.
5. Begin the activity by having a student in Group A read their animal physics card aloud. Then ask the students in Group B to silently read the law listed on their cards and stand up if they think their law corresponds to the behavior.
6. Ask the students who stood up which of Newton's Laws they have listed on their card and why they think the law correlates to the behavior. If students that are standing only represent one law and that law is correctly matched to the behavior, Group B gets a point. Because Group B has correctly matched the behavior to the law, the teacher will collect the animal physics card. If there is more than one law being represented, then Group B will discuss what their final answer will be as a team. If final answer is correctly matched to the behavior, then Group B gets a point. If an incorrect law is given as an answer, a point is taken away.
7. Next, select a student from Group B to read their Newton's Law aloud.

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8. Students in Group A silently read their animal physics card and stand up if they think they have a behavior that matches the law. If only one student stands up and their behavior correctly matches the law, then Group A gets a point. If multiple students stand up (multiple behaviors are represented) for the law, then group A will discuss what their final answer will be as a team. Remember that there are several behaviors that correspond to each of the three laws, therefore there can be more than one correct answer. The students will have to select one to be their final answer. If the final answer is correctly matched to the Law, they get a point. If an incorrect Law is given as an answer, a point is taken away.
9. Repeat steps five through eight until all animal physics cards have been collected.

BACKGROUND INFORMATION

Isaac Newton was a scientist in the 1600s whose greatest achievement was his work in physics. He was especially important in providing the theory and ideas about gravity. By 1666 Newton had written his three laws of motion. These three laws still stand today and are the basis for understanding many physics concepts. The three laws are:

Newton's First Law: An object in motion stays in motion, unless acted upon by another force. For example: a student riding a skateboard will continue to move until they hit a rock, which causes the skateboard to stop moving, but the student to continue moving (sometimes head over heels!).

Newton's Second Law (part A only): When net force acts upon an object, the object accelerates in the direction of the force. For example: when a student kicks a soccer ball, the ball will move in the direction the force (or the kick) was applied.

Newton's Third Law: For every force there is a reaction force that is equal in size, but opposite in direction. For example: when the space shuttle takes off, the fuel exhaust pushes downward against the launch pad while the reaction to that force pushes the rocket upward into the sky. These forces are equal in size, but opposite in direction! In this experiment, students will identify the Laws of Motion and match them to animal behaviors.

MATERIALS

Per class:
- Newton's Law cards, 2 copies and cut apart
- Animal Physics cards, 2 copies and cut apart
- scissors

ANSWERS

A 1	**H . . .3**
B 1	**I 3**
C 2	**J 3**
D 2	
E 2	
F 2	
G . . .3	

A. Animal Physics Card
A jockey rides her horse to the final hurdle of a competition. at the last minute the horse stops in front of the hurdle instead of jumping over it; the horse's impulse sends the jockey off the horse and into the air.

B. Animal Physics Card
A llama is running at a constant speed while carrying packages on its back. The packages are not tied down to the llama. When the llama makes an abrupt stop, the packages are sent into the air.

C. Animal Physics Card
Two male rhinos of equal size are competing for a territory. They are pushing on each other with equal force. There is no resolution to the conflict because neither of the two rhinos is more forceful than the other one.

D. Animal Physics Card
A male antelope tries charging at anther slightly smaller male entering his territory. Because the charging male is only slightly larger than the other, he ends up pushing the other male only a slight distance.

E. Animal Physics Card
A mother elephant gently nudges her calf to drink. The mother elephant is careful of the force she is using because she is much larger than her calf.

F. Animal Physics Card
A male giraffe has a large heavy head that is used to strike other males with tremendous force during confrontations.

G. Animal Physics Card
A fish swimming through water pushes water backwards with its fins. The water propels the fish forward.

H. Animal Physics Card
An eagle soars through the air by pressing its wings downwards. The air in turn propels the bird upwards.

I. Animal Physics Card
Two antelopes begin to charge at one another. Once they strike, they both fall backwards with the same force they pushed into each other with. if one pushes on the other, both move, one to due the action force and the other due to the reaction force.

J. Animal Physics Card
A baby rhino runs playfully at his mother and bumps into her. The baby falls backward from the impact.

Newton’s Law Card

Newton's First Law: An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

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Newton’s Law Card

Newton’s Second Law: the acceleration of an object is dependent upon two variable—the net force acting upon the object and the mass of the object. the acceleration of an object depends directly upon the net force action upon the object and inversely upon the mass of the object. For example: as the net force increases so will the object’s acceleration. However, as the mass of the object increases, its acceleration will decrease.

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Newton’s Law Card

Newton's Third Law: For every action, there is an equal and opposite reaction.

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Physics

4-8 Classroom Activities

Echolocation and Density

OBJECTIVE

Students will solve density problems.

ACTION

1. Distribute the Forest Density and Bat Foraging worksheets to each student. Divide students into groups of four.
2. Explain that each group of students represents a bat population in a forest. The students may opt to name their team of bats. The forest density worksheet represents the forest that the bat teams or populations will be a part of.
3. Ask students to notice the forest is divided into several sections and each section or *quadrant* has a mass and volume numerical unit assigned to it.
4. Explain that the mass and volume unit represents a swarm of insects. The students will have to determine the density of insects in some of these sections based on the given information. Each team of bats needs to consume 3,500 g/cm^3 of insects a day in order to stay healthy. No one quadrant contains this many insects. Therefore the team of bats will have to travel to several sections of the forest to meet their minimum daily requirement of insects.
5. Ask each group to note on the Bat Foraging worksheet the space to write the section (*quadrant*) numbers that their team visits. The next space over is to calculate the density of insects using the mass and volume numerical units. (Recall D=M/V) The last space is for keeping a running tally of all the insect densities the team of bats has consumed. If students fill one worksheet, continue to another. It may take more than eight visits to reach 3,500 g/cm^3.
6. Once a team of bats has visited enough sections to reach 3,500 g/cm^3, have them call out DONE. That team will present their answers to the class. The team must include: the order the team visited each section, the calculated insect densities of each section, and the addition of all the densities to reach the final figure of 3,500 g/cm^3. (3,500 g/cm^{3}is a minimum, more is acceptable as well). The team wins if all their information is accurate. Note: Densities are expressed in g/cm^3. Be sure to convert Mass before calculating the Density, if necessary.

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7. Ask the other groups what their total density of insects consumed was before the end of the activity.
8. Create a class list for the rest of the sections' insect densities that were not used by the winning team's method. Now that all the quadrants densities are known, was there a shorter method to achieving the 3,500g/cm^3 minimum.

BACKGROUND INFORMATION

Bats and dolphins use echolocation to located food, to navigate through obstacles, and to learn more about their environment. Bats send *pulses*, similar to a series of clicks out into the environment. If the *clicks* bounce off of an object and back to the bat, it can then identify whether it's food or a big tree to dodge while flying. For example, if you threw a tennis ball at a wall, the ball would bounce back to you very quickly so you would know that the wall was made of something very hard. But, if you threw the tennis ball at a pillow, it would come back to you very slowly, so you would know that the ball had hit something soft. Now, if you bounced the ball off of something round, the ball would come back at a different angle, and it might come back fast or it might come back slowly. From this, you would know that whatever you hit with the ball was not a flat surface, and you would maybe know if it was hard or soft. While these examples are basic, they are the same concepts used to understand echolocation. In this experiment, groups of students will compete as bats flying through a forest eating a specific mass of insects.

Mass—The measure of the amount of matter in a body.

Density—The ratio of mass to volume for an object. Objects that are lightweight for their size have low densities.

MATERIALS

For each student:
- Bat Foraging worksheet
- Forest Density worksheet
- calculator
- pencil or pen

A bat swoops down to grab a cricket off the top of a cactus.
'photo from http://desktoppub.about.com/

Forest Density Worksheet

$$D = \frac{M}{V}$$

Note: Densities are expressed in g/cm^3. Be sure to convert Mass before calculating the Density, if necessary.

Section 1 M= 1026g V= 15cm^3	**Section 2** M= 1300g V= 3cm^3	**Section 3** M= 1100g V= 12cm^3	**Section 4** M= 986g V= 17cm^3	**Section 5** M= 1789g V= 32cm^3
Section 6 M= 6589g V= 56cm^3	**Section 7** M= 3824g V= 25cm^3	**Section 8** M= 2654g V= 36cm^3	**Section 9** M= 8461g V= 95cm^3	**Section 10** M= 986g V= 745cm^3
Section 11 M= 1kg V= 2cm^3	**Section 12** M= 1kg V= 1cm^3	**Section 13** M= .86kg V= 23cm^3	**Section 14** M= .012g V= 3cm^3	**Section 15** M= .23kg V= 2cm^3
Section 16 M= .7g V= 7cm^3	**Section 17** M= .62g V= 85cm^3	**Section 18** M= .9g V= 3cm^3	**Section 19** M= 1.3kg V= 15cm^3	**Section 20** M= 96kg V= 50,000cm^3
Section 21 M= 1117g V= 73cm^3	**Section 22** M= 1970g V= 36cm^3	**Section 23** M= 7532g V= 26cm^3	**Section 24** M= 9512g V= 77cm^3	**Section 25** M= 2564g V= 7cm^3
Section 26 M= 750g V= 750cm^3	**Section 27** M= .9kg V= 2cm^3	**Section 28** M= 6.1kg V= 36cm^3	**Section 29** M= 10kg V= 75cm^3	**Section 30** M= 1973g V= 2003cm^3

BUSCH GARDENS
TAMPA BAY, FLORIDA

Bat Foraging Worksheet

$$D = \frac{M}{V}$$

Bat Team Name: ____

Running Total Insect Densities:

Quadrant Number:	Mass: / Volume:	Answer:	Running Total Insect Densities
Quadrant Number: _____	Mass: _______ Volume: _______	Answer: _______	_______________
Quadrant Number: _____	Mass: _______ Volume: _______	Answer: _______	_______________
Quadrant Number: _____	Mass: _______ Volume: _______	Answer: _______	_______________
Quadrant Number: _____	Mass: _______ Volume: _______	Answer: _______	_______________
Quadrant Number: _____	Mass: _______ Volume: _______	Answer: _______	_______________
Quadrant Number: _____	Mass: _______ Volume: _______	Answer: _______	_______________
Quadrant Number: _____	Mass: _______ Volume: _______	Answer: _______	_______________
Quadrant Number: _____	Mass: _______ Volume: _______	Answer: _______	_______________

Can you hear me?

OBJECTIVE

The student will define Hertz. The student will solve problems and demonstrate basic unit conversion skills.

ACTION

1. Distribute the Average Animal Hearing Frequency Guide to students. The hearing frequency sheet identifies the hearing ranges of 30 animals (including humans).
2. As a class, discuss sound waves and define frequency and Hertz.
3. Distribute one "What Animal Am I" question to each student.
4. Explain that the "What Animal Am I" question is preceded by information about a certain animal's hearing range. The students will have to determine the frequency of the sound wave that the animal is capable of hearing in Hertz. Since Hertz is expressed as the number of longitudinal waves per second, students may have to convert the unit of time. The students will then correlate their answers to one of the animals listed on the Animal Hearing Frequency Guide. *Note: Several animals' hearing ranges overlap, therefore the students should determine the frequency of the sound wave (Hz) first. Then use the hint listed on the "What Animal Am I?" Card to correctly identify the animal.

Example Problem: I am an animal that can produce 18,000 longitudinal vibrations in one hour. What Animal am I? Hint: two species, African or Asian

Solution: Convert 1 hour to seconds. (1 Hertz = 1 vibration per second.) by 1 hour x 60 minutes / 1 hour x 60 seconds / 1 minute = 3600 seconds.
Then divide 18,000 longitudinal vibrations by 3600 seconds to get 5 Hertz. Use the hint and the Animal Hearing Frequency Guide to match 5 Hertz with elephants (5 to 10,000 Hz).

5. Review the findings by asking the students to stand up when their animal answer is read. For example: The teacher asks for all elephants to stand. The students that determined that their "What Animal am I" question corresponds to an elephant will stand up. The teacher should pick a volunteer or two to document their findings on the chalkboard for all ten animals.

BACKGROUND INFORMATION

Hertz is a unit of measurement used to explain sound frequency. Sound moves in waves, just like the waves seen by dropping a pebble into a puddle. Human and animal hearing ranges are defined by Hertz.

Animals have a wide range of hearing abilities as well as different abilities to hear a wide range of frequencies. For example: when you hear a radio, you are hearing sound waves. Inside the speaker is a circular piece called a diaphragm. The diaphragm vibrates, creating invisible waves through the air, which travel to your ear.

MATERIALS

For each student:

- "What am I?" question card
- Average Animal Hearing Frequency Guide
- calculator

For class:

- scissors

ANSWERS

A: MOUSE

B: RAT

C: OPOSSUM

D: ELEPHANT

E: FERRET

F: GOLDFISH

G: COW

H: PORPOISE

I: BELUGA WHALE

J: BAT

Beluga whales have one of the highest hearing ranges of mammals, up to 123,000 Hz. Humans can hear up to 23,000 Hz.

A. I am an animal that can produce 270,000 longitudinal sound waves in .05 minutes. What animal am I? Hint: I am a member of the rodent family.	A. I am an animal that can produce 352,000 longitudinal sound waves in .065 minutes. What animal am I? Hint: I am a member of the rodent family.
B. I am an animal that can produce 140,000 longitudinal sound waves in .033 minutes. What animal am I? Hint: I have a hairless tail.	**B.** I am an animal that can produce 375,000 longitudinal sound waves in 5 seconds. What animal am I? Hint: I have a hairless tail.
C. I am an animal that can produce 248,000 longitudinal sound waves in .065 minutes. What animal am I? Hint: I carry young in a pouch.	**C.** I am an animal that can produce 128,000 longitudinal sound waves in 2 seconds. What animal am I? Hint: I carry young in a pouch.
D. I am an animal that can produce 36 longitudinal sound waves in .033 minutes. What animal am I? Hint: I am a member of the rodent family.	**D.** I am an animal that can produce 64 longitudinal sound waves in .065 minutes. What animal am I? Hint: I am a member of the rodent family.
E. I am an animal that can produce 64 longitudinal sound waves in .065 minutes. What animal am I? Hint: I am a member of the rodent family.	**E.** I am an animal that can produce 36 longitudinal sound waves in .033 minutes. What animal am I? Hint: I am a member of the rodent family.
F. I am an animal that can produce 44 longitudinal sound waves in 2 seconds. What animal am I? Hint: I use my tail to swim.	**F.** I am an animal that can produce 63 longitudinal sound waves in .05 minutes. What animal am I? Hint: I use my tail to swim.
G. I am an animal that can produce 72 longitudinal sound waves in 3 seconds. What animal am I? Hint: I am a member of the bovid family.	**G.** I am an animal that can produce 90 longitudinal sound waves in .05 minutes. What animal am I? Hint: I am a member of the bovid family.
H. I am an animal that can produce 675,000 longitudinal sound waves in .083 minutes. What animal am I? Hint: I am an aquatic mammal.	**H.** I am an animal that can produce 700,000 longitudinal sound waves in 5 seconds. What animal am I? Hint: I am an aquatic mammal.
I. I am an animal that can produce 480,000 longitudinal sound waves in .065 minutes. What animal am I? Hint: I am an aquatic mammal.	**I.** I am an animal that can produce 270,000 longitudinal sound waves in .05 minutes. What animal am I? Hint: I am an aquatic mammal.
J. I am an animal that can produce 500,000 longitudinal sound waves in 5 seconds. What animal am I? Hint: I am a member of the rodent family.	**J.** I am an animal that can produce 550,000 longitudinal sound waves in .083 minutes. What animal am I? Hint: I am a member of the rodent family.

Average Animal Hearing Frequency Guide

Species approximate ranges

human	64 to 23,000 Hz
dog	67 to 45,000 Hz
cat	45 to 64,000 Hz
cow	23 to 35,000 Hz
horse	55 to 33,500 Hz
sheep	100 to 30,000 Hz
rabbit	360 to 42,000 Hz
rat	200 to 76,000 Hz
mouse	1,000 to 91,000 Hz
gerbil	100 to 60,000 Hz
guinea pig	54 to 50,000 Hz
hedge hog	250 to 45,000 Hz
raccoon	100 to 40,000 Hz
ferret	16 to 44,000 Hz
oppossum	500 to 64,000 Hz
chinchilla	90 to 22,800 Hz
bat	2,000 to 110,000 Hz
beluga whale	1,000 to 123,000 Hz
elephant	16 to 12,000 Hz
porpoise	75 to 150,000 Hz
goldfish	20 to 3,000 Hz
catfish	50 to 4,000 Hz
tuna	50 to 1,100 Hz
bullfrog	100 to 3,000 Hz
tree frog	50 to 4,000 Hz
canary	250 to 8,000 Hz
parakeet	200 to 8,500 Hz
cockatiel	250 to 8,000 Hz
owl	200 to 12,000 Hz
chicken	125 to 2,000 Hz

Animal Speedsters

OBJECTIVE

Students will identify how fast they can run in miles per hour. The student will correlate their speed to other animal speeds.

ACTION

1. One of the most commonly asked questions at a zoological facility is: How fast do various animals run? In this activity students will have an opportunity to calculate how fast they run and correlate it to certain animals' speeds.
2. Lead the class to the gymnasium or track. Measure a straight distance that is about 50 feet long (15 m). Place markers (cones) at the starting and stopping points. Divide the class into groups of two.
3. Instruct the student groups to have one partner at the starting line and the other at the finish line. The student at the finish line (known as the timer) will have a stopwatch or a watch with a second hand to keep time. The timer begins the sprint by saying "Ready, Set, Go" and records the running time in seconds as his or her partner crosses the finish line.
4. Instruct the student groups to switch positions and time the sprint for the other partner.
5. Return to the classroom and introduce the equation Distance= Rate x Time. Explain that this is the equation they will use to calculate how fast they ran the 50 feet. The students must get their answer in miles per hour to compare to the animal chart.

Example Problem: D= 50 feet T= 25 seconds R= ?

D=R x T· R=D/T· R=50 feet/25 seconds R= 2 feet/second

Now convert feet per second into miles per hour. Multiply 2 feet/second by 3600 seconds in an hour to get 7200 feet/hour. Then divide 7200 feet/hour by 5280 feet in a mile to get 1.36 miles/hour or 1.36 mph.

In a shorter version, divide 3600 by 5280 to get a constant of 0.68. Multiply 2 feet/sec by 0.68 to get 1.36 miles/hour.

6. Copy the animal chart onto a dry erase board or chalkboard. Instruct the students to place a mark on the chart where their speed correlates. Once all students have filled in their marks, review the findings. What animals were faster and which were

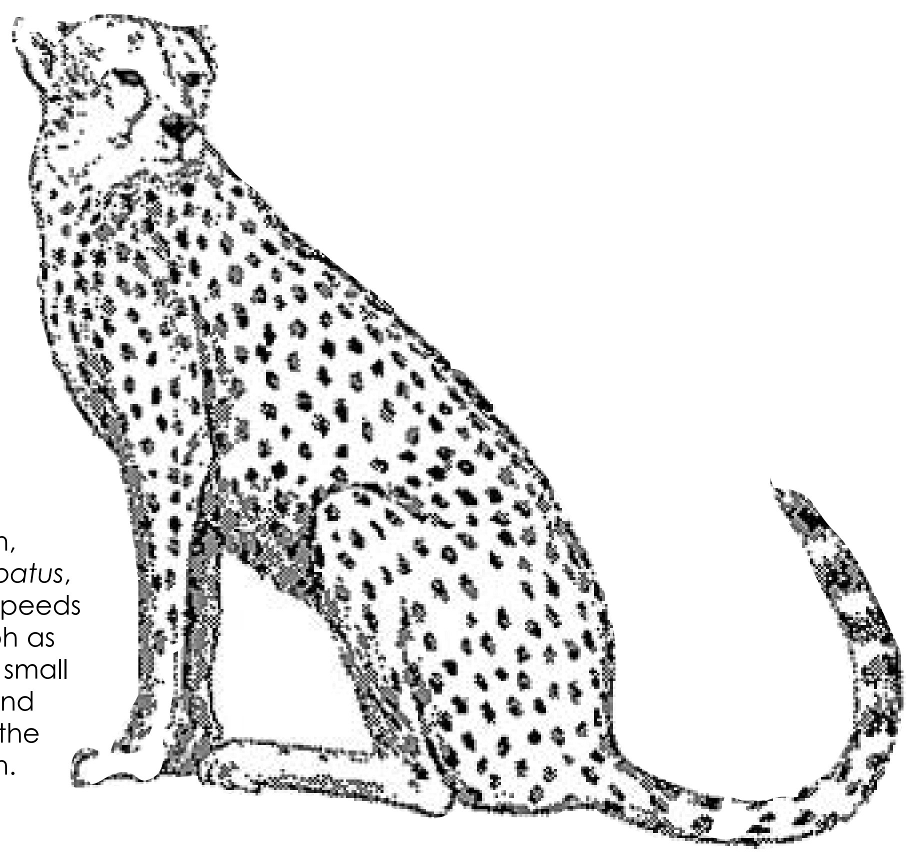
DEEPER DEPTHS

While humans are able to claim many unique abilities, humans are one of the slowest animals on Earth! Miles per hour is the unit of measure devoted to calculating speed. It is defined by: Distance = Rate x Time.

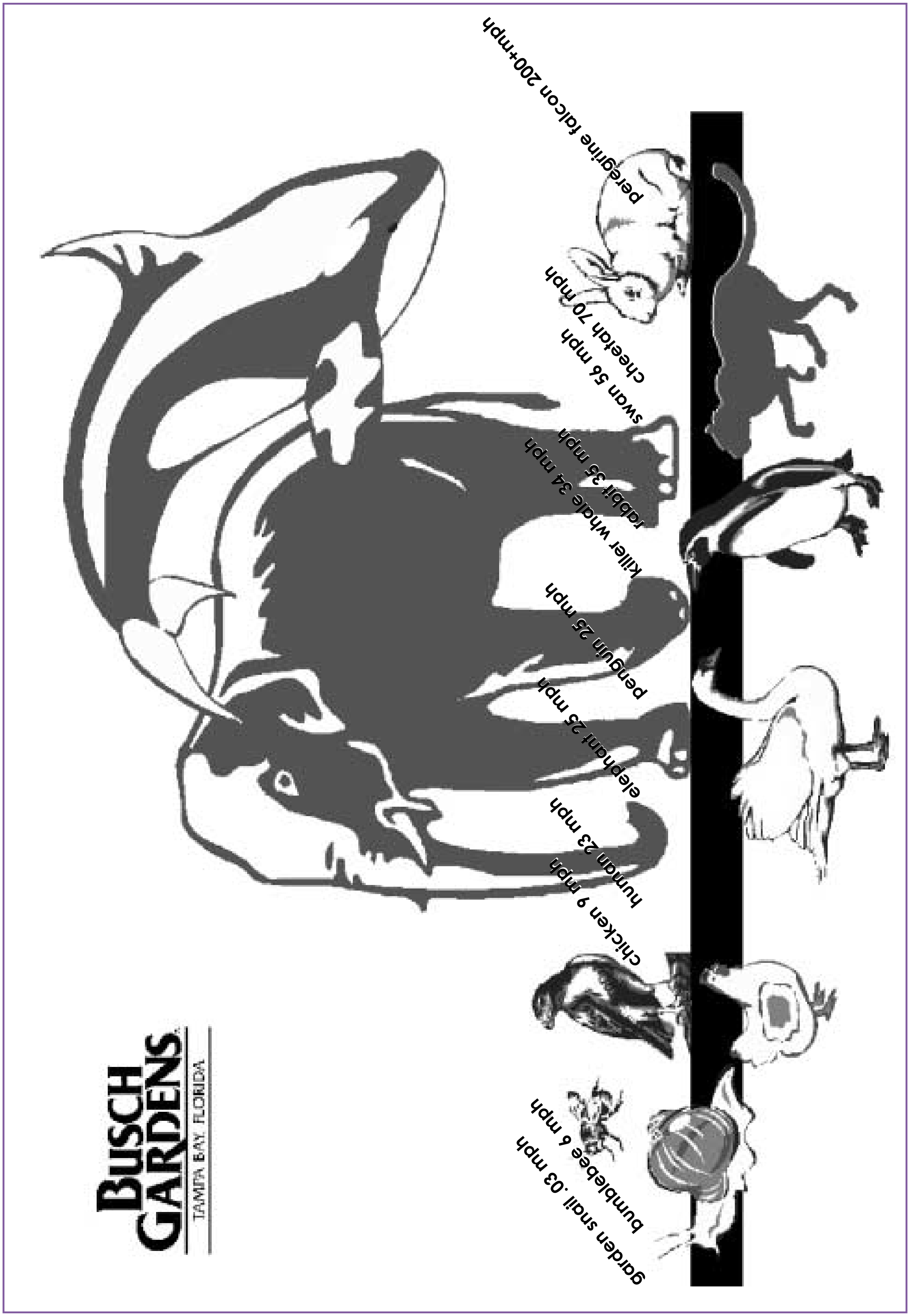
MATERIALS

Per class:

- stopwatches or watches with second hands (per student group)
- tape measure
- two medium sized cones
- animal chart
- gym or track area large enough for students to run 50 (15 m)



The cheetah, *Acinonyz jubatus*, can reach speeds up to 70 mph as they pursue small antelopes and gazelles on the African plain.


peregrine falcon 200+mph
cheetah 70 mph
swan 56 mph
rabbit 35 mph
killer whale 34 mph
penguin 25 mph
elephant 25 mph
human 23 mph
chicken 9 mph
bumblebee 6 mph
garden snail .03 mph
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