Visitor Guide

Hi!

Whether you are a teacher or a family planning a visit, you can use this guide to better understand the science behind this exhibit.

In addition to information on each activity in the exhibit gallery at Carnegie Science Center, this guide provides some tissue engineering (TE) activities to try in your home or classroom, and resources for you to further explore this exciting and important science topic after your experience with us!

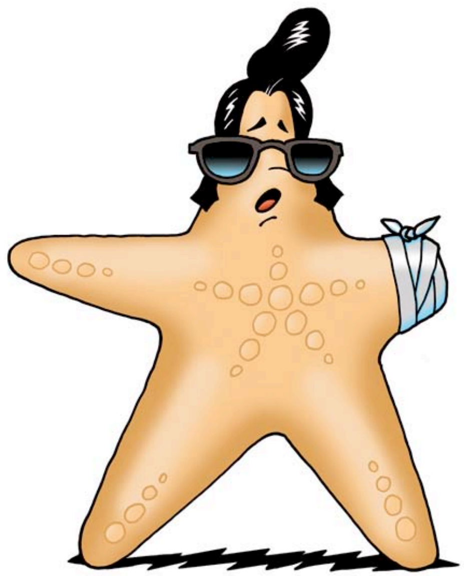

Exhibit Overview:

Tissue Engineering. A phrase that is exciting, mysterious, and controversial. From better skin grafts for burn victims to entire replacement body parts grown in laboratories, this science holds great promise for future generations.

This exhibition presents the basic sciences behind this complex topic and gives some real-world perspectives and applications so that visitors to the science center can become familiar with developments happening today.

For young visitors, it also is a chance to discover the job opportunities possible in a wide range of fields—from applied science to government policy to design and engineering careers.

For everyone, it's a chance to learn a bit more about how humans are put together, what happens when we get injured or diseased, how we heal, and how we might be able to improve and enhance these processes.

Let's get started!

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Science Education Partnership Award (SEPA)
from the National Center for Research Resources,
a component of the National Institutes of Health.

CARNEGIE SCIENCE CENTER · PTEI · SEPA

Education Goals and Approach

The educational objective of this exhibit is to familiarize students in grades 6–8 and other visitors with the fields of tissue engineering and regenerative medicine. Depending on which areas of the exhibit they have the time and desire to visit, visitors should be able to relate several of the following key points:

- All living things are composed of cells.
- Cells have specialized functions.
- Groups of cells working together form specialized tissues, such as muscle, nerve, and connective (such as bone and cartilage) tissues.
- Groups of tissues combine to form organs.
- Some less complex animals, like our headliner the starfish (or sea star), can regenerate major parts of their bodies.
- More complex animals, including humans, can regenerate, but this is limited to smaller parts of our bodies (like blood, hair, and fingernails).
- A distinguishing feature of animals that can regenerate tissue after injury—like the starfish—is the formation of the blastema, a zone of progenitor cells, at the injury site.
- How the blastema grows to produce a replica of the missing part is one of the most alluring aspects of regeneration.
- Several biological, engineering, chemical, and medical science disciplines combine to make up the field of tissue engineering and regenerative medicine.
- The possibility of growing replacement human tissues to construct an organ outside the body is a relatively new development, but it is exciting and happening today in Pittsburgh!
- The future of tissue engineering and stem cell research holds great promise for us as a new way for doctors to treat illnesses and injuries.
- As with all biomedical advances, there are ethical considerations with tissue engineering and stem cell research, as well as myths and misinformation.

The exhibition is divided into three sections:

The Natural World

This set of four activities explores the basic biology of cells—their form, purpose, abilities, and specializations.

The Science of Tissue Engineering

Three activity areas let you learn about some of the research going on today and try your hand at some cool virtual experiments.

CLINICAL APPLICATIONS, ETHICS, ISSUES, AND ANSWERS

Hear first-hand leading researchers talk about tissue engineering applications today and in the future, find answers to commonly asked questions, and register your opinions on some of the ethical issues involved in tissue engineering and stem cell research.

Interactions

Exhibit activities are designed for a wide range of ages and learning styles. These range from simple puzzle games for younger learners to in-depth video interviews with leading scientists in the field today. Interactive styles range from tactile, hands-on exhibits to touch-screen video games.

Have a look…

What To Do:

When you push the "Go!" button to start the counter, you'll have 30 seconds to arrange two sets of mixed puzzle pieces to construct a nerve cell and a blood cell.

What's the Big Idea?

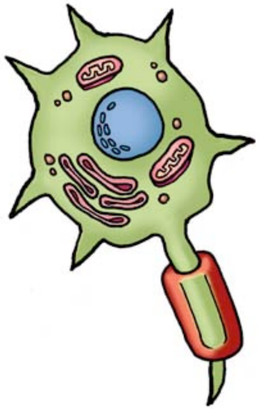
You, and all living things, are composed of things called cells. Something as big as you is made of trillions of cells, but some things—like bacteria—are single-celled organisms that are too small to be seen by the human eye alone. You are a multicellular organism; things with only one cell are called unicellular.

While cells have some things in common, there are differences between bacteria, plant, animal, and human cells. What differences can you see here?

Seamore Says:

- Cells in different parts of your body (or in a dog or in a tree) have different, specialized functions.
- Cells are constantly working, changing, sending, and responding to chemical cues—even correcting their mistakes when possible.
- Most of these cells contain all the genetic information needed to "build" an entire copy of the body of which they are a part.
- Much of this information is found in the nucleus of a cell, a "control center" that keeps all the material together in one place.

Learning Goals for This Activity:



- All living things are composed of one or more cells.
- Individual cells are too small to be seen by the human eye.
- Some organisms are unicellular (like bacteria), and others are multicellular (like humans).
- There are differences between bacteria, plant, animal, and human cells.
- Cells have specialized functions.
- Cells are constantly working, changing, sending, and responding to chemical cues, even correcting their mistakes when possible.
- Most of these cells contain all the genes and other information needed to "build" a human being.
- Much of this genetic information is found in the nucleus of the cells, a "control center" that keeps all the material together in one place.

Activity Tip!

When building the puzzle, notice the cell-wall shapes of the two different types of cells. This will help you sort the pieces faster.

What To Do:

Select a button to zoom in on views of different tissue samples. What similarities and differences do you notice?

What's the Big Idea?

Everything in your body is made up of cells too small to be seen by the human eye, which itself is made up of even more cells. Using the videoscope, you can see slices of tissue—groups of cells, which make up bones, skin, organs, etc. These, in turn, make up you!

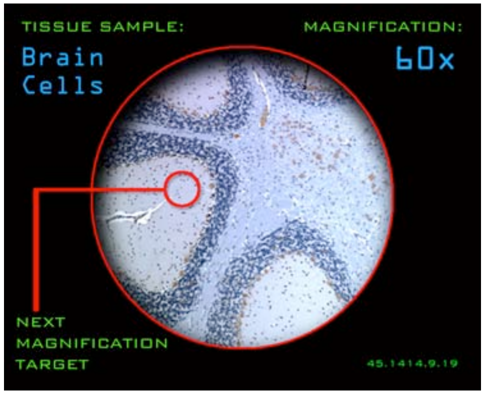
Researchers use equipment like this to reach the level of detail needed to explore cells and learn how they work, and how to fix them when they don't.

Seamore Says:

- While cells all have similarities, they each also have specific tasks to do all the jobs our bodies need to function.
- Like a sports team, cells coordinate with one another to achieve a goal, like forming different types of tissues, fighting off infections, or transmitting information throughout the body.
- Today, damage to most of these cell groups can be irreparable, although mitosis (the cell division process that produces new cells) can handle some minor issues, like healing cuts or broken bones.

Learning Goals for This Activity:

- Cells have specialized functions.
- Groups of cells form specialized tissues, like bones and skin.
- Living things are organized. Smaller components are arranged into larger ones in a hierarchical order of complexity.
- Cells coordinate with one another in performing functions and achieving goals. They work together to form different types of tissues, and different tissues combine to form organs and bodily systems (e.g., digestive, circulatory, etc.).
- Damage to some or most of these cell groups currently can be irreparable.
- The cell division process that produces new cells for growth, repair, and the general replacement of older cells is called mitosis. This process occurs in response to injury, disease, or any need to produce new cells.



Activity Tip!

Set each of the three videoscopes to the same magnification (X) setting, and compare the differences in the cells!

What To Do:

Use the handles to twist two matrices of cells, one 'bone' and one 'skin'. What do you notice about how each moves and flexes?

What's the Big Idea?

The trillions of cells that make up our bodies all have specialized shapes and functions and work together to form different tissues.

However, the cells themselves are pretty much the same—tiny baggies of gooey liquid and microscopic parts. It isn't our cells that make bones rigid or skin stretchy. This is caused by the extracellular matrix (ECM) that binds the cells together. Think of the ECM like a neighborhood where cells live. For instance, bone cells' ECM is a mix of minerals, like calcium, and a softer material called collagen. These surround your soft bone cells with a rigid, yet flexible, covering.

Seamore Says:

- The extracellular matrix (ECM) also plays a role in providing structural and chemical signals that direct the behavior of cells. Some of these cells, like skin, bones, and liver are pretty good at using these signals to heal the tissues they make up. Others though, like brain cells, can be damaged irreparably.
- When you were a microscopic embryo, your cells were all the same and hadn't been given the signals to grow into specific cells for specific body parts. Those embryonic cells are called totipotent.
- When totipotent cells change (differentiate), the genetic material in most of them remains the same—the secret code for all cells.

Learning Goals for This Activity:

- Cells have specialized shapes and functions.
- Groups of cells work together to form different types of tissues, like muscle, nerve, and connective.
- Different tissues combine to make up organs (heart, lung, bladder, etc.).
- The organization of tissues and organs create different bodily systems, such as the digestive, circulatory, and nervous systems.
- The cells themselves do not reflect the physical attributes of the tissue or organ. For example, bone cells are not rigid, and skin cells are not stretchy. This is caused by the extracellular matrix.
- The morphology of a cell may change dramatically during differentiation, but the genetic material often remains the same.
- Damage to some or most of these cell groups currently can be irreparable.
- A cell that is able to differentiate into nearly any of the many different cell types in the body is known as a pluripotent cell. These pluripotent cells often are referred to as stem cells and may be used to develop certain replacement tissues or organs that have been injured or diseased.
- A cell that is able to differentiate into all of the different cell types in the body is known as totipotent. A totipotent cell even has the ability to form the entire body!
- In mammals, only the zygote and early embryonic cells are totipotent.

Activity Tip!

Notice that, like your own bones, the bone cells and extracellular matrix here are not completely rigid; there is some flexibility to your bones before they break.

What To Do:

A zoetrope is a Victorian-era device used to make movies. We've put in slides of a newt's arm growing back for you to see some cell regeneration in action! Bend down and look through the slots in this drum while you spin it at a moderate speed.

What's the Big Idea?

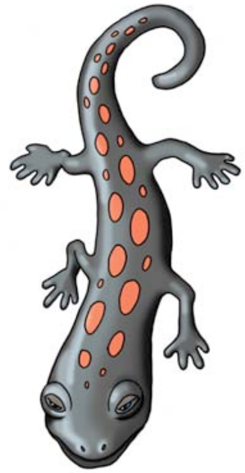
This zoetrope shows actual tissue regeneration, although much faster than in real life. This is a newt regenerating a missing leg (during a 32-day period).

Seamore Says:

- In addition to well-known examples like the sea star (also known as a starfish) being able to re-grow a lost arm or a lizard being able to replace a missing tail, there are other examples in the animal kingdom:
- Butterflies are able, during metamorphosis, to change their cell structures into new tissues and organs.
- The marine animal Hydra can regenerate cells to produce offspring, a form of cloning.
- Humans have a limited and often imperfect ability to regenerate body parts.
- New cells form to create new, fibrous tissues that heal cuts to the skin and broken bones. Because the human body cannot re-build tissue exactly as it was, scars have a different texture than the original tissue. Children under six have grown back fingertips, and the human liver can regenerate itself during a person's lifetime.

Learning Goals for This Activity:

- A goal for tissue engineering scientists is to better understand and perfect the wound healing process. Scars result from the natural process of wound repair in the skin and other tissues like bone. However, with the exception of very minor cuts and scrapes, every wound results in some degree of scarring and is not identical to the tissue it replaces.
- The answer to why a salamander or starfish can regenerate a limb or other body part—seems to lie in the accumulation of cells at the site of injury and the formation of the blastema, which is a distinguishing feature in animals. Tissue engineers aim to demonstrate that they can successfully take the first step and grow a blastema, a collection of cells that can form a new body part. Cells in different parts of the body vary in their rate of reproduction.
- Butterflies are able, during metamorphosis, to change their cell structures into new tissues and organs.
- The Hydra can regenerate cells to produce offspring, a form of cloning.



Activity Tip!

For best results, spin the zoetrope at a slow to medium speed. Moving it too fast will make it blurry.

Try This!

Here's a Natural World extension activity you can try at school or at home!
Visit **PTEI.org** for more on tissue engineering!

Bone Strength/Biotech Company Competition

Introduction
Bone is one of the strongest and most functionally important tissue structures of the human body. It is a living tissue and requires a constant flow of nourishment from an individual's blood and extracellular matrix (or ECM). Contrary to popular belief, bone is not completely solid; rather, is a highly porous tissue.

Bone is porous for three key reasons: 1) strength to weight ratio; 2) remodeling; and 3) as a passageway for nourishment. Bone design provides multiple advantages in strength and function. Student teams are challenged to create their own company, name their tissue engineered-repair construct, and compete for the market share. The student team best able to design a bone construct that can support a mass of 2.5 Kg is awarded (potential prize is candy), and the student team whose bone construct supports the greatest mass is awarded the grand prize (introduce the concept of receiving a grant award or venture capital to develop and market their bone construct).

Objectives
Students will:

- Understand and explain the structure and function relationship of bone.
- Identify the structures (muscle, ligaments, and joints) that allow us to move and resist forces.
- Design and test the strength of their own bone construct.
- Analyze which structural designs are most effective in resisting forces.

Materials

yellum

basic 67 stock paper

tape

ruler

scissors

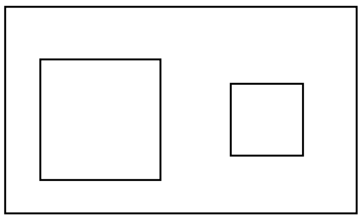
pail (or other loading device)

scale

calibrated weights (or other loading mass)

Procedures

1. The **dimensions** of the bone construct can be set at **22 cm long**. The width can more quickly and easily be established (and confirmed by teacher) by setting the following limits: The bone **must pass through a 3 x 3 cm square and NOT pass through a 2 x 2 cm square.** A simple tool way to achieve this is to cut two squares of the dimensions listed in an index card, and provide a card for each lab group. *(Refer to example as shown.)*



2. **One sheet of paper is permitted for each construct**. Notice that extra paper will be available from each sheet due to the 22 cm length limit. Students may use this extra paper as they see fit. Teachers also may wish to allow groups to build more than one construct. A **maximum of 10 cm of Scotch tape** can be used to secure and reinforce the construct.
3. A **porosity requirement** can be enforced by stating that at least 5 cm of a standard pencil must be able to be inserted into each end.
4. For the **loading test**, the bone construct should be centered and balanced between **a gap of 10 cm**.
5. Students should hold the bucket in place while loading to minimize jarring. Students should **begin loading with 2 Kg**. This is the minimum weight to qualify. After this is held, they may load in any increments desired. *Note: It is important to remind students that the total load represents the mass last successfully held before structural failure. Remind students not to let the bucket fall, as plastic buckets will crack upon impact.*
6. Class data can be compared by showing the following chart on a blackboard or whiteboard.

Biotech Company	Bone Construct	Construct Total	Relative Strength
Name	Name	Mass	Load (TL/CM)

**The winners of the contest (or grant funding!) are determined by the highest relative strength.*

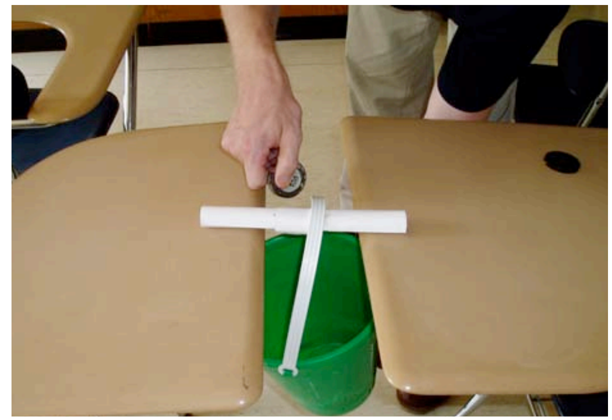


Figure 1: Loading the bone construct for strength testing.

Figure 2: Quantifying bone construct strength. Structural failure upon critical load.

The Science of Tissue Engineering
Dr. Allevable's Lab! Exhibit

What To Do:

There are three video-game simulations at this exhibit. Pick one, and try your hand at tissue engineering techniques:

1. **Stem Cell Wrangler** – Find and grab cells within bone marrow.
2. **Grow with the Flow** – Help blood vessels reach stem cells in a newly implanted scaffold.
3. **Cell Odyssey** – Stem cells injected into the body of a patient get to the site of injury and become the correct cell type.

What's the Big Idea?

Stem cells are special cells in our bodies that have the potential to become nearly any kind of cell in our body and are a natural part of how our body heals. Scientists and engineers are working to understand how to "tap" into the high potential of stem cells to become nearly any cell and, therefore, to become nearly any tissue or organ type. Potentially, some of our organs and tissues can be healed by using stem cells.

Sometimes a special support structure, called the scaffold, may be used in combination with the stem cells. The scaffold supports the growing cells at the injury site. In time, the stem cells multiply and replace the scaffold with healthy new tissue! Stem cells have a fantastic ability to know what parts of the body need to be healed. Stem cells follow natural chemical signals in the body to find any injuries.

Seamore Says:

- Your body is full of natural signals called proteins. Your cells are constantly making different proteins, depending on what kind of cell they are and how they are feeling.
- The body also produces chemical signals, also called growth factors, that tell stem cells when to multiply and what cell type to become.
- Growth factors are an integral part of the natural healing process of the body!

Learning Goals for this Activity:

- Several biological, engineering, chemical, material sciences, and medicine combine to make up the fields of tissue engineering and regenerative medicine.
- Skin and bone tissue regeneration are where science has, to date, had the most success.
- The future of tissue engineering holds great promise as a new way for doctors to treat illnesses and injuries.
- Regenerating heart and nerve cells hold great promise as advances are made.

Activity Tip!

For more information on the screen, touch the book icon.

The Science of Tissue Engineering

Super Cells! Exhibit

What To Do:

Take a peek into our microscope for a lesson in stem cell basics!

What's the Big Idea?

Stem cells are those that have the ability to self-replicate and give rise to any of the many different cells of our body. You might think of them as the building blocks of our body. Unlocking the secret of stem cells' ability to become whatever they want to be is key for scientists. If they can control what kind of "specialized" cell a stem cell becomes when it replicates, there are nearly unlimited possibilities that can help us remain healthy —growing new bone or nerves, repairing a damaged heart, replacing failing organs, and more!

Seamore Says:

There are three basic types of stem cells:

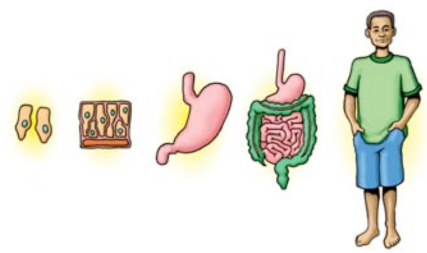
Totipotent: These have "total potential"—from a single one of these, our entire body can emerge! Totipotent stem cells only can develop into an entire body if they are in the womb, an environment that provides all of the signals necessary for development. This also means that one of these types of stem cells can become any type of cell in our body. These stem cells also are known as early stem cells and are the group of cells that result when the newly fertilized egg (or zygote) begins to divide.

Pluripotent: Pluripotent stem cells have a huge amount of potential as well and can become most any of the different cell types of our body, but they can't form an entire body. Pluripotent cells are found in the blastocyst, a hollow 'ball' of cells that begins to form five days after fertilization. A mass of cells form the inner cell mass (or ICM) of this ball, which ultimately develops into the fetus. Embryonic stem cells come from the ICM. Other cells, called tropoblasts, make up the outside of the ball and become the placenta. Scientists are finding stem cells in the placenta, too!

Multipotent: These have great potential also. Multipotent cells often are referred to as adult stem cells. But, don't be fooled—kids have these cells, too! Multipotent cells can give rise to a more limited number of cell types. Their main job is to make more of the same cells in an organ when other cells grow old or diseased and die.

Learning Goals for This Activity:

- Stem cells are unspecialized cells that have the potential to develop into many different, specialized cell types in the body.
- Stem cells have the unique ability to renew themselves and serve as the body's repair system by renewing themselves and replenishing more specialized cells in the body.
- The two broad categories of stem cells are mature (adult) and early (embryonic). It is expected that stem cells could be used to create an unlimited supply of cells, tissues, or even organs that could be transplanted to restore function lost to illness, disease, and injury.
- Mature stem cells are found in mature body tissues, as well as in the umbilical cord and placenta.
- Early stem cells, often called embryonic stem cells, are found in the inner cell mass of a blastocyst after approximately five days of development.
- In a developing embryo, stem cells can differentiate into all of the specialized embryonic tissues, making them pluripotent.
- Adult stem cells are primarily multipotent. They can yield all of the cell types associated with the tissues from which they originate. The mature stem cell is an unspecialized cell that is found in a specialized tissue and renews itself for a lifetime.



- While stem cell research still is in its infancy and specific treatments have not yet been developed, many experts expect treatments will be possible in the future for the following: 1) type 1 diabetes in children; 2) nervous system diseases, such as Parkinson's and Alzheimer's, and spinal cord injuries; 3) primary immunodeficiency disease; 4) diseases of bone and cartilage; and 5) cancer.

The Science of Tissue Engineering

You've Got Nerve! Exhibit

What To Do:

Try your hand at selecting the right combination of ingredients to regenerate nerve tissue. Press and hold one button in each column to see if you can reconnect the signals to the brain.

What's the Big Idea?

Some cells, like many nerve cells throughout your body, come to a point where they no longer replicate. The effects of age, disease, or damage to these cells can prevent the right signals getting to your brain. Other types of cells, though, continue to reproduce throughout your lifetime.

Researchers study this behavior in order to find ways to get certain cells, like nerve cells, to replicate certain ways for specific injuries. Tissue engineers are making progress in discovering ways to encourage replication in cells that normally do not reproduce. However, it's a tricky recipe for each of the many different types of cells. Some ingredients that work with one type of cell would kill another type.

Seamore Says:

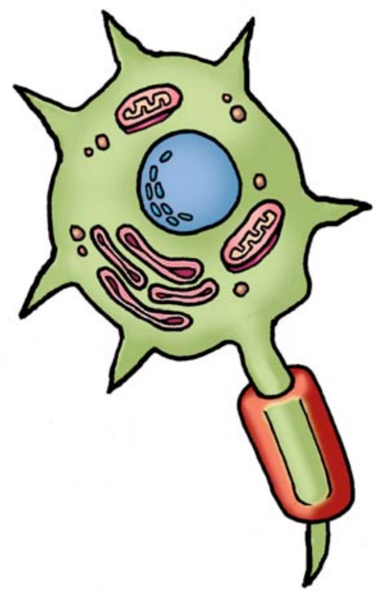
- The most common causes of nerve damage that can affect brain function are stroke, Parkinson's disease, Alzheimer's, cancer, and traumatic injury.
- In addition to those in the medical field, this research involves a lot of structural engineering—from tiny scaffolds for bone cells to grow over to microscopic mesh that supports new skin cells as they grow in place over a burn injury.
- There's still a lot to discover in this area. Perhaps one day you'll be involved in this important research and will be able to help many people!

Learning Goals for This Activity:

- Some cells, like many nerve cells, come to a point where they no longer replicate; other cells continue to reproduce.
- Researchers study this behavior in order to find ways to tailor cell replication for specific injuries.
- Science is making progress in discovering ways to encourage replication in cells that normally do not reproduce.

Activity Tip!

Choose carefully—there's only one right combination.



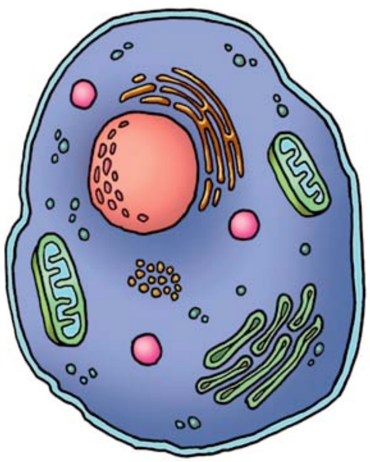
Stem Cell Q & A – Answers to Some Commonly-Asked Questions About Stem Cell Therapies

Q: Can scientists use stem cells to grow a whole new lung or heart or kidney if I need one?

A: Nope—not quite yet. However, scientists are growing tissues for many of our body parts: brain, eyes, esophagus, heart, bone, cartilage, bladder, kidney, and skin. These can be used to repair injuries and help cure disease. But, it's important to remember that we're a long way off from a 'spare parts kit', so look both ways before you cross the street!

Q: Where do stem cells come from?

A: Early stem cells, often called embryonic stem cells, are in the inner cell mass of a blastocyst, which is taken from fertilized, frozen eggs donated for research. The advantage of these stem cells is that they can become all cell types of the body. A disadvantage is that, since they don't come from a person's own body, his or her body may reject them.



Adult stem cells can form cells of many kinds of tissue. The advantage of using adult stem cells is that as they are a humans' own cells, and their bodies would not reject their own cells. Unlike embryonic stem cells, however, adult stem cells cannot become just any type of cell.

Work is progressing on many fronts to find the best sources of stem cells for research and treatment.

Q: So what are they going to be able to fix with stem cells?

A: Some day, doctors expect to use stem cells to treat:

- Spinal cord injury
- Parkinson's disease
- Sickle cell disease
- Stroke damage
- Diabetes
- Liver disease
- Heart disease
- Blood circulation problems
- Hemophilia
- Muscular dystrophy

Try This!

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The Termite Activity! – Autoimmune Problems and Rejection

Introduction

Tissue engineers must consider how the immune system might respond when a patient receives any type of implant, including the replacement parts they are working on growing in the lab. Tissue engineers and other biomedical researchers know that abnormal immune responses can result in big problems, such as chronic degenerative disease (like Lupus). Our immune components (cells) communicate. But, because their communication is pretty complex, they get help from chemical messengers.

One group of these chemical messengers are called *Chemokines* (a big and fancy word!). *Chemokines* often are able to specifically target a certain type of immune cell and direct its movement toward the source of the signal. For example, a wound or infection site often releases a *chemokine* that serves to 'recruit' immune cells such as neutrophils to the area. Neutrophils are one of the first responders at the site of injury, usually within minutes. Neutrophils are the predominant cells in pus.

This type of immune system messenger and cell interaction is the focus of this activity. Termites, along and other arthropods can be used to represent immune motile cells, and various inks can be used to represent *Chemokine* messengers.

Objectives

Students will:

- Learn to construct a simple model of an immune pathway.
- Learn to manipulate and interpret the behavior of arthropods and relate that behavior to normal immune functioning.

Materials

- Arthropods (mealworms, ants, termites, sow bugs, etc.)
- Long plastic trough
- Various types of pens (must include at least one of Papermate® brand)
- Paper

Procedure

- Have students draw four lines (any direction) with different writing utensils on a sheet of paper (one writing utensil must be a Papermate® pen).
- Students then will place the paper in a long plastic trough (to prevent arthropods from escaping).
- Students will place one termite and several other arthropods (sow bugs, centipedes, etc.) into the trough.
- Students are asked to observe the arthropods and make observations about their specific behavior and the relationship to normal immune cell function.

WHAT TO DO:

Select a video on a touch-screen to find out more about the people and work going on with tissue engineering today.

LEARNING GOALS FOR THIS ACTIVITY:

- Regeneration of bodily tissues and organs is limited in humans. Today's researchers are seeking means of enhancing regeneration either by stimulating these processes within our body or by developing tissues outside of the body, followed by implantation and continued monitoring.

- Stem cells, either embryonic (early) or adult (mature), currently are considered the most effective tool for regenerating damaged or diseased tissues. These cells can be injected (seeded) into a compromised tissue, or they can be loaded onto a three-dimensional matrix (mold) and allowed to develop in a laboratory prior to implantation.

- All bodily cells normally live in a characteristic, controlled environment known as the extracellular matrix (ECM). Tissue engineers strive to learn how to: 1) seed cells into the ECM of a damaged tissue or a tissue engineered scaffold; 2) manufacture artificial ECMs (scaffolds) with the appropriate physical and cell-supporting characteristic; 3) utilize natural ECMs to support tissue regeneration; and 4) control cell behavior within natural ECMs or scaffolds.

WHAT'S THE BIG IDEA?

Research at places like the McGowan Institute for Regenerative Medicine, Carnegie Mellon University, Duquesne University, and Allegheny Singer-Research Institute already are beginning to help patients with a variety of conditions and injuries. And, this work is led by a variety of researchers who do this for a number of reasons.

In this exhibit, you'll learn about the work of these leading researchers:

- *Anthony J. Atala, MD Chair of the Department of Urology, Wake Forest University School of Medicine*

  Dr. Atala is an internationally recognized expert in tissue engineering. His ground-breaking research has made great strides in the effort to treat, and ultimately cure, damaged or diseased organs. Using cells from the patients' own bodies, he has created urethra tubes through which urine is excreted from the body, blood vessels, bladders, wombs, muscle, and cartilage.

- *Eric Lagasse, PhD Director of the Cancer Stem Cell Center at the McGowan Institute for Regenerative Medicine*

  Dr. Lagasse's cutting-edge research looks at the link between cancer and regenerative medicine. Akin to finding a needle in a haystack, one area of his current research is focused on the identification of cancer stem cells to treat liver and prostrate cancers.

- *Kacey G. Marra, PhD Co-Director of the Adipose Stem Cell Center at the McGowan Institute for Regenerative Medicine*

  Dr. Marra's research focuses on using adipose-derived stem cells (stem cells from fat!) for tissue engineering applications such as cartilage, fat, and bone regeneration following traumatic injury. Another area of her work focuses on "long gap" nerve repair, another area that is very important in traumatic injury for wounded servicemen and women, as well as civilians.

- *Stephen Francis Badylak, DVM, PhD, MD Deputy Director of the McGowan Institute for Regenerative Medicine*

  Regenerative medicine expert Dr. Badylak shocked the medical world when two of his patients re-grew severed fingertips in just six weeks. The major focus of Dr. Badylak's work is on the use of mammalian-derived extracellular matrix (ECM) for remodeling and regeneration of many different tissues and organs, including tracheal, cardiovascular, liver, lower urinary tract, limb, digit, and many more. Another critical area focuses on developmental biology and its role in regenerative medicine.

- *Joon Sup Lee, MD Director of the Cardiovascular Institute at the University of Pittsburgh Medical Center*

  Dr. Lee is an interventional cardiologist at the University of Pittsburgh Medical Center and is the leader of a clinical trial to study if a patient's own stem cells can treat a form of severe coronary artery disease.

ASK THE SCIENTISTS

WHAT TO DO:

Select a video on a touch-screen to find the answers to some commonly-asked questions.

WHAT'S THE BIG IDEA?

People have lots of questions about tissue engineering. There nearly always is something new in the news—from cloning sheep to healing wounds. Moreover, some parts of the science of tissue engineering are not without controversy.

We've rounded up some of the most frequently asked questions:

1. *What tissue engineering and regenerative medicine procedures and technologies are available today, and when can we expect more to be available?*
2. *Are animals involved in tissue engineering and regenerative medicine, either as patients or in research?*
3. *Where do stem cells come from?*
4. *Can you clone me?*
5. *Are all stem cells the same? What are some pros and cons?*
6. *What careers can lead to work in tissue engineering? What type of background do I need to have?*

LEARNING GOALS FOR THIS ACTIVITY:

- Tissue engineered products have already made an impact in the health field. Skin was the first commonly used fabricated tissue. Cartilage also has been successful. The first engineered organ, the human bladder, is considered a landmark in biomedical history.
- Animals not only contribute to important biomedical issues; they also can benefit from the products and techniques developed by researchers.
- Stem cells are considered special in their ability to renew themselves and to give rise to a variety of different cell types. Scientists continue to explore the use of various types of stem cells, as well as their advantages and disadvantages. Stem cells can be found in the embryo (inner cell mass of the blastocyst), the umbilical cord, the placenta, and in the maturing human (adult, or more accurately, the post-embryo).
- Stem cells extracted from different sources appear to have different advantages and disadvantages. Embryonic stem cells are able to develop into a greater variety of tissues. However, they may cause more of an immune response in the host patient and may even behave abnormally over time, including the promotion of tumors. Adult, umbilical cord, and placental stem cells are thought not to produce an immune response in the host and are less likely to develop into tumors, but they are often more difficult to find, extract, and expand (increase the population size for therapeutic use).
- Tissue engineers are primarily concerned with therapeutic cloning (the generation of new tissue), which is quite different than reproductive cloning, an attempt at growing and entire organism (such as a human).
- A number of fields contribute to the field of regenerative medicine, including biology, physics, engineering, chemistry, materials science, mathematics, and health. In addition, support also is provided by such fields as business, law, political policy, and ethics.

SPEAK OUT!

WHAT TO DO:

Learn about some of the ethical issues surrounding tissue engineering, and have a chance to register your opinion about each.

THIS TOUCH-SCREEN ALLOWS YOU TO REGISTER YOUR OPINION ON SOME OF THESE ETHICAL SITUATIONS:

Question 1: In helping a patient to become pregnant, a number of embryos usually are created in fertility clinics to be used in IVF (in vitro fertilization). Once an embryo creates a healthy pregnancy, the extra ones are frozen and stored, without charge, for future use by the same donors. After one year, the donors must choose to pay for continued storage, destroy the embryos, or donate them for research.
What should be done with extra embryos?

Question 2: Tissue Engineering applications are likely to be more expensive than conventional treatments. They range from elective use—making lips fuller or reducing wrinkles due to aging—to quality of life applications like replacing torn cartilage in a person's knee and life-saving treatments such as grafting skin on a child's third degree burns.
Should healthcare plans cover costs of all uses of tissue engineering treatments?

Question 3: While it is illegal for athletes to use performance enhancing drugs, athletes may be able to enhance their performance using tissue engineering techniques applied to their own stem cells to accelerate muscle growth.
If available, effective and safe, should an athlete be able to utilize their own stem cells to enhance their performance?

WHAT'S THE BIG IDEA?

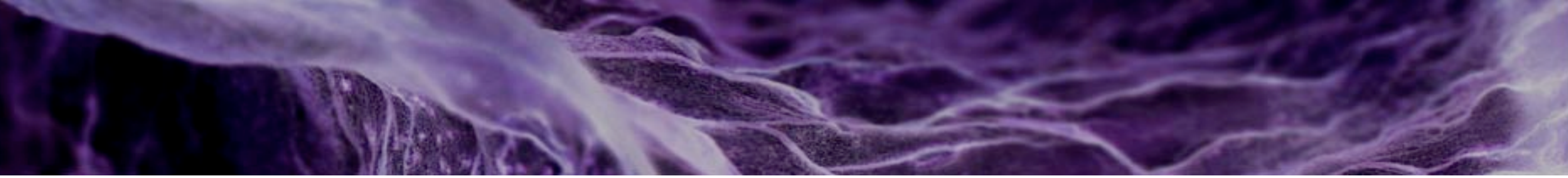
Whether you've already been able to have a look at the exhibition or if this is your first stop, you probably have some opinions about the ethical issues involved in the science of tissue engineering.

Question 4: Tissue engineering therapies are developed by scientists who receive funding from many sources: federal or state government, industry, and private foundations. While researchers can decide what to work on, funding sources influence the scope of the research.
When decisions about limits placed on tissue engineering research or clinical use are made, who should make them?

Question 5: Having access to cells or other biological material for research and therapy is central to the success of regenerative medicine. Cells that can be used range from those found in umbilical cords to adult "fat" or muscle tissues. Somatic cell nuclear transfer (SCNT) and embryonic stem cells are other sources. Accessing each of these has unique ethical and scientific challenges, as well as risks and benefits.
Would you donate your cells for research or therapies?

Question 6: Stem cell transplants are an effective treatment for children with leukemia, Hodgkin's disease, sickle cell disease, and Fanconi anemia. While cells may be available from The National Marrow Donor Program, there is an estimated "1 in 400 chance" that they will be a match. Parents who have a child with any of these diseases could decide to have another baby so that this child 's umbilical cord blood, stem cells, or bone marrow could be used to treat their sick child.
Is it right to create a life to save a life?

Question 7: Animals in research range from single-celled bacteria to primates and consenting humans! Different animals are used in different studies based on similarities to humans. Believe it or not, pigs and humans have a lot in common when scientific research is involved.
Is it right to experiment on animals to perfect tissue engineering techniques? If so, what types of animals do you think should be used?



Try This!

Here's a CLINICAL APPLICATIONS, ETHICS, ISSUES, AND ANSWERS extension activity you can try at school or at home! Visit **PTEI.org** for more on tissue engineering!

Ethical questions like those in this exhibit are debated at the highest levels of government, research, and education. However, everyone is really an "ethicist" of sorts! We make ethical decisions every day. Developmental learning research shows that, by age six, we should all have developed a sense of what is "right" and "wrong". As you grow older, parents, teachers, friends, experiences, religion, and such all shape your personal ethics. If you become a graduate student, teacher, scientist, doctor, or a researcher, you have to add a professional ethic to your personal one.

To read some case studies that involve professional ethics dilemmas in science and in tissue engineering, go to **PTEI.org**, and click on the "If a Starfish Can Grow a New Arm, Why Can't I?" link under Additional Resources. Try some of the "role plays", and practice the method posted there to recognize and resolve ethical issues from different perspectives.

Plus, explore the whole PTEI web page for other cool tissue engineering activities and information!

Web sites to visit to explore the science of tissue engineering even further!

EDUCATIONAL SUPPORT & RESEARCH ORGANIZATIONS

Pittsburgh Tissue Engineering Initiative
www.ptei.org

SEPA: Educational Resources - Overview
www.ncrrsepa.org/ed_overview

National Science and Technology Council (NSTC)
www.tissueengineering.gov

CLASSROM ACTIVITIES & MATERIALS

Nothwest Associatino for Biomedical Research - Education Materials
www.nwabr.org/education

Duquesne University I Regenerative Medicine Partnership in Education
www.sepa.duq.edu

Iowa State University Bioethics Outreach on Stem Cells
www.bioethics.iastate.edu/classroom/stemcells.html

Learn.Genetics ™ Activities from the University of Utah
learn.genetics.utah.edu

Tissue Engineering: Parts A, B, & C
www.liebertpub.com/ten

WEBCASTS & VIDEOS

Podcast Index of 'Regenerative Medicine Today' at the McGowan Institute
www.regenerativemedicinetoday.com

HHMI's BioInteractive - Stem Cells: Lecture Series
www.hhmi.org/biointeractive/stemcells/lectures.html

BACKGROUND INFORMATION AND REFERENCE

National Institutes of Health 'Stem Cell Basics'
stemcells.nih.gov/info/basics/basics1

US: Coalition on the Public Understanding of Science
www.copusproject.org

International Society for Stem Cell Research: Glossary
www.isscr.org/glossary

Kansas University - Stem Cell Research Basics
www.kumc.edu/stemcell/glossary.html

Stem Cell Terminology: Practical, Theological And Ethical Implications
www.encyclopedia.com/doc/1G1-96379528.html

Stem Cell Basics
www.pacificord.com/downloads/1.1a-res.../StemCellBasics.pdf

Tissue Engineering – Wikipedia
en.wikipedia.org/wiki/Tissue_engineering

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