I. Abstract

For many years there has not been an efficient way to heal skin damage. We have invented an alternative to taking healthy skin and placing it on the damaged part, which is called skin grafting. Our vision is a new process which eliminates scarring, pain, and death. Plant leaves provide a base for stem cells to grow into skin cells. We are proposing taking plant leaves and removing the tissue until only the veins are left. Plant leaves' veins are similar to human veins and offer the critical blood flow through veins which provide the nutrients and hormones. Our team designed a new device that will extract epidermal skin cells from our own bodies and spray it on wounds. In addition, breakthroughs in using bacterial enzymes, which create protein fragments named peptides, allowing the skin to heal within days.

II. Description

1. Present Technology

Today, there are many reasons why skin can be damaged. A person can get burned, someone can get skin cancer, or badly cut. The current technology used today is taking healthy skin and putting it on the wound.

The skin is the largest organ in the body and consists of three layers, the epidermis, the dermis, and the hypodermis. The epidermis is the first layer, which is waterproof. The dermis is the second layer. It contains basal cells, blood vessels, and lymph vessels. The hypodermis is the third layer and contains most of the body fat and adipose tissue.

The skin grows really fast. There are 19 million skin cells in every inch of your body. Your body is making new skin cells and getting rid of old cells all the time. Your body gets rid of 30-40 thousand old skin cells a day. The skin you see on your body right now will be gone in a month. The top 18 to 23 layers of skin are made of dead cells. New skin cells form at the very bottom of the epidermis, the top layer of your skin. In one inch of skin, you have 650 sweat glands, 20 blood vessels, 60,000 melanocytes, (the thing that gives your skin color) and 1,000 or a few more nerve endings.

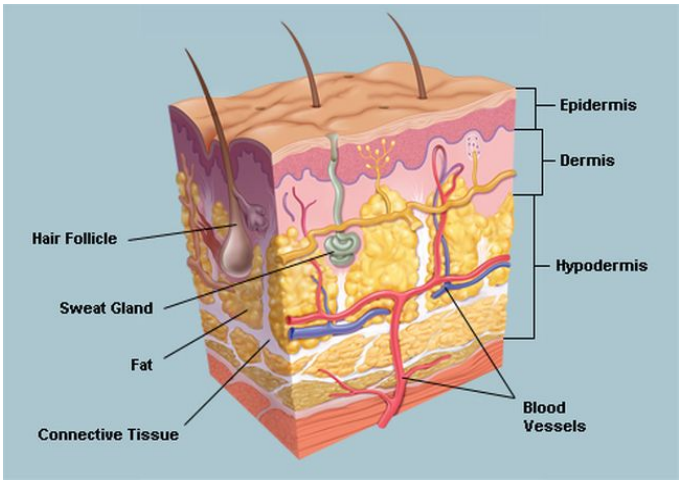

Figure 1: Skin Layers

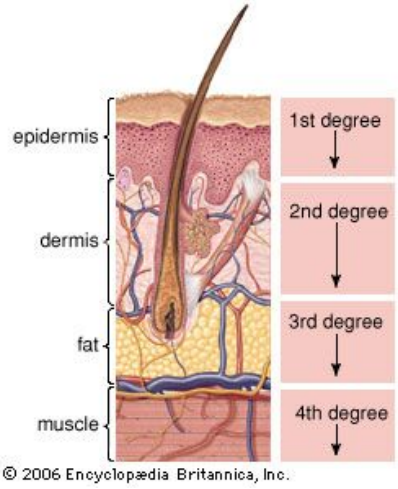

Figure 2: Skin Damage Classification

When your skin is damaged, the doctors classify it as first-degree, second-degree, third-degree, and fourth-degree. A first-degree burn is the least fatal. It only damages the first layer of skin, named the epidermis. A second-degree burn damages the epidermis and the dermis. Some symptoms include pain, peeling skin, swelling, and white or charred skin. A third-degree burn damages all the layers of skin and if not treated can be fatal. There may be little pain due to nerves being damaged. Fourth-degree burns damage all the layers of skin, fat, flesh, and can even burn to the bone. There is no pain because nerves have been destroyed or damaged. If a burn is a fourth-degree burn, it will most likely result in death.

One of the present technology to address severely damaged skin is skin grafting. Skin grafting is when the doctor puts healthy skin on the area you burned or severely damaged. At the start of the process, the doctor will clean your healthy skin. After that, they will cut skin out from other parts of the body depending on how much skin you need. Doctors will then clean the

damaged skin and cut it out. Then, the doctors will stitch the healthy skin on. Finally, they cover it and wrap it.

Skin grafting has limitations. The big problem with skin grafting is after sealing the burn there is still a large wound where the healthy skin used to be. It is a painful procedure and can restrict the ability to move. Sometimes, the skin is unable to grow with the patient. It is only able to cover two to three times as much as the area they took the skin from. The site of which it is taken from must be healthy and clean.

2. History

History of Skin Grafting

Skin grafting was created about 2500-3000 years ago at the Hindu Tilemaker Castle. They used skin grafting to reconstruct amputated noses. Later uses were in the mid-to-late 19th century.

History of Human Cells and Stem Cells

In the mid-1800s, humans discovered that cells were what made up our life and some could reproduce others. In the early 1900s, it was discovered that some cells could produce blood cells. In the year 1978 scientist discovered stem cells. The first, vitro stem cells line was developed using mice in 1981. The very first embryonic stem cells line was created by using a hamster. In 1997 they cloned a lamb using stem cells. In 1998, Thomson developed embryonic stem cells. That year Gearheart, obtained germ cells from cells in fetal gonad tissue. On July

Fourth, 2009 Pennsylvania state trooper Matt Uram received a 2.5-degree burn. Doctors used stem cells from his thigh to spray on his wound.

History of Plant Veins for Human Use

The scientists, Glenn Gaudette and Joshua Gershlak, used plant veins to transform spinach leaves into a beating human heart tissue. They wanted to engineer a solution to organ shortage. Glenn Gaudette stated, "We have a lot more work to do, but so far this is very promising."

3. Future Technology

In the future, if anyone has skin damage, our vision is they will no longer need to go to the hospital and have their healthy skin used to replace their damaged skin. We will avoid death, scarring, and severe pain by using this new technology. When someone gets burned we want them to be able to take a leaf from a tree, soak it in a solution and put it on the wound. We will take the skin device, extract epidermal cells from our own skin, and then spray the stem cells on the wound. To heal faster, we will need a breakthrough in speeding up the cell production with peptides, which are created from collagen breaking down in the active site of the bacterial enzyme. A few days later their skin will be healed without pain or scarring.

Leaves are the key factor of our project and the veins are critical. We use leaves because of their veins, which operate similarly to our blood vessels in our circulatory system. The circulatory system is the way blood moves throughout your body in a fast-paced continuing cycle. The main part of this loop is the heart. The heart pumps blood through the veins and

arteries. Arteries carry blood away from the heart, while veins carry blood to the heart. Capillaries exchange blood from the arteries to the veins.

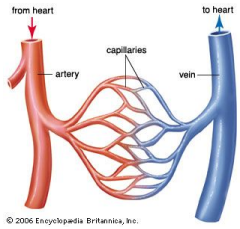

Figure 3: Circulatory system

Our blood vessels are similar to leaf veins, they both are a network of tubes to bring nutrients to different parts of the plant or body where it is needed. Veins are important in our skin because they bring nutrients to the skin cells. The nutrients allow the cells to do their job. When our skin is burned our blood vessels are damaged, the wound is open, causing potential infection and death.

Our vision is to have the skin heal quickly without pain, scarring, and death. We need to remove the plant's cellular material to prepare the plant's structure for human blood flow and to allow skin cells to grow and do their job. As shown in Figure 4, our team boiled water and sodium carbonate to get rid of the cellular material. After all of the skin of the leaf is rubbed off we had the skeleton with the stem and veins prepared to support the blood flow.

Figure 4: Team preparing leaves for human veins

New skin cells form at the very bottom of the epidermis. We will be able to rapidly grow skin cells on the plant's veins. To achieve this we must use stem cells. "Stem cells are a class of undifferentiated cells that are able to differentiate into specialized cell types." [1] Stem cells come from two main sources: Adult tissue (adult stem cells) and Embryos (embryonic stem cells). We will use adult stem cells found in the skin called epidermal stem cells as shown in Figure 5.

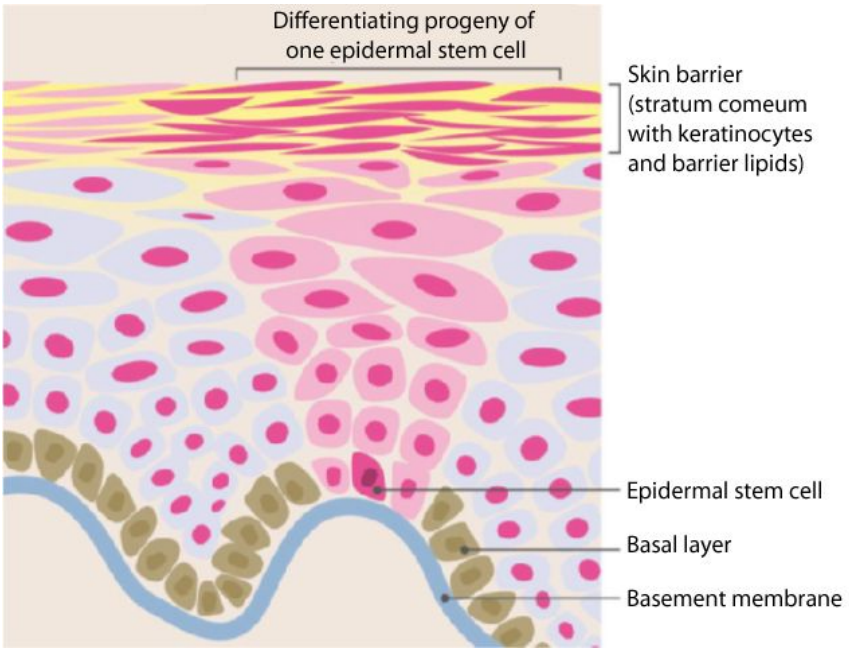

Figure 5: Epidermal stem cells found in the skin

The stem cells would be collected by a skin device, which would draw stem cells already in your skin. When the skin device is loaded, you would spray the cells on the prepared leaf on the damaged skin.

1

[1] Team, The MNT Editorial. "What Are Stem Cells?" *Medical News Today*, MediLexicon International, 19 July 2017, www.medicalnewstoday.com/info/stem_cell.

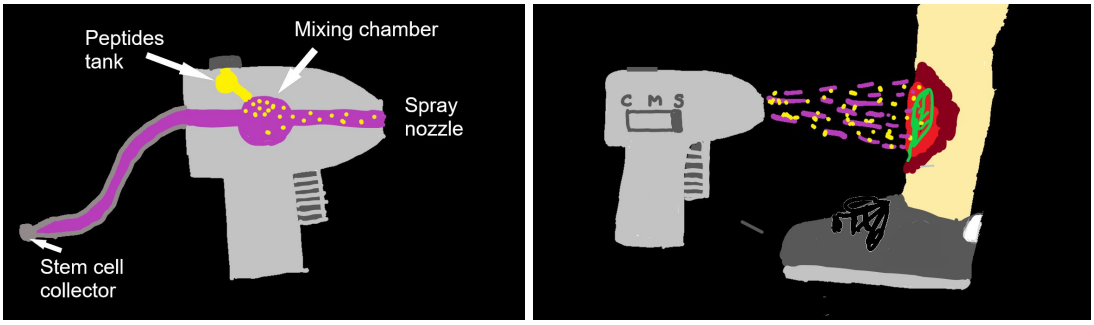

Figure 6: Team illustration of the skin device

Based on the research from Tufts Center for Innovations in Wound Healing Research, we will be using Clostridium histolyticum to speed up the healing process. This bacteria is commonly found in feces and soil. Clostridium histolyticum, consists of bacterial enzymes, which break down collagen, creating peptides. The peptides created by this process can make the cells develop faster and should heal within days.

4. Breakthroughs

We want to speed up the process of healing burned skin. To do so, we need to have breakthroughs in using bacterial enzymes. When we spray on the cells, it will instantly heal the burn. This will improve the process of healing burns quickly and without scarring. The cells will allow the skin to heal faster instead of taking weeks or months. Another breakthrough we would need is to be able to connect the leaf veins to the blood vessels without a doctor needed.

From our experiments, we know that stripping the leaf is very time-consuming. It took two to four hours to complete. To make this technology practical, we would need a breakthrough to remove the cellular material of the leaf quickly, or we could package pre-stripped leaves for instant use.

Veins play an important part in our project. We would need to know how much volume could go through the veins. Our team conducted a study to prove that blood would be able to flow through the veins. We experimented with red and blue dye using carnations to find out if blood could flow through the leaf veins. As shown in figure 7, the veins transported the dye similar to how the blood would move through plant veins.

Figure 7: Team proving veins will transport blood by using carnations and dye

An experiment we would like to do in the future is to find the amount of blood in human veins and how much liquid is in the plant veins. This will help us compare how much liquid the veins can contain.

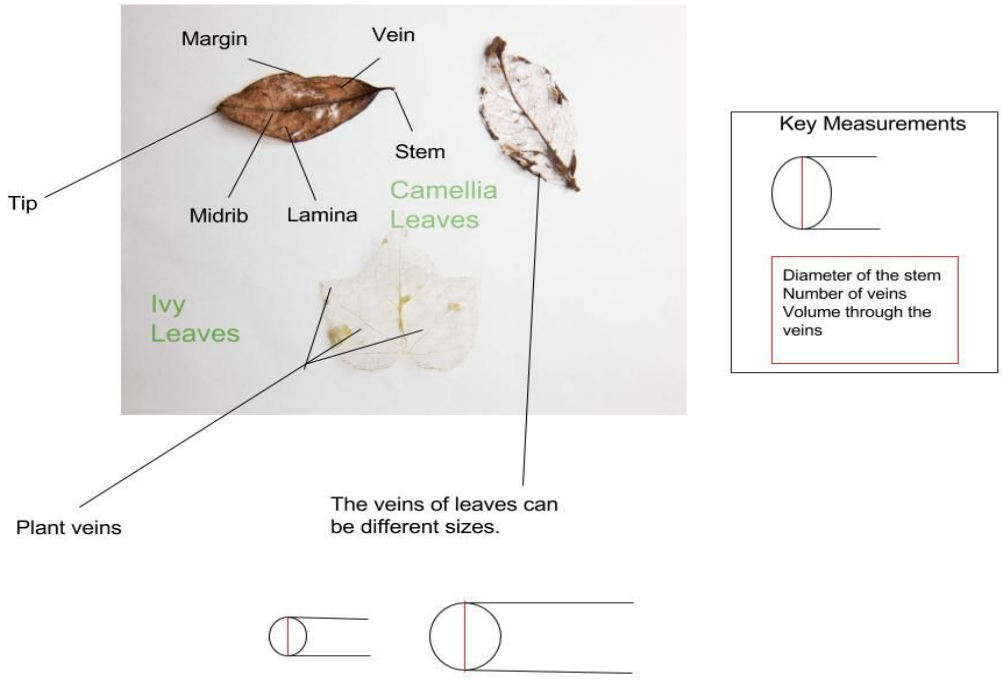

Figure 8: Explaining leaf parts and diameter

One study we would perform is to find is the diameter and volume of plant vessels. The data we need is how much volume is going through the veins. We also need to compare it to skin vessels. "Diameter opening in the stem would allow more volume to pass through the leaf" as Dr. Glenn Gaudette and Dr. Joshua Gershlak said in our interview. This is important because to find out which leaves would work best based on the volume and blood needed for the skin. To find the volume of blood moving through the veins, these are the calculations based on Charlie Drewes' work, who is a professor at Iowa State University:

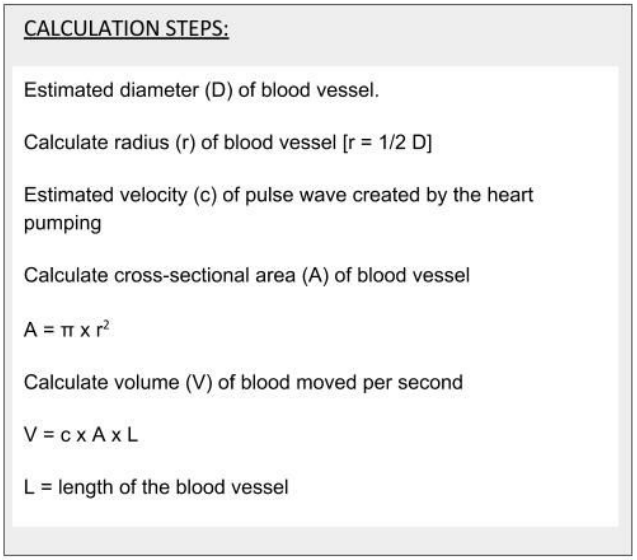

Figure 9: Calculations to understand the volume of blood flow through a vein

5. Design Process

We were first inspired by Dr. Glenn Gaudette and Dr. Joshua Gershlak after watching a TV show featuring them. On the TV show, they demonstrated how spinach leaves can let the blood flow to help heart issues. On America's Got Talent, we saw Kechi talk about her severe burns after a plane crash. Our team wanted to heal skin damage. We then researched skin and learned the skin also needs blood flow for the cells. We split the team into a plant team and a skin team for research.

Our team researched how we could use stem cells on leaves. Originally, we were going to use embryonic stem cells until we discovered epidermal stem cells. Epidermal stem cells are found in the skin, unlike the embryonic stem cells that are harder to obtain. Our team developed the idea to extract the epidermal stem cells from our own skin and be able to spray it on our own wounds.

Early in the project, we researched the idea of using or making artificial epidermis skin. Burke and Yannas made the artificial epidermis skin. It made it easier to apply skin grafts to a burn victim. The skin that leaves the lab must be used almost immediately because it is so fragile. The skin is also very expensive; an article in 2001 claimed that an 8 by 10-inch sheet of skin cost $2,000. This is one of the downsides of artificial skin and why we rejected it.

We debated about an option to speed up the process of the healing. Macrophage cells and bacterial enzymes were our two options. We were researching reptiles because they have the potential to regrow limbs. We discovered macrophage cells. Macrophage cells are cells that help heal wounds. The macrophage cells are produced from stem cells and found in bone marrow which would be harder to extract. We decided on bacterial enzymes over macrophage cells because they would be easier to obtain. Bacterial enzymes create protein fragments that are called peptides, which makes cells develop faster. That is the reason we chose the bacterial enzymes over the macrophage cells.

6. Consequences

With every new technology there are positive and negatives impacts on society. Positives about our method are that it is a lot faster than the present method, skin grafting. Skin grafting can be difficult because a doctor is needed. Skin grafting requires skin of different size and thickness, which can be hard to obtain. Skin grafting will leave exposed areas of skin, unlike our solution. Our solution will be easy, fast and eco-friendly. One of the negatives of our project is lack of research and testing. Some human bodies may reject plant veins as real veins. This is why you would need a lot of testing on humans.

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Figure 4: Created by team

Figure 5: *Stem Cells*. www.iphytoscience.com/images/double_02.jpg.

Figure 6: Created by team

Figure 7: Created by team

Figure 8: Created by team

Figure 9: Drewes. *Calculation of the Blood Volume That Moves through the Dorsal Blood Vessel in Lumbriculus Variegatus*, www.eeob.iastate.edu/faculty/DrewesC/htdocs/LV-DBV-calc.htm.

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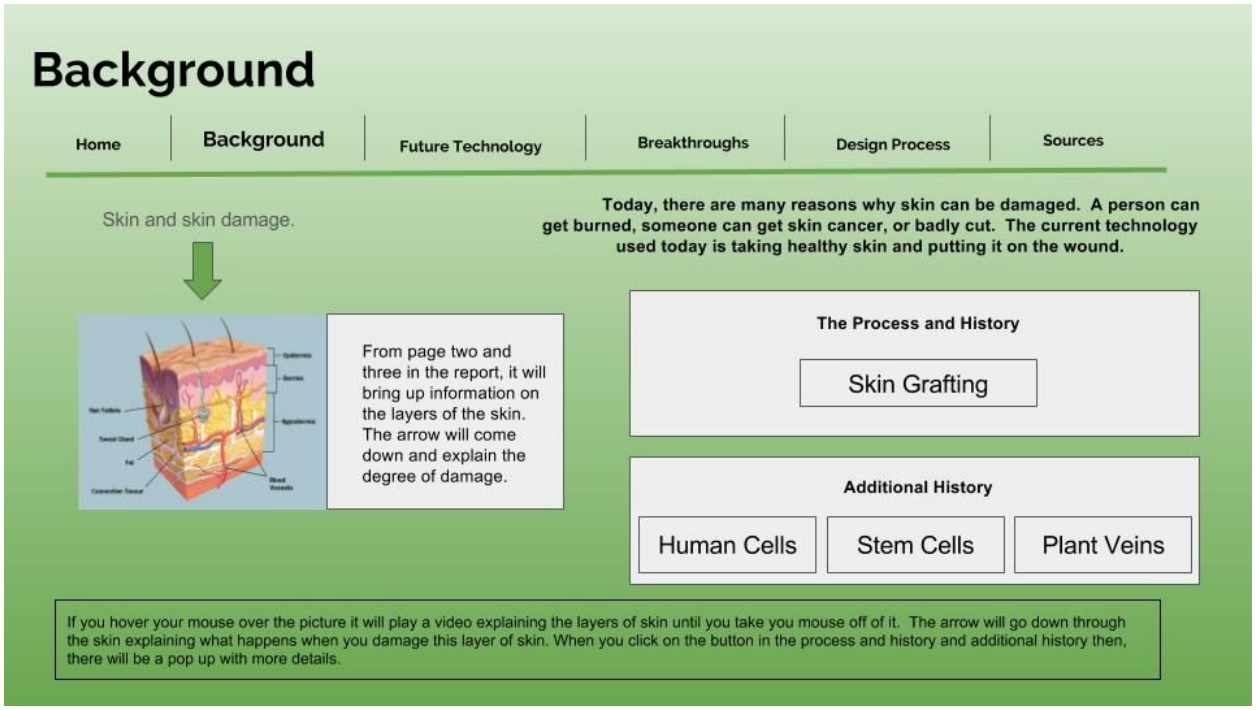
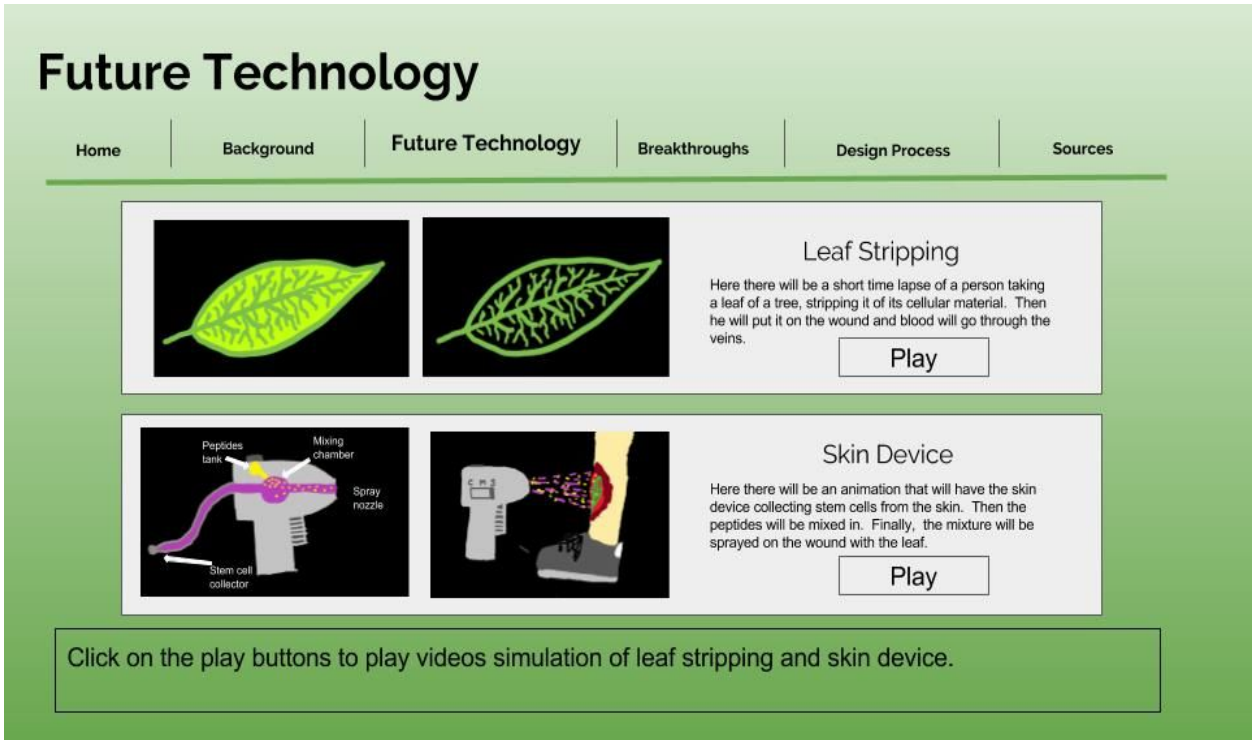
IV. Web Pages

Page 1

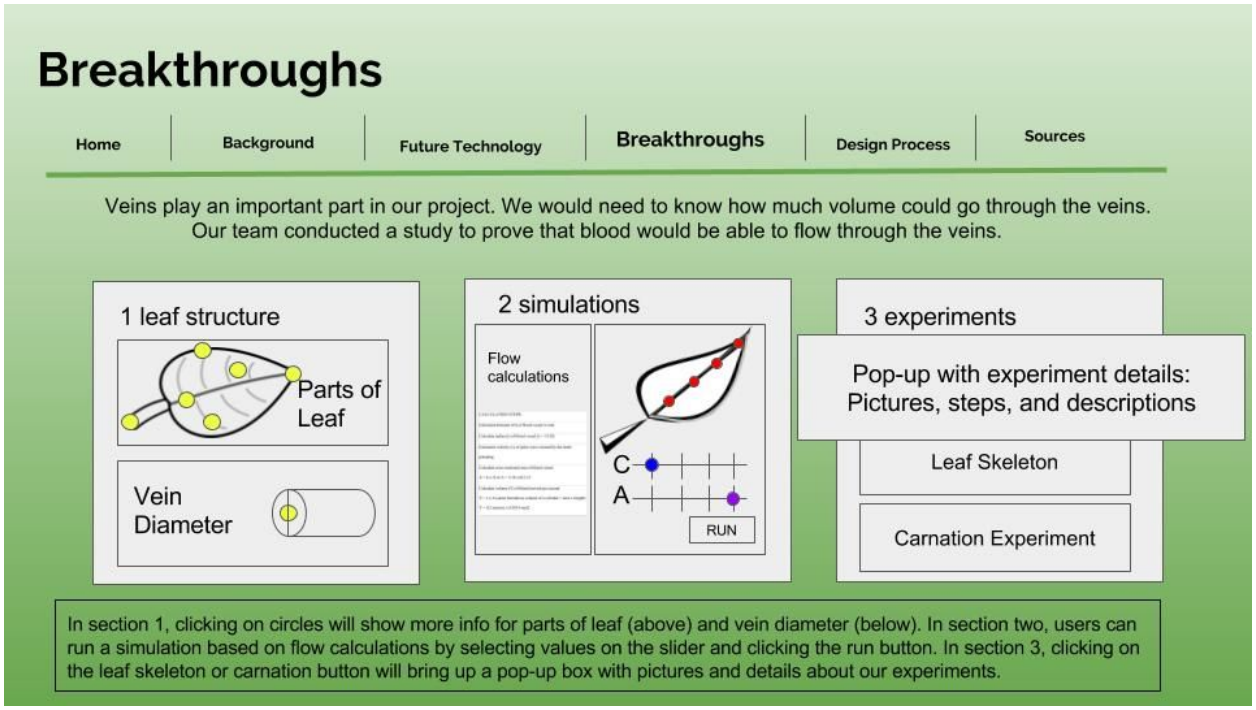
Page 2


Background
Home
Background
Future Technology
Breakthroughs
Design Process
Sources
Skin and skin damage.
Today, there are many reasons why skin can be damaged. A person can get burned, someone can get skin cancer, or badly cut. The current technology used today is taking healthy skin and putting it on the wound.
From page two and three in the report, it will bring up information on the layers of the skin. The arrow will come down and explain the degree of damage.
The Process and History
Skin Grafting
Additional History
Human Cells
Stem Cells
Plant Veins
If you hover your mouse over the picture it will play a video explaining the layers of skin until you take you mouse off of it. The arrow will go down through the skin explaining what happens when you damage this layer of skin. When you click on the button in the process and history and additional history then, there will be a pop up with more details.

Page 3


Future Technology
Home
Background
Future Technology
Breakthroughs
Design Process
Sources
Leaf Stripping
Here there will be a short time lapse of a person taking a leaf of a tree, stripping it of its cellular material. Then he will put it on the wound and blood will go through the veins.
Play
Peptides tank
Mixing chamber
Spray nozzle
Stem cell collector
Skin Device
Here there will be an animation that will have the skin device collecting stem cells from the skin. Then the peptides will be mixed in. Finally, the mixture will be sprayed on the wound with the leaf.
Play
Click on the play buttons to play videos simulation of leaf stripping and skin device.

Page 4


Breakthroughs
Home
Background
Future Technology
Breakthroughs
Design Process
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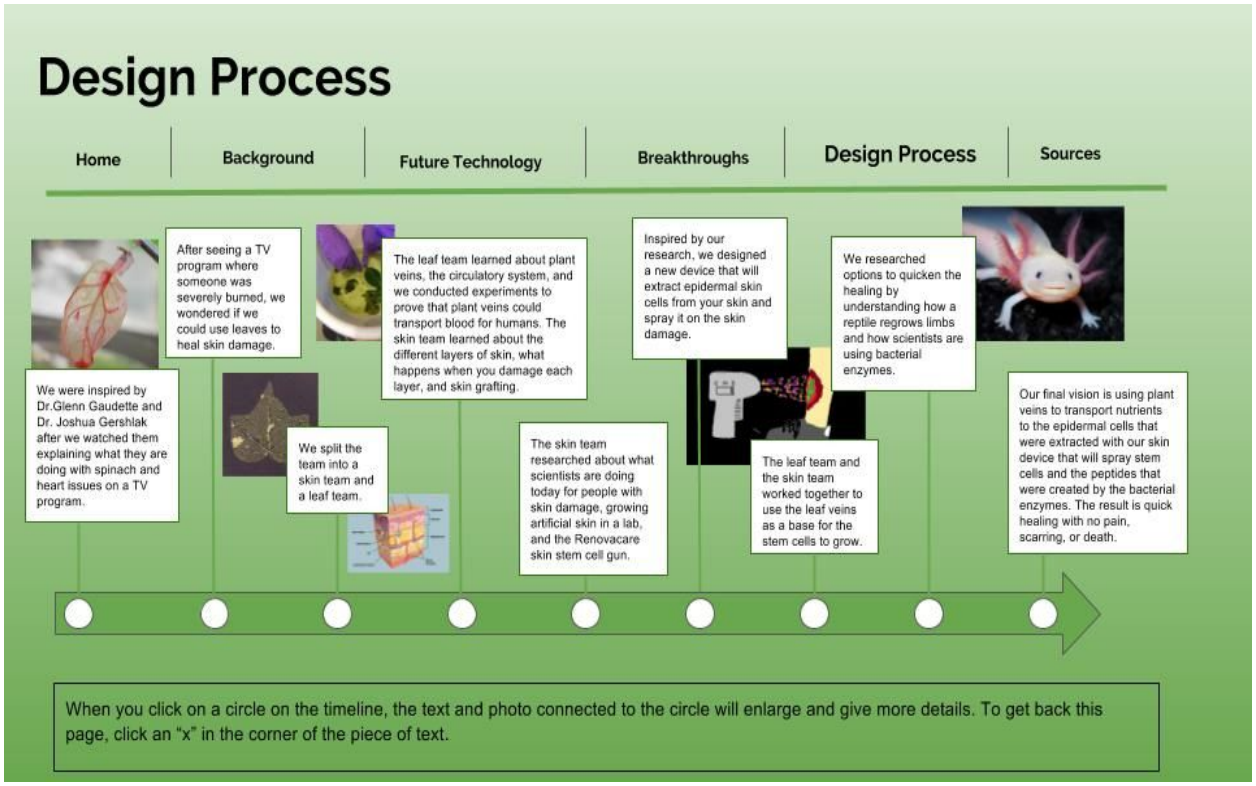
Veins play an important part in our project. We would need to know how much volume could go through the veins. Our team conducted a study to prove that blood would be able to flow through the veins.
1 leaf structure
Parts of Leaf
Vein Diameter
2 simulations
Flow calculations
C
A
RUN
3 experiments
Pop-up with experiment details: Pictures, steps, and descriptions
Leaf Skeleton
Carnation Experiment
In section 1, clicking on circles will show more info for parts of leaf (above) and vein diameter (below). In section two, users can run a simulation based on flow calculations by selecting values on the slider and clicking the run button. In section 3, clicking on the leaf skeleton or carnation button will bring up a pop-up box with pictures and details about our experiments.

Page 5


Design Process
Home
Background
Future Technology
Breakthroughs
Design Process
Sources
We were inspired by Dr.Glenn Gaudette and Dr. Joshua Gershlak after we watched them explaining what they are doing with spinach and heart issues on a TV program.
After seeing a TV program where someone was severely burned, we wondered if we could use leaves to heal skin damage.
We split the team into a skin team and a leaf team.
The leaf team learned about plant veins, the circulatory system, and we conducted experiments to prove that plant veins could transport blood for humans. The skin team learned about the different layers of skin, what happens when you damage each layer, and skin grafting.
The skin team researched about what scientists are doing today for people with skin damage, growing artificial skin in a lab, and the Renovacare skin stem cell gun.
Inspired by our research, we designed a new device that will extract epidermal skin cells from your skin and spray it on the skin damage.
The leaf team and the skin team worked together to use the leaf veins as a base for the stem cells to grow.
We researched options to quicken the healing by understanding how a reptile regrows limbs and how scientists are using bacterial enzymes.
Our final vision is using plant veins to transport nutrients to the epidermal cells that were extracted with our skin device that will spray stem cells and the peptides that were created by the bacterial enzymes. The result is quick healing with no pain, scarring, or death.
When you click on a circle on the timeline, the text and photo connected to the circle will enlarge and give more details. To get back this page, click an "x" in the corner of the piece of text.