centre de développement pédagogique
pour la formation générale en science et technologie

Working document

Carnivore, omnivore or herbivore?

Physical adaptations of the giant panda

Student booklet
(AST)

October 2010

Context

Cyrille Barette, a biologist, has studied the giant panda, an animal that defies science on several aspects. To do so, he did a comparative study of three bears: the black bear, the sloth bear and the giant panda. All these animals are from the Ursidae family, in the order of Carnivores, in the Mammals class of the animal kingdom.

The panda presents several adaptations that mean that it now almost exclusively has a herbivorous diet. Indeed, it eats almost only bamboo. Its teeth are set towards the back of its mouth, allowing it to accentuate the "citrus-press" effect offered by the jaw joint, located just above the tooth line. Since its teeth are so far back, the panda can bite harder. Its molars are also very large, allowing it to grind its food well. Mr. Barette established a parallel between the panda's jaw and a nutcracker.

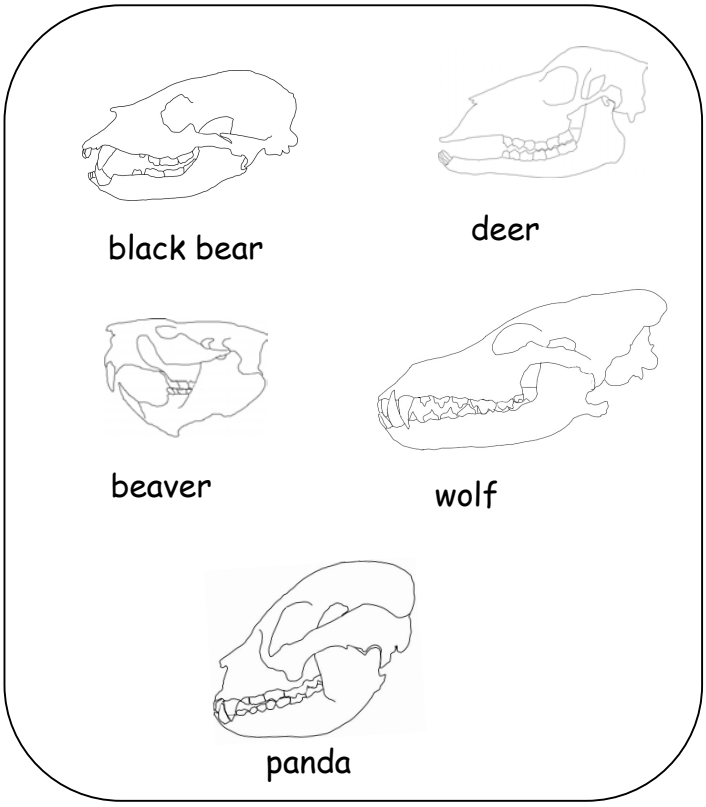
We suggest you play the role of a mechanical engineer in order to study different objects having similarities with jaws. You will become a biomechanical specialist which will certainly allow you to better understand this animal, the diversity of fauna and the methods of classification used in science.

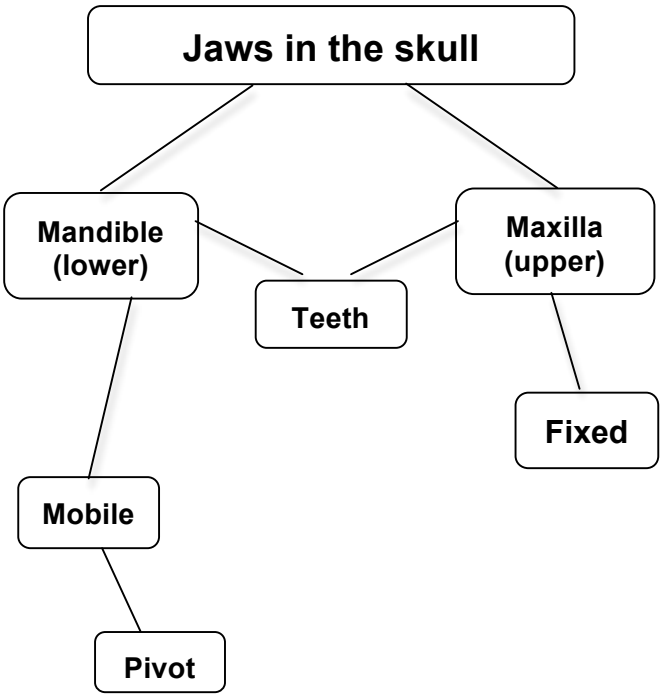
Your challenge:

You must recreate Mr. Barette's work and model the jaws of the black bear and of the giant panda in order to illustrate your understanding of what distinguishes them from one another and to explain their particularities.

ACTIVITY 1: Analysis of objects and jaws

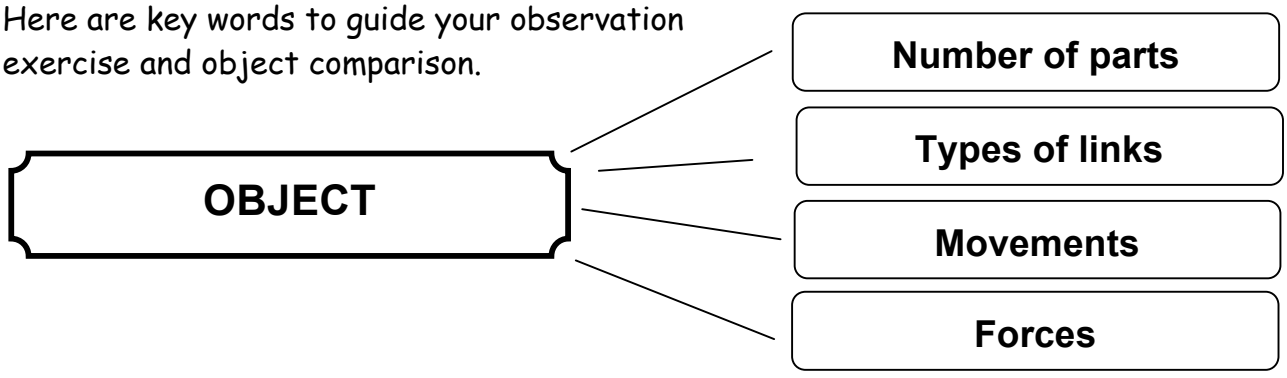
Like Mr. Barette, you must now establish similarities between various objects and the skulls of the following animals. Initially, observe the skull models shown to you.





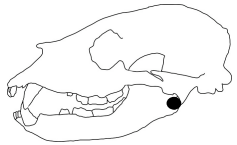
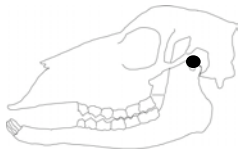
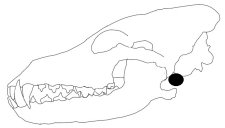
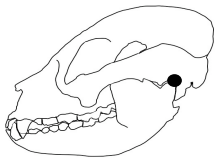
Consult annex 1 at the end of this document to help you along. It pertains to jaws and dentition.

Here are key words to guide your observation exercise and object comparison.



Question 1. Complete the table using annex 1 and the supplied images.

SKULLS COMPARISON TABLE

Animal skull	What type of teeth are there ?	What is their mechanical function?	Location of the rotation point (pivot)	Number of teeth	Diet
Black bear 	A- Incisor B- Canine C- Molar	Crush ____ Cut/grate ____ Shred/slice ____	❑Far above the upper teeth ❑A bit above the upper teeth ❑At the same level as the upper teeth	42	❑ carnivore ❑ herbivore ❑ insectivore ❑ omnivore
Deer 	A- Incisor B- Canine C- Molar	Crush ____ Cut/grate ____ Shred/slice ____	❑Far above the upper teeth ❑A bit above the upper teeth ❑At the same level as the upper teeth	32 including 12 on the maxilla	❑ carnivore ❑ herbivore ❑ insectivore ❑ omnivore
Beaver 	A- Incisor B- Canine C- Molar	Crush ____ Cut/grate ____ Shred/slice ____	❑Far above the upper teeth ❑A bit above the upper teeth ❑At the same level as the upper teeth	20	❑ carnivore ❑ herbivore ❑ insectivore ❑ omnivore
Wolf 	A- Incisor B- Canine C- Molar	Crush ____ Cut/grate ____ Shred/slice ____	❑Far above the upper teeth ❑A bit above the upper teeth ❑At the same level as the upper teeth	Sup 28 to 32 Inf 30 to 40	❑ carnivore ❑ herbivore ❑ insectivore ❑ omnivore
Panda 	A- Incisor B- Canine C- Molar	Crush ____ Cut/grate ____ Shred/slice ____	❑Far above the upper teeth ❑A bit above the upper teeth ❑At the same level as the upper teeth	40	❑ carnivore ❑ herbivore ❑ insectivore ❑ omnivore

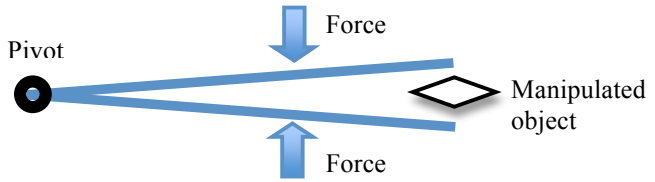
Question 2. Is there a link between the dentition of the observed animals and their diet? Explain your answer.

Question 3. Observe the position of the pivot of the jaw in each of the skulls. Is there a link between the position of the pivot and the diet of each of the animals represented in the table? Explain your answer.

It is important to underline that ruminants have a herbivorous diet and carry out a side to side grinding movement thanks to the mobility of the mandible. This movement allows the vegetation to be ground, in order to draw from it the maximum in nutritional elements. This movement, combined with their unique digestive system, allows ruminants to extract the energy necessary to their activities. The panda can not execute this movement and does not possess the digestive system of a ruminant. As to "carnivores", or rather animals that have a carnivorous diet, they draw their energy from the consumption of protein and energy rich meats. The term "carnivore" is often confused with the order of Carnivores.

Question 4. Complete the table of common tools versus jaws on the following page.

COMMON TOOLS VERSUS JAWS COMPARISON TABLE

Name of common tool	**Part that could be similar to the mandible**	**Part that could be similar to the maxilla**	**Part similar to the mandible joint (pivot)**	**Make a sketch indicating the location of the force that must be applied on the tool; the place where the rotation (pivot) occurs, as well as the location of the object manipulated by the tool.**
Example: Tweezers	One of the two pinchers	One of the two pinchers	Junction between the two pinchers	
Nutcracker				
Scissors				
Paper stapler				

While comparing each of the common tools, what do you notice in regards to the position of the force, the object manipulated and the pivot?

- **NOTE: This information will be useful to you at the end of activity 2.**

ACTIVITY 2: Simple machines, the case of levers

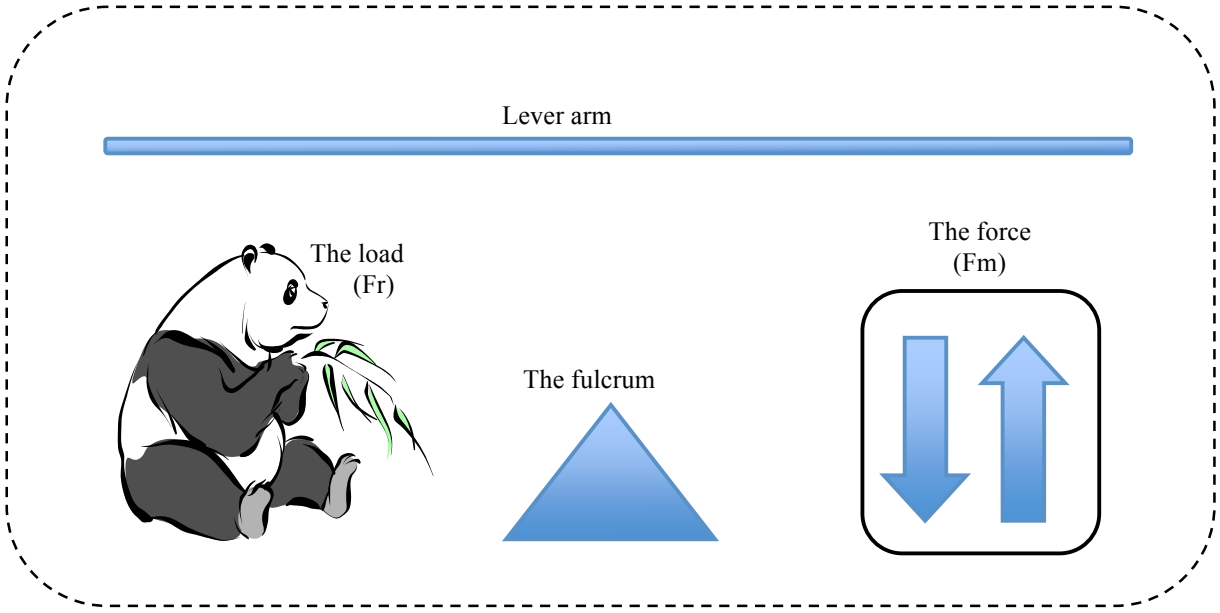
Thousands of years ago, man already used simple machines without really understanding them. Whether it was to lift an enormous boulder, to draw water from a deep well or to move heavy weights over long distances, the principle was present without having been scientifically explained. Today, these inventions are based upon principles related to mechanical physics. There are a few simple machines:

- The lever
- The inclined plane
- The wheel
- Combinations of these, for example: the corner, the screw, etc.

In this task, you will have to work more specifically on types of levers. The lever is a solid bar, mobile around a fixed point, allowing the force applied to a load to be multiplied; often used to lift a heavy burden (translation of an Antidote definition).

Principle:
There are three parts to a lever. Depending on their position in the set, this means three types of levers.

1. The force (Fm): represented by a big arrow
2. The fulcrum (pivot): represented by the triangle
3. The load (resisting force) (Fr): represented by the panda



Now, let's define these parts:

What is **mechanical force**?

_____

_____

Mechanical force is always represented by a big arrow.
It is determined by these characteristics:

- The application point (the location)
- The direction
- The intensity (the amount of force)

The instrument allowing force to be measured is the dynamometer. The dynamometer gives a measurement in Newton (N).
What is a **fulcrum** (pivot)?

_____

_____

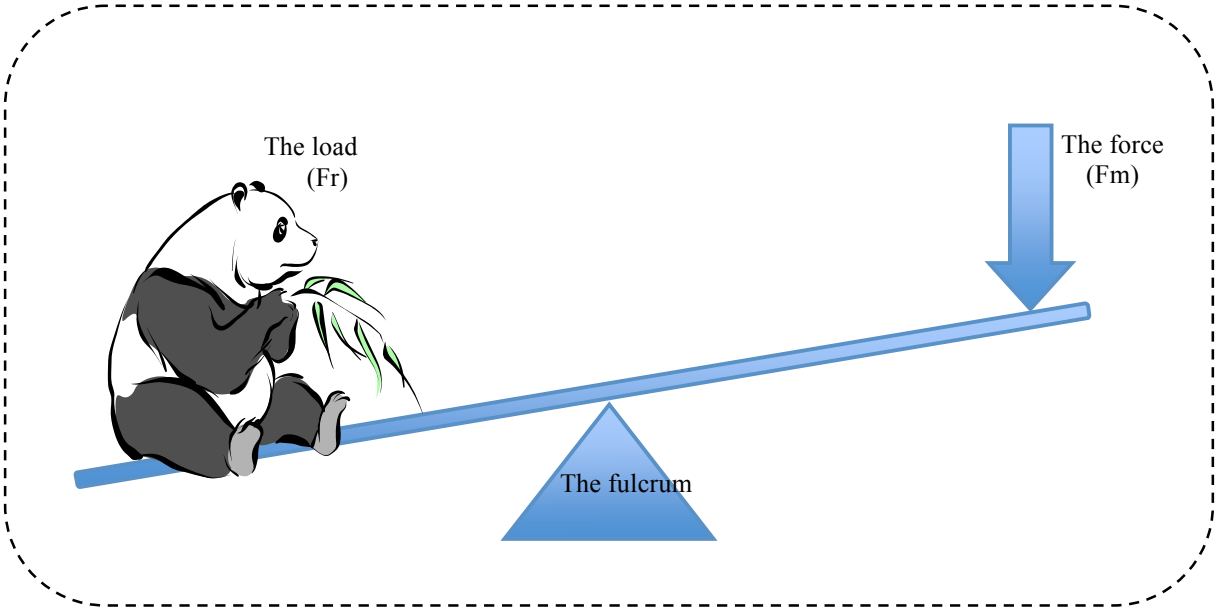
What is the **resisting force** (the load)?

_____

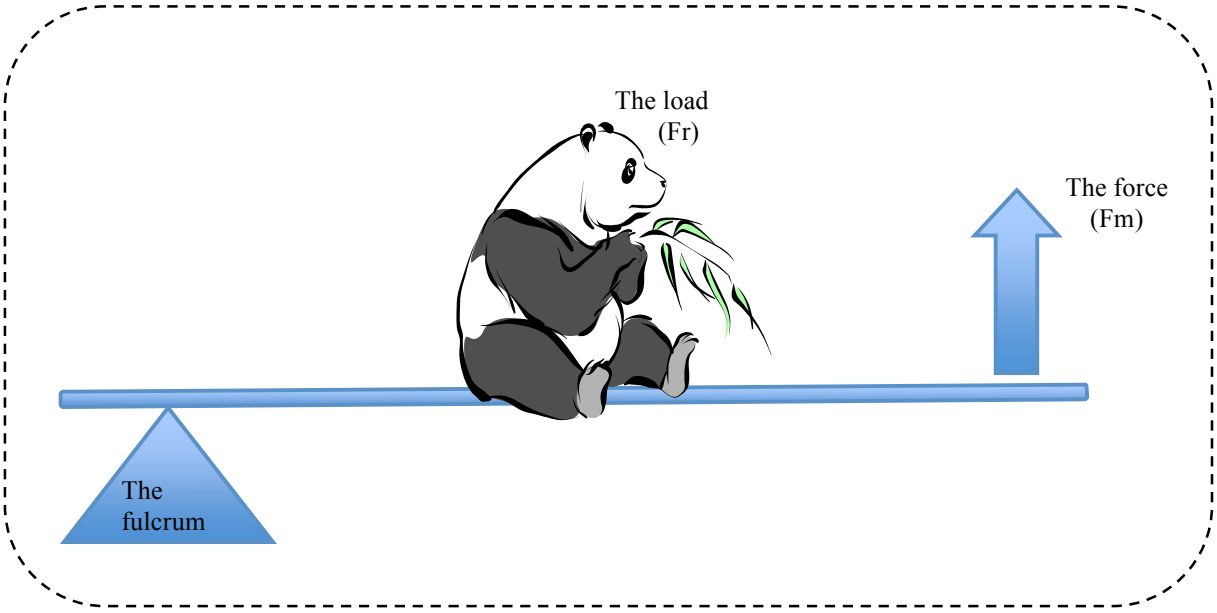
_____

Now, let's see the three categories of levers:

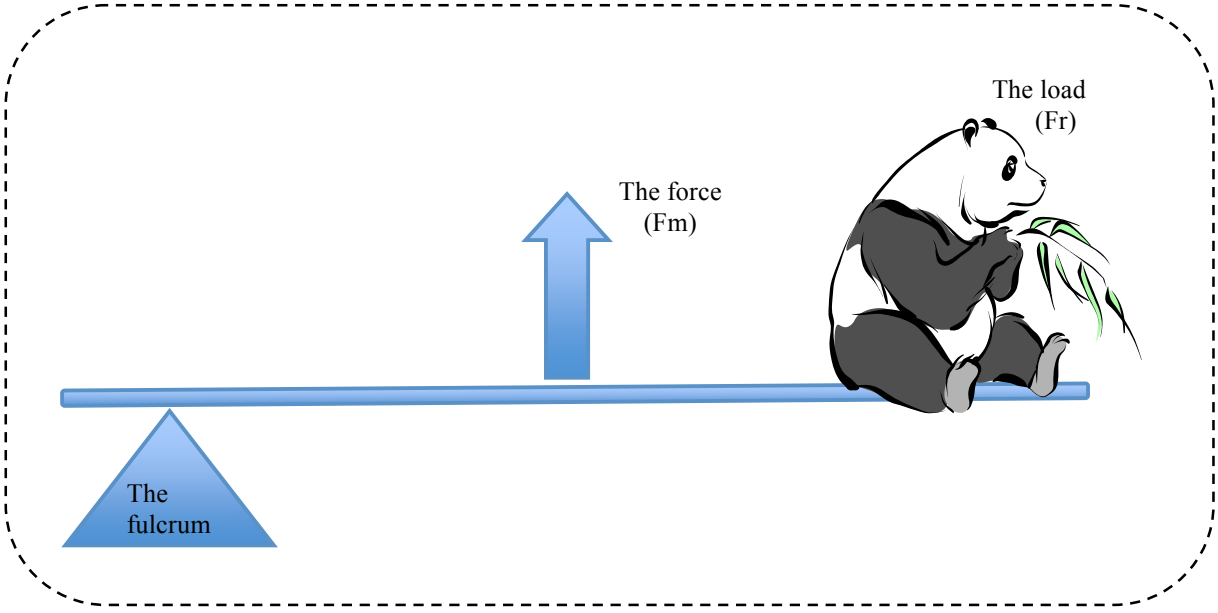
1- Class 1 lever: In this type of lever, the fulcrum is located between the applied force and the load. Examples: tweezers, scissors, teeter-totter.



2- Class 2 lever: In this type of lever, the load is between the applied force and the fulcrum. Examples: wheelbarrow, nutcracker, bottle opener.



3- Class 3 lever: In this type of lever, the applied force is between the load and the fulcrum. Examples: tweezers, moving or lifting a hockey stick, shovel.



MANIPULATIONS AND EXERCISES:

Observe and manipulate the objects at your disposal.

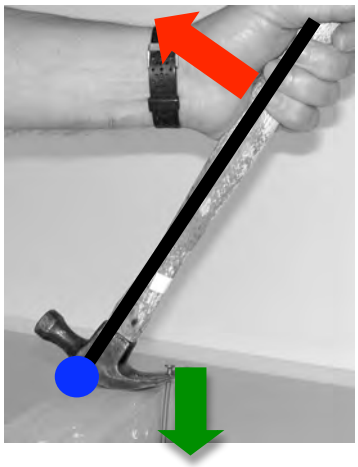
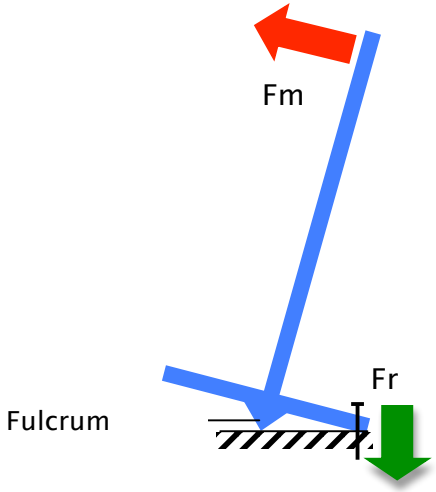
On the image corresponding to the observed object, indicate by:

1. RED ARROW: The location and direction of the force (Fm).
2. GREEN ARROW: The location of the load or resistance (Fr).
3. BLUE CIRCLE: The location of the fulcrum.
4. BLACK LINE: The lever arm.
5. TYPE: Specify the type of lever.

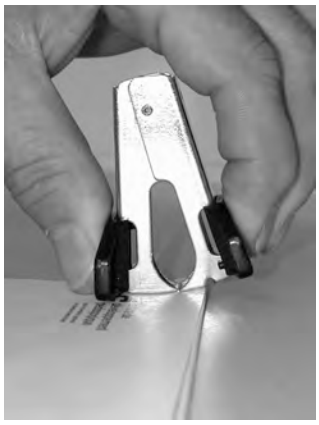
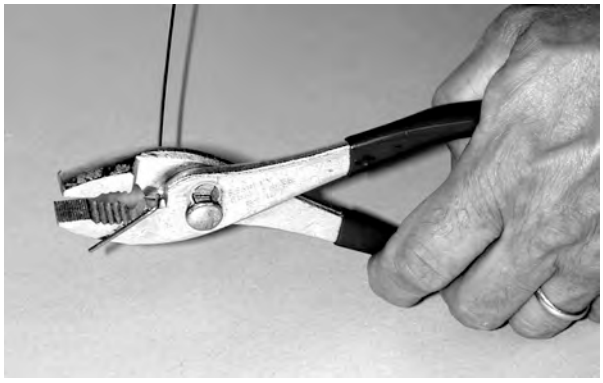
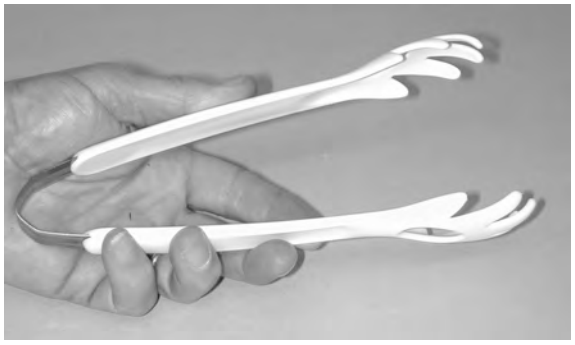
In the right hand column:

1. DRAW a sketch of the object.

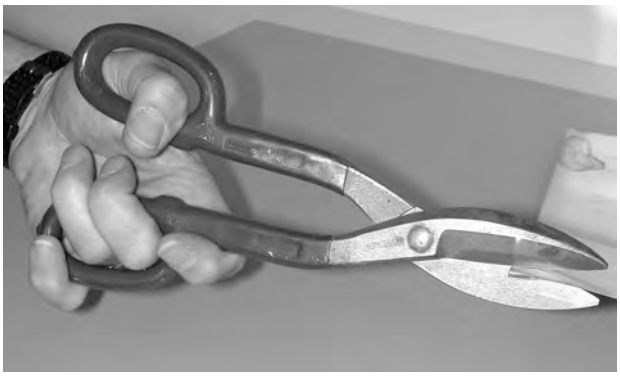
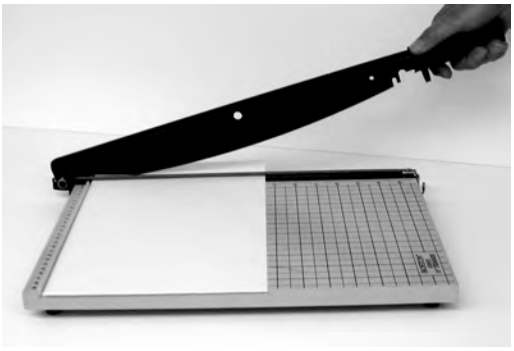
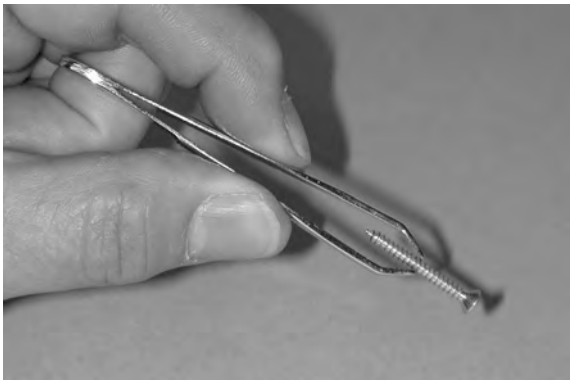
Repeat these observations and manipulations for each object.

Object	Diagram
 TYPE:_____CLASS 1 LEVER _____	
 TYPE:_____	

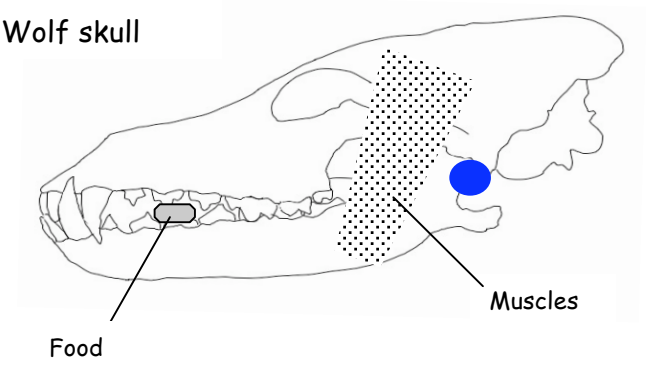
MANIPULATIONS AND EXERCISES (continued):

Object	Diagram
 TYPE:_____	
 TYPE:_____	
 TYPE:_____	

<u>MANIPULATIONS AND EXERCISES</u> (continued):

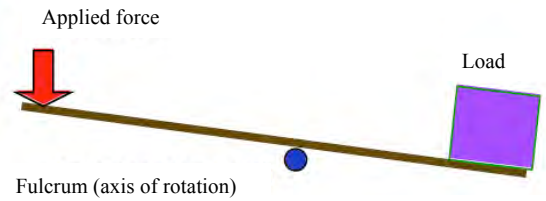
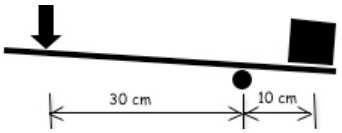
Object	Diagram
 TYPE:_____	
 TYPE:_____	
 TYPE:_____	

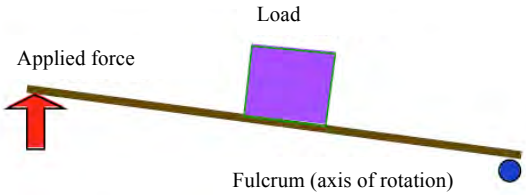
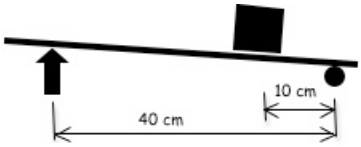
MANIPULATIONS AND EXERCISES (continued):

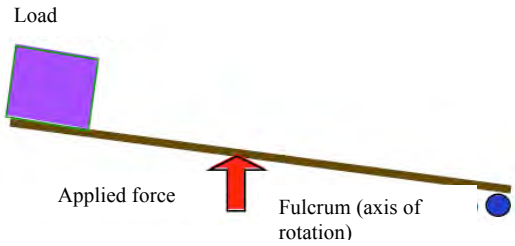
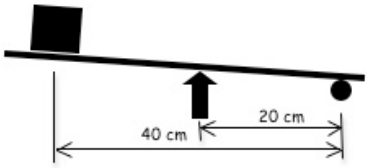
Object	Diagram
 TYPE:_____	
Wolf skull 	It is not necessary to make a sketch. Simply indicate the driving force, the load, and the lever arm and identify the pivot.

MECHANICAL ADVANTAGE

There is said to be a **mechanical advantage** when the applied force necessary is inferior to the load. It is expressed by a number corresponding to the ratio between the two lengths (pivot - motor and pivot - load). If I force four times less than the value of the load, I have a mechanical advantage of four.

<table>
<tr>
<td> 
</td>
<td>Example: Class 1 lever
 

Ratio Lm/Lr = 30/10 = 3
Positive advantage</td>
</tr>
<tr>
<td> 
</td>
<td>Example: Class 2 lever
 

Ratio Lm/Lr = 40/10 = 4
Positive advantage</td>
</tr>
<tr>
<td> 
</td>
<td>Example: Class 3 lever
 

Ratio Lm/Lr = 20/40 = 1/2 = 0.5
Negative advantage</td>
</tr>
</table>

Among the objects previously observed, which would you choose to explain the similarities with the jaw?

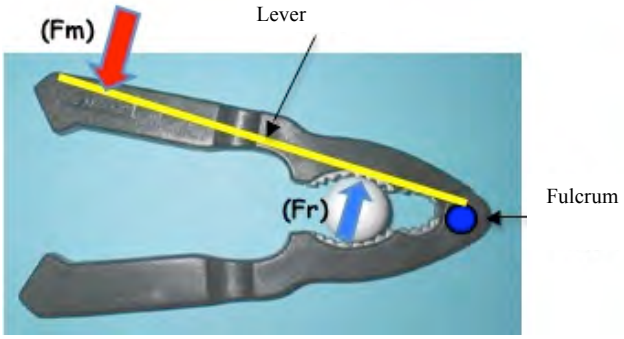
Which parts of the object are similar to the jaw and what adjustments would have to be made?

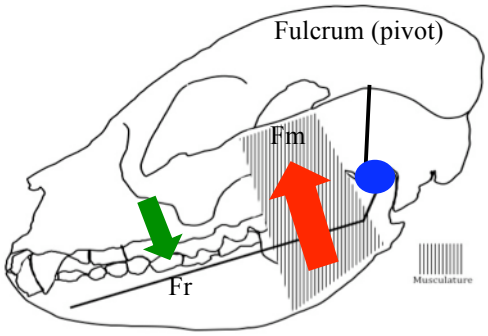
Explanations:

Explanatory drawings, if necessary

ACTIVITY 3: The jaw and levers

In the previous exercise, we explored different types of levers. Here now are sketches of a nutcracker and the panda's skull. On the panda skull, indicate the applied force and load. Inspire yourself from the image of the nutcracker. Complete the table.





	Nutcracker	Panda
What element acts as the "Force"?		
What element acts as the "Load"?		
Where is the fulcrum?		
Compare the levers in the two drawings		

Which of these two systems has the greater mechanical advantage to ensure grinding? Explain.

ACTIVITY 4: The jaw and diet

The giant panda and the black bear have different diets. The former is a bamboo specialist while the latter eats several types of food, vegetal or animal. The purpose of the exercise is to compare the jaws and food mastication of the two ursine.

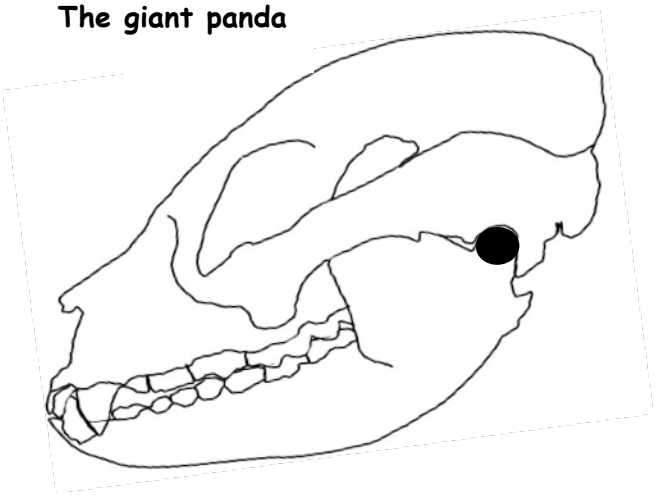
MANDATE:

1. Carry out an assembly that represents the giant panda's jaw as closely as possible.
2. Place a marshmallow between its teeth and observe the distortion of the marshmallow.
3. Sketch the assembly.
4. Carry out an assembly that represents the black bear's jaw as closely as possible.
5. Place a marshmallow between its teeth and observe the distortion of the marshmallow.
6. Sketch the assembly.
7. Compare the distortion of the marshmallow in the cases of the giant panda and black bear.

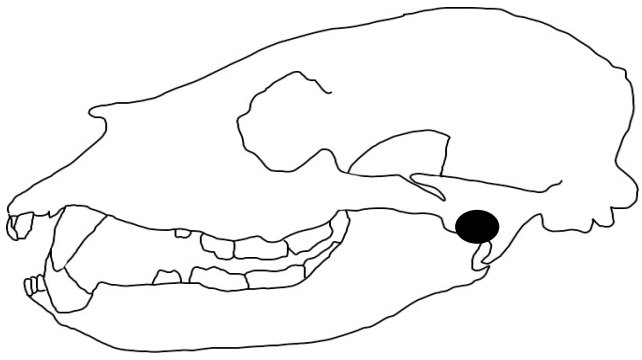
Elements to be considered that will help you:

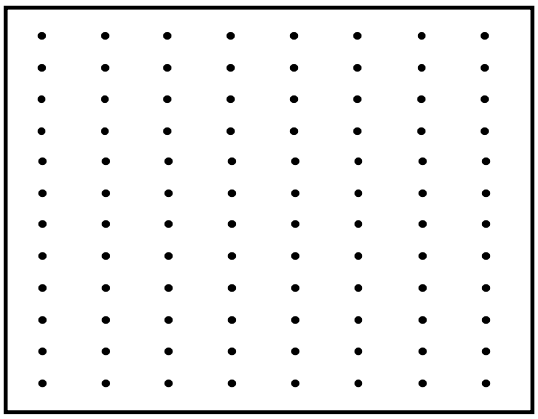
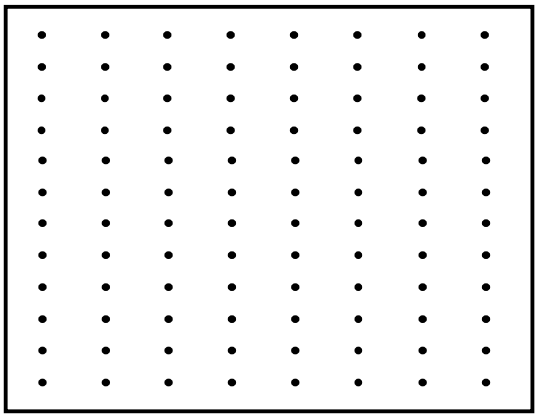
- Which teeth crush? Where are they located?
- At rest (when the jaws are closed), are the mandible and maxilla aligned?
- At rest (when the jaws are closed), are the upper and lower teeth aligned?
- Where is the fulcrum (the pivot) located?
- Did you work within the zone defined on the panel?

The giant panda



The black bear



The giant panda	Observations and explanations:
	
The black bear	**Observations and explanations:**
	

What do you retain from this activity? (Knowledge, manipulations, choice of the context, etc.)

ANNEX 1

Some information pertaining to the anatomy of skulls

The jaw bones …
The maxilla: upper jaw bone
The mandible: lower jaw bone

Mammals' dentition
Mammals' dentition can contain different types of teeth: incisors, canines, premolars and molars.

Types of teeth:

- **Incisors:** sharp, flattened teeth that **cut and grate** foods, located in the central anterior (front) part of the mandible and maxilla (definition from Antidote).
- **Canines:** sharp, sometimes prominent teeth located between the incisors and the molars. They are located on each side of the incisors. They are used to **shred and cut** food.
- **Premolars:** teeth located between the canines and the molars. They are also used to **grind and crush** foods.
- **Molars:** large teeth used to **grind and crush** foods. They are located at the back of the mouth. Their volume is larger than that of the premolars.

Carnivorous teeth are "sharp molars or premolars located on each side of the carnivore's jaws". (Definition from Antidote).

Panda skull