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inspiring discovery

THE BONE ZONE

A Facilitator's Guide to Bones

Our Vision

Canadians recognize that Science[1] is intrinsic to their lives and acknowledge the fundamental importance of a quality Science education to prepare young people for our rapidly changing world.

Our Mission

Let's Talk Science is striving to improve Science literacy through innovative educational programs, research and advocacy. We exist to motivate and empower young Canadians through Science education.

[1]Our Science includes life and physical sciences, technology, engineering and mathematics.

Let's Talk Science,
National Office
1584 North Routledge Park
London, Ontario, Canada
N6H 5L6
Tel: 519-474-4081
Fax: 519-474-4085
Email: info@letstalkscience.ca
www.letstalkscience.ca

Charitable Number:
BN88540 0846 RR0001

Developed by Nancy Lee, Susan Schofield and Margaret Whitehead
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A. Description of Workshop

Grade for Workshop/ Appropriate Age

This activity is designed for use in Grade 3-5 classrooms or with children ages 8 to 11.

Overview of Workshop

Experience our 'bone-ified' activities to discover how our skeletal system provides protection, support and movement through challenges, demonstrations and role-playing activities. Students build a model hand and test it for strength and stability.

Science Topics

- Anatomy
- Nutrition
- Testing Materials
- Structural Strength

Overall Objectives

- To introduce that our skeletal system has 3 functions: support, protection and movement.
- To reinforce that bones are living things.
- To test materials for strength and stability.

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B. How to Run This Workshop

Physical Requirements

You will need an area at the front of the class to do demonstrations. You will need space around the classroom for group activities.

Materials and Set-Up

Note: For more detail, see Kit List

Introduction	Activity #1 – Support Challenge	Demonstrations	Activity #2 – Protection Challenges	Activity #3 – Making a Hand	Activity #4 – Testing the Hand
Picture of bridge	*Toilet paper rolls (2-3 per group)	Glass jar with chicken bone in vinegar	Beach ball	*Cardstock (1 pg. per child)	Ball (1 per group)
Picture of helmet	*Straws (approx. 10 per group)	2 Tongs to hold bone	String	*Coarse string (5 pre-cut at ~45 cm long per child)	Cup (1 per group)
Picture of rollerblades	*Plasticine (2 small balls per group)	Text book (from classroom)	Safety pin	*Straws (Phalanges) (14 pre-cut, 1-1.5 cm pieces per child)	Paper clip (1 per group)
	Text book (from classroom)	*Toilet paper roll	Lightbulb	*Straws (Metacarpals) (5 pre-cut, 2-3 cm pieces – metacarpals)	Elastic (1 per group)
		Toilet paper roll filled with straws	Water balloon	Scissors (20-25)	Styrofoam plate (1 per group)
			Bean bag	Pencils (20-25)	Test hands (1 fun foam and 1 cardboard per group)
			Protection activity Task Cards	*Clear tape (narrow) (20 – 25 rolls)	*Worksheet for testing hand activity
				Poster Task Card for wall at front	
				Sample hands (4) in stages for poster Task Card	
				Tracer hands (4-5)	

***Consumable items**

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Timing of Activity

Part of Workshop:	Suggested Timing:	Cumulative Timing:
General Introduction	5 min.	5 min.
Introduction to Topic	10 min.	15 min.
Activity #1	10 min.	25 min.
Demonstrations	10 min.	35 min.
Activity #2	10 min.	45 min.
Discussion	10 min.	55 min. **(OPTIONAL)**
Activity #3	30 min.	85 min.
Activity #4	20 min.	105 min. **(OPTIONAL)**
Wrap-Up	5 min.	110 min.

C. Introduction to Topic

Objectives of Introduction

- To introduce the three main things bones do for us – support, protect and help us to move.

Suggested Discussion, Q & A

Our body is an incredible machine.
Many things inside our body help this machine to function. Bones are one of these things. There are three main things that bones do for us.
By examining these three pictures, we are going to find out what these are.

(Show picture of BRIDGE.)

What is the purpose of a bridge?
To bring cars from one place to another
Why doesn't it bend in the middle?
Good support

What is another example of something that supports?
Houses, chairs, tables…

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(Show picture of HELMETS.)

What is the purpose of a helmet?
To protect our head

What are some other examples of things that protect?
Eggshell protects egg, varnish protects a table, hockey pads protect our body….

(Show picture of ROLLERBLADING)

What is the purpose of rollerblades/bikes?
To help us move – movement.

What are some other examples of things that help us move?
Cars, scooters,…

Amazingly, the bones of our body do all three things at once – support, protect and help us to move. (use examples to relate our bones to support / protection / movement)

D. Activities

ACTIVITY #1: SUPPORT CHALLENGE (10 min.)
No Task Cards – Oral Instructions

Objective of Activity

- To demonstrate that triangles and cylinders are some of the strongest shapes or structures.
- To relate cylinders to the shape of our bones and the composition of our bones.
- To learn that bones are living things.

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Suggested Instructions, Q & A

What are some of the strongest shapes or structures that you know of?
Hint: What shapes are most bridges and buildings made out of?
Triangles, cylinders

Keep this in mind when you are completing this challenge.

DELIVERY HINT: Form groups of 4-5 that will work together for the entire workshop.

(Hand out a zip-bag with two toilet paper rolls, a ball of plasticine, and approximately 10 straws to each groups.)

Give oral instructions: ***Using the materials provided, can you arrange them in a way to support a text book?***

Debrief through DEMONSTRATIONS

BRIGHT IDEA: While you are debriefing the activities, feel free to add in a "Bone-ified" fact at any time. You can have these written out to post on the board, or just read them to the class. If you don't have time, leave the hand-out with the teacher when you leave.

A) Paper Tube Demo

(Show two paper tubes - one with straws inside and one without.)

Our bones are built like the tube with the straws inside. It's made of a network of fine tubes that blood travels through.

Which one would collapse first if I pressed down on it with a book? Why?
The one without the straws would collapse first because it is not as strong.

Bones are made up of two main layers. The outer layer of bone is hard and sturdy because it is made of crystals of minerals such as calcium. It sets the shape of the

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bone and anchors the muscles. The next layer is made up of little canals that carry veins, arteries, cells and fluid that keep the bones strong and healthy. In the core of your bones is a jelly-like substance called marrow. Bone marrow is vitally important for a healthy body because is makes new red blood cells.

Our bones are almost as tough as cast iron (a frying pan) or concrete, only much lighter!

Why do bones need to be so strong?
To hold our body up

Why do they need to be light?
So they won't weigh us down.

Has anybody ever broken a bone?

B) Chicken Bone Demo

How do you think your bones have changed as you've been growing up?
Bones are living things. When you were born, you had approximately 300 bones. As an adult, you have 206 bones.

What happened to them?
Your bones start fusing together. When babies are born, their skulls can be squished, and when you get older the plates join together.
Wiggle the tip of your nose around. When you are born, your bones are soft like this. They are made of a rubbery substance called cartilage.

(Show chicken bones.)

Why do you think this one is so rubbery?
The acid in the vinegar has leached out the calcium in the bones

Look at how soft your bones would be without calcium. Bones are made of calcium and protein.

Where do you find calcium?
Calcium is found in milk, cheese, broccoli, almonds, sesame seeds….

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ACTIVITY #2: PROTECTION CHALLENGES (10 min.)
Use Protection Task Cards

Objective of Activity

- To demonstrate how our bones protect important organs and body parts.

Suggested Instructions, Q & A

(Go through the instructions on the Task Card with the class.
Hand out object to protect and Task Card to groups.)

DELIVERY HINT: Explain to the students that it is very important to "protect" the object – not just hold it up. Tell them that you should not be able to come around and take the object away from them – it should be well protected.

DELIVERY HINT: If the students do this activity very fast, you can challenge them to try and move with their object as well.

Activity Wrap-Up

(Have students present their challenge by reading their card and explaining how they protected their object. Debrief by explaining how their body parts represented our bones and the objects represented different important body parts.)

What do these objects represent in our bodies?
Suggestions for comparison:
Beach ball – could represent the heart protected by ribs
String – could represent spine/spinal cord protected by vertebrates
Safety pin – could represent the bones in your ear protected by your skull
Light bulb – could represent brain protected by skull

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Water balloon – could represent your bladder protected by you pelvis
Bean bag – could represent your heart/lungs protected by your ribs

What would happen if we didn't have these parts protected?
We could damage these important organs or body parts easily.

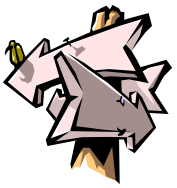
Discussion

You have at least 206 bones.
Everybody feel along your fingers and the rest of your hand and count how many bones you think are in your hand?
How many did you count?
19

There are 8 other "carpal" bones in your wrist, bringing the total to 27.
About half the bones in your body are in your hands and feet!

Bones don't simply work on their own.

- Bones join together to form **joints**.
- The end of each bone is covered by a tough, smooth substance called **cartilage**, that protects the bone surface.
- Our bones are held together by strong stretchy bands called **ligaments**.
- **Tendons** attach **muscle** to bone.



<u>CHOICE</u>: Move on to Activity #3 at this point if you are running out of time or if this discussion does not meet the needs of your provincial curriculum (Alberta). If you skip this discussion, you can spend more time on Activity #4.

Discussion Continued…

(Put these term cards on the board and explain one at a time.)

<u>DELIVERY HINT:</u> Use a model of a bone to point out the various parts you are going to discuss.

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JOINTS

Joints are found where two bones come together.

Can you give me an example of a place in your body where two bones come together?

Elbow, Knee, Hip, Shoulder….

(depending on their answer, go over different types of joints as time permits and have the students move each type of joint on their own body)

- Hinge Joint – works something like the hinge of a door
  (ex. elbow, knuckles, jaw, knee - knee joint is the biggest joint in the body)
  -can only move back and forth

- Ball-and-socket Joint - make a fist with one hand and cup the fingers of the other hand around it to demonstrate
  (ex. shoulders, hips)
  -can swing your arms and legs around in a full circle

- Saddle Joint – can move more freely than a hinge joint but not as much as a ball-and –socket joint
  (ex. thumb, wrist, ankles)
  -allows you to stand on your toes, lean forward and backward, pick up tiny objects such as needles

- Pivot Joint
  (ex. spinal column and bottom of skull)
  -allows us to turn our head from side to side

- Gliding Joint
  (ex. between your vertebrae)
  -allow a small amount of movement as the two flat surfaces glide over each other
  -permits us to twist and bend

- Sutures
  (ex. skull)
  -allow no movement at all

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Some people say they are "double-jointed" because they can move their bones beyond the "normal" range (ex. fingers, thumb, elbow, back…). This is because the ligaments holding their joints together can stretch farther than normal, not because they actually have two joints.

CARTILAGE

There is a tough pad that protects the surfaces of the bones called cartilage. Cartilage is soft bone that has less calcium than hard bone (when you are born, most of your bone is still cartilage).

The tip of your nose is cartilage. Wiggle it around and you can get an idea of what cartilage feels like. Bend your ears – feel the flexibility of the cartilage!
Sharks and rays have no hard bones in their bodies at all. Their skeletons are entirely made up of cartilage.

LIGAMENTS, TENDONS AND MUSCLES

Bones are connected together with stretchy straps called ligaments

What moves our bones?
Muscles

Tendons connect the muscles to the bones.

The muscles that lift your fingers are not in your hand.

Where do you think they are?
They are in your arm, and the tendons come down to your hand.

See if you can see your tendons when you wiggle your fingers. Your fingers would be fat if you had all of these muscles in them!

Place your hand on the desk so your middle finger is tucked in. All your other fingers should be sticking out. Try lifting your thumb, index finger, and pinky. Now try lifting your ring finger. (should be very hard to do)
There is an intertendon connection between your middle finger and your ring finger. This restricts their ability to move on their own.

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ACTIVITY #3: MAKING A HAND (30 min.)
Use Poster Task Card on wall at front

Objective of Activity

- To familiarize students with the bones in your hand, and how they help us to move (our fingers).

Suggested Instructions, Q & A

Instructions for poster task card:

1) Trace your hand and wrist. Make sure to spread your finger out! Cut it out.
2) Tape 3 phalanges to one finger. ***Use the tape <u>across</u> the straw! Leave space between the straws.***
3) Do this for each finger. **The thumb only has 2 phalanges.**
4) Tape 5 metacarpals to the palm of the hand.
5) Take one piece of string. Tie a knot in the end.
6) Thread the string through the phalanges and out the metacarpal.
7) Using new pieces of string, do the same thing for each finger.
8) Pull the strings at your wrist to make the fingers move.

<u>DELIVERY HINT</u>: Explain each step on the Poster Task Card before students begin activity.

<u>DELIVERY HINT</u>: Put examples of 4 "stages" of making the model hand up beside the Poster Task Card.

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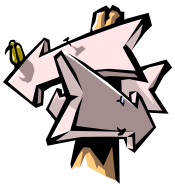
BRIGHT IDEA: Have a hand tracer or pre-photocopied hands available for students who have smaller hands or find tracing and cutting difficult.

(Hand out materials and put Poster Task Card and 4 stages of model hands on wall at the front of the classroom.)



CHOICE: This next activity may be omitted or shortened if time becomes an issue. Alberta facilitators should be sure to include this as it relates directly to the curriculum.

ACTIVITY #4: TESTING THE MODEL HANDS (20 min.)
Use Bone Zone Worksheet

Objective of Activity

- To investigate properties of different materials and to test for strength and stability.

Suggested Instructions, Q & A

(Have a zip-bag of a set of materials and a stack of worksheets and pencils ready at the front for each group to pick up when they are ready to start testing.
Go over instructions for worksheet with students as they complete their model hands.)

Activity Wrap-Up

Which materials were easiest to pick up? Which were the hardest?
Does your model hand work as well as your own hand? Why not?

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E. Wrap-Up

We spent a lot of time talking about our bones.
How do we keep our bones healthy?
Calcium, good posture, stretching before physical activities

Where do you find calcium?
Milk, cheese, broccoli, almonds, sesame seeds….

Everyone stand up.
Remember the three things our bones do – SUPPORT, PROTECTION, MOVEMENT.
Now imagine yourself without bones. (collapse)

- *What was your favourite activity today?*
- *Do you think Science is fun?*
- *Do you like Science?*
- *Do you have any questions for me?*

F. Glossary

Blood Vessels
A tubular structure through which blood flows.

Bone
The hard connective tissue of which the skeleton of most vertebrates is formed.

Bone Marrow
A soft tissue contained within the central cavity and internal spaces of a bone.

Calcium
An essential element for living organisms that is required for normal growth and development. In animals it is an important part of bones and teeth and is present in the blood because it is required for muscle contraction and other metabolic processes.

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Cartilage
A tough connective tissue which is softer than bone as it does not contain as many mineral salts. Cartilage is found on the ends of bones where they meet in a joint.

Distal
Describing the part of an organ that is farthest from the organ's point of attachment to the rest of the body. For example, the hands and feet are at the distal ends of arms and legs, respectively.

Joint
The point of contact between two (or more) bones, together with the tissues that surround it.

Ligament
A tough elastic structure of tissue that connects bones together at movable joints.

Metapcarpal
The bones that make up the hand that articulate with the bones of the wrist and those of the fingers.

Muscle
A special elastic tissue that contracts or relaxes to produce movement.

Phalange
The bones that make up the digits of the hand or foot. They articulate with the metacarpals of the hand or with the metatarsals of the foot.

Proximal
Denoting the part of an organ that is nearest to the organ's point of attachment. For example, the knuckles are at the proximal end of the fingers. **(Medial is in the middle)**

Red Blood Cells
The most numerous type of blood cell, which contains the red pigment haemoglobin and is responsible for oxygen transport.

Synovial Fluid
A liquid secreted by the synovial membrane which lubricates a joint and reduces friction between the bones where they are moving.

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Synovial Membrane
The lining of the sac which surrounds a movable joint.

Tendons
A tough tissue that connects a muscle to a bone.

White Blood Cell
Colourless blood cells with a nucleus which are important in defence against disease.

G. Background Information

Bone Formation
When you are born, your bones are soft. They are made of a rubbery substance called cartilage. Soon after birth, bones begin to harden. Your body begins to coat the bones with layers of calcium phosphate, which is obtained from milk. It is deposited on the bone from the centre and builds outward. This process is called calcification.

Your bones are alive. Like other parts of your body, they take in food through the blood, grow, and are repaired.

30% of bone is living tissue, cells, and blood vessels.
45% of bone is mineral deposits, mostly calcium phosphate. This material gives bones their hardness.
25% of bone is water.

Classification of Bones
Bones come in many sizes and shapes. The shape of each bone fills a particular need. The femur, for example, must withstand great weight and pressure, and its hollow cylindrical design provides maximum strength with minimum weight.
Bones are classified by their shape as long (humerus), short (carpals of wrist), flat (skull, ribs, sternum), or irregular (vertebra, hip bones).

Bone Composition
Bones make up only 1/5 - 1/7 of a person's body weight. Bones are hard and strong but they are light because they are not solid. A living bone consists of three

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layers: the periosteum, or outside skin of the bone; the hard compact bone; and the bone marrow. If we were to cut a living bone in half, we would see that it contains various layers. First is a layer of thin, whitish skin which is packed with nerves and blood vessels and supplies the cells of which the hard bone below is built. Next is a dense, rigid bone called the compact bone. It is shaped like a cylinder and is so hard that surgeons must use a saw to cut through it. It is honeycombed with thousands of tiny holes and passageways, through which run nerves and blood vessels that supply oxygen and nutrients to the bone. This dense layer supports the weight of the body and is made up of mostly calcium and minerals, so that it feels no pain. The "skin," however, is very sensitive, so that when a bone is broken, injured nerve fibers run through the compact bone and send messages which relay the pain signals to the brain. If we cut though the compact bone, we find that its cylinder surrounds and protects the spongy bone marrow which contains a material much like gelatin. This marrow produces either red blood cells (which carry oxygen), white blood cells (which fight infection), or platelets (that help stop bleeding). These three bone layers work together with nerve signals which speed back and forth and with blood streams which move between the layers. Thighbones are usually stronger, pound for pound, than reinforced concrete.

The Skeletal System – an overview

The average human adult skeleton has 206 bones joined to ligaments and tendons to form a protective and supportive framework for the attached muscles and the soft tissues which underlie it. The skeleton has two main parts: the axial skeleton and the appendicular skeleton. The axial skeleton consists of the skull, the spine, the ribs and the sternum (breastbone) and includes 80 bones. The appendicular skeleton includes two limb girdles (the shoulders and pelvis) and their attached limb bones. This part of the skeletal system contains 126 bones, 64 in the shoulders and upper limbs and 62 in the pelvis and lower limbs. There are only minor differences between the skeletons of the male and the female: the men's bones tend to be larger and heavier than corresponding women's bones and the women's pelvic cavity is wider to accommodate childbirth. The skeleton plays an important part in movement by providing a series of independently movable levers, which the muscles can pull to move different parts of the body. It also supports and protects the internal body organs. The skeleton is not just a movable frame; it is an efficient factory which produces red blood cells from the bone marrow of certain bones and white cells from the marrow of other bones to destroy harmful bacteria. The bones are also a storehouse for minerals - calcium, for example - which can be supplied to other parts of the body. Babies are born with 270 soft

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bones - about 64 more than an adult; many of these will fuse together by the age of twenty or twenty-five into the 206 hard, permanent bones.

Broken Bones and Splints

As rugged as our bodies are, they are often susceptible to painful and disabling injuries such as strains, sprains, dislocations and fractures. When sudden pressure pulls a bone out of its socket at the joint, the injury is called a dislocation. When a bone actually breaks, it is called a fracture and these may vary in seriousness. The older a person is, the longer it takes for a bone to heal; a child may recover within a few weeks and an elderly person may take several months. At all ages, some bones will heal faster than others. An arm may heal in a month, but a leg may take up to six months. Once a bone mends, it is usually stronger along the fracture line than it was before the break. Fractures of the bone are classified in two categories: the simple fracture and the compound fracture, in which the skin is pierced and the flesh and bone are exposed to infection. A bone fracture begins to knit almost as soon as it occurs, so it is important that the bone be set as quickly as possible. If the victim must be moved and no medical help is available, it is also important for a "splint" to be applied to prevent movement of the fractured limb.

Joints, Ligaments and Cartilage

A need for strength makes the bones rigid, but if the skeleton consisted of one solid bone, movement would be impossible. Nature has solved this problem by dividing the skeleton into many bones and creating joints where the bones intersect. Joints come in a variety of designs, each especially built for the limb it serves. Joints permit bodily movement and are held together by fibres called "ligaments". Joints are "oiled" continuously to prevent friction. Some joints, like those connecting the skull's series of bones, allow no movement. Others may permit only limited movement; the joints in the spine allow some movement in several directions. Most joints have a greater range of movement, and these are called "synovial" joints. The skeleton is made up of many kinds of movable joints. The bearing surface is made smooth by slippery cartilage to reduce friction. Larger joints are lubricated by "synovial" fluid. Connections called "synovial" joints are sturdy enough to hold the skeleton together while permitting a range of motions. The ends of these joints are coated with cartilages which reduce friction and cushion against jolts. Between the bones, in a narrow space, is the joint "cavity", which gives us freedom of movement. Ligaments then bind these bones to prevent dislocations and limit the joint's movements. The bones are held in position and controlled in movement by the ligaments.

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A ligament is a tough band of white, fibrous, slightly elastic tissue. This is an essential part of the skeletal joints; binding the bone ends together to prevent dislocation and excessive movement that might cause breakage. Ligaments also support many internal organs; including the uterus, the bladder, the liver, and the diaphragm and they help in shaping and supporting the breasts. Ligaments, especially those in the ankle joint and knee, are sometimes damaged by injury. A "torn" ligament usually results from twisting stress when the knee is turned while weight is on that particular leg. Minor sprains are treated with ice, bandages and sometimes physical therapy, but if the ligament is torn, the joint may be placed in a plaster cast to allow time to heal, or it may require surgical repairs. If a ligament is made up of several thick bands of fibrous branches, it is called a "collateral ligament". The word "ligament" comes from the Latin word, "ligamentum", meaning a band or tie.

H. Suggested Resources

Websites

Inner Learning Online
www.innerbody.com

A Look Inside the Human Body
http://www4.tpgi.com.au/users/amcgann/body/

Introductory Anatomy: Bones
http://www.leeds.ac.uk/chb/lectures/anatomy3.html

Gross Anatomy: At the University of Arkansas for Medical Science
http://anatomy.uams.edu/HTMLpages/anatomyhtml/bones.html

Books

Allison, L. (1976). Blood and Guts – A Working Guide to Your Own Insides.
California: Yolla Bolly Press.
ISBN: 0-316-03442-8

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Stein, S. (1992). The Body Book. New York: Workman Publishing Company.
ISBN: 0-89480-805-2

Posters

The Skeletal System – Trend Enterprises
From Scholar's Choice – T-38093 ($3.29)

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