

# Herbivores, Omnivores, Carnivores...Oh My!

## The Nutritional Requirements of Different Species in a Community

### Background

Tina Vega, zookeeper at Brookfield Zoo, is constantly addressing the nutritional needs of different species in her care. The nutritional needs within a wild community or a zoo’s animal collection can be highly diverse. Different species are not only adapted for catching and eating their food with specialized teeth, claws, beaks or talons, but also possess highly specialized digestive organs that help them break down their individual diets. Some animals have very long digestive tracts to break up the tough cellulose of plant material where carnivores have relatively short intestinal tracts. In this laboratory activity, you will assess the needs of select species from an African community as zookeepers like Tina do in order to determine whether they are an herbivore, omnivore or carnivore.

**How would you define the following?**

**Carnivore:** \_\_\_\_\_  
 \_\_\_\_\_

**Omnivore:** \_\_\_\_\_  
 \_\_\_\_\_

**Herbivore:** \_\_\_\_\_  
 \_\_\_\_\_

**Detritivore:** \_\_\_\_\_  
 \_\_\_\_\_

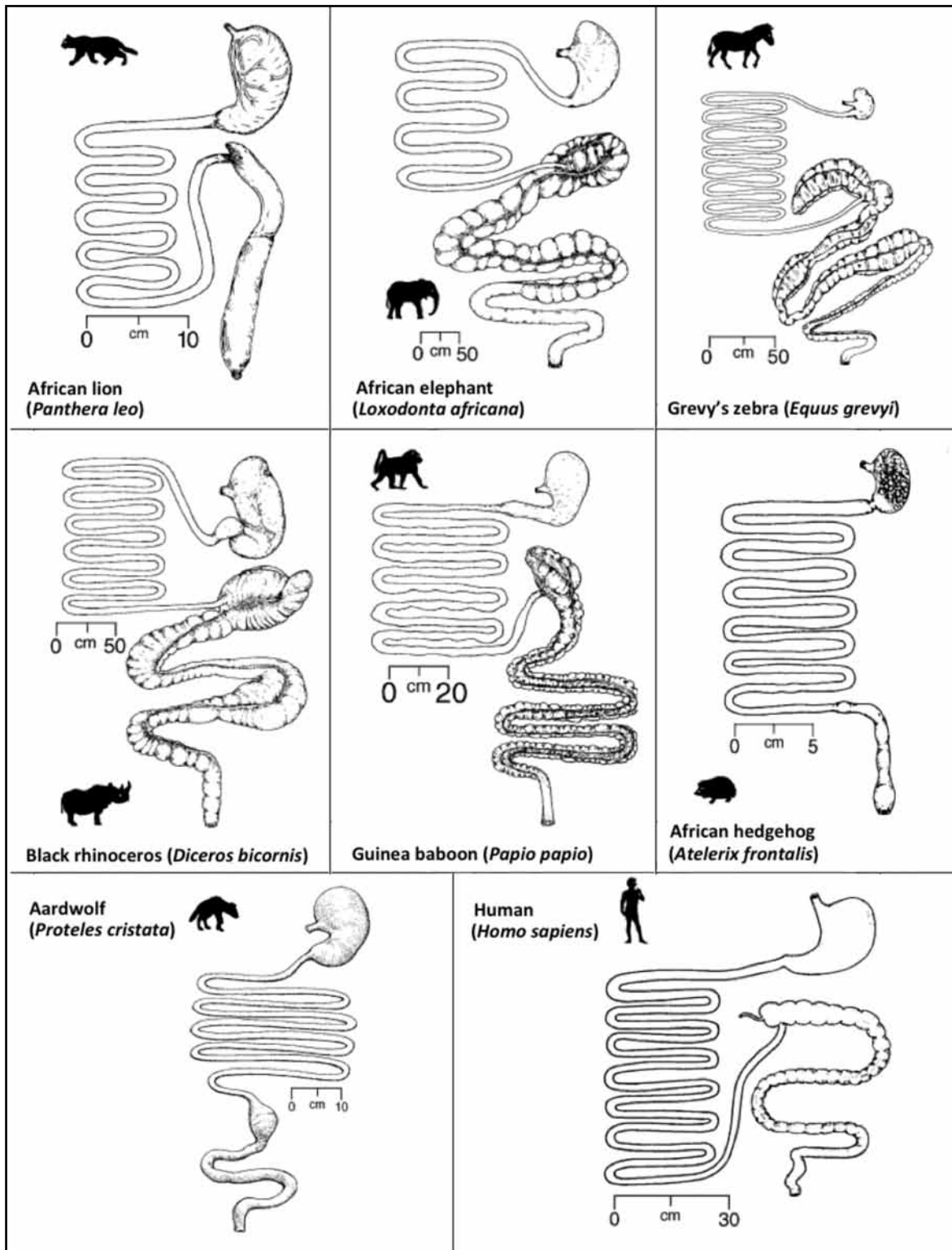
### Predictions

Using the diagrams of the digestive systems below, hypothesize to what feeding niche each species belongs. (C = carnivore, O = omnivore, H = herbivore) belongs. (C = carnivore, O = omnivore, H = herbivore)

Species	Feeding niche (Circle one)	Evidence
Panthera leo	C O H	
Loxodonta africana	C O H	
Equus grevyi	C O H	
Diceros bicornis	C O H	
Papio papio	C O H	
Atelerix frontalis	C O H	
Proteles cristata	C O H	
Homo sapiens	C O H	

**Big question: What other organ(s) besides what is pictured play an important role in mechanical digestion?** \_\_\_\_\_

Ask your teacher for this next data set once you have completed this form.



## Data Set 2: Dentition

Name: \_\_\_\_\_

Mammals have highly specialized dentition, or tooth anatomy, that allows them to consume their own individual diets. Sharp, pointed teeth help animals tear; sharp, flat teeth help animals snip or cut, and large, flat teeth help grind tough materials. Using the skulls below, determine which belongs to the animal species based on their adaptations to diet. Using the species listed in Table 1, write your responses below, explaining how the tooth anatomy led you to your answers.



Species common name: \_\_\_\_\_

Scientific name: \_\_\_\_\_

Evidence: \_\_\_\_\_



Species common name: \_\_\_\_\_

Scientific name: \_\_\_\_\_

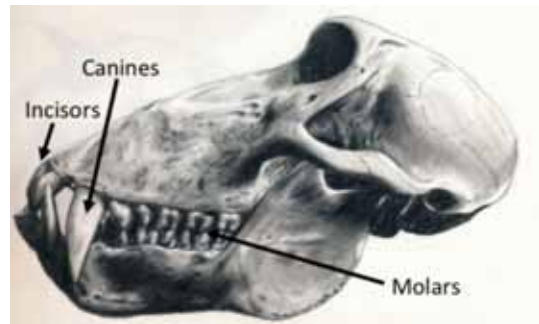
Evidence: \_\_\_\_\_



Species common name: \_\_\_\_\_

Scientific name: \_\_\_\_\_

Evidence: \_\_\_\_\_



Species common name: \_\_\_\_\_

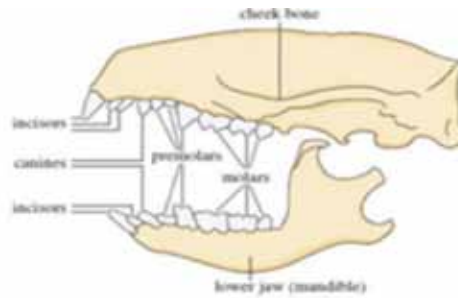
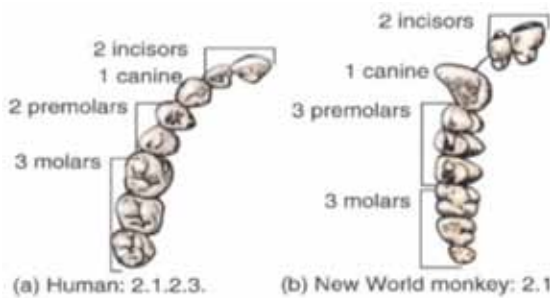
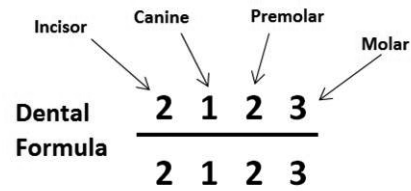
Scientific name: \_\_\_\_\_

Evidence: \_\_\_\_\_

## Data Set 2: Dentition

Name: \_\_\_\_\_

**Dentition** pertains to the development of teeth and their arrangement in the mouth. In particular, it is the characteristic arrangement, kind, and number of teeth in a given species. Observing the type of teeth an organism has can tell us what type of food for which they have adapted. Dental formulas, like the example below, represent the numbers and types of teeth a species possesses and comparing them can help us determine the diet of a species. Using the additional diagrams below as evidence, complete the following tasks.



Using the hedgehog skull below, compose the dental formula in the box at the right.




Use the dental formulas provided at the right to compare and contrast in order to answer the following questions.

Why do some species listed lack canine teeth? \_\_\_\_\_

\_\_\_\_\_

What does this tell you about the function of canine teeth? \_\_\_\_\_

\_\_\_\_\_

All of these species have molars. What does this tell you about the function of molars and premolars? \_\_\_\_\_

\_\_\_\_\_

What makes plant material more difficult to digest? Why? \_\_\_\_\_

\_\_\_\_\_

**Big question: Based on this new data, do all species require the same macromolecules in their diet?** \_\_\_\_\_

Ask your teacher for this next data set once you have completed this form.

Zebra	3	1	4	3
	3	1	4	3
Human	2	1	2	3
	2	1	2	3
Elephant	1	0	0	3
	0	0	0	3
Lion	3	1	3	1
	3	1	2	1
Baboon	2	1	2	3
	2	1	2	3
Aardwolf	3	1	4	1
	3	1	3	1
Rhino	0	0	3	3
	0	0	3	3

## Data Set 3: Dietary requirements

**Table 1** Using the nutritional requirements provided, determine the minimum daily amounts of each nutrient for each species. Each of the values represents the daily **minimum requirement** as mass (kg). Some diets vary due to different levels of fiber (indigestible plant material) consumed. There is 0.454 kg in 1.0 lbs. Do the conversions and fill in the table below.

Species	Protein (minimum kg needed)	Fats (minimum kg needed)	Carbohydrates (minimum kg needed)	Daily Amount Required	
				kg	lbs
Panthera leo	≥ 1.32	≥ 0.50	0.00	5.50-6.80 kg	
Loxodonta africana	≥ 4.41	≥ 1.10	≥ 41.36	55.15-59.25 kg (more dry than fresh)	
Equus grevyi	≥ 0.90	≥ 0.11	≥ 5.40	7.50-8.50 kg (mostly dry over fresh)	
Diceros bicornis	≥ 1.64	≥ 0.41	≥ 15.38	20.50-22.50 kg (more dry than fresh)	
Papio papio	≥ 0.11	≥ 0.02	≥ 0.16	0.40-0.65 kg (mostly fresh over dry)	
Atelerix frontalis	≥ 0.005	≥ 0.001	≥ 0.0008	0.015 – 0.020 kg	
Proteles cristata	≥ 0.055	≥ 0.125	0.00	0.25-0.30 kg	
Homo sapiens	≥ 0.22	≥ .08	≥ 0.40	1.00-1.40 kg	

### What about detritivores?

Here is the digestive system of a vulture. Vultures are detritivores, meaning they consume dead organisms.

### Observations & Inferences

As you continue to compare this system to the others, name some differences that birds seem to have that the mammals above do not:

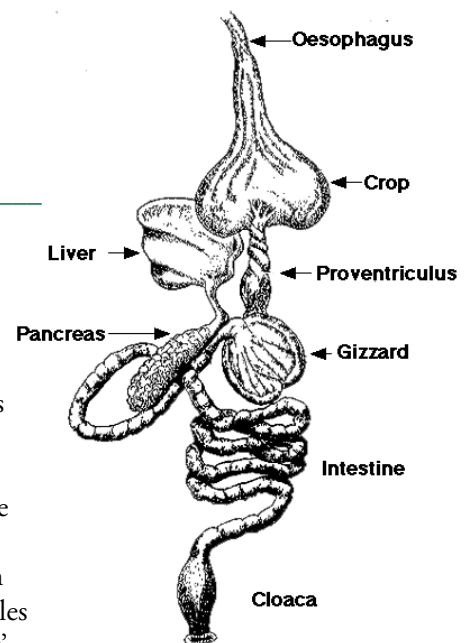
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### Dietary Planning: This is critically important information for you to design your diets!

Different species can have very specific needs. When feeding animals, whether it is at the zoo or your own pet at home, it is vital for you to provide a diet that is biologically appropriate. Using the tables on the next page, each student in your group will formulate a biologically appropriate diet for a different species using the data in Table 1 above. Using the data sheet from the Zoo Commissary, include appropriate dietary items in each table that meet or exceed each species' minimum needs. Be sure each student in your group is responsible for one of the species tables on the next page and write their name in the space provided so all group members' data is included in each of your completed forms. For information about the needs of each species, see the Species Information Cards. Each species should be offered a minimum of three (3) food items daily. If you cannot make three (3) or more food items work for your species, consult your teacher. To get the mass of total portion to be fed each day, multiply the portion size by the percentage of each macromolecule category (protein, fat, carbohydrate). If you are struggling to keep within the recommended range for your species, consider reducing the portion size, which will not have an impact on its macromolecule percentages.



**Species Name:** African lion (*Panthera leo*)

**Name:** \_\_\_\_\_

DIETARY ITEM	Proteins			Fats			Carbohydrates		
	Mass	%	Portion size	Mass	%	Portion size	Mass	%	Portion size
<b>TOTAL DAILY MASS</b>									

**Species Name:** Grevy's zebra (*Equus grevyi*)

**Name:** \_\_\_\_\_

DIETARY ITEM	Proteins			Fats			Carbohydrates		
	Mass	%	Portion size	Mass	%	Portion size	Mass	%	Portion size
<b>TOTAL DAILY MASS</b>									

**Species Name:** Guinea baboon (*Papio papio*)

**Name:** \_\_\_\_\_

DIETARY ITEM	Proteins			Fats			Carbohydrates		
	Mass	%	Portion size	Mass	%	Portion size	Mass	%	Portion size
<b>TOTAL DAILY MASS</b>									

**Species Name:** African hedgehog (*Atelerix frontalis*)

**Name:** \_\_\_\_\_

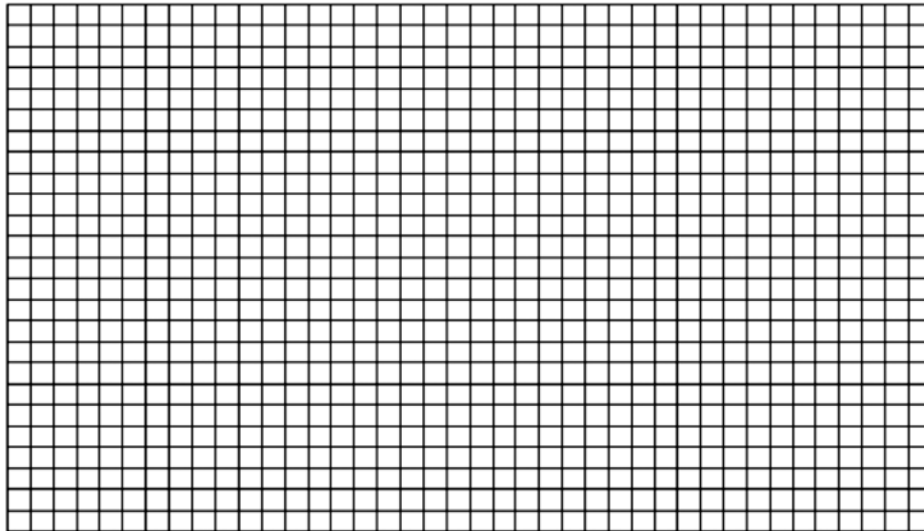
DIETARY ITEM	Proteins			Fats			Carbohydrates		
	Mass	%	Portion size	Mass	%	Portion size	Mass	%	Portion size
<b>TOTAL DAILY MASS</b>									

**Big question:** Based on this new data, do all species obtain the same amount of energy from their diet?

## Data Set 4: Metabolic Rates & Energy Needs (Extension)

**Metabolic rates:** In the table below, complete the weight (mass) conversions to gain a better understanding of each species' size. Then plot the mass in kilograms (kg) against the resting metabolic rate below in order to ascertain if relationships exist between these data sets.

Animal	Mode of Thermoregulation	Weight (g)	Weight (kg)	Weight (lbs)	Resting metabolic rate (kcal/min)
Baboon	Endotherm	25,000			0.36
Nile Crocodile	Ectotherm	162,700			0.0012
Aardwolf	Endotherm	32,390			21.6
Elephant	Endotherm	3,311,000			33.6
Zebra	Endotherm	531,000			5.4
Nile Monitor lizard	Ectotherm	14,530			0.00024
Lion	Endotherm	171,700			1.8



### Analysis Questions

1) **CLAIM:** Does a relationship exist between body mass and metabolic rate? \_\_\_\_\_

\_\_\_\_\_

2) **EVIDENCE:** Cite at least two (2) pieces of evidence from the data that supports your claim: \_\_\_\_\_

\_\_\_\_\_

3) **REASONING:** How does your evidence support your claim? Are there exceptions to your statement? \_\_\_\_\_

\_\_\_\_\_

## Data Set 4: Energy Needs (Extension)

Name: \_\_\_\_\_

In order to determine how much of a single food item an organisms would need, you will pull data from the data sets to which you have access when filling out the table below. To determine how much energy an organism needs in a day, calculate the kcal/min and figure out the total number of minutes per day.

Animal	Animal Weight (kg)	Animal Weight (lbs)	Daily energy needs (kcal)	Food item and mass (g or kg)	Energy available in food (kcal)	Daily food quantity needed (g or kg)
Baboon						
Nile Crocodile						
Aardwolf						
Elephant						
Zebra						
Nile Monitor lizard						
Lion						

1) How did you figure out the animal weights?

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2) How did you figure out the daily energy needs?

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3) How did you figure out the daily food quantity needed?

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4) Why do lions need less energy in a zoo versus the wild?

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5) Why must lions expend more energy than their herbivorous prey?

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6) With this knowledge, why would living in a pride be more beneficial?

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7) Why are energy needs different in ectotherms versus endotherms?

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**Analysis Questions**

**1) In what types of foods is the protein content the highest?**

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**2) In what types of foods is the carbohydrate content the highest?**

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Species	Trophic level (Circle one - Primary, Secondary, Tertiary)	Evidence
Panthera leo	P S T	
Loxodonta africana	P S T	
Equus grevyi	P S T	
Diceros bicornis	P S T	
Papio papio	P S T	
Atelerix frontalis	P S T	
Proteles cristata	P S T	
Homo sapiens	P S T	

**3) By filling in the table provided, determine at which level each organism exists based on their dietary requirements.**

**4) Does the type of animal (i.e. mammal, reptile, amphibian, bird) necessarily determine at which trophic level that organism exists?**

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**Why or why not?**

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**5) Why are detritivores a critical part to any community?**

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**6) Which of the animals at your lab table live in social groups? How could this affect their nutritional needs?**

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**7) Do individual animals have the same dietary needs every single day of the year? Why or why not?**

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**8) Does the diet you designed exactly meet the requirements stated above? Do you think the requirements as stated are exactly what each animal needs everyday? Explain why or why not.**

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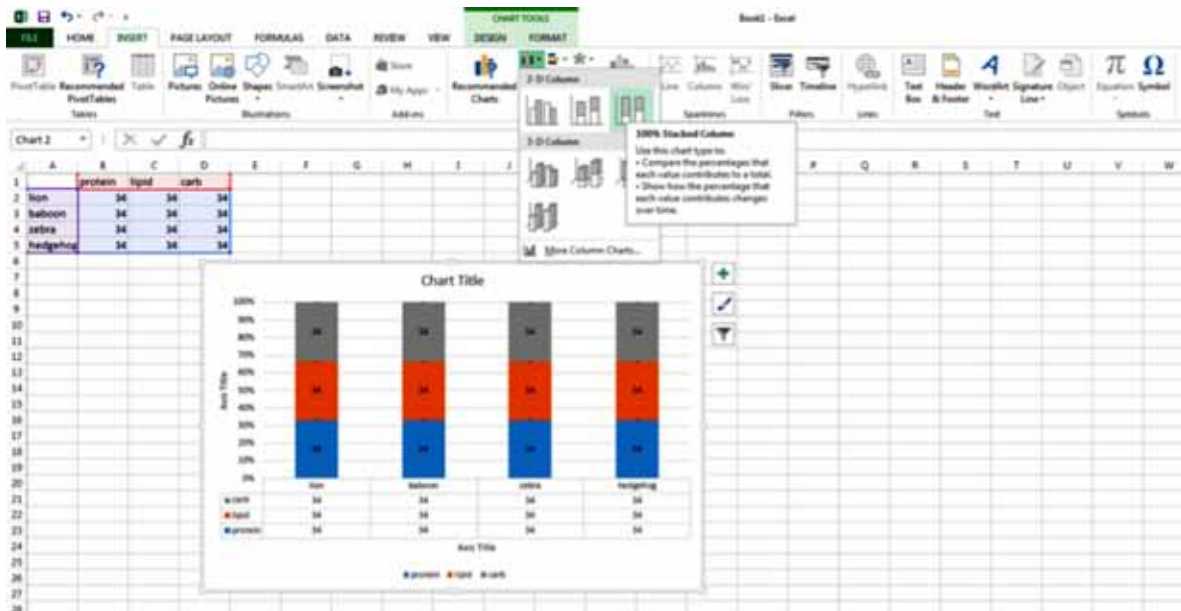
## Data representation

In order to represent the data each group member compiled as part of each of the four animals' dietary plans, design a way to represent the protein, fat and carbohydrate needs of each species so they can be compared in the same representation. You may use graph paper, Microsoft Excel or some other form as directed by your teacher.

### When using Microsoft Excel, you may follow the procedure below:

- 1) Enter your species list in Column 1 and nutrient headings in Row 1.
- 2) Enter the TOTAL DAILY MASS data for each category.
- 3) Highlight only the cells that contain information you entered.
- 4) Click Insert and then find the icon for "Insert Column Chart."
- 5) Choose the "100% Stacked" Column Chart for your data.
- 6) Once the graph appears, click on the '+' sign to the right of the graph and be sure all boxes are checked.
- 7) Go to the paintbrush icon below that and choose "Color." Choose a greyscale monochromatic if you are printing in black and white.
- 8) Be sure to click and change the Chart Title and Axis Titles to appropriately represent your data.
- 9) Print your graph so that each group member has a copy to attach to this completed lab activity.

**NOTE:** If your screen does not appear as the one below does, you may be using a different version of MS Excel and should consult your teacher. The image below is only an example and is NOT accurate or complete.



**Zoo Commissary:** Nutritional analysis of available animal foods.

(Note: All figures are averages and may vary within +/-5%.)

<b>Dietary item</b>	<b>Portion Size</b>	<b>Protein Content (%)</b>	<b>Fat Content (%)</b>	<b>Carbohydrate Content (%)</b>	<b>Energy Available (kcal)</b>
<b>Animal Matter</b>					
Beef (partial calf)	3.0 kg	60.0	8.9	–	5,760
Deer, white-tailed	5.0 kg	80.7	6.3	–	7,850
Mouse, domestic	30 g	64.2	17.0	–	150
Pig, domestic (partial)	3.0 kg	50.7	33.2	–	11,280
Rabbit, domestic	1.0 kg	72.1	13.0	–	1,360
Rat, domestic	100 g	57.9	23.7	–	600
Chicken (whole)	2.5 kg	64.9	22.4	–	7,975
Duck, mallard	2.5 kg	63.1	26.4	–	5,275
Quail, Japanese	1.5 kg	71.5	31.9	–	2,880
Lizard, anole	10 g	67.4	6.2	–	50
Frog, green	10 g	71.2	10.2	–	50
Toad, southern	20 g	61.8	13.7	–	92
Crickets (100 count)	10 g	64.9	13.8	3.0	45
Mealworms (Tenebrio –100 ct)	10 g	52.7	32.8	3.6	21
Superworms (Zophobas -50 ct)	10 g	56.9	26.2	5.8	24
Wax worms (100 ct)	10 g	42.4	46.4	2.5	70
Earthworms – 25 count	30 g	62.2	17.7	2.0	22
<b>Dietary item</b>	<b>Portion Size</b>	<b>Protein Content (%)</b>	<b>Fat Content (%)</b>	<b>Carbohydrate Content (%)</b>	<b>Energy Available (kcal)</b>
<b>Plant Matter</b>					
Alfalfa hay (dry – bale)	5.0 kg	19.0	1.5	56.0	9,000
Orchard grass (dry – bale)	5.0 kg	12.9	1.5	85.0	9,145
Grass hay (dry - bale)	5.0 kg	11.0	1.5	65.0	8,350
Timothy hay (dry - bale)	5.0 kg	3.8	1.5	80.9	9,700
Red clover hay (dry – bale)	5.0 kg	14.3	1.5	77.8	8,800
Kale (fresh)	200 g	4.3	1.2	7.4	100
Dandelion greens (fresh)	200 g	2.7	0.7	12.7	90
Turnip greens (fresh)	250 g	1.5	0.3	8.9	81
Apple (fresh)	200 g	1.1	3.6	89.5	104
Banana (fresh)	175 g	3.0	0.6	64.5	156
Cantaloupe (fresh)	750 g	7.8	1.4	89.1	255
Grapes, bunch (fresh)	300 g	4.0	4.1	57.6	207
Orange (fresh)	190 g	5.2	1.2	67.5	89
Strawberries - box (fresh)	225 g	6.7	4.7	90.1	72

## Species Information Cards

### African Lion *Panthera leo*

African lions currently range in east, south and central Africa, in grassy plains, savannahs, open woodlands and scrub country. Their historic range was much wider, and some still persist in India.

In the wild, lions eat wildebeests, zebras, buffalo, gazelles, wart hogs and other ungulates that may be in its area. If large game is scarce, they will eat small game and even rodents. At the zoo, the lions are fed a diet of fortified meats.



Daily requirements: 5.50-6.80 kg total  
Protein: minimum 24-28% ( $\geq 1.32$  kg)  
Fat: minimum 9-15% ( $\geq 0.50$  kg)  
Carbohydrates: Not applicable

### Grevy's Zebra *Equus grevyi*

Grevy's zebra can be found in the grasslands, savannas and open country of Africa, including Kenya and Ethiopia. It is largest horse species on Earth today.

Grazers like zebras prefer tall coarse grasses which, when removed, expose the shorter, more succulent blades preferred by wildebeest and gazelle. At the zoo, the zebras are fed a diet of different types of plant material.



Daily requirements: 7.50-8.50 kg total  
Protein: minimum 12-14% ( $\geq 0.90$  kg)  
Fat: minimum 1.5% ( $\geq 0.11$  kg)  
Carbohydrates: minimum 72-75% ( $\geq 5.40$  kg)

### Guinea baboon *Papio papio*

Baboons inhabit the savanna and savanna woodlands of extreme West Africa, from Senegal to Sierra Leone.

In the wild, they consume mostly fruit, but also some grass, leaves, insects and worms. In the zoo, fruits and vegetables as well as some small, live food are on their menu.



Daily requirements: 0.40-0.65 kg total  
Protein: minimum 28-30% ( $\geq 0.11$  kg)  
Fat: minimum 5-10% ( $\geq 0.02$  kg)  
Carbohydrates: minimum 40-45% ( $\geq 0.16$  kg)

### African hedgehog *Atelerix frontalis*

African hedgehogs are found in scattered populations from Senegal in western Africa to southern Somalia and Tanzania on the continent's eastern edge. Their habitats are semiarid areas and dry savannahs.

In the wild, they eat worms, snails, arthropods, frogs, lizards, snakes, eggs, nestling birds, small mammals, carrion, fruits, seeds, peanuts, fungi, and roots. At the zoo, they are fed worms, insects, vegetables, and some fruit



Daily requirements: 0.015-0.020 kg  
Protein: minimum 30-35% ( $\geq 0.005$  kg)  
Fat: minimum 8-15% ( $\geq 0.001$  kg)  
Carbohydrates: 5-15% ( $\geq 0.0008$  kg)

Name: \_\_\_\_\_

**Assessment (Advanced level)**

1) Variations exist among individuals within a population as well as among individuals in different populations that may be separated by geography. These variations can include differences in body size between the sexes as well as size that varies according to climate. A zoo has obtained a male and female African lion for their breeding program. The female lion #487 is 255 pounds and the male lion #512 weighs 415 pounds. They want to be sure they are providing each individual with the appropriate amount of food. Zoo researchers has found that lions generally need to consume 3% of their body weight daily. Using the information available in this lab activity. Create an appropriate daily diet for each of the two lions..

**Lion #487**    **Weight (lbs):** \_\_\_\_\_    **Mass (kg):** \_\_\_\_\_

DIETARY ITEM	Proteins			Fats			Carbohydrates		
	Mass	%	Portion size	Mass	%	Portion size	Mass	%	Portion size
<b>TOTAL DAILY MASS</b>									

**Lion #512**    **Weight (lbs):** \_\_\_\_\_    **Mass (kg):** \_\_\_\_\_

DIETARY ITEM	Proteins			Fats			Carbohydrates		
	Mass	%	Portion size	Mass	%	Portion size	Mass	%	Portion size
<b>TOTAL DAILY MASS</b>									

2) Explain how the daily energy needs are different between the zebra and its predator, the lion.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



Name: \_\_\_\_\_

**Assessment (Differentiated version)**

- 1) Variations exist among individuals within a population as well as among individuals in different populations that may be separated by geography. These variations can include differences in body size between the sexes as well as size that varies according to climate. A zoo has obtained a male and female African lion for their breeding program. The female lion #487 is 255 pounds and the male lion #512 weighs 415 pounds. They want to be sure they are providing each individual with the appropriate amount of food. Zoo researchers have found that lions generally need to consume 3% of their body weight daily. *(Note: 3% is a general rule. Slightly over 3% is acceptable.)*  
 Using the information available in this lab activity create an appropriate daily diet for each of the two lions. Include, at minimum, 2 items in each diet.

**Lion #487**      **Weight (lbs):** \_\_\_\_\_      **Mass (kg):** \_\_\_\_\_

DIETARY ITEM	Proteins			Fats			Carbohydrates			Energy Available
	Portion size (kg)	%	Mass of protein content	Portion size (kg)	%	Mass of fat content	Portion size (kg)	%	Mass of carb content	Kilocalories
<b>TOTAL DAILY MASS</b>										

**Lion #512**      **Weight (lbs):** \_\_\_\_\_      **Mass (kg):** \_\_\_\_\_

DIETARY ITEM	Proteins			Fats			Carbohydrates			Energy Available
	Portion size (kg)	%	Mass of protein content	Portion size (kg)	%	Mass of fat content	Portion size (kg)	%	Mass of carb content	Kilocalories
<b>TOTAL DAILY MASS</b>										

- 1) Explain how the daily energy needs are different between the zebra and its predator, the lion. Be certain to include any pertinent differences in the digestibility of these organisms' food sources, along with differences in digestive tracts and energy spent on digesting. Cite any behaviors you feel may play a role as well.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

2) An Asian wild horse (*Equus ferus przewalskii*) lives in social groups called herds and grazes on the grasses of the Mongolian plains. Thanks to managed breeding programs in zoos, this species that was once almost extinct has increased in numbers. A zoo put together the following diet after doing careful research and corresponding with other conservation institutions. Using this information as evidence, as well as the data you have already analyzed previously, you will make a claim as to which of the species in this lab activity it is most like and provide evidence to support this claim.

DIETARY ITEM	Proteins			Fats			Carbohydrates			Energy Available
	Portion size (kg)	%	Mass of protein content	Portion size (kg)	%	Mass of fat content	Portion size (kg)	%	Mass of carb content	Kilocalories
Alfalfa hay	2.0			2.0			2.0			
Orchard grass hay	2.0			2.0			2.0			
Grass hay	3.0			3.0			3.0			
Apple (fresh)	0.4			0.4			0.4			
<b>TOTAL DAILY MASS</b>										

**Claim:** The Asian wild horse is most similar to the \_\_\_\_\_ .  
*Common name* *Scientific name*

**Evidence:** In this section, you briefly state evidence you will make sense of later. Be brief!

**How do you think the digestive system compares? (Cite specific digestive system structures studied, along with comparative sizes.)**

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**How do you think the dentition compares? (Cite specific teeth that would be present/absent.)**

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**How do you think its diet compares? (Cite what types of molecules should be absent and/or present.)**

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**How do you think its energy needs compare? (Cite kcal values for each organism. Resist making any comparisons.)**

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## Animal Nutrition Lab Instructional Tool - Additional Support



### STEP 1: Calculate minimum daily food requirements:

Write down the lion's weight in lbs. Convert the lions weight from lbs to kg. Then find three percent (3%) of the lions' weights in kg to obtain the minimum daily food requirements. Remember that this is the minimum and that being slightly over is acceptable.

### STEP 2: What's on the menu?

Review the Zoo Commissary list of available foods. Choose at least 3 different food items to make up the animal's daily food amounts. Write the type of items in the column. Then continue to fill in the three sections that say portion size of the diet item you chose. If you have trouble getting 3 items on your species' menu, you should consider reducing the portion size first. Reducing the portion size will not change how much protein or fat it contains, for example, so it should be an easy fix for you. Consult your teacher if you are still having difficulty.

### STEP 3: Calculate the Mass of each content:

The % of each nutrient content is listed in the zoo commissary list. Enter the % for each category as it corresponds to the commissary list. You will then take that % of each nutrient content and multiply it by the whole portion size to find how much of the total portion size is made up of each nutrient (proteins, fats, and carbohydrates).

### Step 4: Energy Available in kilocalories:

The Zoo Commissary list also provides you with kilocalories of each diet item. If the portion size is not equivalent to the diet you have chosen. You will have to figure out how to find the kilocalories for the portion you need. For example, the portion of alfalfa hay listed is 5kg, which is 9,000 kilocalories. To find the energy available for 1kg divide 9000kcal/5kg. This calculation would give you 1kg=1800kcal. Since you know what 1kg is equivalent to, take this number and it apply it to the created diet amounts you have entered.

### Step 5: Total Daily Mass

The Total Daily Mass will be calculated by adding the data in each column and writing the total at the bottom.

Conversion Table	
1 kg = 1000g	1 g = .001 Kg
1 kg = 2.2 lbs	1 lb = 0.454 kg

## Notes: