

# ANIMAL INSIDE OUT

A **BODY WORLDS** Production



Per[]t  
Museum of Nature and Science

EDUCATOR'S  
**GUIDE**

Grades

6-12

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# WELCOME

## A LETTER FROM ANIMAL INSIDE OUT

Dear Students,

Did you know that giraffes are the tallest mammals on earth, ranging in height from 14-19 feet? Can you imagine that the heart of a bull is five times larger than that of a human? While our own bodies are capable of some pretty amazing feats, all animals have their own traits, characteristics and incredible skills that make them unique.

The specimens presented in “ANIMAL INSIDE OUT, a BODY WORLDS Production” were created by German anatomist, Dr. Gunther von Hagens, inventor of the revolutionary Plastination process. Thanks to the donation of various animals from zoos and other institutions, we began our work on the specimens you will see in this one-of-a-kind exhibition, intended to help people understand more about the animal kingdom through anatomy.

When you visit with your school or family, you will see how intricate the blood vessels of animals are, what the muscular system and various organs of different animals look like and how they compare to other animals, including humans. ANIMAL INSIDE OUT will show you why giraffes have such long necks, reveal why camels have humps and how the hoofs of certain animals make them better equipped to navigate the terrain of their native habitats. Combined with the activities inside this guide we hope you will learn more about the anatomy of animals and how each species, large and small, plays an important role on our planet.

Albert Einstein once wrote that we should widen “our circle of compassion to embrace all living creatures and the whole of nature and its beauty.” The animals presented in ANIMAL INSIDE OUT—wild, exotic, domestic, previously unknown and even those familiar to us, offer a glimpse into the biology and diversity on our planet. The plastinated specimens are our contribution to the epic on evolutionary biology and the diversity of life on our planet.

It’s my sincere hope that you enjoy this anatomical safari!



*Angelina Whalley*  
Dr. Angelina Whalley

Creative & Conceptual Designer  
ANIMAL INSIDE OUT, a BODY WORLDS Production

# THE MIND BEHIND THE EXHIBITION

## **Animals have fascinated me all my life.**

As a child, I was enthralled by the small animals I encountered in the woods.

The first specimens I dissected were beetles, frogs, and other small animal corpses that my friend, Dietrich and I found during our jaunts to the woods. These deaths which were so random and yet so normal must have colored my view of death and shaped my thoughts on mortality, preparing me psychologically for my career as an anatomist.

My childhood years were filled with a certain awe for nature and the varieties of life that populated it. But in my teenage years, my interest in biology was replaced by an interest in electronics and space. I became the resident expert on all things related to Sputnik, and soon in the gadgets I saw in early James Bond films.

Later as an adult, I renewed my relationship with animals by frequently visiting zoos and aquariums. The larger than life animals I admired—giraffes, elephants, and gorillas—were filled with a controlled grace that I found wondrous.

They lumbered, they sauntered, they ambled, their elegance so surprisingly disproportionate to their size. In the last decade, I have traveled to Africa and Antarctica to see up close the creatures that had captured my childhood imagination.

In an accelerated technological age, when our environments are fashioned from steel and concrete, being in close proximity to animals—both domestic and wild—return us to authenticity. Outside of the rainforests and flora, they and we are the last remaining pieces of nature. They are our co-habitants on this spinning blue globe. This exhibition, ANIMAL INSIDE OUT, is both a celebration and an homage to animals both familiar and rare.



*Gunther von Hagens*

Dr. Gunther von Hagens  
Anatomist, Inventor of Plastination and

Creator of ANIMAL INSIDE OUT, a BODY WORLDS Production

# Q&A WITH KIDS

## Children Visiting ANIMAL INSIDE OUT—Interview with Dr. Gunther von Hagens' Creator of BODY WORLDS & Inventor of Plastination



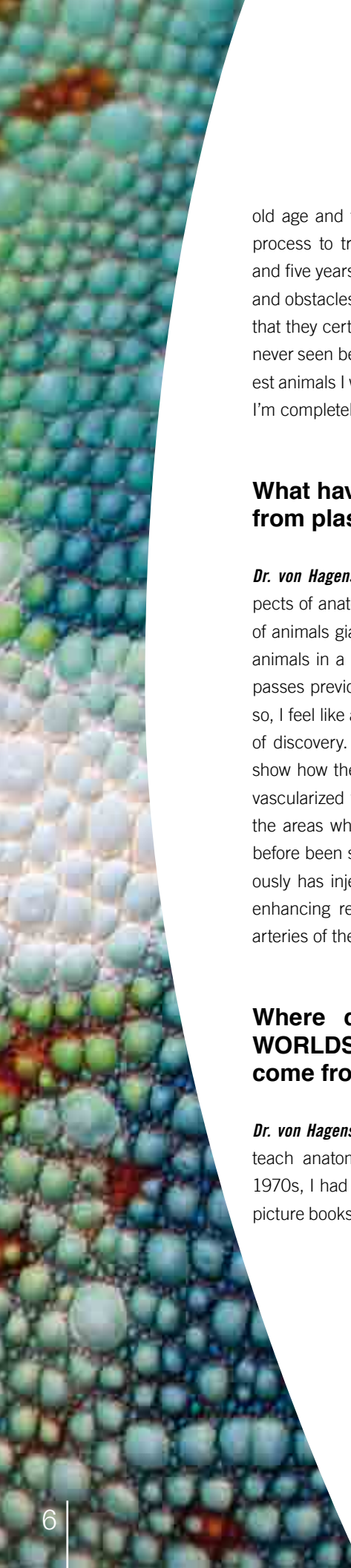
### **Were you ever scared to work with dead animals and bodies?**

*Dr. von Hagens:* When I was a child I spent my time in the woods, chasing frogs and listening to the sounds of animals in the forest. Occasionally, I would find small, dead creatures—like beetles and snakes, which I would take with me to dissect. I was always curious to see what they were like on the inside.

When I was about six years old, my jaunts in the woods came to a halt. I became very sick and nearly died. I was in hospital for many months and became very comfortable in that environment of the sick and dying. The doctors and nurses who cared for me became my heroes, and I wanted to become like them. Later when I worked in a hospital as an orderly and then a nurse, (long before I became a doctor), one of my duties was to transport the dead to the morgue. Other workers didn't like this job because it frightened them, but I was never afraid. Being afraid of death is not a good way to live.

### **What is the largest animal you have ever plastinated?**

*Dr. von Hagens:* For years now, I have been working on plastinating animals. A few years ago, I plastinated not only some smaller animals, but some large ones, such as a horse (2000), a camel, and a gorilla (2003). In particular, these large animals require all of my imagination. The larger they are, the bigger the anatomical and technical challenge they present. When I completed the plastination of these animals I was certain that they would be the largest animals I would ever plastinate, however, to my great surprise and honor I was donated two elephants by the Neunkirchen Zoo in Germany, in 2005. The animals died in captivity—one of

A vertical strip on the left side of the page shows a microscopic view of plant cells, likely from a leaf. The cells are roughly hexagonal and packed together, with various shades of green and blue. Some cells have darker, reddish-brown spots, possibly indicating chloroplasts or other organelles. The overall texture is granular and detailed.

old age and the other of heart failure. The whole process to transform the two elephants took four and five years respectively. Through the challenges and obstacles faced to transform them I must admit that they certainly have allowed a view of elephants never seen before. I now presume they are the largest animals I will ever plastinate, but I hesitate to say I'm completely certain.

### **What have you learned from plastinating animals?**

*Dr. von Hagens:* I have discovered many new aspects of anatomy when working on the plastination of animals giant and small. My team and I dissect animals in a detailed and careful manner that surpasses previous preservation techniques. In doing so, I feel like a researcher on an anatomical journey of discovery. For example, we have been able to show how the underside of a giraffe's skin is more vascularized where it has dark spots, compared to the areas where it has lighter fur. This has never before been shown so clearly, as no one else previously has injected an entire giraffe with a contrast enhancing resin that penetrates even the minute arteries of the skin, as we have done.

### **Where did the idea for BODY WORLDS & ANIMAL INSIDE OUT come from?**

*Dr. von Hagens:* Dr. von Hagens: When I used to teach anatomy to students in medical school in the 1970s, I had to use illustrated anatomy atlases and picture books to show the organs and body systems.

I tried to use real human organs and specimens, but at that time the specimens were preserved in blocks of plastic so you could not touch them, or study the placement of the organs properly. I realized one day that if the plastic was inside the body and not outside it, the specimen would be rigid and easy to grasp, and study and work with. I was only trying to solve a problem, I wanted to educate my students so they would become better doctors, as I don't think doctors should be poking around inside your body and operating on you if they don't know important things about it. But something very unusual began to happen after I began to plastinate organs and specimens. The janitors and secretaries and office workers at the university began to stop by the lab; they were fascinated by the plastinates. This was when I began to think of anatomy for lay people, which is what BODY WORLDS is. It is very different from anatomy for medical professionals because it has to be interesting and dynamic and not scary to look at.

In the human BODY WORLDS exhibitions, curator Dr. Angelina Whalley and I decided to incorporate some animal specimens. Visitors often found them as fascinating as human specimens. This led us to come up with the concept of ANIMAL INSIDE OUT.

### **How long does it take to prepare the specimens for display?**

*Dr. von Hagens:* Plastination takes a very long time. A whole-human body can take up to 1,500 working hours to prepare. Larger animals like elephants, giraffes and horses can take three years or more. Smaller specimens and slice specimens take an average of 3-6 months depending on the size and level of dissection.

# EXHIBITION OVERVIEW

## Travel on an anatomical safari

Explore the intricate biology, zoology and physiology of the world's most spectacular creatures, large and small in this fascinating new exhibition by BODY WORLDS creator, anatomist Dr. Gunther von Hagens.

ANIMAL INSIDE OUT takes visitors on an anatomical safari of more than 100 specimens. Each animal is painstakingly preserved by the remarkable process of Plastination, invented by Dr. von Hagens.

From goats to giraffes, elephants to eels and octopuses to ostriches visitors will discover the form and function of animals both exotic and familiar. Animal biology textbooks spring to life in this unforgettable museum learning experience.



*Ostrich*

# AMAZING FACTS

Giant squid  
can snatch prey up  
to 33 feet (10 meters) away  
by shooting out their two feeding tentacles,  
which are tipped with hundreds of powerful  
sharp-toothed suckers.

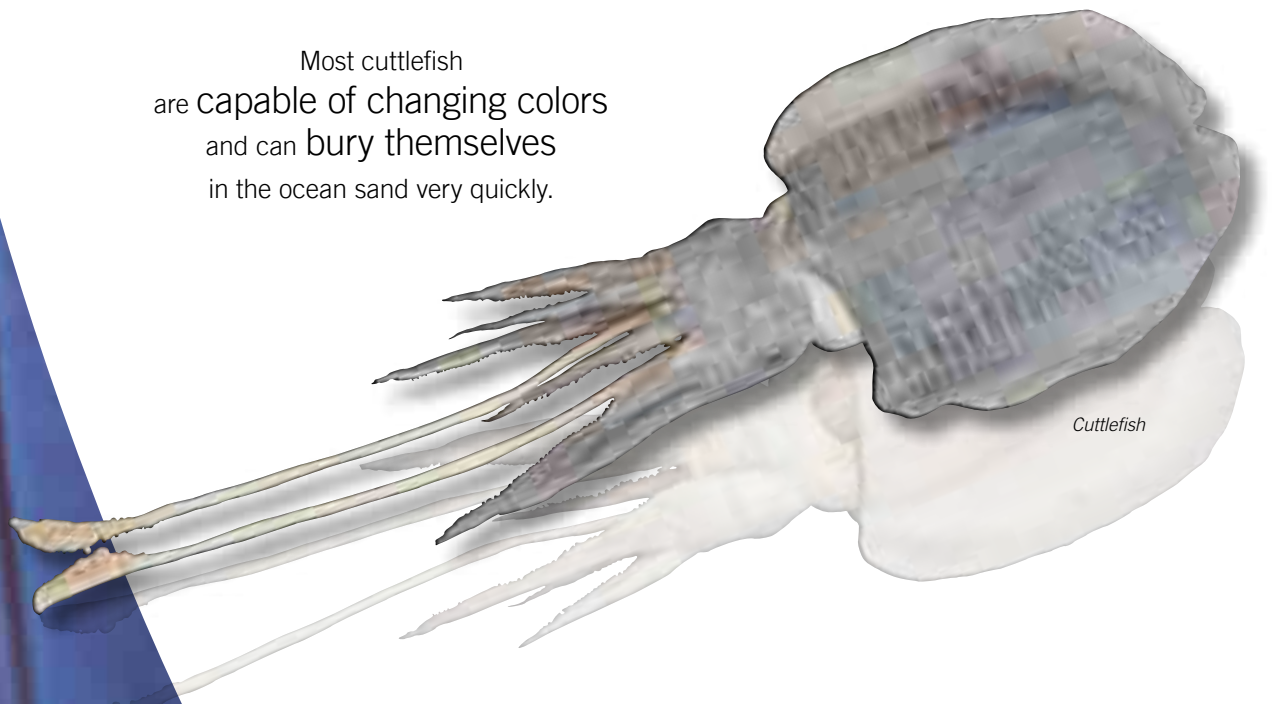
Sharks  
have been swimming the seas  
for 400 million years—  
longer than dinosaurs  
have been walking the earth.

Sea scallops  
grow rapidly during the first several years of life.  
Between the ages of 3 and 5, they commonly increase  
50% to 80% in shell height  
and quadruple their meat weight.

The maximum speed of a snail  
is 1 mile a week  
or about .006 miles an hour.

Mackerel,  
unlike any other species, are likely to die  
if their incredibly thin and specialized skin  
is touched by human hands.  
It is theorized that it may be the oils in human hands.

Most cuttlefish  
are capable of changing colors  
and can bury themselves  
in the ocean sand very quickly.



Cuttlefish



Frogs don't need to drink  
the way humans do:  
they **absorb water**  
through their **permeable skin!**

A bull's heart  
is around **5 times heavier**  
than a human heart.

The combination of the cat's inner ear  
(vestibular apparatus) and **tail**  
provide the cat with its incredible balance  
and acrobatic prowess.

Giraffes  
are the **tallest mammals on earth,**  
ranging in height from **14-19 feet.**

An adult bull giraffe  
can feed on the leaves of trees over **19 feet**  
above the ground!

Chickens  
can travel up to  
**nine miles per hour.**

Reindeer  
have long, coarse **hair with hollow cores,**  
which keeps them insulated in colder climates.



Reindeer are **very strong swimmers**  
and can travel across wide, rapid and frigid rivers.

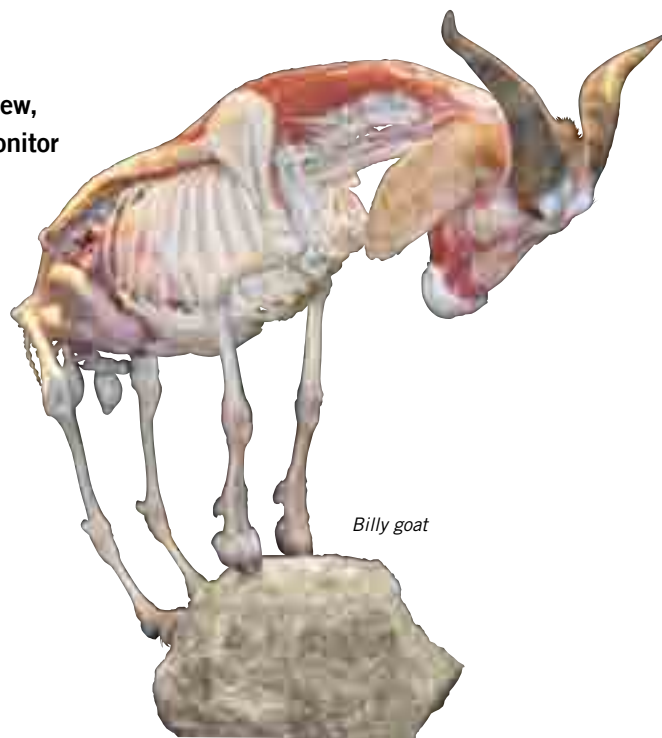
# PLANING YOUR VISIT

## CHAPERONE RESPONSIBILITIES

Thank you for volunteering to be a chaperone on your school's visit to ANIMAL INSIDE OUT at the Perot Museum of Nature and Science. Being a chaperone is a great way to enjoy your visit and it is also an important responsibility. As a chaperone, you are responsible for helping your students get the most out of this amazing learning experience. This guide explains the Museum's school visit expectations:

- All adults accompanying a school group to the ANIMAL INSIDE OUT exhibit are responsible for students behavior and experience (this includes teachers).
- Please ensure that you and your group of students (7 students or less per chaperone) stay together during your time in the ANIMAL INSIDE OUT exhibit and in the Museum.
- While your students are engaged in learning, questioning and reflecting on the exhibit, we ask that you help us reinforce some basic museum etiquette:
  - o Keep your voices low.
  - o No running in the exhibit or in the Museum.
  - o Do not gather at the entrance or exit of the exhibit.
  - o Groups with poor conduct may be asked to leave.
  - o Do not block the flow of traffic for our other visitors.
  - o No photography or filming while viewing Animal Inside Out.
  - o Some teachers may take advantage of the unique learning opportunity by requiring students to complete assigned activities. Please remind students not to lean on the specimen cases or touch the specimens. They should use a notebook or clipboard to fill out their papers.

**We know that this is a fascinating exhibit to view, but please remember your top priority is to monitor and remind your students of the Museum's expectations to ensure a positive experience for everyone.**



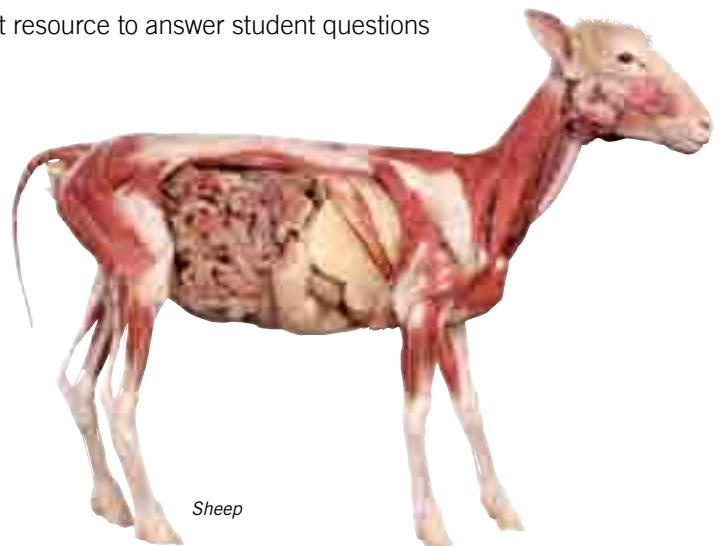
*Billy goat*

# NOTE TO EDUCATORS

## STRATEGIES TO HELP THE EDUCATOR COME PREPARED

The Perot Museum has compiled a list of suggestions to help you come prepared for the ANIMAL INSIDE OUT exhibit. These suggestions will enable you to prepare your students and adult chaperones for their ANIMAL INSIDE OUT experience.

- Reserve your tour for ANIMAL INSIDE OUT with school group reservations.
- Educator materials are available for pre/post student learning that correlate with the exhibit and Texas Essential Knowledge and Skills for Science. Many of the lessons have a component that can be completed while viewing the exhibit.
- Review student behavior expectations with your students prior to your visit:
  - Keep your voices low.
  - No running in the exhibit or in the Museum.
  - Do not gather at the entrance or exit of the exhibit.
  - Groups with poor conduct may be asked to leave.
  - Do not block the flow of traffic for our other visitors.
  - No photography or filming while viewing ANIMAL INSIDE OUT.
  - Some teachers may take advantage of the unique learning opportunity by requiring students to complete assigned activities.  
Please remind students not to lean on the specimen cases or touch the specimens. They should use a pencil and notebook or clipboard to fill out their papers.
- Review adult chaperone expectations with your adult chaperones prior to your visit. These expectations can be found in “Chaperone Responsibilities”
- [www.animalinsideout.com](http://www.animalinsideout.com) is a great resource to answer student questions about the plastination process.



Sheep

# STRATEGIES FOR TEACHING IN THE EXHIBIT

ANIMAL INSIDE OUT is an amazing opportunity for educators to use as a teaching tool and for students to make meaningful connections with classroom material in an informal setting.

The exhibit is relevant from kindergarten through college.

The Perot Museum has developed educator materials that correlate with the exhibit. These lessons are aligned with the Texas Essential Knowledge of Skills for Science.

The Table of Contents lists the lessons the Museum has developed and the grade level TEKS the lessons are aligned with.

Animal adaptations, body systems, anatomy and physiology are core concepts that easily align with the ANIMAL INSIDE OUT exhibit.



*Bactrian camel*

# ESSENTIAL QUESTIONS

## 1. How are animal groups anatomically similar?

By examining and comparing the anatomy among species, similarities and differences are observed, establishing a relationship between species. When characteristics are shared among a large number of similar species, they are viewed as ancestral. While those limited to one or a few species are viewed as derived. The comparison

of a variety of characteristics possessed by similar species allows scientists to differentiate between species that are truly closely related and those that illustrate the interconnectedness. ANIMAL INSIDE OUT encourages the visitor to make the connection of how living things are more alike anatomically than what can be seen externally.

## 2. Do animals in nature have anatomical similarities to humans?

All species are similar at the molecular level. They are made of a cell or cells, surrounded by a plasma membrane and containing DNA and RNA. There are 500 genes common to all species (Utah) it's the combination of the other thousands of genes that allow for such great diversity present on Earth today. The main goal of ANIMAL INSIDE OUT is to illustrate the interconnectedness of all species when the covering is removed. From the outside, the diversity of life is evident by all of the different and unique life forms on Earth. Through revealing their, and our, internal structures the interconnectedness of life can be better understood. Multicellular organisms consist of body systems, some more complex than others.

As an example, this case can be made by comparing bird wings and primate skeletal structure in the forearms. Each of the organisms possess-

es a humerus (upper arm in primates), radius and ulna (both comprising the forearm in primates), carpals and metacarpals (primate wrist bones) and phalanges (primate fingers). The main difference between these organisms is the use of the structure and the size and number of certain bones.

Humans tend to identify the most with gorillas and chimpanzees when it comes to likeness. Certainly, there are more similarities in body structure than dissimilarities, such as similar muscle groups, an opposable thumb on the hand to allow for grasping and handling objects, as well as common reproductive strategies. There are specific structures on humans that allow for walking upright on two feet all of the time that are unique to humans and are either not found in apes or are slightly modified. (Summers)



*Octopus*



### 3. How do animals use specific adaptations to survive in their environments?

ANIMAL INSIDE OUT highlights the unique adaptations in animal groups that allow for survival and proliferation of their species. For example, sharks have adapted to their environment so well they have been present in some form for over 300 million years. Sharks belong to the most numerous and diverse classification of vertebrates on Earth, fish, and are categorized as cartilaginous fish. This means their skeletal structure is made of cartilage not bone, as with other fish. Sharks have extremely well developed sensory organs; this enables them to be considered apex predators in Earth's oceans.

The reindeer is another example of an animal that has highly developed adaptations for the extremely cold environment it lives in. Reindeer

hair is hollow like a straw. This adaptation allows the reindeer to float when swimming. The hairs are also designed to trap air inside separate hair and serves as a good insulator. Heat is trapped close to the body by a long, thick winter coat. The reindeer also has the ability to cool down its limbs in the winter in order to conserve body heat. The blood vessels constrict, restricting the flow of warm blood to the limbs and saving heat and energy for the muscles higher up in the animal's body since the reindeer's lower legs are primarily tendons and ligaments. When the outside temperature warms to above 0° F the blood vessels open and allow warm blood to flow to the legs again. (Dieterich, Morton and Station, pg. 15)

### 4. Why is understanding anatomy critical to discovering more about the evolution of living organisms and the natural world?

The nature of science is an effort to understand, or better understand, the natural world and how it works. Science asks the questions: What is there? How does it work? How did it come to be this way? The homology of past and present living organisms is revealed by studying the anatomy and cellular similarities and differences of organisms. There are 500 genes that are common to all species. This commonality provides strong evidence that all living things descended from the same ancestor. Comparative anatomy brings

to light the concealed similarities to establish a relationship between different species of living organisms. Developmental biology allows scientists to study the embryological development of living things. Developing embryos provide evidence for common ancestry. This provides clues to the evolution of present day organisms. The applicability of evolution in science allows for progress in medical science, agriculture and conservation.

#### REFERENCES:

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# FAQ

## **What is the purpose of the exhibition?**

The purpose of ANIMAL INSIDE OUT is to inspire a deeper appreciation and respect for the animal world. The exhibition will allow visitors the unique opportunity to explore the intricate biology and physiology of some of the world's most spectacular creatures, using the amazing science of Plastination. A visit to ANIMAL INSIDE OUT will go beyond what is seen in zoos, aquariums and animal parks. Visitors will be better able to understand the inner workings of animals and compare them to human anatomy, resulting in a new understanding of the amazing beauty of both animals and humans.

## **Is this exhibition appropriate for children?**

ANIMAL INSIDE OUT was designed for visitors of all ages to better understand animal anatomy. Children and adults will be delighted when they discover curiosities about animals – like the reason why reindeers can navigate icy ground, what the giraffe's tongue is capable of, and why bulls have such strength. This exhibition provides an opportunity to see and learn about animals like never before.

## **What is Plastination?**

Invented by scientist and anatomist Dr. Gunther von Hagens in 1977, Plastination is the groundbreaking method of halting decomposition to preserve anatomical specimens for scientific and medical education. Plastination is the process of extracting all bodily fluids and soluble fat from specimens, replacing them through vacuum-forced impregnation with reactive resins and elastomers, and then curing them with light, heat or certain gases, which give the specimens rigidity and permanence. For more information about Dr. von Hagens, the inventor of the Plastination technique and creator of the BODY WORLDS exhibitions and ANIMAL INSIDE OUT, please visit [www.bodyworlds.com](http://www.bodyworlds.com).

## **Where did the animals on display come from?**

ANIMAL INSIDE OUT, a Body Worlds Production is made possible with cooperation between various university veterinary programs, zoos and animal groups. No animal was harmed or killed for this exhibition.

Among the animals in the exhibition, are human specimens, originating from the Institute for Plastination's body donation program. The generosity of these individual donors has made it possible to present human specimens in this and all of the BODY WORLDS exhibitions.

Dr. Gunther von Hagens and Dr. Angelina Whalley, creators of ANIMAL INSIDE OUT, are honored to be able to conserve and present these biological wonders of nature for anatomical study. They hope that this exhibition will show visitors the similarities between humans and animals, leading to a greater respect and appreciation for all animals.

### **Where have the animal plastinates been shown before?**

More than 100 Animal plastinates are being shown for the first time, together in this unique exhibition. The majority of the specimens had never been seen before. Some animal plastinates had been previously incorporated in BODY WORLDS The Original exhibitions. The popularity of these animal specimens prompted curator, Dr. Angelina Whalley, to compose ANIMAL INSIDE OUT, a BODY WORLDS Production.

### **What will be the subsequent exhibition locations?**

ANIMAL INSIDE OUT will be on display in North America beginning March 14, 2013. This exhibition will have its North American debut at the Museum of Science and Industry, Chicago (MSI). The exhibition will continue touring zoos, museums and science centers. Please check the Exhibition tab for updates on future locations.

### **How long will I need to fully appreciate the exhibition?**

This comprehensive exhibition includes detailed information on the specimens shown and further explorations of the animal kingdom. Average duration of a visit to ANIMAL INSIDE OUT is one hour. Guests are welcome to remain in the exhibition as long as they wish, within opening hours.

### **Can I take photographs or film in the exhibitions?**

Taking photographs and filming, including the use of mobile phone cameras, is not allowed in the ANIMAL INSIDE OUT exhibition. Exceptions are made for accredited members of the media.



*Cross-section of a crocodile*



# Head of the class:

## classification of organisms

TEKS 6.12 C Recognize that the broadest taxonomic classification of living organisms is divided into currently recognized domains.

Readiness Standard     Supporting Standard  
ELPS

### ESSENTIAL QUESTION

How do scientists **classify** organisms on Earth?

### LESSON OBJECTIVE

Students will sort word cards/pictures and place into the correct **classification** on the graphic organizer.

### LEARNING STYLE

Spatial     Auditory/Musical     Linguistic     Kinesthetic  
 Logical     Interpersonal     Intrapersonal

### MATERIALS

Per Class:    Word cards, graphic organizer

Per Group:    Pictures

### DIRECTIONS

1. Give students a set of word cards, pictures and a graphic organizer
2. Instruct them the student to cut apart and organize the word cards into the correct classification on the graphic organizer.
3. Once the word cards are classified correctly, students should glue the cards under the correct classification on the graphic organizer.
4. Glue completed graphic organizer into science journal.
5. Have them test their analytical skills by sorting the pictures into the correct classification.

## ACADEMIC VOCABULARY

Taxonomy, classification, organism, domain, unicellular, bacteria, multicellular, prokaryotic, eukaryotic, asexual reproduction, sexual reproduction, nucleus

## POSSIBLE QUESTIONS

1. Are only multicellular organisms eukaryotes?
2. How are prokaryotes and eukaryotes different?
3. Which domain contains the most diversity in life forms? Why?



**Beluga whale**



**Ferroplasma acidiphilum  
archaea**



**Volvox**



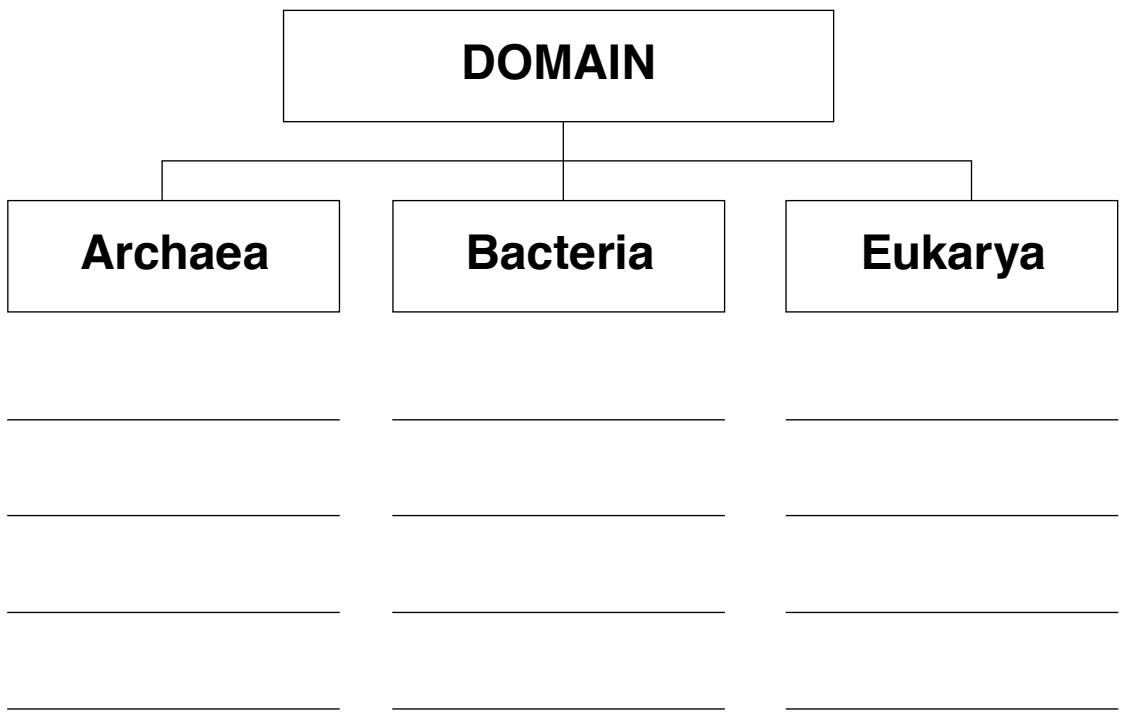
**Fungus**



**Flower**



**Staphylococcus aureus**



<b>Only unicellular</b>	<b>Do not contain a nucleus</b>
<b>Contains a nucleus</b>	<b>Multicellular and unicellular types</b>
<b>Only unicellular</b>	<b>Do not contain a nucleus</b>
<b>Prokaryotic</b>	<b>Prokaryotic</b>
<b>Eukaryotic</b>	<b>Asexual reproduction</b>
<b>Asexual and sexual reproduction types</b>	<b>Asexual and sexual reproduction types</b>

# THAT FOOD YOU EAT:

A look at how food goes from a solid to stored energy.

7.6B Distinguish between physical and chemical changes in matter in the digestive system.

## ESSENTIAL QUESTION

What is the process that food goes through from a solid to stored energy in the digestive system?

## LESSON OBJECTIVE

**The student will connect classroom learning with an activity in the museum.** He/She will use the specimens in the exhibit and analyze. The student will fill out the provided table with an animal in the exhibit.

## MATERIALS

Per Student: Museum-School Connection page

## DIRECTIONS

1. Student will complete the Museum-Connection page at the museum.
2. Follow up at school.

## ACADEMIC VOCABULARY

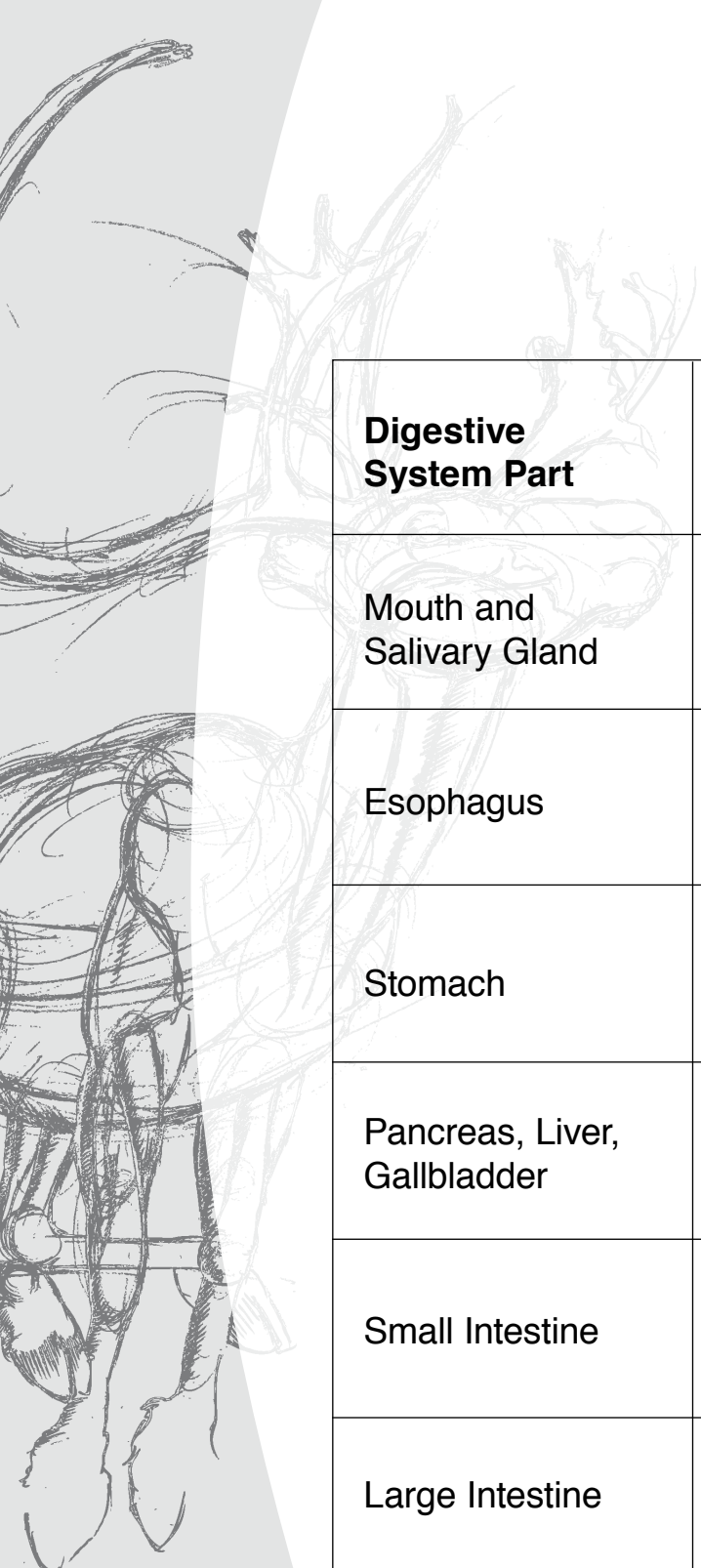
Digestive system, physical change, chemical change, mouth, saliva, esophagus, stomach, pancreas, liver, gallbladder, small intestine, large intestine

# THAT FOOD YOU EAT:

A look at how food goes from a solid to stored energy.

- The body's digestive system converts the food you eat into the energy you need to live. The journey through your digestive system is a long one for food. It starts in the **mouth**, where **teeth grind and tear the food into small pieces**. **Saliva** then wets and softens the food, and begins to **dissolve carbohydrates**. Once the food is **properly mashed and wet**, it is **pushed by muscle action** into the **pharynx, or throat**, and down the **esophagus**, which leads to the **stomach**.
- When food reaches the **stomach** it is **mixed and broken down further by acids the stomach produces**. The stomach protects itself from these acids by secreting a layer of mucus that lines the inside of the stomach. **Some things, such as water and sugars, can be absorbed right out of the stomach and into the bloodstream**. The things that need more digestion have further steps ahead of them. **When the stomach has made the food a liquid, the food passes through a valve into the small intestine**.
- The **small intestine** has a large surface area because it contains **villi**. Villi are tiny little structures like very short hairs that stick out into the small intestine. **Through the walls of the villi nutrients from food pass into the bloodstream. The bloodstream carries the nutrients to your cells so they can live. Once all the useful nutrients have been taken from food in the small intestine, the unusable parts pass into the large intestine, or colon**. In the **large intestine, water is extracted from the waste and the material hardens into feces. The feces are passed out of the body when you go to the restroom**.
- The **pancreas, liver** and **gallbladder** play an important role in digestion. The **pancreas makes enzymes that help digest, proteins, fats and carbohydrates. The liver makes bile, which helps the body absorb fat. Bile is stored in the gallbladder until it is needed. Enzymes and bile travel into the small intestine through ducts**.

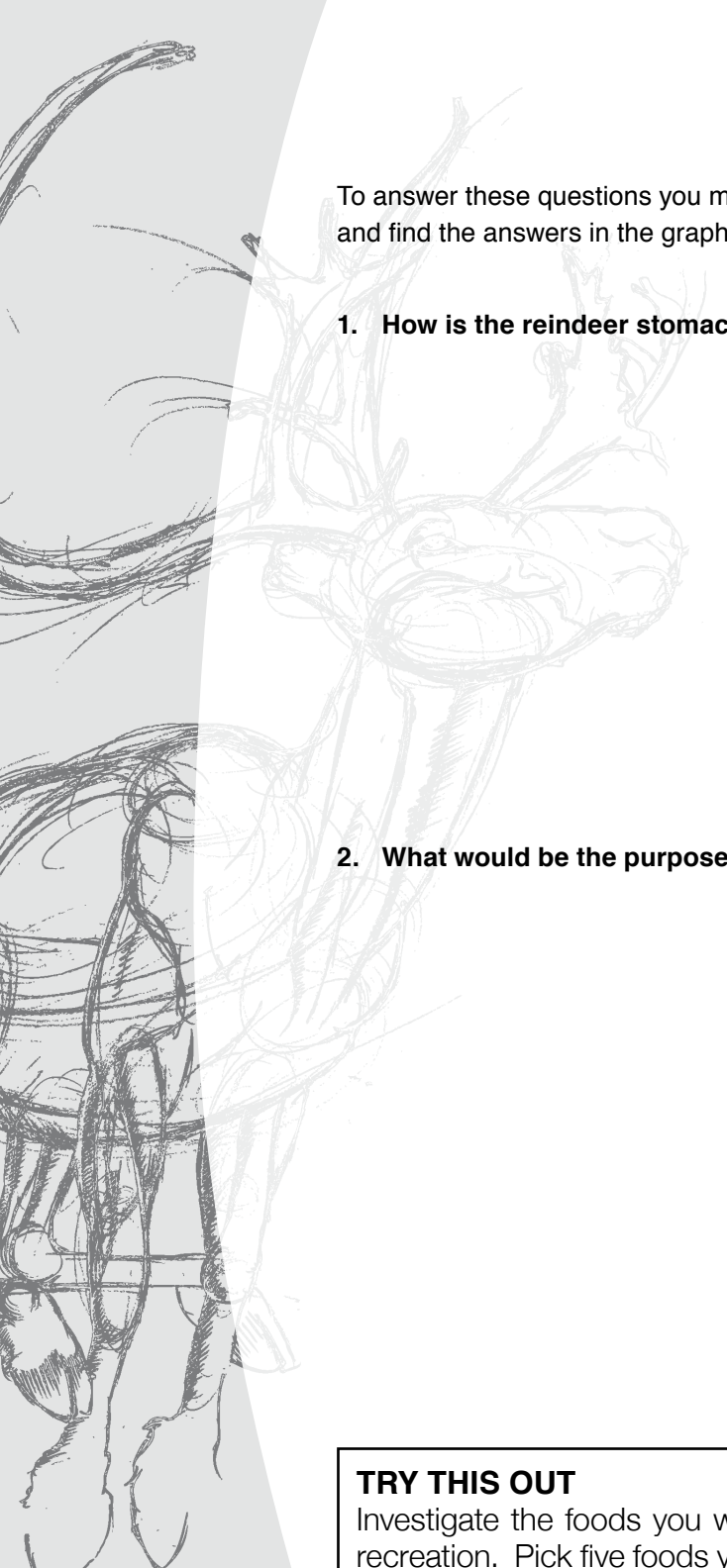
\* Information courtesy of BODY WORLDS Student Guide



<b>Digestive System Part</b>	<b>Physical Changes Occurring</b>	<b>Chemical Changes Occurring</b>
Mouth and Salivary Gland		
Esophagus		
Stomach		
Pancreas, Liver, Gallbladder		
Small Intestine		
Large Intestine		

\* Information courtesy of BODY WORLDS Student Guide





To answer these questions you must locate the reindeer specimen and find the answers in the graphics

1. How is the reindeer stomach different from a human stomach?

2. What would be the purpose for this adaptation?

**TRY THIS OUT**

Investigate the foods you would eat if you needed energy for sports or active recreation. Pick five foods you think would be good sources of energy and conduct your research. Were they good choices?

# GILLS VS. LUNGS:

## Comparison of adaptations

7.12A Investigate and explain how internal structures of organisms have adaptations that allow specific functions such as gills in fish, hollow bones in birds, or xylem in plants.

### ESSENTIAL QUESTION

How are lungs and gills different in functionality?

### LESSON OBJECTIVE

**The student will connect classroom learning with an activity in the museum.** The student will compare/contrast lungs and gills. The student will use the specimens in the exhibit to compare how lungs are different than gills and how shark gills are different than fish gills.

### MATERIALS

Per Student: Museum-School Connection page

### DIRECTIONS

1. Student will complete the Museum-Connection page at the museum.
2. Follow up at school.

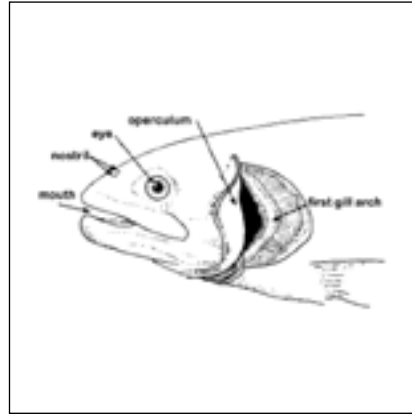
### ACADEMIC VOCABULARY

Gills, lungs, respiratory system, gas exchange, oxygen, carbon dioxide, esophagus, trachea, bronchiole, alveoli

# GILLS VS. LUNGS:

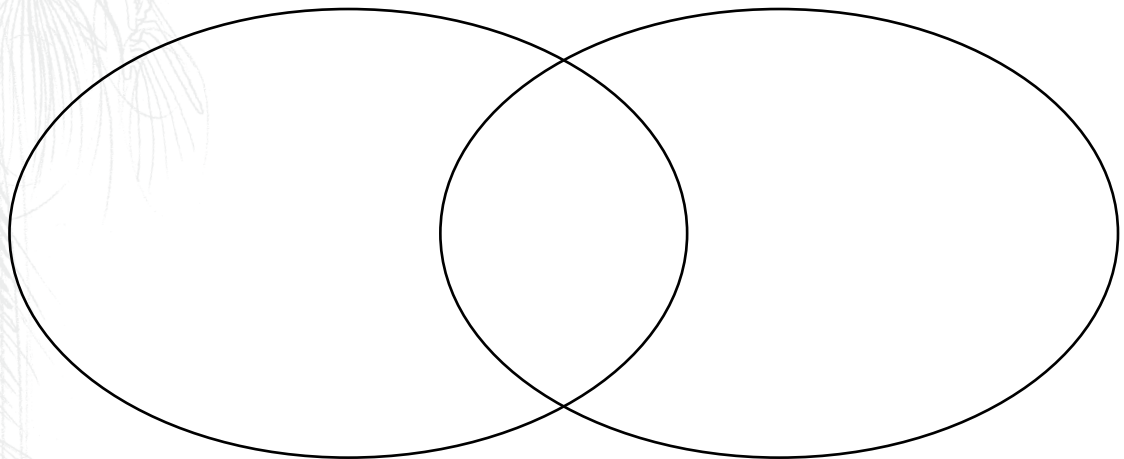
## Comparison of adaptations

LUNGS	GILLS
<ul style="list-style-type: none"> <li>• Air enters through the nose or mouth.</li> <li>• Travels past your esophagus, moistened as it goes down the trachea into the lungs.</li> <li>• As air enters the lungs, lungs expand outward due to contraction of the diaphragm.</li> <li>• Once inside the lungs, air travels through tubes called bronchi.</li> <li>• Then moves into smaller tubes called bronchioles.</li> <li>• Bronchioles get smaller until they reach the alveoli which are sacs the size of a grain of sand.</li> <li>• Oxygen and carbon dioxide exchange takes place at the alveoli.</li> <li>• Oxygen is more abundant in the air.</li> </ul>	<ul style="list-style-type: none"> <li>• Water (contains dissolved oxygen) is forced into the mouth and then to the gills.</li> <li>• Water runs across the gills in order for the gas exchange to take place.</li> <li>• The gill works by providing a surface where the water comes in contact with the blood of the fish.</li> <li>• Gills provide a really large surface area for gas exchange.</li> <li>• Gills contain several filaments to ensure enough oxygen is absorbed.</li> <li>• Oxygen is not as abundant in water as it is in the air.</li> </ul>



**LUNGS**

**GILLS**



In the Venn diagram above, **compare and contrast fish gills and human lungs** (**how are they the same and how are they different?**)

Compare the differences between gills on a shark and gills on a fish. Why do most sharks have to continue to swim in order to breathe? What is missing on a shark that is found on other fish?

# PUMP UP THE VOLUME

7.12B Identify the main functions of the systems of the human organism, including the circulatory, respiratory, skeletal, muscular, digestive, excretory, reproductive, integumentary, nervous, and endocrine systems.

## ESSENTIAL QUESTION

Does the amount of blood a human heart pumps vary with the action or amount of exertion?

## LESSON OBJECTIVE

**The student will connect classroom learning with an activity in the museum.** They will compare the human heart to the hearts of other animals in the exhibit. The student will calculate how much blood their heart pumps by doing different actions. They will then compare their own results to the heart of a cow.

## MATERIALS

Per Student: Museum-School Connection page

## DIRECTIONS

1. Student will complete the Museum-Connection page at the museum.
2. Follow up at school.

## ACADEMIC VOCABULARY

Circulatory system, heart, volume

# How much blood does your heart pump per minute?

This activity will allow you to determine how much blood is pumped out of your **left ventricle** each minute. You will first determine your heart rate by taking your pulse and then use this number to determine the amount of blood your heart pumps. To do this multiply your pulse rate by the volume of blood pumped by your left ventricle (approximately 80 mL). Do this for different levels of activity and compare your results.

## DIRECTIONS

1. First find your pulse on your wrist, count the number of beats for 15 seconds. Multiply this number by 4 (example: 16 beats x 4= 64 Beats Per Minute or BPM). This is your resting heart rate.
2. Now find your heart rate doing different activities and calculate how much blood your heart pumps per stroke and per minute.
3. Formula for blood pumped per minute:  
Multiply BPM x 80 mL (amount of blood pumped per stroke)  
= volume of blood pumped per minute ( example: 64 BPM x 80mL= 5120 mL per minute)

Type of activity	Pulse rate per minute	Amount of blood pumped per stroke	Amount of blood pumped per minute
Sitting, at rest			
Lying on the floor			
After 2 minutes of running in place			



**1. What does “stroke volume” mean?**

**2. What major factors control how fast your heart beats?**

**3. Calculate how much blood your heart pumps in a day:**

Find the bull's heart in the exhibit. A cow's heart pumps approximately 995 ml per stroke.  
If a cow had a resting heart rate of 39 BPM, how much blood would it pump in one minute?

**How does that compare to your heart?**

# BODY SYSTEM

## AMUSEMENT PARK

TEKS7.12B Identify the main functions of the systems of the human organism, including the circulatory, respiratory, skeletal, muscular, digestive, excretory, reproductive, integumentary, nervous and endocrine systems

Readiness Standard     Supporting Standard  
ELPS

### ESSENTIAL QUESTION

How do the body systems interact with each other? How are they affected if one is diseased?

### LESSON OBJECTIVE

The student will make a final product illustrating how the human body systems work together and interact to keep us healthy by creating an amusement park theme for the body systems.

### LEARNING STYLE

Spatial     Auditory/Musical     Linguistic     Kinesthetic  
 Logical     Interpersonal     Intrapersonal

### MATERIALS

Per Student    Requirements for the project



## REQUIREMENTS (must be included in your final product)

1. Map of your park (this can be 2D or 3D). Must be in color.
2. Name of your amusement park.
3. Your name.
4. Map size: Cannot be smaller than 11x17
5. At **least** 3 “items” are in your park that convey the 3 body systems you are describing (must be labeled on map)
6. **Some items you might find in an amusement park:** Rides, concessions (food & drink), facilities (restrooms \*digestive system, emergency station \*white blood cells, park manager office \*brain), transportation (sidewalks, monorail, gondola, train, shuttle bus \*circulatory system), landscaping (plants, fences, landmarks \*integumentary system), employees (custodians, ride operators, security, ticket booth people, maintenance, costumed park characters \*lymphatic system, cells, virus, bacteria), announcement system (speaker, music \*nervous system/mouth/ears), tickets (to get on rides \*transfer of gases, endocrine system).
7. Description of all items in your park (rides, concessions, transportation...) and how it applies to your chosen body systems (must be on a separate sheet of paper). Example: The digestive system starts with the mouth breaking down the food we eat to begin the process of breaking down food to a product our bodies can store. How would you apply these concepts to some item in an amusement park? What would you add to your design that is similar to something you would find in an amusement park?

## ACADEMIC VOCABULARY

Circulatory, respiratory, skeletal, muscular, digestive, excretory, reproductive, integumentary, nervous and endocrine systems, homeostasis

## POSSIBLE QUESTIONS

1. If one body system is diseased, does it ultimately affect the other systems in the human body?
2. Does it take a lot of work for the human body to stay in homeostasis?

## TECHNOLOGY INTEGRATION AND WEBSITES

<http://www.nsta.org/publications/interactive/nerves/> nervous system  
<http://www.anatomyarcade.com/>  
<http://ethemes.missouri.edu/themes/648>

# HAND MUSCLE

## Structure

TEKS- Biology 5.B Examine specialized cells, including roots, stems and leaves of plants; and animal cells such as blood, muscle and epithelium.

Readiness Standard     Supporting Standard  
ELPS

### ESSENTIAL QUESTION

What does the bone and muscular structure of the human hand look like?

### LESSON OBJECTIVE

Students will be able to create a model of the structure of the human hand and identify the functions of muscles, tendons, joints, and ligaments.

### LEARNING STYLE

Spatial     Auditory/Musical     Linguistic     Kinesthetic  
 Logical     Interpersonal     Intrapersonal

### MATERIALS

Per Student    Foam board, markers, 10 pieces of 40cm cut string, 46 cut straw pieces.

### DIRECTIONS

- Have students examine/research images of the bone and muscle structure of a human hand make sketches of the location of the phalanges, metacarpals, carpals, ulna/radius bones, tendons, and ligaments
- Provide students with a piece of foam board, large enough for their hand. Students will trace their hand and wrist on the piece of foam board
- Using the sketches students made earlier, have them carefully draw the phalanges, carpals, metacarpals and part of the ulna/radius on one side of the hand
- Have students color-code the bones for the phalanges, metacarpals, carpals, and ulna
- Using the information from their research, have students mark an X on their hand where the tendons would be on both the front and back of the hand.

## DIRECTIONS

- Have students cut the joints so the phalange sections are separated out
- Have students attach the tendons (straws) to the locations marked on their hand cut out.
- Have students glue muscle (string) to each phalange tip
- Attach the muscle from each phalange through the corresponding tendons
- Have students discuss the relationship between muscle, tendon, and bone
- Have students complete question guide

## ACADEMIC VOCABULARY

Muscles—move the bones

Tendons—connect muscle to bone

Joints—where two bones come together

Ligaments—connect bones to bones

## POSSIBLE QUESTIONS

What are the relationships between muscles, bones, tendons, joints, and ligaments, and what are the functions of each?

## TECHNOLOGY INTEGRATION AND WEBSITES

<http://www.eorthopod.com/content/hand-anatomy>

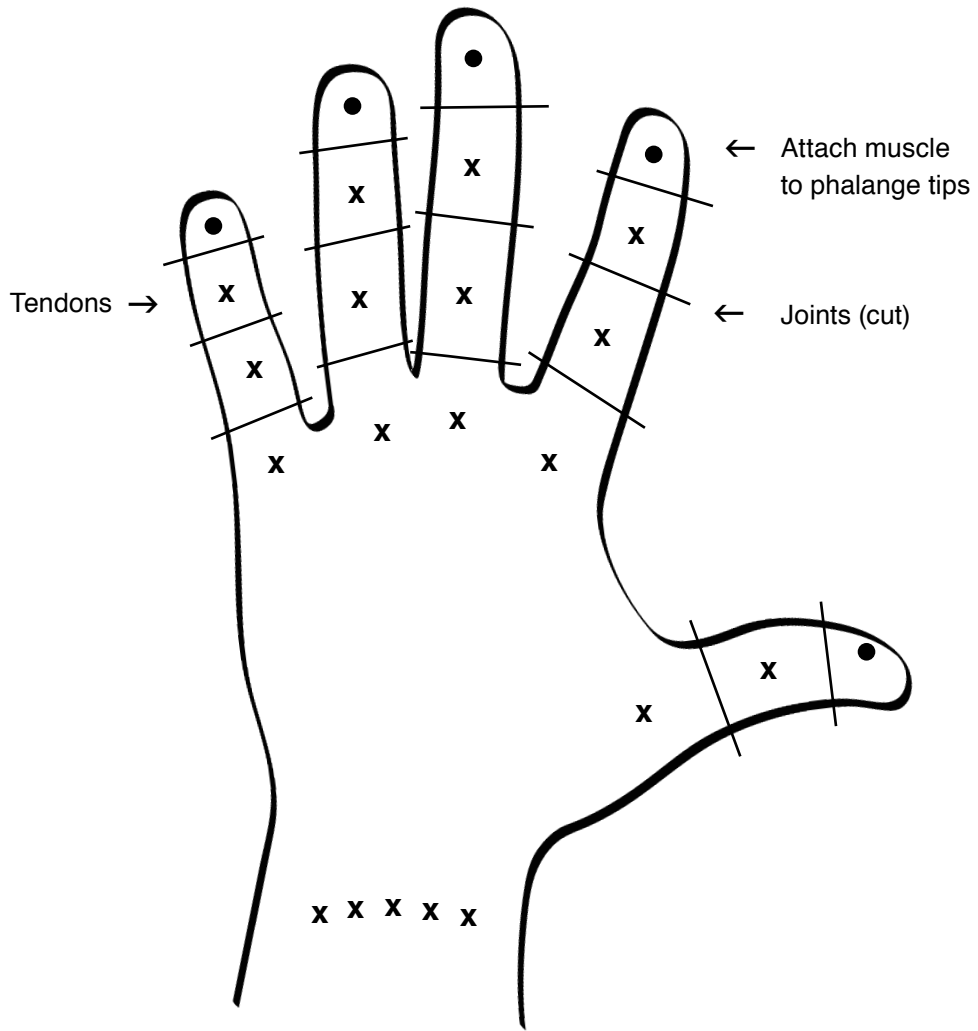
## ACTIVITY MODIFICATIONS

Provide students that need one, a diagram of the hand cut out.

Teacher modeling/demonstration of how to cut out the hand and attach the tendons & muscles.

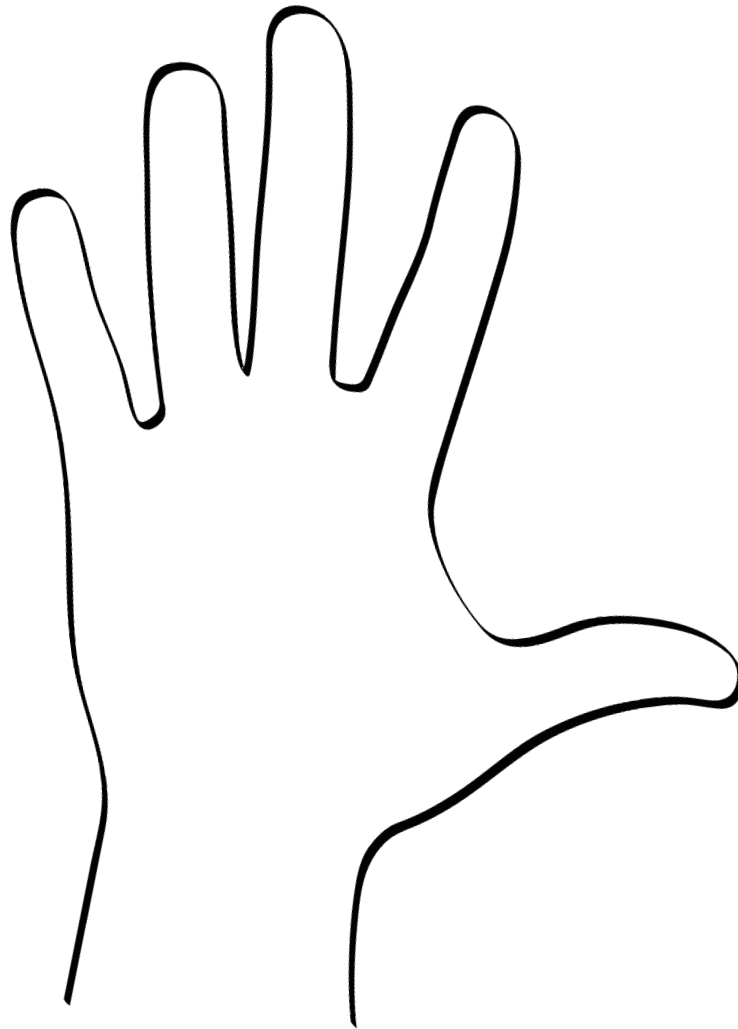
# TEACHER EXAMPLE

## of Hand Cutout



# QUESTION GUIDE

1. Identify the locations of the **phalanges**, **metacarpals**, **carpals**, and **ulna**



# QUESTION GUIDE

2. Describe the relationship between **muscles, bones, tendons, joints,** and **ligaments**

3. Define the functions of the following parts

a. **Muscle**

b. **Tendon**

c. **Joint**

d. **Ligament**

# COMPARING STRUCTURES: Analogy and Homology

TEKS- Biology 7.A Analyze and evaluate how evidence of common ancestry among groups is provided by fossil record, biogeography, and homologies, including anatomical, molecular, and developmental.

Readiness Standard     Supporting Standard

## ESSENTIAL QUESTION

How do homologous structures support the theory common ancestry, and natural selection?

## LESSON OBJECTIVE

Students will be able to observe and record various anatomical structures, compare their similarities to other animals, and determine if the similarities are analogous or homologous.

## LEARNING STYLE

Spatial     Auditory/Musical     Linguistic     Kinesthetic  
 Logical     Interpersonal     Intrapersonal

## MATERIALS

Per Student    Student worksheet, Pen/Pencil

## DIRECTIONS

- Provide students with the “Comparing Structures: Analogy and Homology” worksheet to be completed at their museum visit

## ACADEMIC VOCABULARY

**Homologous Structures**—parts of the body that are structurally and genetically similar to other comparative species’ parts.

**Analogous Structures**—structures that have a similar function, but are not genetically similar

# COMPARING STRUCTURES:

## Analogy and Homology

Animals have many similar characteristics, or traits. By examining these traits, we can determine how closely related species are. There are two ways to classify similar traits among species:

### **Homologous Structures**

parts of the body that are structurally and genetically similar to other comparative species' parts.

### **Analogous Structures**

structures that have a similar function, but are not genetically similar

### **Identify whether each example describes homologous or analogous structures.**

The wings of birds and butterflies

Bone structure of human hand and bat wing

Human eye and squid eye

Hooves of giraffes and sheep



# COMPARING STRUCTURES:

## Analogy and Homology

As you walk through the exhibit, observe the species on display. Note their various structures, how they are used, and what other species has a similar structure.

Record the information in the table below.

<b>Species &amp; Structure Observed</b>	<b>How is the structure used?</b>	<b>What species has a similar structure?</b>	<b>Analogous or homologous?</b>

How do homologous structures support the theory of evolution, common ancestry, and natural selection?

# COMPETITION

## and Pasta Hunters

TEKS- Biology 7.D Analyze and evaluate how the elements of natural selection, including inherited variation, the potential of a population to produce more offspring than can survive, and a finite supply of environmental resources, result in differential reproductive success.

Readiness Standard     Supporting Standard  
ELPS

### ESSENTIAL QUESTION

How do animals use specific anatomical adaptations to survive in their environment?

### LESSON OBJECTIVE

Students will be able to identify how specific traits can be better suited for survival, and how favorable traits are passed from generation to generation.

### LEARNING STYLE

Spatial     Auditory/Musical     Linguistic     Kinesthetic  
 Logical     Interpersonal     Intrapersonal

### MATERIALS

Per Class:    2 packages of spaghetti noodles  
                  7 various utensils (forks, spoons, knives, tweezers, salad tongs, spatula, etc..)  
                  Stopwatch

Per Group:    Graph paper, clipboard (or something to be able to write on while outdoors)  
                  paper cup

Per Student: Paper, pencils

## DIRECTIONS

- In this activity students will be acting as hunters, or predators searching for food.
- Begin class by asking students what characteristics make for a good predator, and what it takes to survive.
- Divide students into 7 groups. Provide each group with a data sheet, graph paper, and one utensil, and paper cup.
- Explain to the students they will be hunters themselves, and their prey is pasta noodles. Have them read the hunting rules. Answer any questions.
- Take the students to an outside area with plenty of space.
- Spread the pasta noodles over a large enough area for your class size
- Give students one minute to use their tool to pick up as many pasta noodles as they can in the allotted time.
- After one minute, groups must count the number of pasta noodles collected.
- The group who collected the least amount of pasta will not survive the next season.
- Count the amount of pasta noodles remaining and double that number for the next round (reproduction).
- Repeat the game until only one group remains.
- Have students come back and discuss their findings.
- What group was able to survive the longest, and why do they think that was?

## ACADEMIC VOCABULARY

### **Inherited traits**

Genetic characteristics passed to offspring by their parents

### **Natural selection**

A process in nature in which organisms with traits better suited to their environment tend to survive and reproduce

### **Adaptation**

The changes in structure or behavior of an organism to allow better chances of survival in it's environment

## POSSIBLE QUESTIONS

1. Which groups had the least favorable variation during the first hunting year?  
How do you know it was unfavorable?
2. Which group had the most favorable variation? Explain.
3. Make a multi-line graph showing the productivity of each tool for each hunting year.  
What variable is on the x-axis? What variable is on the y-axis?
4. How do animals use specific anatomical adaptations to survive in their environments?
5. Using the knowledge gained from this activity,  
relate animal characteristics to their ability to survive in their environment.
6. What are some possibilities that could happen if you placed an animal  
in a foreign environment?

## PROJECTS TO EXTEND LEARNING

The game can be adapted to also discuss the survival characteristics of the prey as well. By using different types of pasta (shape, color, etc.), you can repeat the game including reproducing the number of each type of pasta after each round. Students can then observe and graph the types of pasta that were left after each round, and discuss the possible reasons for why some pasta may have survived better.

# COMPETITION and Pasta People

## Variations of the Pasta People

Your teacher will assign hunting tools that will represent each groups' variations, or differences. Follow these hunting rules:

### Hunting Rules

1. Name your group according to its tool variation.
2. Pasta may not be picked up with hands and fingers—only tools may be used, and all pasta picked up must be placed in your cup.
3. The tools will be used for hunting a population of pasta in a grassy area.
4. There are 250 pasta on the first hunt. At the end of the two-minute hunt, pasta will be counted from each group's cup.
5. The group with the least number of pasta pieces will, sadly, not survive.
6. The extinct group must help with the spreading out of more pasta, because the number of pasta left on the ground will double due to reproduction.
7. The hunting years (trials) will continue until one variation has out-competed all the other variations to extinction.

HUNTING YEAR #1	
Tool/Group	Number of Pasta Collected

Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

**HUNTING YEAR #2**

<b>Tool</b>	<b>Number of Pasta Collected</b>

**HUNTING YEAR #3**

<b>Tool</b>	<b>Number of Pasta Collected</b>

**HUNTING YEAR #4**

<b>Tool</b>	<b>Number of Pasta Collected</b>

Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

**HUNTING YEAR #5**

<b>Tool</b>	<b>Number of Pasta Collected</b>

**HUNTING YEAR #6**

<b>Tool</b>	<b>Number of Pasta Collected</b>

## QUESTIONS

- 1. Which groups had the least favorable variation during the first hunting year? How do you know it was unfavorable?**
- 2. Which group had the most favorable variation? Explain.**
- 3. Make a multi-line graph showing the productivity of each tool for each hunting year. What variable is on the x-axis? What variable is on the y-axis?**



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## QUESTIONS

**4. How do animals use specific anatomical adaptations to survive in their environments?**

**5. Using the knowledge gained from this activity, relate animal characteristics to their ability to survive in their environment.**

**6. What happened to the pasta population as the number of hunter groups declined?**

# WEBSITES FOR ANIMAL INSIDE OUT

<http://science.education.nih.gov/>

[http://www.nlm.nih.gov/research/visible/visible\\_human.html](http://www.nlm.nih.gov/research/visible/visible_human.html)

<http://nationalzoo.si.edu/Animals/default.cfm>

<http://www.elephantnaturepark.org/aboutelephants/anatomy.htm>

<http://www.nsta.org/publications/interactive/nerves/> **nervous system**

<http://evolution.berkeley.edu/evosite/lines/IIbcomparative.shtml> **comparative anatomy**

[http://www.visionlearning.com/library/module\\_viewer.php?mid=68&mcid=&l= penguins](http://www.visionlearning.com/library/module_viewer.php?mid=68&mcid=&l= penguins)

[http://www.ucmp.berkeley.edu/education/lessons/breeding\\_dogs/](http://www.ucmp.berkeley.edu/education/lessons/breeding_dogs/)

<http://www.indiana.edu/~ensiweb/lessons/chr.con2.html> **chimpanzees/humans**

[http://www.ucmp.berkeley.edu/education/lessons/env\\_diffs.html](http://www.ucmp.berkeley.edu/education/lessons/env_diffs.html)

**experimental design with brine shrimp 3-5 grade**

[http://evolution.berkeley.edu/evolibrary/misconceptions\\_faq.php](http://evolution.berkeley.edu/evolibrary/misconceptions_faq.php)

<http://www.exploratorium.edu/cooking/meat/meat-chart.html> **muscle comparison in animals**

<http://sciencecases.lib.buffalo.edu/cs/collection/> **national center for case study teaching**

<http://learn.genetics.utah.edu/content/variation/related/>

<http://learn.genetics.utah.edu/>

<http://www.anatomyarcade.com/>

[http://www.starstriathlon.org/Virtual\\_Instruments.html](http://www.starstriathlon.org/Virtual_Instruments.html)

<http://www.real3danatomy.com/bones/>



# GLOSSARY

## **Adaptation**

A physical or behavioral characteristic that allows organisms to better survive in a particular environment

## **Analogous**

Structures that have a similar function, but are not genetically similar

## **Camouflage**

Coloring or pattern on an animal that helps it blend in with its environment

## **Circulatory system**

The system that circulates blood through the body, consisting of the heart and blood vessels

## **Classification**

The systematic grouping of organisms according to the structural or evolutionary relationships among them

## **Digestive system**

The alimentary canal together with the salivary glands, liver, pancreas, and other organs of digestion.

## **Endocrine system**

The bodily system that consists of the endocrine glands and the hormones that they secrete

## **Environment**

All of the biotic and abiotic factors that act on an organism, population, or ecological community and influence its survival and development.

## **Excretory system**

The systems that excrete wastes from the body. For example, the system of organs that regulates the amount of water in the body and filters and eliminates from the blood the wastes produced by metabolism. The principal organs of the excretory system are the kidneys, ureters, urethra, and urinary bladder

**Function**

Also called physiology and includes the mechanical, physical, and biochemical processes of living organisms

**Habitat**

The area or natural environment in which an organism or population normally lives. A habitat is made up of physical factors such as soil, moisture, range of temperature, and availability of light as well as biotic factors such as the availability of food and the presence of predators

**Hibernation**

Sleep like state in the winter

**Homeostasis**

The tendency of an organism or cell to regulate its internal conditions, such as the chemical composition of its body fluids, so as to maintain health and functioning, regardless of outside conditions

**Homologous**

Parts of the body that are structurally and genetically similar to other comparative species' parts.

**Inherited traits**

A genetically determined characteristic or condition

**Integumentary system**

The body system consisting of the skin and its associated structures, such as the hair, nails, sweat glands, and sebaceous glands.

**Learned traits**

A learned trait is a behavior that an animal develops by observing other animals or being taught

**Ligament**

A sheet or band of tough fibrous tissue that connects two bones or holds an organ of the body in place

**Migration**

Moving from one place to another in a pattern, often to find food

**Muscular system**

All the muscles of the body collectively, especially the voluntary skeletal muscles

**Natural selection**

The process by which organisms that are better suited to their environment than others produce more offspring

**Nervous system**

The system of neurons and tissues that regulates the actions and responses of vertebrates and many invertebrates. The nervous system of vertebrates is a complex information-processing system that consists mainly of the brain, spinal cord, and peripheral and autonomic nerves

**Organism**

An individual form of life that is capable of growing, metabolizing nutrients, and usually reproducing. Organisms can be unicellular or multicellular

**Respiratory system**

The system of organs and structures in which gas exchange takes place, consisting of the lungs and airways in air-breathing vertebrates, gills in fish and many invertebrates, the outer covering of the body in worms, and specialized air ducts in insects

**Skeletal system**

The bodily system that consists of the bones, their associated cartilages, and the joints. It supports and protects the body, produces blood cells, and stores minerals.

**Structure**

An organ or other part of an organism

**Taxonomy**

A system of arranging animals and plants into natural, related groups based on some factor common to each, as structure, embryology, or biochemistry: the basic taxa now in use are, in descending order from most inclusive, kingdom, phylum (in botany, division), class, order, family, genus, and species.