



Teachers in Residence

Biomaterials

Secondary Level Lesson Plan



Centre for Research in Medical Devices

“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 device 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.

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

Biomaterials Introduction Lesson

Secondary School 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:

Sustainability

Students should be able to:

9. Discuss medical, ethical, and societal issues.
10. Appreciate the benefits that people obtain from ecosystems.

Learning Outcomes

Children should be enabled to:

1. Appreciate what a biomaterial is.
2. Give examples of biomaterials.
3. Recognise why the design of biomaterials is important for their function.
4. Understand the uses of scaffolds in biomedical procedures.
5. Design a scaffold.

Keywords and Definitions

	Keyword	Definition
1.	Biomaterial	A material that can be engineered to help the body heal itself.
2.	Natural	Existing in or derived from a biological source; not made or caused by humankind. Ex. Alginate, collagen, or agarose.

3.	Synthetic	A material made by chemical synthesis, especially to imitate a natural product. Ex. Polymer, ceramic or metal.
4.	Biocompatible	Not harmful or toxic to living tissues.
5.	Scaffold	Made from biomaterials to guide the growth of new tissues.
6.	Proliferate	When cells make more cells.
7.	Differentiate	A cell behaving in a specific way.
8.	Migrate	Movement of a cell in a particular direction.
9.	Sphere	A tiny ball that medicine can be put inside and released from slowly.
10.	Medical Device	Any material, apparatus, software or other article used to: Diagnose, prevent, monitor or treat a disease or injury; or investigate, replace or modify a part or process of the body.
11.	Noncarcinogenic	Does not have the potential to cause cancer.
12.	Nontoxic	Not poisonous or toxic.
13.	Polymer	A large molecule made up of repeating smaller molecules (monomers).
14.	Collagen	The main structural protein found in connective tissues.

Learning Activities

Children will:

- Complete the K and W parts of the KWL chart.
- Learn about synthetic and natural sources of biomaterials.
- Learn about how biomaterials can be shaped into scaffolds to support new tissue growth.
- Learn how cells and medicine can be added to scaffolds.
- Participate in a group activity to make a scaffold.
- Evaluate their work using a worksheet.
- Fill in the L part of the KWL chart.

Extra Info / Files

	Web Address	Brief Description
1.	www.youtube.com/watch?v=ptE8dEdSbeY	Biomaterials
2.	www.youtube.com/watch?v=T_uMkdKS6wQ&t=213s	Biomaterials
3.	www.youtube.com/watch?v=h4UyF85xWKU	How to make a scaffold

Resources

- Teacher Lesson Plan
- PowerPoint to guide lesson
- Interactive KWL worksheet
- Evaluation sheet

- One set of materials for each group making a scaffold:
 - Balloon
 - Bowl of PVA glue
 - String or yarn
 - Scissors

Methodologies

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

Assessment

- Self-assessment – evaluation sheet
- Teacher observation – making of scaffolds
- 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

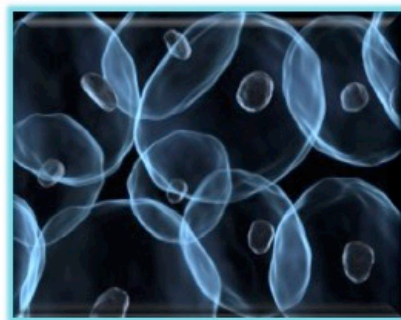
Differentiation By:

- Teaching style
- Support
- Task

Power Point Presentation – Biomaterials



Slide 1



Teachers in Residence Programme
Iseult Mangan and Tom Flanagan

Slide 2

MEDICAL DEVICES

Any material, apparatus, software or other article that is used to:

- *Diagnose, prevent, monitor or treat* a disease or injury
- *Investigate, replace or modify* a part or process of the body



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CAN YOU NAME SOME MEDICAL DEVICES?

tongue depressor



hip implant



tooth implant



arm/leg prosthesis



stethoscope



thermometer



stent



disposable gloves

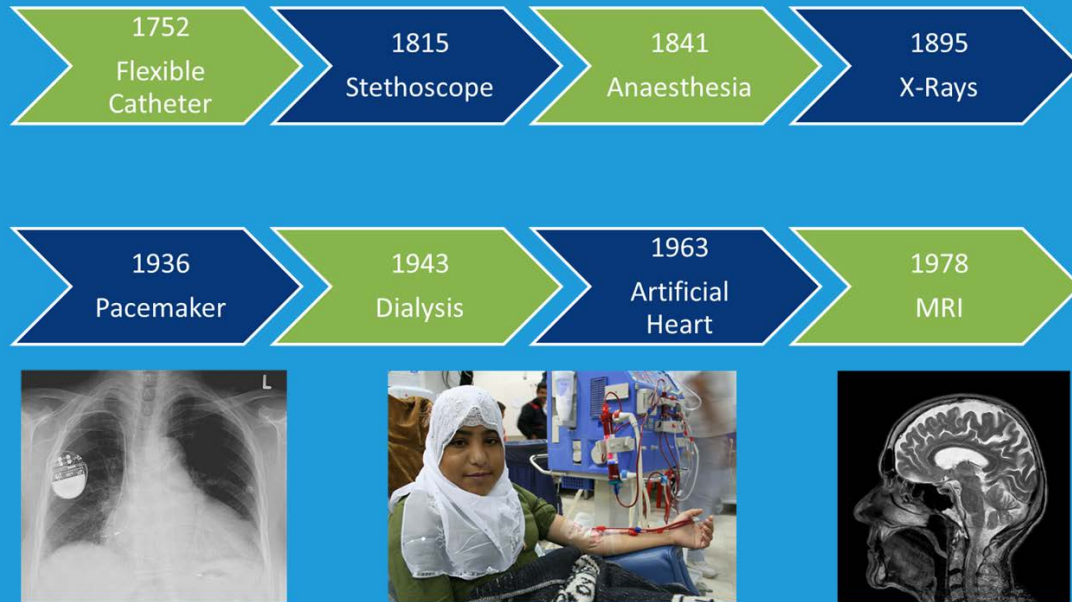


heart valve replacement



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MILESTONES-MEDICAL DEVICES



Slide 5

Biomaterials are used to make various medical devices

What are **BIOMATERIALS**?

Slide 6

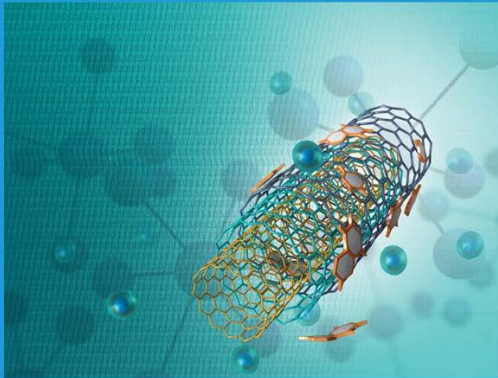
K-W-L Chart		
Topic: <u>Biomaterials</u>		
What I Know	What I Want to Know	What I Learned

www.vocabulary.com

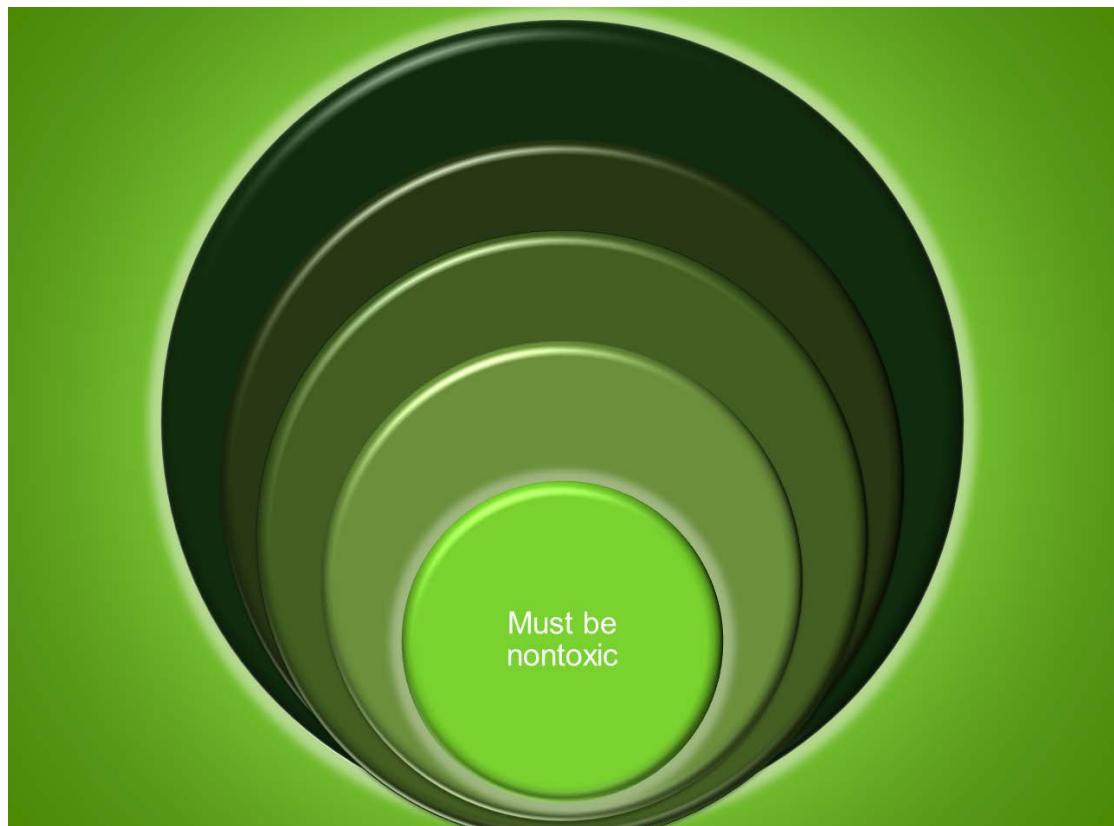
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WHAT ARE BIOMATERIALS?

- A biomaterial is made from a **natural** or **synthetic** material that can be engineered to help the body heal itself
- A biomaterial can be introduced into the body as part of an implanted medical device or used to replace an organ
- A biomaterial can be temporary or permanent





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SYNTHETIC BIOMATERIALS

Materials made by humans, like plastic or metal



Good:

They are easy to make and exactly the way you need

Bad:

Sometimes the body does not like them

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SYNTHETIC BIOMATERIALS

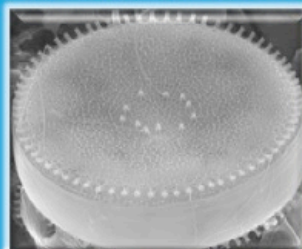
Type	Where would you use them in the body?	Examples
Metal	Hips, knees, shoulders, ankles	Wires, screws, plates, artificial joints, stents
Polymer	Face, trachea, kidney, liver, heart, teeth/dentistry, hips, knees	Tubes, dentures, adhesives, sealants, sutures, coatings
Ceramic	Teeth/dentistry, joints	Crowns, dentures, artificial joints, bone repair
Composite	Teeth/dentistry, limbs	Prosthetic limbs, dental cement, crowns

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NATURAL BIOMATERIALS

Materials from nature and made from cells

Algae found in freshwater and seawater



Shells of crabs and prawns

Silk from butterfly cocoons



Alginate from seaweed

Good: The body likes them

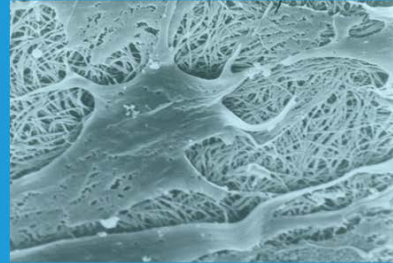
Bad: People can't make them

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NATURAL BIOMATERIALS

Example: *Collagen*

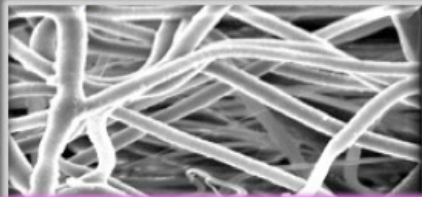
- Most commonly found protein in animals
- Forms a large component of connective tissues
- There are at least ten types of collagen in the body
 - Type I-skin, bone and tendons
 - Type II-cartilage in joints
 - Type III-blood vessels
- Used as a biomaterial for wound healing, in the skin for cosmetic surgery



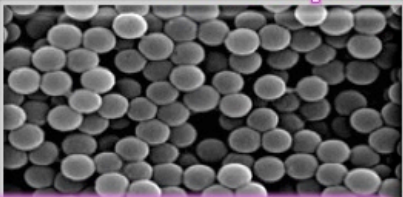
Cells are very happy to grow on collagen!

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Fibres

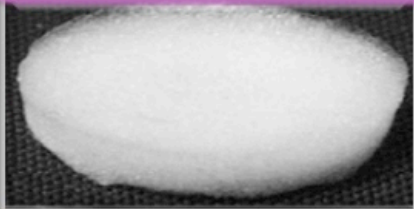


Nanospheres

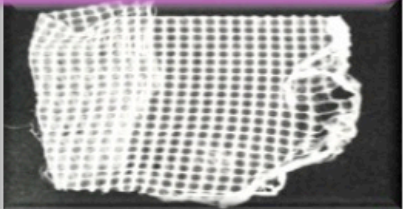


Scaffolds can be made out of biomaterials to support new tissues to grow

Sponges



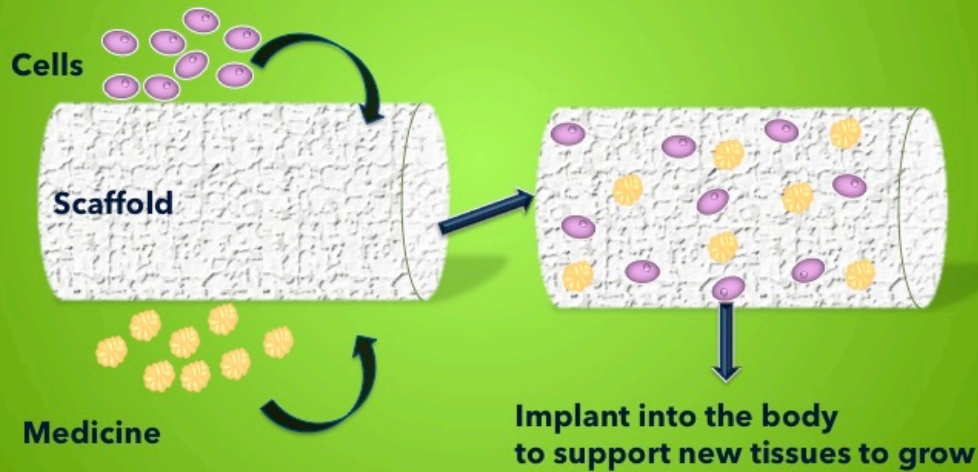
Meshes



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Cells can be added to scaffolds...

...to repair tissues, like the heart or tendons



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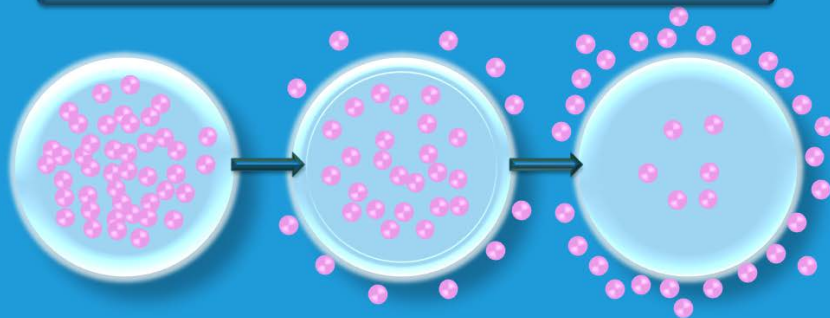
MEDICINE CAN BE ADDED TO SCAFFOLDS

Medicine makes cells do different things:

Make more cells —————> proliferate

Behave in certain ways —————> differentiate

Move into scaffold —————> migrate

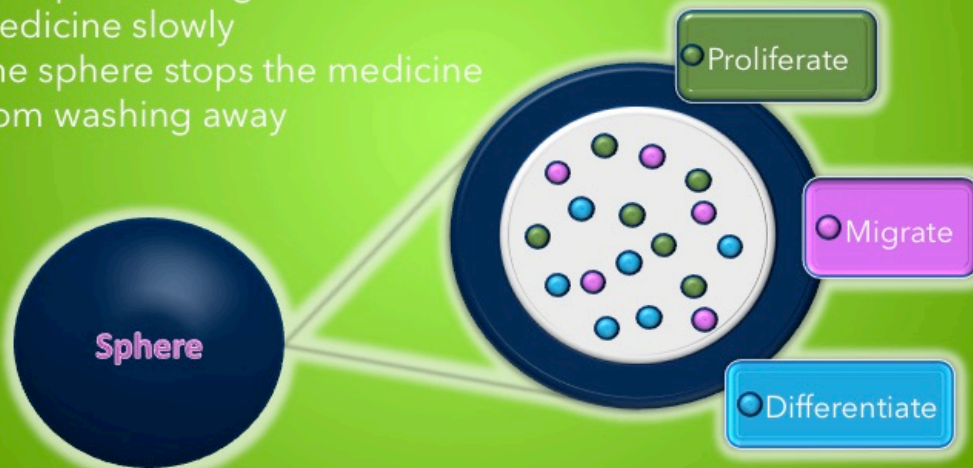


Medicine in a sphere can be released over a long period of time

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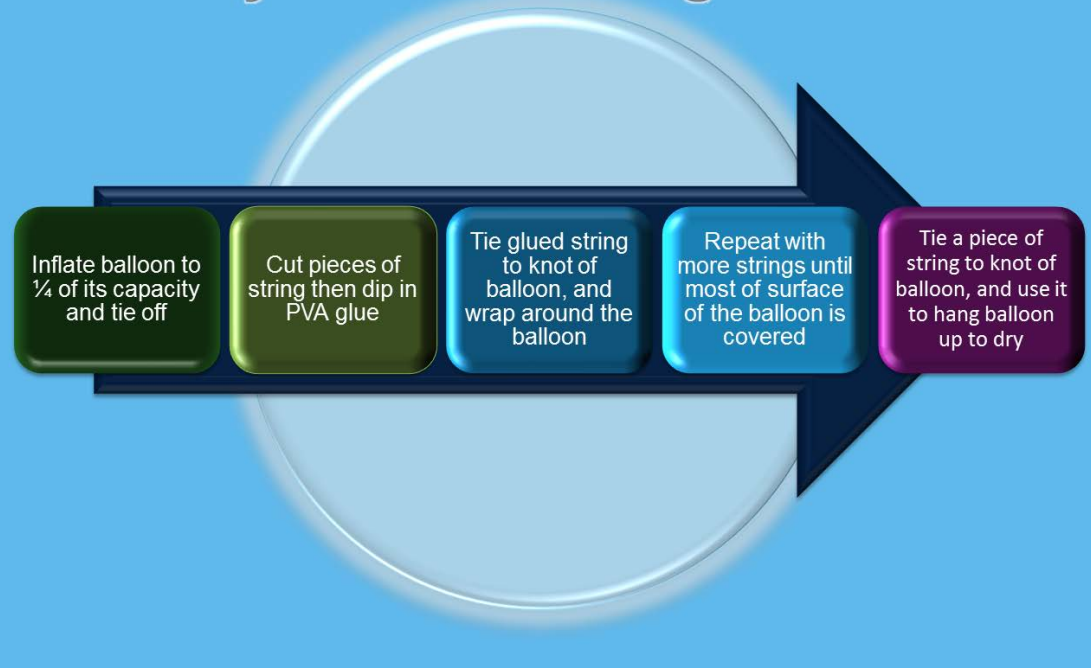
Spheres protect the medicine

- The medicine can be put into a very tiny ball called a **sphere**
- The sphere lets go of the medicine slowly
- The sphere stops the medicine from washing away



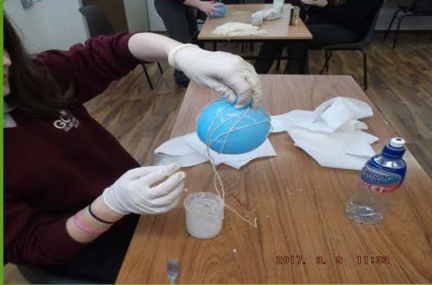
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Activity: Make a collagen scaffold



Slide 18

Activity: Make a collagen scaffold



Once the glue has dried:

- 1) Gently push the balloon away from string
- 2) Burst the balloon and remove carefully from string mesh

You should now have a large replica of a collagen scaffold!

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Centre for Research in Medical Devices

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References:

1. Handbook of Materials for Medical Devices, 2003 ASM International
2. "Milestones in Medical Technology," New York Times, Published October 10, 2012
3. www.celldataservices.co.uk/biomaterials
4. commons.wikimedia.org
5. www.flickr.com
6. www.pixabay.com
7. vimeo.com
8. www.gojiberryblog.com/2011/09/11/how-to-revive-your-plants/
9. gpwalsh.com/the-shift/
10. animals.nationalgeographic.com/animals/invertebrates/red-crab/

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AngioMatTrain



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



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K-W-L Chart

Topic: Biomaterials

What I K now	What I W ant to Know	What I L earned

BIOMATERIALS

Draw a picture of the scaffold that you created.



Do you think that the scaffold was made successfully? Why or why not?

If you were making the scaffold again, what would you do differently?

State three things that you learned today:

1. _____

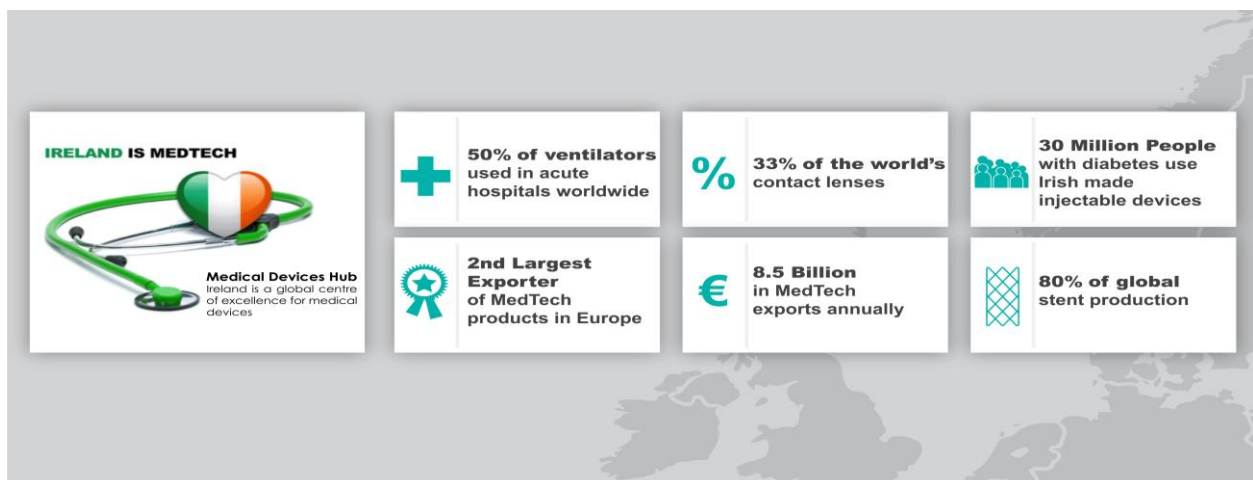
2. _____

3. _____

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.

Companies plan to promote growth in the biomaterials and medical devices sector. Therefore, many opportunities for jobs will exist within this industry in Ireland. This area of work is multidisciplinary and requires people with a range of training including scientists, engineers, IT specialists, and medical graduates. Many types of jobs exist within this industry from inventing new devices, testing devices, maintaining equipment, and working with clinicians and patients. Major employers in Ireland include Johnson and Johnson, Boston Scientific, Medtronic, and Abbot Laboratories.



Source: IDA Ireland, 2017

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