Teachers in Residence

The Musculoskeletal System

Secondary Level Lesson Plan

Research Ireland Centre for Medical Devices

Taighde Éireann Research Ireland

"Breaking Barriers"

THE PHILOSOPHY BEHIND OUR LESSON PLANS

Teachers participating in CÚRAM's Teachers in Residence programme have developed a 'learning module' on MedTech in Ireland that links with multiple streams and themes in the primary and junior cycle curricula. The primary and secondary lesson plans were created **by teachers for teachers** and are accessible online to use in classrooms all over the world.

During their residencies, teachers developed the contents of the lesson plans by working directly with CÚRAM researchers, while learning about the medical devices research being carried out at CÚRAM. Primary teachers were paired with secondary teachers to create plans covering five major themes: biomaterials, heart, brain, musculoskeletal system and stem cells. The partnership between the primary and secondary teachers ensured that the materials created follow a natural progression from one age group to the next.

The lesson plans were further designed and formatted by a Visual Artist who used various teaching methodologies to suit the multiple intelligences and range of learning styles and abilities present in classrooms. By using a range of teaching approaches we hope to engage all children at all levels whatever their natural talents or interests may be.

All presentations, lesson plan booklets and optional resources are free to download at: https://curamdevices.ie/public-engagement/teachers/. We hope that you and your students find these resources an enjoyable way to learn about our research centre and the MedTech industry!

Sincerely,

Dr. Sarah Gundy

Programme Manager-Teachers in Residence

Musculoskeletal System Lesson Plan

Junior Cycle Science Curriculum Links

Strand One: The Nature of Science

Element:

Understanding about Science

Students should be able to:

1. *Appreciate* how scientists work and how scientific ideas are modified over time.

Element:

Investigating in Science

Students should be able to:

3. *Design, plan* and *conduct* investigations; *explain* how reliability, accuracy, precision, fairness, safety, ethics and selection of suitable equipment have been considered.

Element:

Science in Society

Students should be able to:

10. *Appreciate* the role of science in society; and its personal, social and global importance; and how society influences scientific research.

Strand Five: Biological world

Element:

Systems and Interactions

Students should be able to:

6. *Evaluate* how human health is affected by: inherited factors and environmental factors including nutrition; lifestyle choices.

Element:

Sustainability

Students should be able to:

9. *Discuss* medical, ethical, and societal issues.

Learning Outcomes

Children should be enabled to:

1. Identify the main parts of the human skeleton and state the main functions of the musculoskeletal system.
2. Describe the general structure and action of muscles (working in opposition).
3. State the function of tendons and the relationship between these and bones.
4. Outline some of the problems arising in the musculoskeletal system and describe possible methods of treatment.
5. Appreciate what a medical device is.
6. Construct a paper model of the human hand.
7. Problem-solve ways of how to fix a tendon that has been cut in the hand.

8. Demonstrate the relationships between bones, tendons and muscles by use of model.
9. Appreciate that the suitability of biomaterials are based on the properties of the biomaterials and their ability to match the original tissue.

Keywords and Definitions

	Keyword	Definition
1.	**Bones**	Make up the skeleton and provide support and protection to the body.
2.	**Long bone**	Bones that support the weight of the body and facilitate movement. (Femur, tibia, humerus)
3.	**Short bone**	Bones that provide stability and some movement. (Carpals and tarsals)
4.	**Irregular bone**	Bones that have a complex shape, which help to protect internal organs. (Vertebrae, sacrum, coccyx)
5.	**Flat bone**	Bones that protect internal organs. (Sternum, scapula, ribs)
6.	**Osteogenic cells**	Bone cells that develop into osteoblasts. The only bone cells that divide.

7.	**Osteoblasts**	Bone cells that make and secrete a collagen matrix and calcium salts. Responsible for forming new bones.
8.	**Osteocytes**	Osteoblasts that have become trapped in the matrix they have secreted. The most common and mature type of bone cell.
9.	**Osteoclasts**	Bone cells that break down and reabsorb bone.
10.	**Muscle**	Tissues that contract and lengthen to make the body move.
11.	**Flexion**	The movement that decreases the angle between two bones. Opposite of extension.
12.	**Extension**	The movement that increases the angle between two bones. Opposite of flexion.
13.	**Antagonistic pairs**	Pairs of muscles that contract (agonist) and relax/lengthen (antagonist) together to start or stop movement.
14.	**Agonist**	The contracting muscle of an antagonistic pair.
15.	**Antagonist**	The muscles that oppose the force of movement of the agonist muscles.
16.	**Joint**	Where bone connects with bone. Joints allow for different types of movement.

17.	**Pivot joint**	Allows rotational movement. Found between the C1 (atlas) and C2 (axis) vertebrate.
18.	**Hinge joint**	Allows swinging movement. Found in the elbow, ankle, and knee.
19.	**Saddle joint**	Similar to hinge joint, but allows more range of motion. Found in the thumb.
20.	**Plane joint**	Allows sliding movement. Found between the small bones of the wrists (carpals) and ankles (tarsals).
21.	**Ball-and-socket joint**	Allows movement in three planes and is the most mobile type of joint. Found in the hip and shoulder.
22.	**Condyloid joint**	Allows movement similar to ball-and-socket joint without rotation. Found in the wrist.
23.	**Ligament**	Connective tissue that connects bones with bones.
24.	**Cartilage**	Connective tissue that covers and protects the ends of bones at joints.
25.	**Tendon**	Connective tissue that connects muscles to bones.
26.	**Strain**	An overstretched or torn muscle.
27.	**Sprain**	An overstretched or torn ligament.

28.	**Arthroscope**	Flexible tube with a camera that can be inserted into the body.

Learning Activities

Children will:

- Complete The K and W parts of the KWL Chart.
- Engage in talk and discussion on the musculoskeletal system.
- Participate in a group activity to construct a model hand and repair it using a selection of materials.
- Present their work to the class.
- Engage in talk and discussion on biomaterials and medical devices.
- Evaluate their work.
- Fill in the L Part of the KWL Chart.

Extra Info / Files

	Web Address	Brief Description
1.	www.youtube.com/watch?v=94Q-fvCAJzQ	"Muscle Basics: What Athletes Need to Know About the Muscular System"
2.	www.youtube.com/watch?v=0vlLiPT_Otw	"Bone Basics: How They Heal and How to Keep them Healthy"

3.	www.youtube.com/watch?v=hdes6W76OOw	"The Basic Science of Tendons and Tendinitis"
4.	theinteractivehand.worldsecuresystems.com/	Website exploring the hand including tendons and bones.
5.	www.innerbody.com/image/skel13.html	2D and 3D views of the hand

Resources Provided

- Teacher Lesson Plan
- PowerPoint to guide lesson
- Hand template
- Interactive KWL worksheet
- Evaluation worksheet
- Optional: "Mending Legends"-A 26 minute documentary produced by CÚRAM exploring the physical and psychological impact of tendon injuries amongst sports players, and highlighting the progressive attitudes towards scientific research in Ireland. A trailer to the film can be viewed using the following link: https://vimeo.com/189779551.
  The film is available on request by contacting Sarah at sarah.gundy@nuigalway.ie.

Materials Needed

- Hand template printed out on thicker paper (can use regular paper)
- Scissors
- String
- Straws (large)
- Tape
- Toothpicks
- Paperclips
- Thread, yarn or ribbon
- Ice lolly sticks
- Elastic bands
- Pipe cleaners

Instructions

- Divide the class into groups of two, three or four depending on class size and amount of materials.
- Each student is given a hand template, scissors, string, a straw and tape.
- Each student or group of students is given a "Biomedical Engineering Kit" containing any assortment of the following: Toothpicks, paperclips, thread, yarn, ribbon, ice lolly sticks, elastic bands, pipe cleaners, and/or string.
- Each student cuts out the hand following the dashed lines on the hand template.
- The students cut up a straw into three pieces to fit onto the bones of the finger.

    - Make sure the students cut the straws small enough in order to leave enough space between them when they are taped to the paper finger!
- The students tape a piece of string to the red bone at the tip of the finger.
- The students put the string through the three pieces of cut up straw.
- The students tape the three pieces of cut up straw to the blue, green and yellow bones of the paper finger.
    - Make sure the students leave a big space between the straws!
    - Make sure the students do not tape the string!
- The students bend the paper between the straws for the finger to move easier.
- The students repeat the procedure for the remaining fingers.
- Once the hand is finished, the students use scissors to cut the string between two straws on a finger.
    - The cut to the string acts like a damaged tendon.
- The students repair the "tendon" using the biomaterials available in the "Biomedical Engineering Kit".
- Option: Hand templates can be cut out, and string and straws can be cut up for students ahead of the lesson to make it a bit easier or save time.

Teachers' Tips

- Students should construct the hand one finger at a time. That way if time is running short they will still have a finger to damage and repair.
- If available, a three dimensional model of the skeleton is beneficial for the lesson.
- There is no right or wrong answer to how the students fix their tendon. The idea is to get them thinking about what materials would be appropriate to maintain movement in the finger.
- Some students just use another piece of string to fix the tendon which is perfectly acceptable and is analogous to a tendon replacement using the palmaris longus as discussed in the PowerPoint presentation!

Methodologies

- Talk and discussion
- Active learning
- Guided and discovery learning
- Collaborative learning
- Free exploration of materials
- Investigative approach

Assessment

- Self-assessment – evaluation worksheet
- Teacher observation – construction of medical devices
- Teacher questioning – KWL, talk and discussion

Linkage and Integration

- **Maths** – problem solving
- **STEM** – I.T. / Engineering
- **Art** – construction
- **S.P.H.E.** – working together co-operatively
- **English** – oral language through talk and discussion and presenting their work

Differentiation by:

- Teaching style
- Support
- Task

PowerPoint Presentation – Musculoskeletal System

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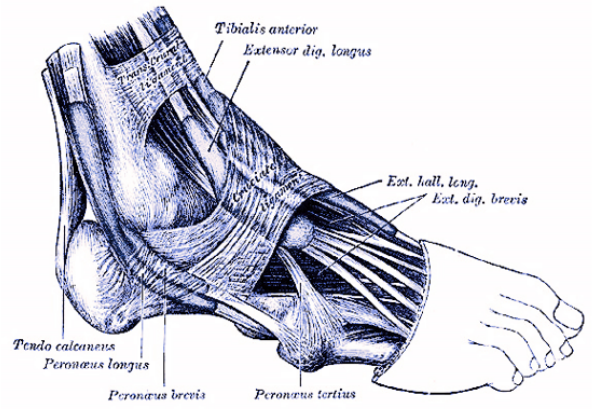
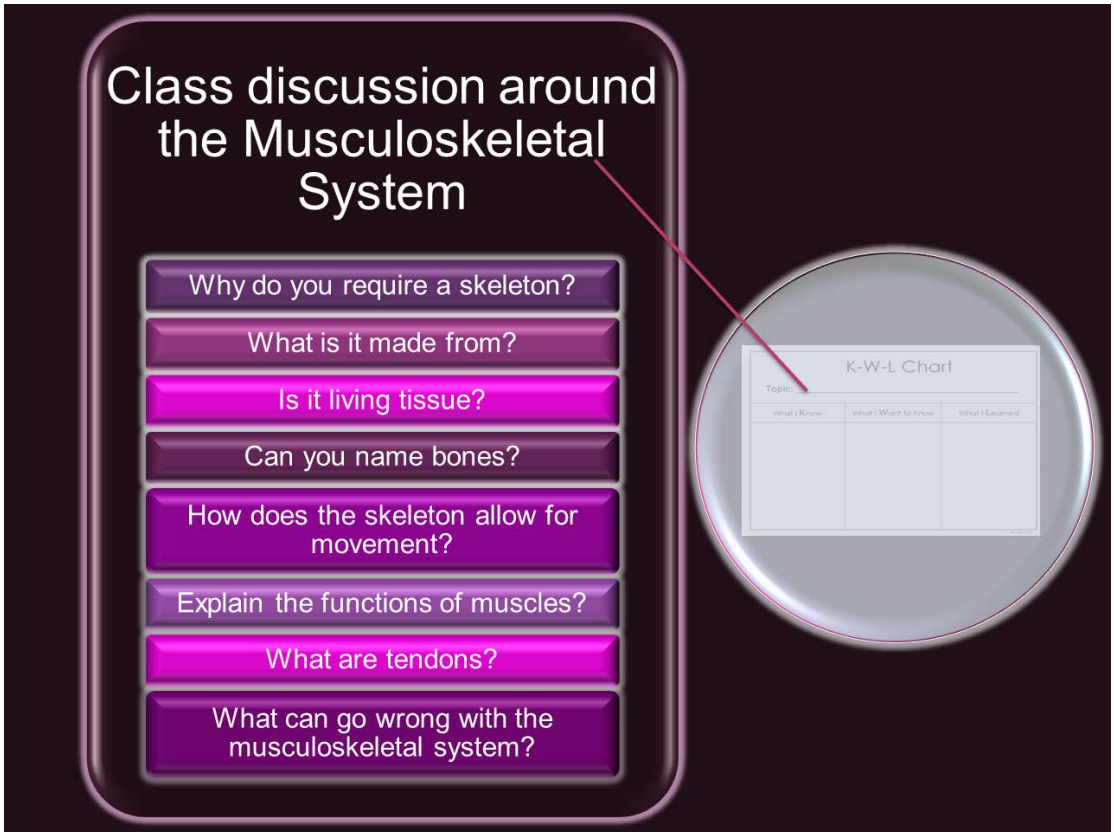


cúram
SFI Research Centre for Medical Devices

Teachers in Residence Programme
Andrew Fogarty and Clive Monahan

Slide 2



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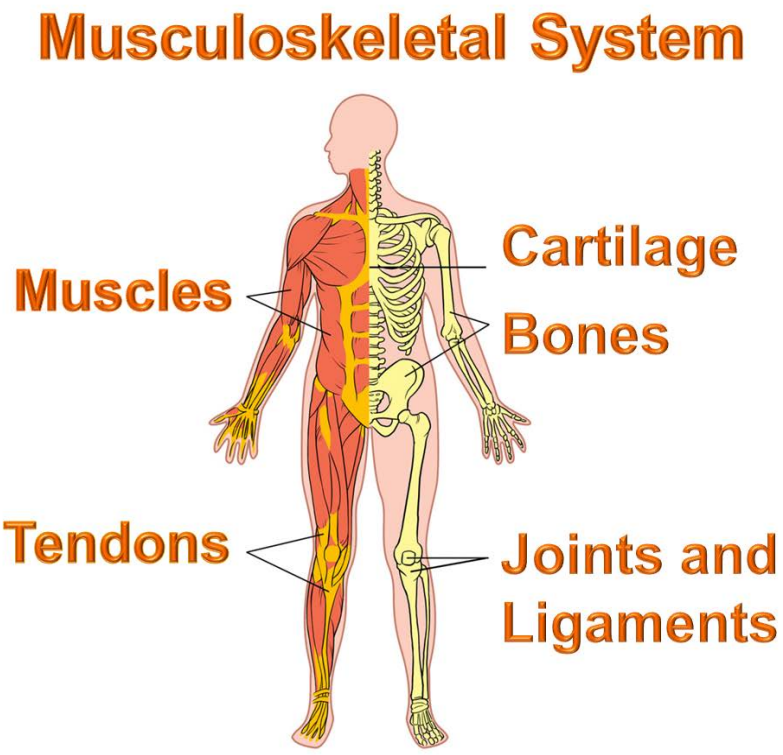

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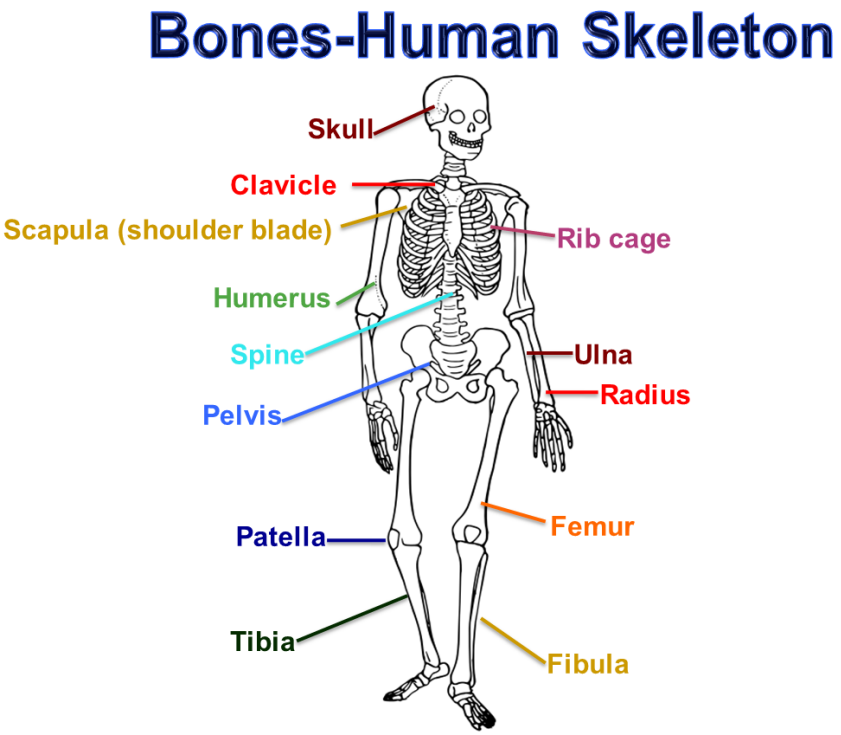

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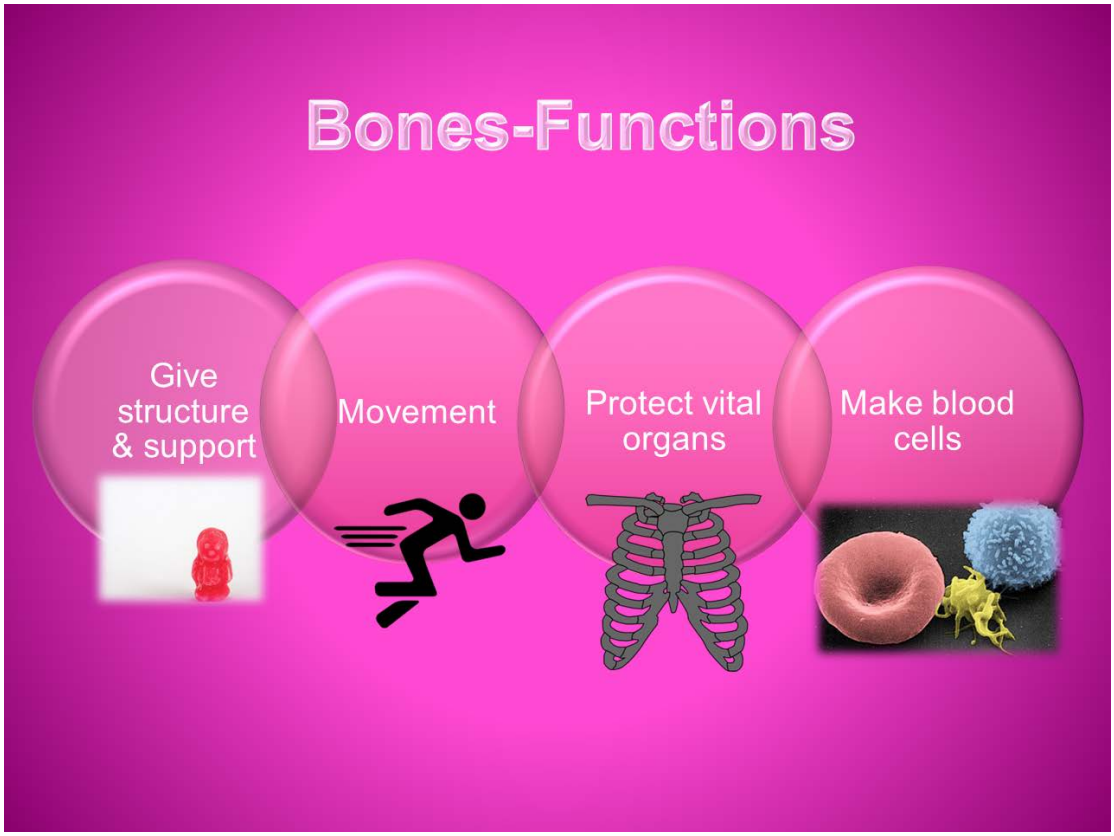

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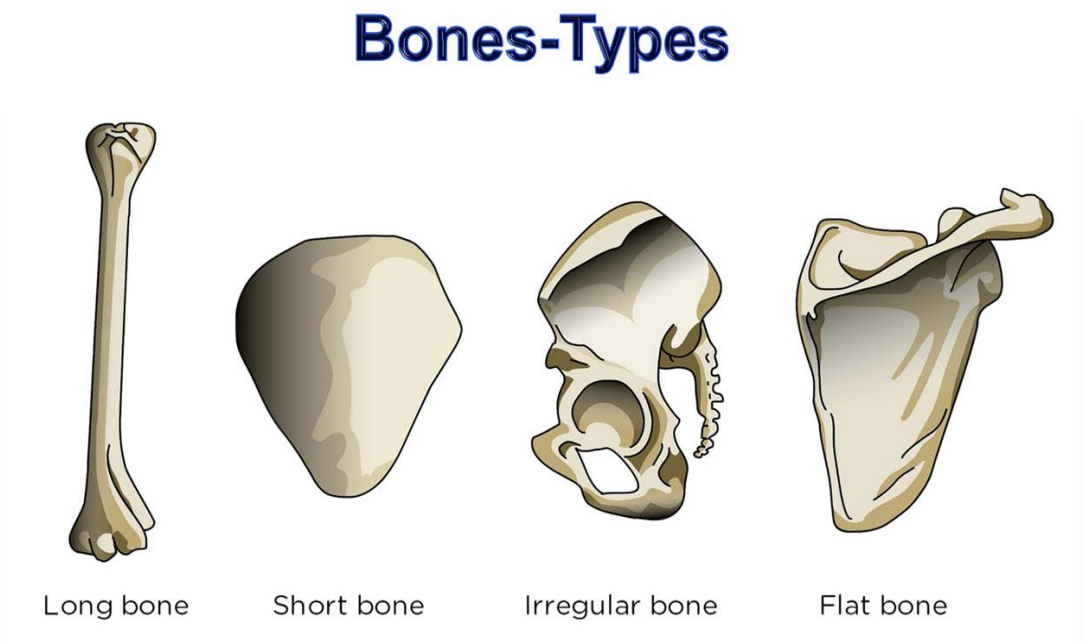

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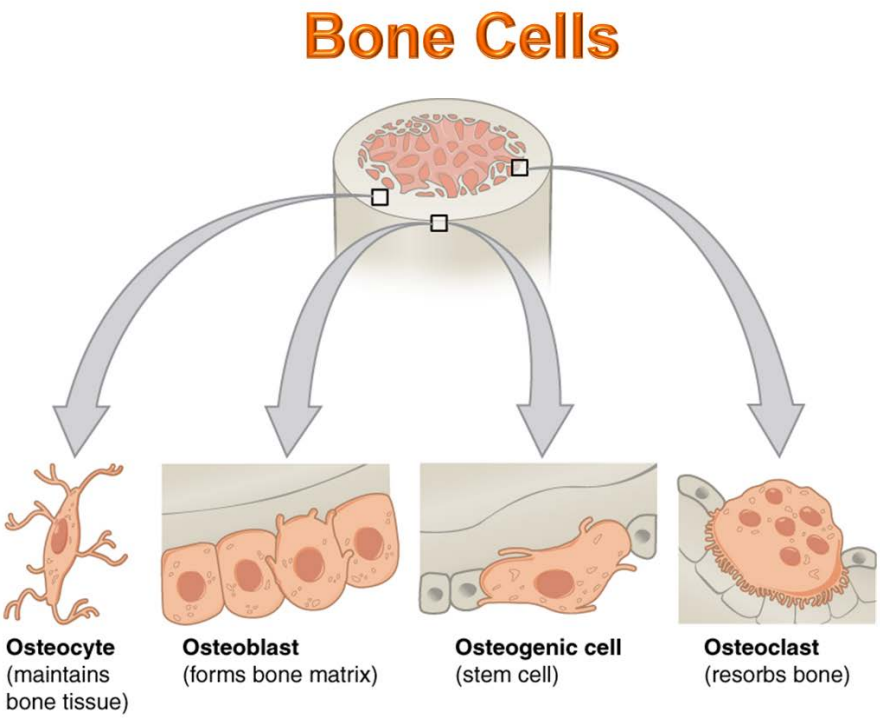

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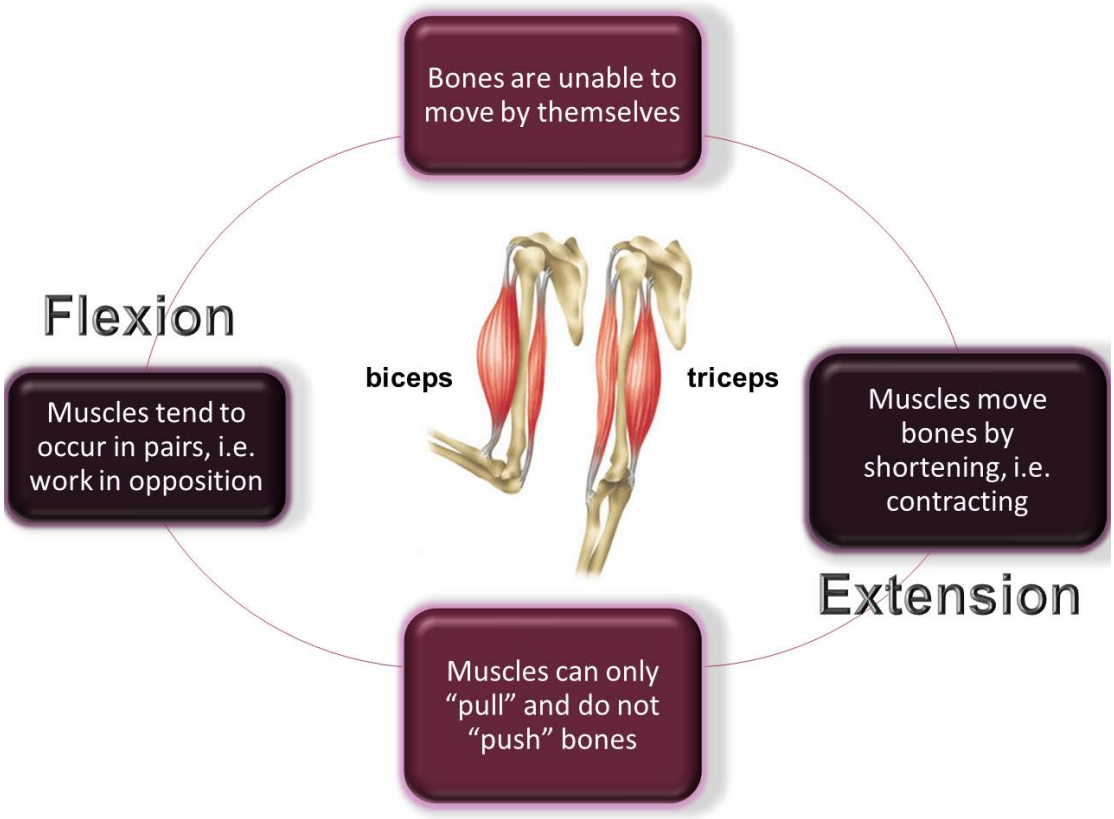


Slide 10

Muscles-Antagonistic Pairs

Biceps (Agonist)

As you bend your elbow and raise your forearm which muscle is contracting?

As you straighten your elbow and lower your forearm which muscle is contracting?

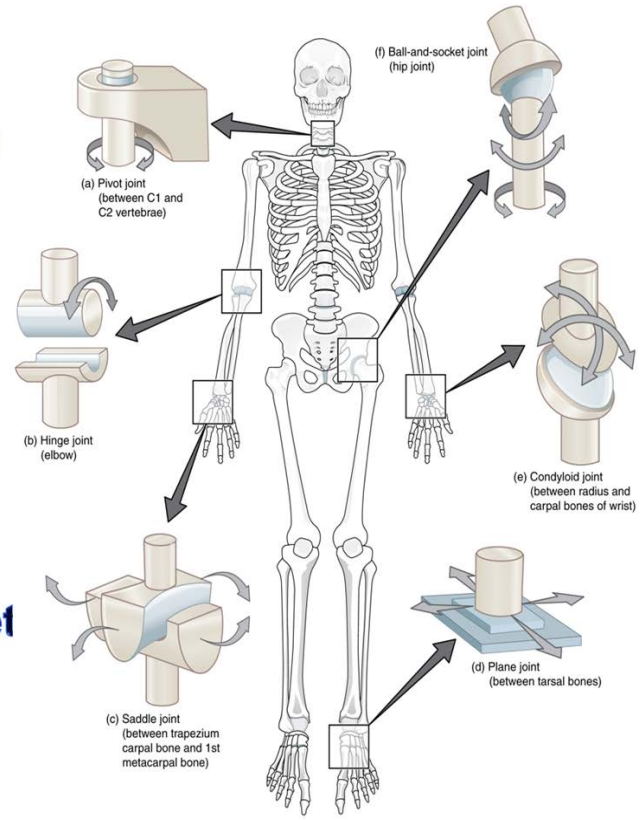
Triceps (Agonist)

What are the antagonist muscles and what are they doing?

Slide 11

Joints

- Connect bones to bones
- Six types:
  - Pivot
  - Hinge
  - Saddle
  - Plane
  - Condyloid
  - Ball-and-Socket



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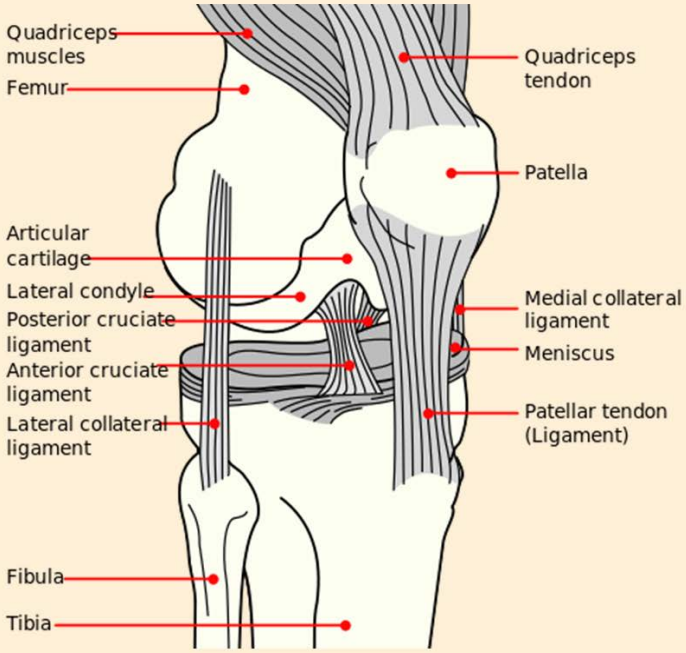
Joints-Cartilage and Ligaments



Slide 13

Tendons-Connect Muscles to Bones

Slide 14

Do you have this tendon in your wrist?

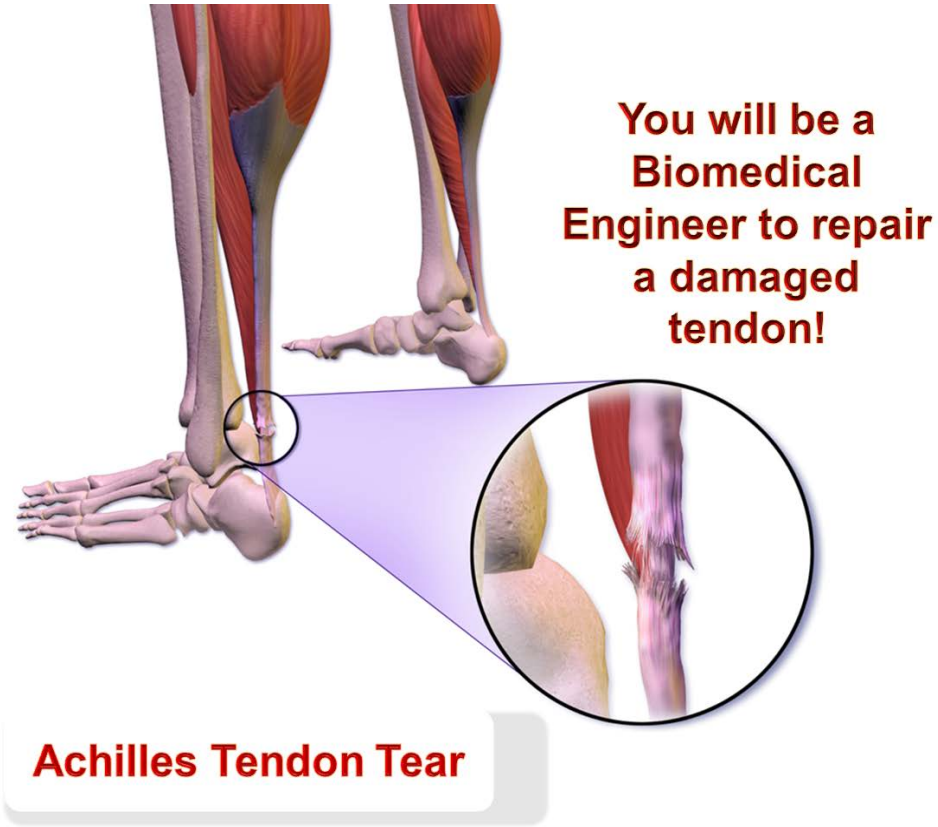
- Most people have it
- 14% of people do not have it
- Was used by humans years ago to flex the wrist
- Not needed anymore and can be removed
- Can be used to replace damaged tendons

Slide 15

Damage to MS System

What	Damage	Medical Treatment
Bones	• Simple fracture • Compound fracture	• Cast • Plates • Pins
Muscles	• **Strain** • Tears	• RICE • Brace
Cartilage	• Break down • Tears • Loose pieces	• Assess damage with **arthroscope** • Clean with saline solution
Ligaments	• **Sprain** • Tears	• Brace • Surgery
Tendons	• Tears • "Snapped"	• RICE • Splint • Brace

Slide 16



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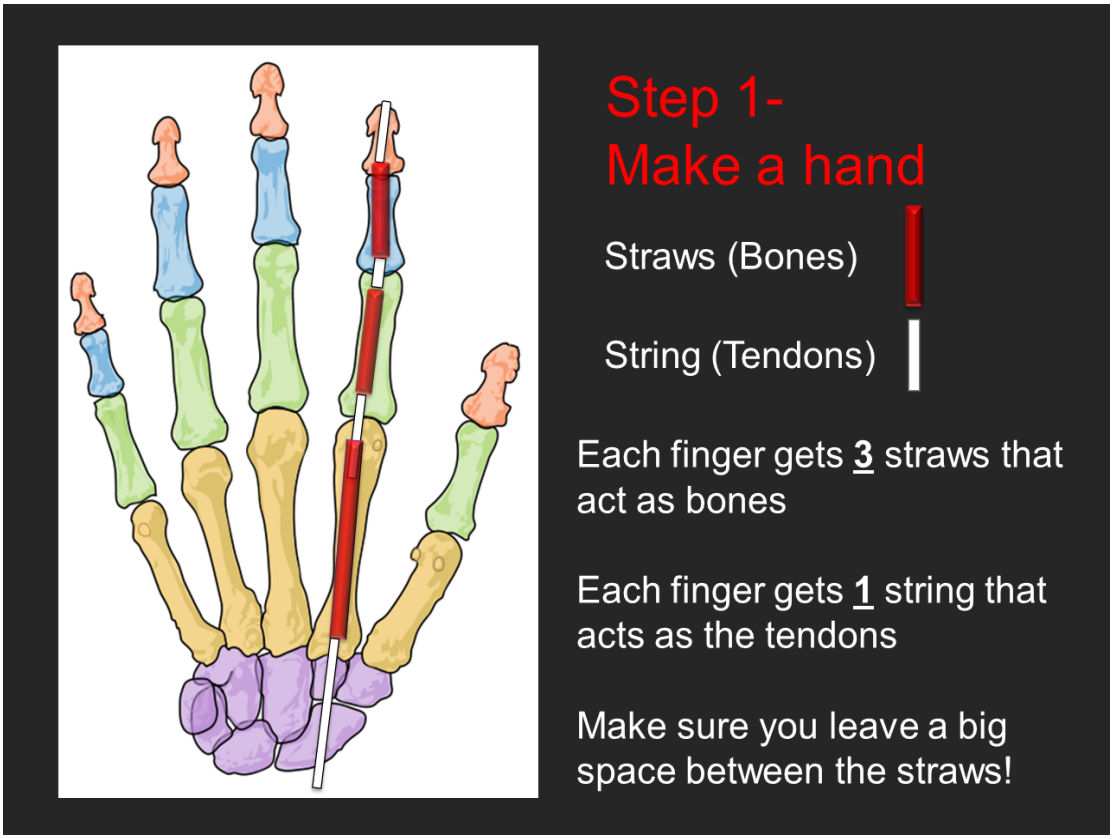

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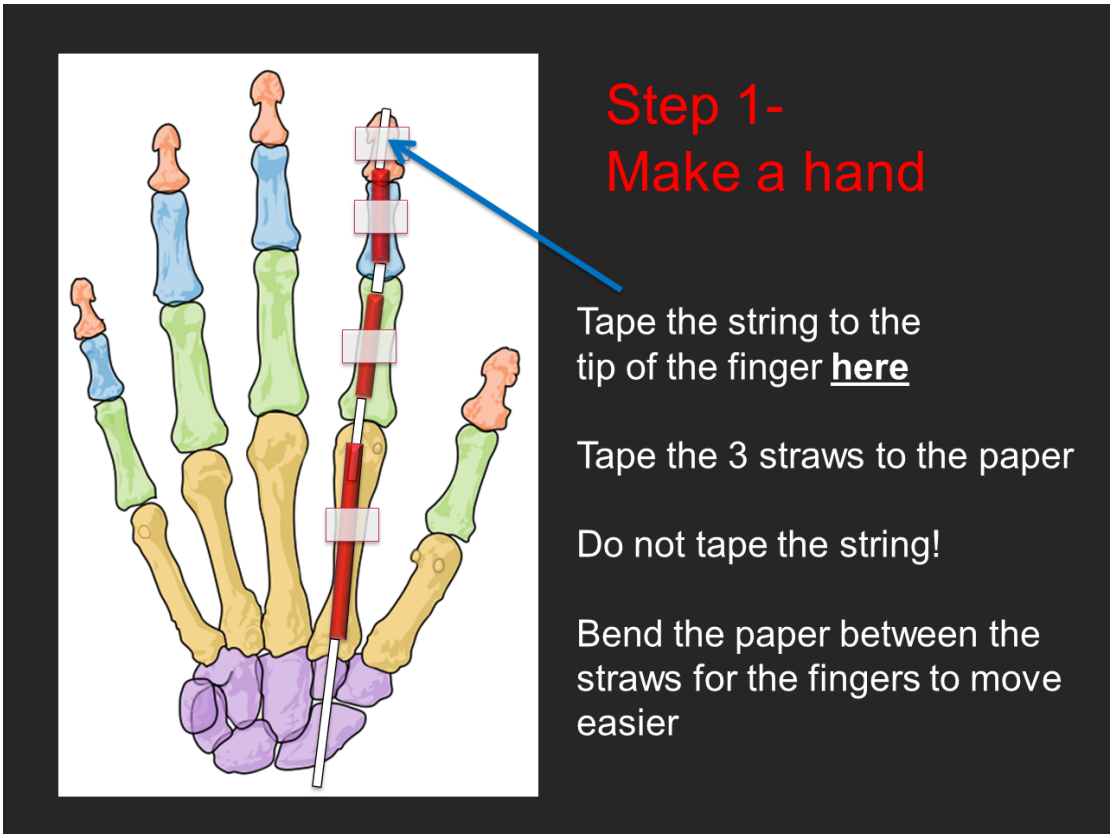

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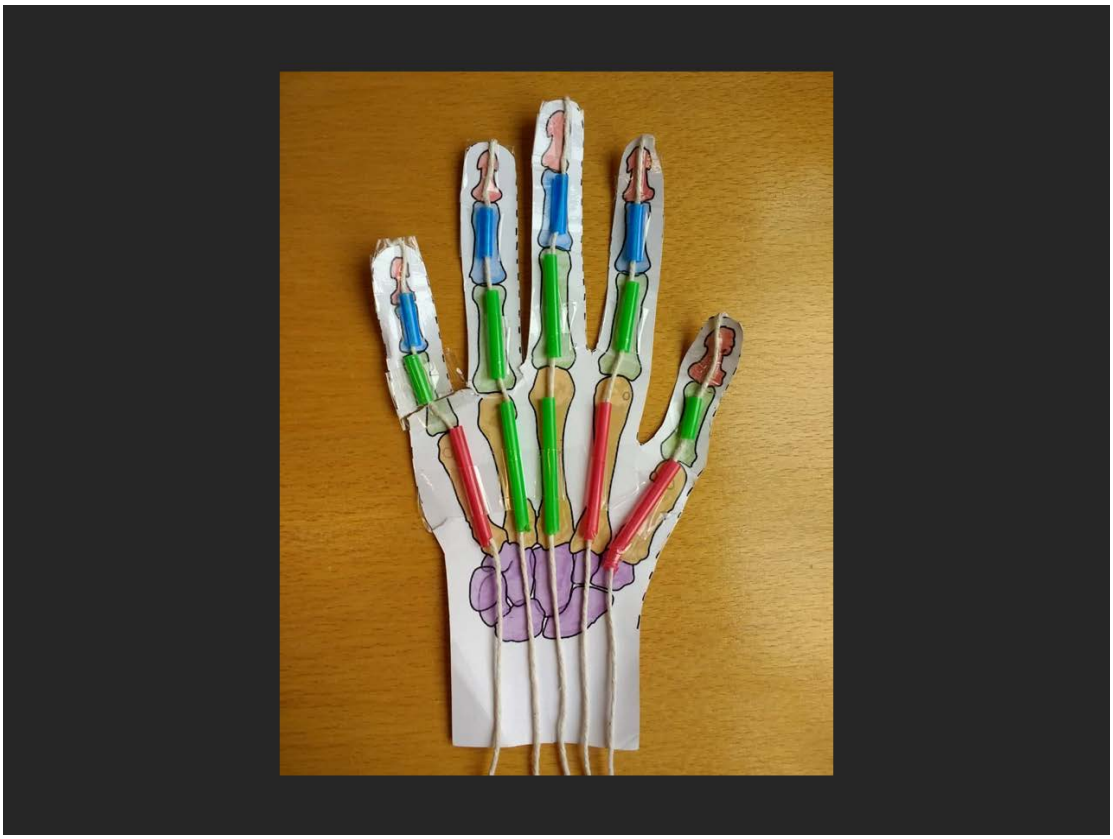

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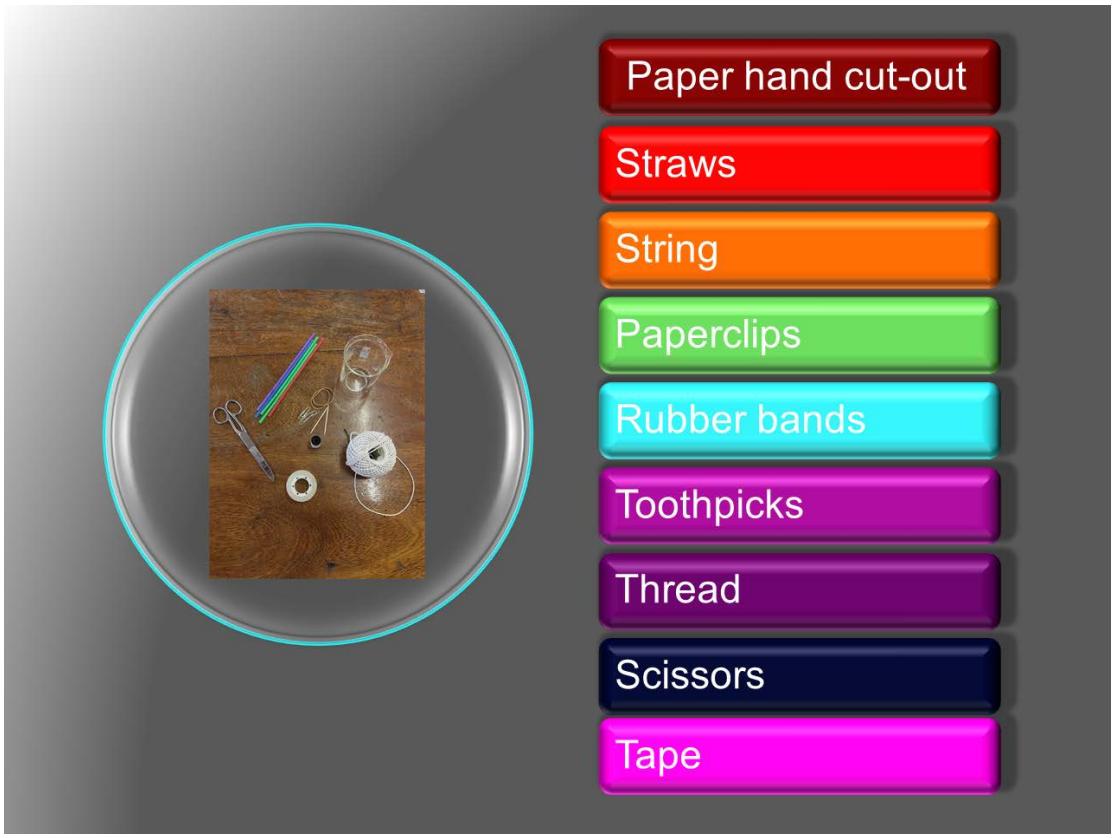


Slide 22

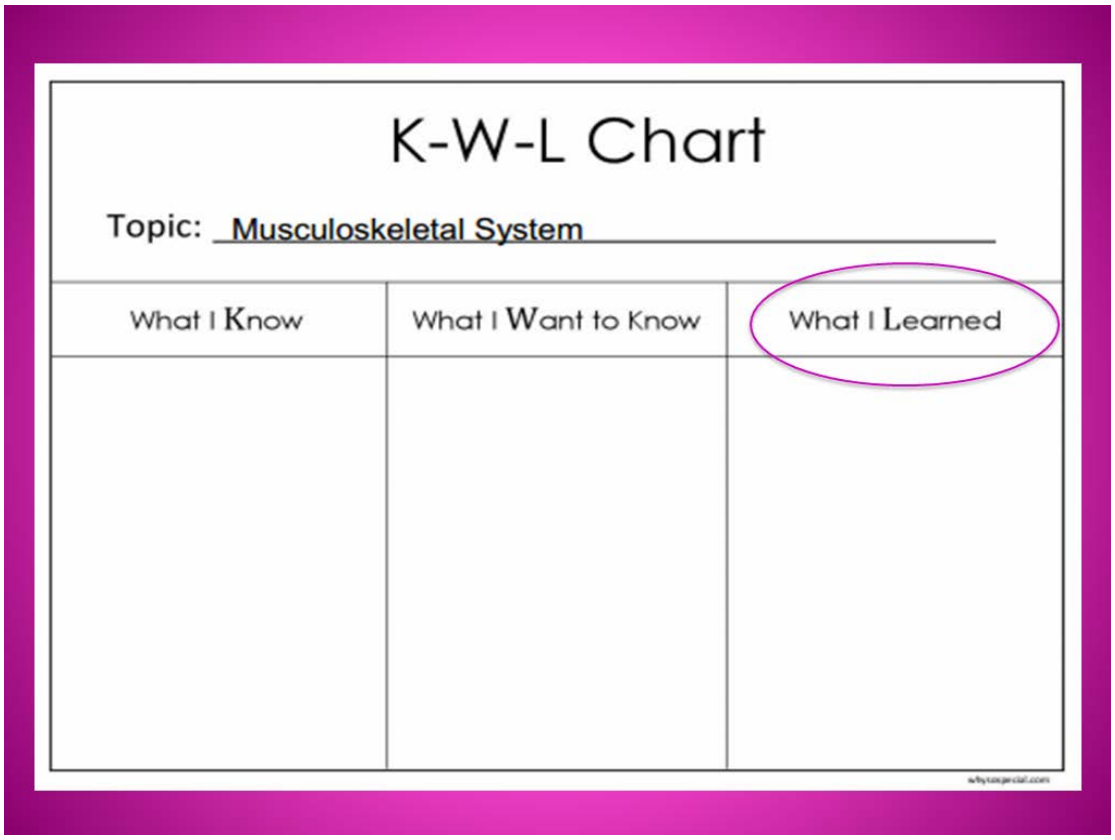
EVALUATION

1.) Do you think your medical device is successful? Why or why not?

2.) If you were building the medical device again, what would you do differently?

3.) Answer the questions on the worksheet.

Slide 23



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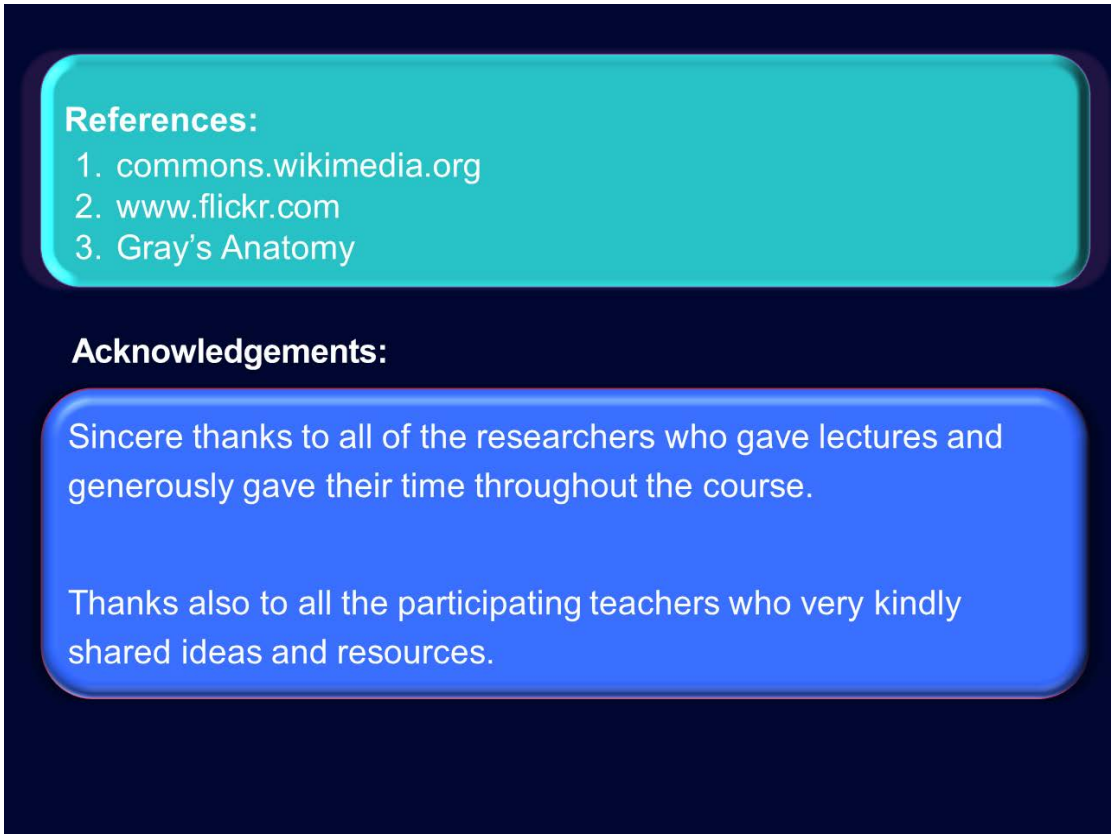

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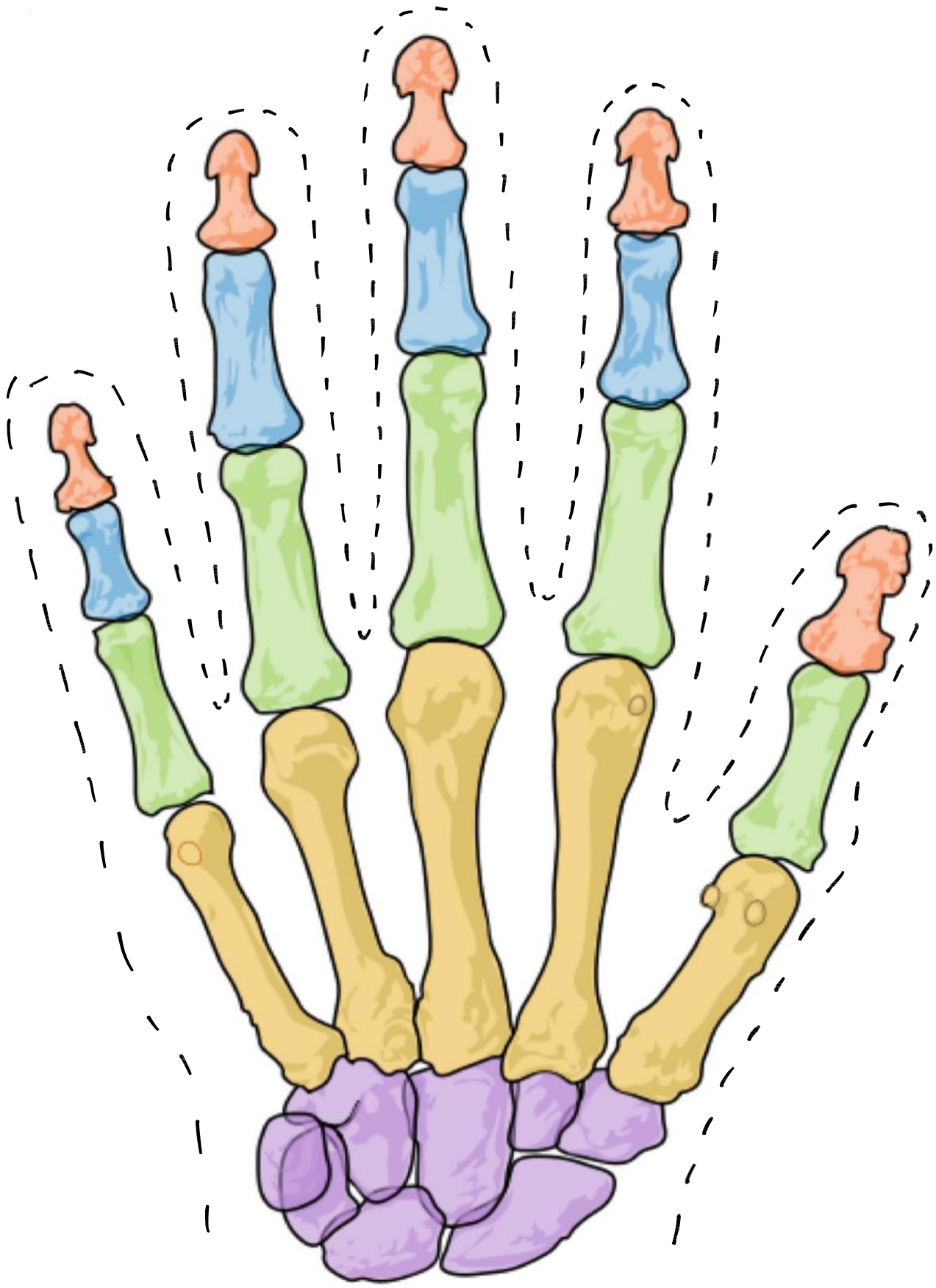
AngioMatTrain brain mattrain Tendon Therapy Train
Engineering *in vitro* microenvironments for translation of cell-based therapies for tendon repair

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund

Science Foundation Ireland SFI For what's next

Slide 26



K-W-L Chart

Topic: Musculoskeletal System

What I Know	What I Want to Know	What I Learned

Musculoskeletal System

Secondary Level Worksheet

Please answer the following questions into your exercise copy:

1. Explain why bones may be described as living tissue.
2. Outline the main functions of the skeleton.
3. Name the organ that is protected by the skull.
4. List the three main bones in the (i) arm and (ii) leg.
5. State another name for the collar bone.
6. What is the purpose of a joint in the skeleton?
7. Describe three types of joints giving examples of each.
8. Explain the impact of diet on healthy bones.
9. Outline the difference between ligaments and tendons.

Reflection using 3-2-1 method:

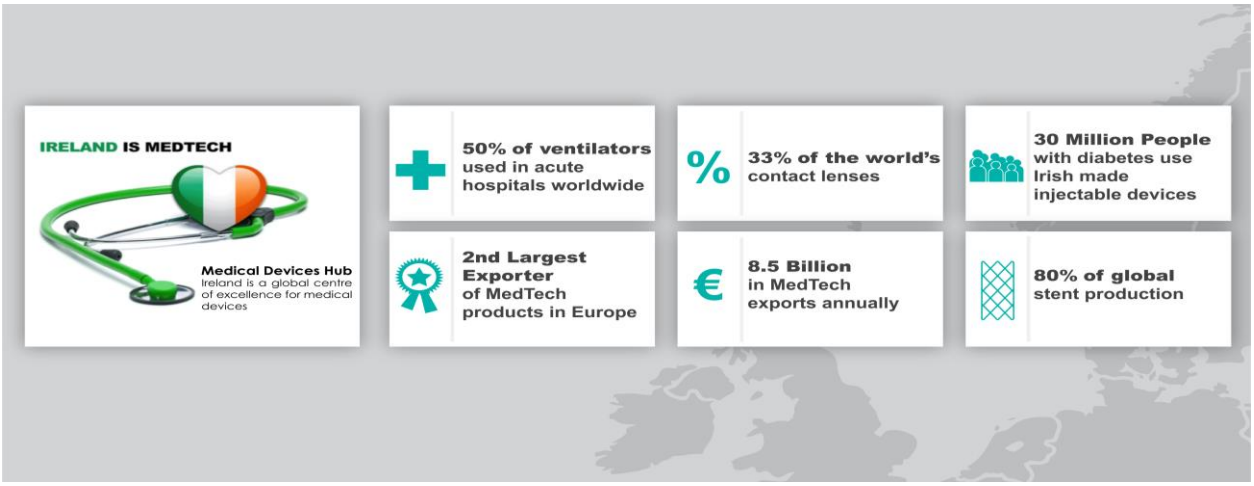
Please reflect on the activities you have completed and include the following into your exercise copy:

- 3 new pieces of information
- 2 interesting facts
- 1 question

FACTS ABOUT MEDTECH IN IRELAND

- Ireland is the second largest exporter of MedTech products in Europe.
- Ireland's MedTech sector employs 29,000 people across 450 companies.
- Ireland has the highest number of people working in the MedTech industry than in any other European country, per head of population.
- 18 of the world's top 25 MedTech companies have a base in Ireland.
- Galway employs one third of the country's MedTech employees.

A wide range of products relevant to treating damaged musculoskeletal tissues are manufactured in Ireland. These include hip and knee implants, bone cement, and surgical blades used for cutting and shaping bones. In fact, 75% of global orthopaedic knee production comes from Ireland. Stryker is one of the world's leading MedTech companies producing medical devices to treat the musculoskeletal system. Styker has four manufacturing sites and a Research and Development Innovation Centre based in Cork and Limerick. Zimmer Biomet, with facilities in Galway and Shannon, supplies hospitals and orthopaedic surgeons with implants for hips, knees, extremities, spine and trauma.



Source: IDA Ireland, 2017

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