The Diagnostic Band (TDB)

I. Abstract:

Our vision is for everyone to be able to diagnose multiple problems by themselves, quickly. Especially during this pandemic, people are spreading pathogens unknowingly, and it's costing people their lives. We have designed a wearable band along with a nanobot that will allow you to diagnose: viruses, diseases, body injuries, environmental conditions, and safety issues by yourself, at any time. We will use Artificial intelligence, nanotechnology, ultrasound, and sensors for diagnostics. To power our nanorobot and our band, we will harvest Radio Frequency (RF) energy and use radio waves for communications.

II. Description

1. Present Technology

Today there are wearables that can track heart rate, activity, sleep, exercise, weight, and blood pressure. What we don't have today is a wearable that can detect internal and external health issues all in one device. In our vision, our band can diagnose multiple problems, whereas most bands today typically are very heavy and can only track basic health or fitness indicators. On top of that, they are sometimes not 100% accurate. Many fitness trackers measure users' steps and heart rate, but they don't get into the deep diagnostics of biomarkers or other internal indicators. For now, those who want to screen for a disease or a medical condition still need to go to the doctor.

Some types of medical devices and technology used by doctors are stethoscopes, sphygmomanometers, ophthalmoscopes, electrocardiographs, X-Rays, MRIs, ultrasounds, CTs, pathology tests, diagnostic tests, bone scans, thermometers. A big limitation is that most of these devices cost a lot of money and thus require a lot of training to use them, as well as access to a medical facility and a trained professional.

The CDC currently recommends a nasopharyngeal swab to test for the virus COVID-19. This method is uncomfortable and it can take several days for your test results to arrive. In addition, false positives are relatively common.

2. History

We focused on the history of the wearables technologies related to health. The first known wearable related to health was the eyeglasses. The eyeglasses were created in the 13th-century by Salvino D'Armate. The next major health subject that an invention was made to help with was hearing. In 1938, the wearable healing aid was developed by Aurex Corp. 2006 was the year when companies started to release improved mobile health products. Nike and Apple partnered together in 2006 to create a wireless system between the iPod and Nike+ footwear. The iPod and Nike+ footwear came in a kit. The kit stored information about time spent running, calories you burned, how far you ran, and pace. In the year 2010, Philips designed a device known as the Philips Lifeline. This enables seniors to call for help if they fall in their house, or anywhere on vacation. April 24th, 2015 was the release date of the Apple Watch. The Apple Watch had fitness tracking and health monitoring capabilities.

3. Future Technology

The vision for our diagnostic band is to have a quick, portable, and effective diagnostic device. It can act as a monitor for an ongoing condition. Our diagnostic band targets users that don't have access to medical care, cannot afford medical care, and users that need a quick and accessible diagnostic and monitoring device.

Our diagnostic band will diagnose viruses, diseases, body injuries, safety, and environmental conditions. To diagnose external conditions, we will use different types of sensors and artificial intelligence. To diagnose internal conditions, we will use a nanorobot. Our nanorobot will communicate with our band using radio waves to diagnose internal conditions.

On the band there will be a small screen that will be able to show time, weather, have a camera, health related information, etc. When it senses something about your body or the environment it will give you a notification. There will also be the option to have bluetooth headphones/earbuds.

Because our device is used for self-diagnosing, the device must alert the user if a condition is detected. The device will inform the user what condition they have, accompanied with a quick overview of what the condition is. The device will also provide how severe the condition is and what to do. The device will keep track of your schedule and hobbies.

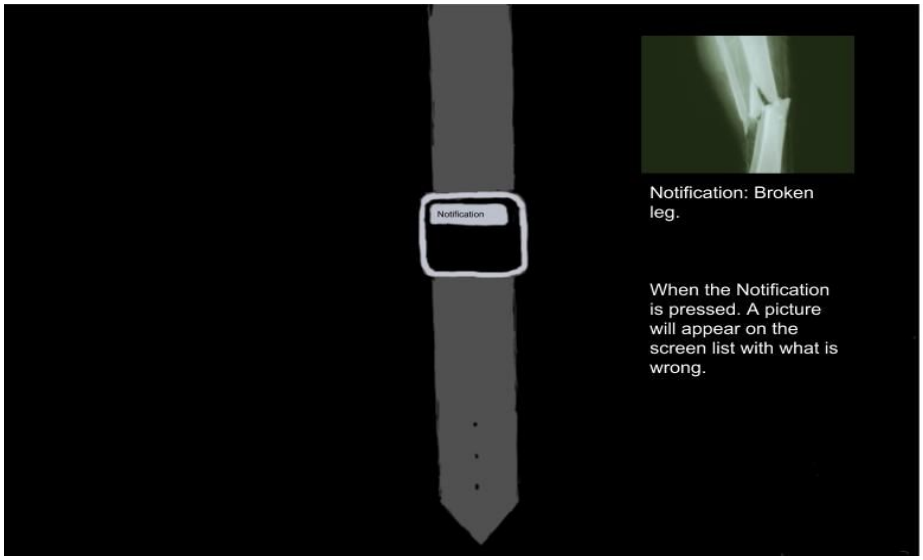


Figure: 1

As shown in Figure 1, the band will have a small screen that will display different information about your body. Whenever it detects a problem in your body, a notification will appear on the screen. When the notification is pressed, it will list the problem/s and/or it will show an image of what's wrong with your body. When it is turned on for the first time there will

be multiple applications that can be downloaded such as a phone app where you can call people. There will also be an application where you can see the data that the band has collected.

A key technology behind our band and nanorobot is the use of biosensors. A biosensor is a device used for the detection of an analyte. This combines a biological component with a physicochemical detector component. As shown in Figure 2, a biosensor consists of three different parts such as the transducer, the recognition layer, and the analyte. The analytes will be bacteria, viruses, sweat glands, blood, pollutants in the air, cancerous cells, etc. The different types of sensors are optical, mechanical, electrical, and magnetic.

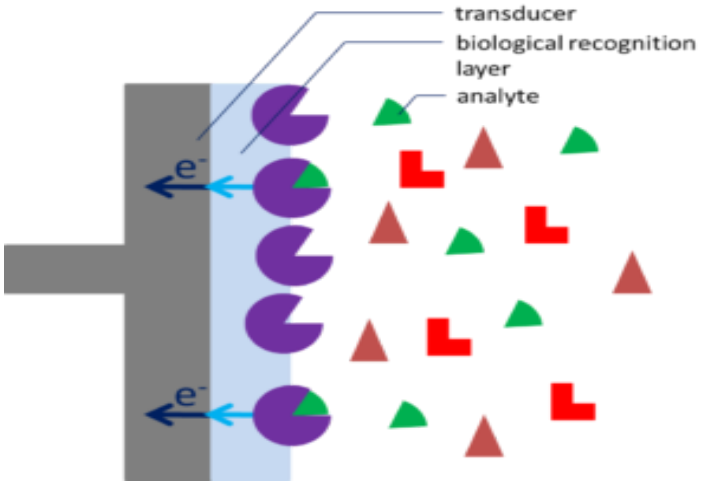


Figure: 2

Internal problems may not be successfully and accurately monitored by technologies on the outside. We decided on a nanorobot that will traverse the body and relay information back to the band. The nanorobot will include sensors and ultrasound imaging that will analyze the body to ensure that the body is healthy and working properly. They can be deployed into the body by injection.

"Nanotechnology is the science, engineering, and technology conducted at the nanoscale."[1] We are using a nanorobot to diagnose diseases and body injuries. Some injuries and diseases our nanorobot can diagnose are asthma, cancer, diabetes, kidney disease, heart disease, muscle and ligament soreness, concussions, and broken bones. Nanorobots can also eliminate the need for MRIs, X Rays, and CT Scans.

Our nanobot will use sensors to detect viruses. The sensors will be used to quickly and accurately test for COVID-19 and other viruses. This will eliminate the long wait time to getting your test results.

The nanorobot will determine if a cell is cancerous by looking at the size and shape of the cell, the size and shape of the cell's nucleus, and the arrangement of the cells. If the nanorobot finds that a cell is abnormal, it will send a message to your band and your band will display a notification on its screen telling you to visit a doctor and that you potentially could have cancer.

Our nanorobot will also be able to diagnose broken bones and fractured bones by taking images and looking at the broken bones, pulled muscles, ligaments, etc. This will also send a notification to your band that will tell you that you have a broken bone, a pulled muscle, or a ligament problem and to see a doctor for treatment.

The design of the nanorobot is very important. In general, our nanorobot will need to include a controller, a locomotion device, sensors, a manipulator/end effector, and a power source.

[1] "What Is Nanotechnology?" *What Is Nanotechnology? | Nano*, www.nano.gov/nanotech-101/what/definition.

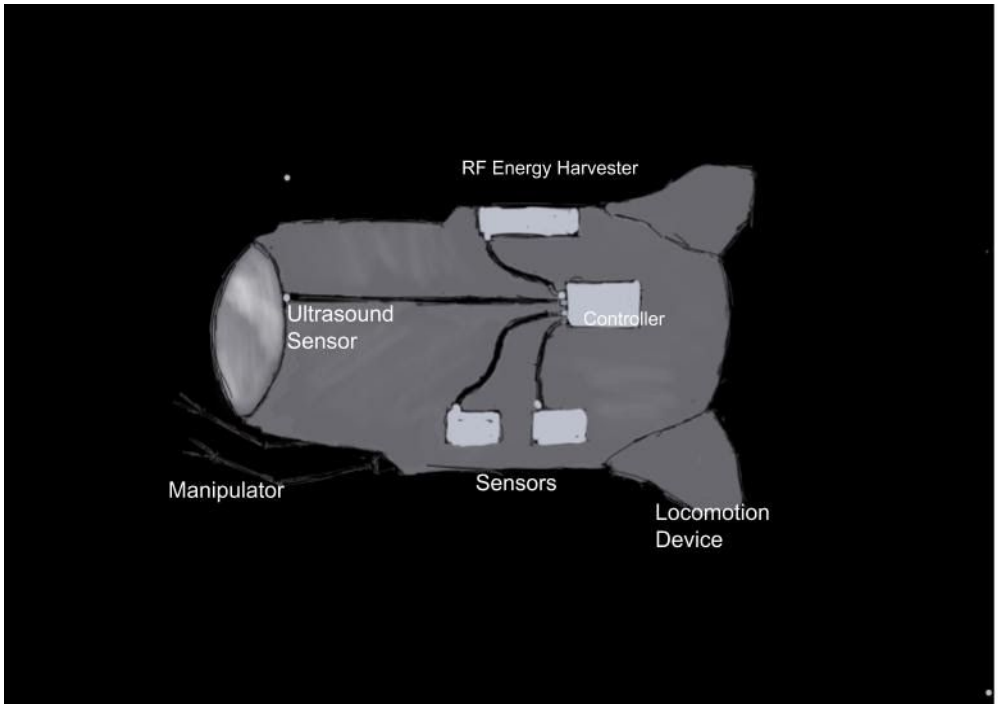


Figure: 3

Our nanorobot, as illustrated in Figure 3, will include fins as a locomotive device to move through the bloodstream. It will have a manipulator claw to grab cells and to analyze them. Inside the controller, we will include artificial intelligence and programs to understand the data from the sensors and to communicate back to the band. We will need an ultrasound for imaging, so that we can detect bone fractures and injuries.

A power source is the energy source for the robot and band. To power our nanorobot and our band, we will harvest Radio Frequency (RF) energy. In the air, there is RF energy from Wi-Fi, radios, microwaves, cell phones, etc. We will use an RF energy harvester to gather RF energy and convert it to electricity. As shown in Figure 4, an antenna will capture RF energy, then an RF-to-DC converter will convert it to electricity. DC power management circuitry will

distribute the electricity to different parts of the nanorobot and the band that require electricity (e.g. sensors, screen, controllers, and etc.)

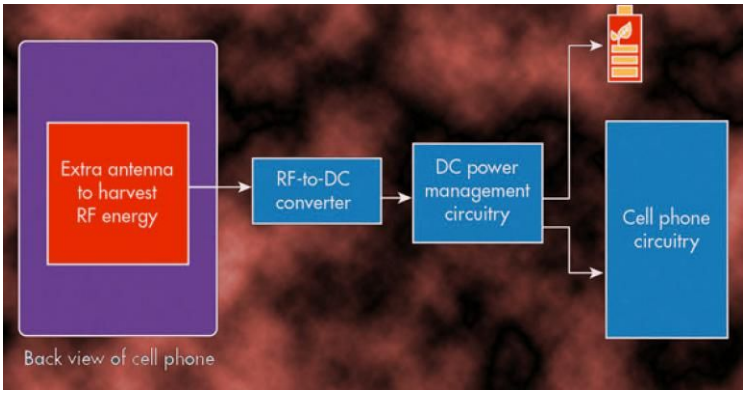


Figure 4:

In our vision, our nanorobot will use an ultrasound to examine your body for broken bones or any other body injuries and diagnose your injuries. An ultrasound is a part of medical imaging. It uses sounds or vibrations with ultrasonic frequencies to examine a fetus or look inside your body for broken bones. We will use an ultrasound image over an X-Ray image because an X-Ray gives off radiation.

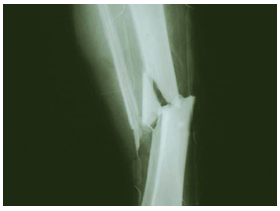


Figure: 5

The nanorobot and the band will communicate via electromagnetic radio waves. Communication between the band and the nanorobot is essential, as information collected from the robot needs to be sent to the band for the user to access it. The band will also use electromagnetic radio waves to communicate to emergency services and to contact the band.

All waves consist of energy transmitted by particles. Electromagnetic (EM) waves can travel in a vacuum, unlike mechanical waves. EM waves will travel in a straight line unless another force changes its course. Electromagnetic radiation consists of interconnected electric and magnetic fields, both containing energy. The electric field will change with time, creating a magnetic field. The magnetic field will also change with time, creating an electric field. The fields travel across space, endlessly creating each other in an electromagnetic wave.

The waves we have decided to use are electromagnetic radio waves from the electromagnetic radiation spectrum. If you look at the EM spectrum in Figure 6, wavelengths get smaller or tighter as you move up. Here we will find X-Rays and gamma rays. These rays are accessible by only trained handlers, as they can be harmful. On the other hand, television and radio waves, which are located at the bottom of the spectrum, are longer and not dangerous.

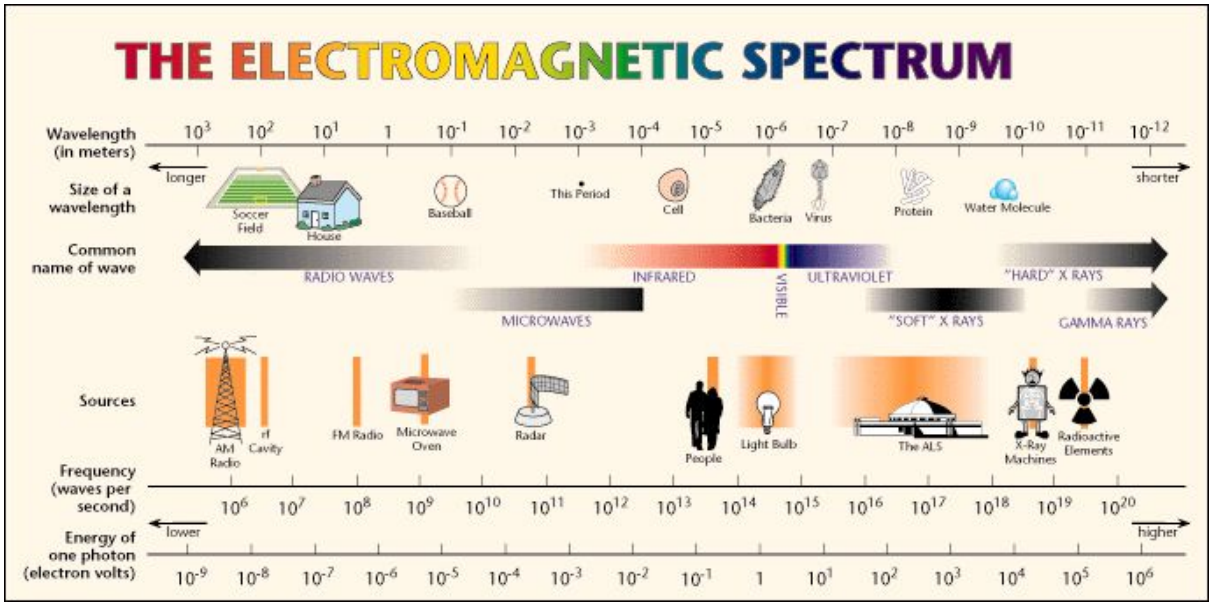


Figure: 6

4. Breakthroughs

For our project to succeed, many breakthroughs are needed. Nanosensors are important because they will be used to detect health problems inside of the body. They will also be able to provide the additional details we need to monitor someone's health beyond what is available today. The nanosensors in the nanorobot track and detect internal issues by monitoring and checking for changes to various biomarkers in the body. Currently, a professor named Thomas Webster and his team investigated the use of nanosensors to detect and treat bacterial and viral infections. The study evaluated different nanoparticles that were known to be causes of the infections. We would need to conduct similar studies to look into different nanoparticles in the body. Our study would focus on leveraging different types of nanosensors that are available. These include optical, mechanical, and electrical sensors that can track different types of signal changes. We could then test and evaluate changes to different biomarkers in the body so that our nanorobot would be able to monitor and identify more illnesses, infections, and diseases. Some additional breakthroughs that we need are how we will power the nanorobot. Since the nanorobot will work inside of the body, there needs to be a way to make sure that the nanorobot can power itself indefinitely. We will need to investigate how much power is needed by the nanorobot to move around the body and what are safe and effective ways to charge the nanorobot. One test that needs conducting is to power the nanorobot using radio frequency energy (RF). RF energy is non-invasive, but exposure can be harmful. More research needs to be done to see if there is a safe and effective way to use RFs as an energy source. It's also important that we know how to control the nanorobot. We are planning on using artificial intelligence and the information from the biosensors to travel to parts of the body. This would need to be tested and proven safe.

5. Design Process

Our initial vision was a band that would make it easy to self diagnose a wide varieties of conditions and illnesses, internal and external. We listed all the conditions and we organized them on a table, along with the technology to diagnose the disorder. We then realized it would be difficult to diagnose and monitor internal conditions accurately and successfully with an external device, so we settled on an additional solution.

Our team had to decide on a way to diagnose health conditions inside of the body. We came up with an idea to include a smartphone and plugins to help measure things using blood or saliva. We then decided that it wouldn't be able to diagnose all of the things we needed, so we came up with the idea of a nanorobot. Later, we discussed using nanosensors to help diagnose everything in our table.

When we were designing the nanorobot we had a debate on how to power the robot. With hydropower, the nanorobot will have to be in the blood flow in order to be powered and the band wouldn't work with hydropower. We decided on thermal electricity. We then learned that thermal electricity wouldn't work because it requires two different temperatures. It would work on the band as it could use the body heat and the temperature of the air. However, the nanorobot would only be exposed to the temperature of the body heat. We then discovered RF energy. RF energy would use energy from Wi-Fi and turn it into power. Due to these reasons we chose RF Energy over hydropower and thermal electricity.

6. Consequences

With almost all new technology, there are positive and negative implications on society. There are many positive implications and negative implications with our project. Our wearable

band will help with early detection of diseases and illnesses. The band will be able to detect and determine the conditions of your environment and if it is healthy or not. Our band will also cut down the time and money it takes to go to the doctor's. There are also some negative consequences, meaning that this project may not be appealing to the public for various reasons. People may be allergic to the material the nanorobot uses, causing an allergic reaction inside the body. The body may not be welcome to such a foreign device suddenly entering the bodily system, causing the immune system to blindly fight the bot. The nanorobot might also fight the body. The new circulating nanorobot may accidentally impact or interact with a cell in the body, causing an unwanted tumor. However, with much emerging technology and ongoing advance research, the negative impacts could be managed and minimized.

III. Bibliography:

Figure 1: Created by team

Figure 2: "Biosensor." *Wikipedia*, Wikimedia Foundation, 25 Jan. 2019, en.wikipedia.org/wiki/Biosensor.
"Biosensor." *PalmSens*, www.palmsens.com/biosensor/.

Figure 3: Created by team

Figure 4: Browne, Jack. "Harvesting Energy from RF Sources." *Microwaves & Radio Frequency*, 23 Mar. 2017, www.mwrf.com/systems/harvesting-energy-rf-sources.

Figure 5: "Ultrasound Won't Help Broken Bones Heal, Expert Panel Says." *UPI*, UPI, 23 Feb. 2017,
ww.upi.com/Ultrasound-wont-help-broken-bones-heal-expert-panel-says/1121487885026/.

Figure 6: "The Electromagnetic Spectrum." *CODAR Observations of the Chesapeake Bay Mouth Outflow*, marine.rutgers.edu/cool/education/class/josh/em_spec.html.

ONLINE ARTICLES:

Statistics for problem statement:
"1 In 4 Americans Refuse Medical Care Because They Can't Afford It." *New York Post*, New York Post, 7 June 2017,
nypost.com/2017/06/07/1-in-4-americans-refuse-medical-care-because-they-cant-afford-it/.

"World Bank and WHO: Half the World Lacks Access to Essential Health Services, 100 Million Still Pushed into Extreme Poverty Because of Health Expenses." *World Health Organization*, World Health Organization,
www.who.int/news-room/detail/13-12-2017-world-bank-and-who-half-the-world-lacks-access-to-essential-health-services-100-million-still-pushed-into-extreme-poverty-because-of-health-expenses.

Present Technology:
Griffin, Andrew. "It's Now Far Easier to Self-Diagnose on Google." *The Independent*, Independent Digital News and Media, 21 June 2016, www.independent.co.uk/life-style/gadgets-and-tech/news/google-diagnosis-sick-ill-health-search-symptoms-a7093161.html.
Elsevier. *10th Edition*, Mosby,
www.elsevier.com/physical-sciences-and-engineering/chemistry/journals/new-chemistry-research/wearables-for-dia betes.

Smith, Chris. "How Wearables Can Detect Sport's Deadly Invisible Injuries." *Wareable*, 27 Apr. 2017, www.wareable.com/sport/wearables-for-detecting-deadly-injuries-988.

Heart
"Portable Device Can Detect Heart Attacks." *Daily Mail Online*, Associated Newspapers, 10 Sept. 2002, www.dailymail.co.uk/health/article-137600/Portable-device-detect-heart-attacks.html.

"Wireless Wearable Biosensor for Vital Signs Monitoring | Philips Healthcare." *Philips*, www.usa.philips.com/healthcare/clinical-solutions/early-warning-scoring/wireless-biosensor?origin=7_700000001754099_71700000039871306_58700004299165275_43700035766549364&gclid=CjwKCAiA5qTfBRAoEiwAwQy-6Yn-lyXcb3i9dIeL1Xko8q20w9joz7gch1hW28fwxzoN3S0izhw0gxoCE2QQAvD_BwE&gclsrc=aw.ds

"Wearables for Managing Epidemics." *Wearable Technologies*, 24 May 2017, www.wearable-technologies.com/2014/11/wearables-for-managing-epidemics/.

"Wearables for Managing Epidemics." *Wearable Technologies*, 24 May 2017, www.wearable-technologies.com/2014/11/wearables-for-managing-epidemics/.Goodlett, Ashley. "COMM 303-50 Final Project." *LinkedIn SlideShare*, 6 Dec. 2014, www.slideshare.net/algood01/comm-30350-final-project.

"Wearable Hydration Monitor." *LVL*, www.onelvl.com/.

Brain, Marshall. “How Fast Does Blood Flow throughout the Human Body?” *BrainStuff*, Stuff Media, 30 Sept. 2009, www.brainstuffshow.com/blogs/how-fast-does-blood-flow-throughout-the-human-body.htm.

Kidney Wearable:
Rahman, Lu. “Wearable Kidney Monitor Receives Innovation Award.” *Medical Plastics News*, Medical Plastics News, 18 May 2017, www.medicalplasticsnews.com/news/wearable-kidney-monitor-claims-innovation-award/.

“What Do Doctors Look for in Biopsy and Cytology Specimens?” *American Cancer Society*, www.cancer.org/treatment/understanding-your-diagnosis/tests/testing-biopsy-and-cytology-specimens-for-cancer/what-doctors-look-for.html.

Imaging:
Craig Freudenrich, Ph.D. “How Ultrasound Works.” *HowStuffWorks Science*, HowStuffWorks, 28 June 2018, science.howstuffworks.com/ultrasound.htm.

Ultrasound Image:
“Ultrasound Won't Help Broken Bones Heal, Expert Panel Says.” *UPI*, UPI, 23 Feb. 2017, www.upi.com/Ultrasound-wont-help-broken-bones-heal-expert-panel-says/1121487885026/.

Radars:
“Weather Instruments.” *Ice-Albedo Feedback: How Melting Ice Causes More Ice to Melt - Windows to the Universe*, www.windows2universe.org/earth/Atmosphere/weather_instruments.html.

Sensors:
“What Is A Sensor? - Definition from WhatIs.com.” *WhatIs.com*, whatis.techtarget.com/definition/sensor.
“GCSE Bitesize: The Role of Sensors in Control.” *BBC*, BBC, www.bbc.co.uk/schools/gcsebitesize/ict/measurecontrol/0computercontrolrev2.shtml.

Computers:
How The Computer Works: The CPU and Memory, homepage.cs.uri.edu/faculty/wolfe/book/Readings/Reading04.htm.
How Do Computers Work? A Simple Introduction.” *Explain That Stuff*, 25 Dec. 2018,
“SSD vs HDD.” *StorageReview.com - Storage Reviews*, 2 Dec. 2011, www.storagereview.com/ssd_vs_hdd.

Consequences:
"Positive and Negative Aspects." *Nanotechnology* ,
nanotechnologyforstudents.weebly.com/positive-and-negative-aspects.html.
Winchester, Henry. "A Brief History of Wearable Tech." *Wareable*, 6 May 2015,
www.wareable.com/wearable-tech/a-brief-history-of-wearables.

"Who Invented Eyeglasses?" *Reference*, IAC Publishing,
www.reference.com/history/invented-eyeglasses-fb2608ab5f8be2fe.

History:
"Infographic: The History of Wearables." *Philips*,
www.philips.com/a-w/about/news/archive/future-health-index/articles/20160929-infographic-history-wearables.html.

"Nike+." *Wikipedia*, Wikimedia Foundation, 14 Sept. 2018, en.wikipedia.org/wiki/Nike%2B.
"Apple Watch." *Wikipedia*, Wikimedia Foundation, 22 Jan. 2019,
en.wikipedia.org/wiki/Apple_Watch.

Powering the Robot:
"Harnessing Body Heat to Power Electronic Devices." *Phys.org - News and Articles on Science and Technology*, Phys.org,
phys.org/news/2018-11-harnessing-body-power-electronic-devices.html.
Davis, Sam. "Body Heat Can Be the Source of Power for Wearable Devices." *Power Electronics*, 6 July 2017,
www.powerelectronics.com/alternative-energy/body-heat-can-be-source-power-wearable-devices.
Browne, Jack. "Harvesting Energy from RF Sources." *Microwaves & Radio Frequency*, 23 Mar. 2017, www.mwrf.com/systems/harvesting-energy-rf-sources.

Pollution Wearable
Harvey, Chelsea. "How Wearable Technology Could Change the Way We Think about Air Pollution." *The Washington Post*, WP Company, 28 June 2016,
www.washingtonpost.com/news/energy-environment/wp/2016/06/28/this-futuristic-suit-will-turn-colors-to-tell-us-about-air-pollution/?noredirect=on&utm_term=.bec01d39dc5b.

Alba, Davey. “This Wearable Detects Pollution to Build Air Quality Maps in Real Time.” *Wired*, Conde Nast, 27 Nov. 2017, www.wired.com/2014/11/clarity-wearable/.

Biopsy details
https://www.cancer.org/treatment/understanding-your-diagnosis/tests/testing-biopsy-and-cytology-specimens-for-cancer/what-doctors-look-for.html

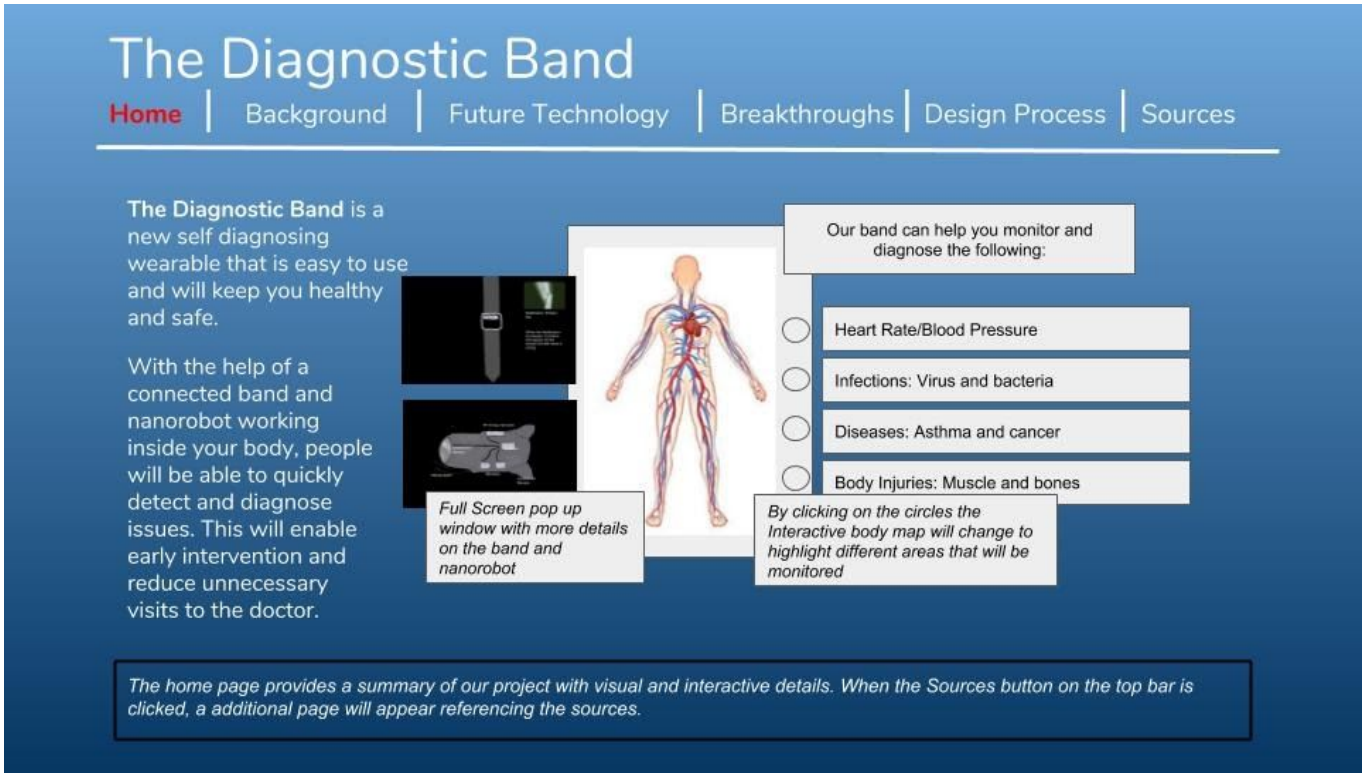
Image for nanorobot:
https://moneyinc.com/10-ways-nanorobots-will-change-the-future/

Biosensors:
Image - https://en.wikipedia.org/wiki/Biosensor
https://www.google.com/imgres?imgurl=https://www.palmsens.com/shared/content/uploads/2018/01/Biosensor-300x265.png&imgrefurl=https://www.palmsens.com/biosensor/&h=265&w=300&tbnid=sO4z020zBW7qYM:&q=biosensor&tbnh=160&tbnw=181&usg=AI4_-kSo6C8iv06pbdsXVcyDCC_UrxUzuQ&vet=12ahUKEwimgqi84fDfAhULJnwKHZMCA_MQ9QEwAHoECAkQBg..i&docid=GvTCtiYNhcZ6iM&sa=X&ved=2ahUKEwimgqi84fDfAhULJnwKHZMCA_MQ9QEwAHoECAkQBg

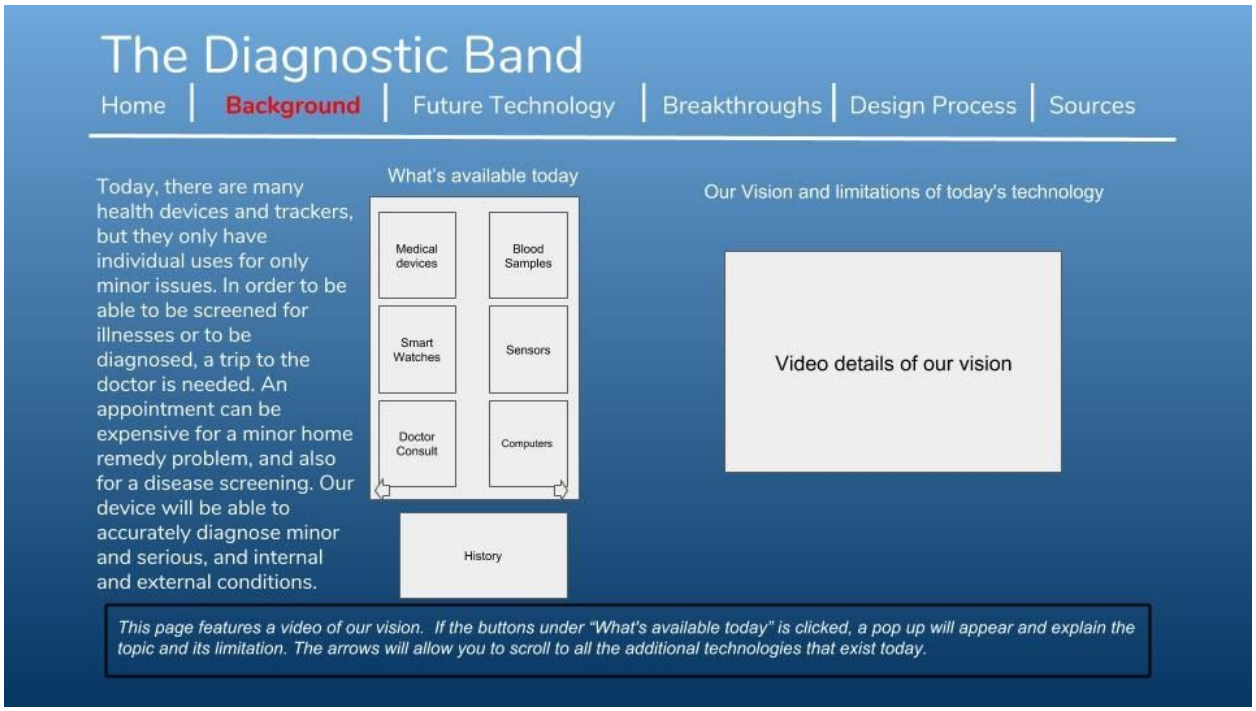
Picture: https://www2.lbl.gov/images/MicroWorlds/EMSpec.gif
Nanotechnology: “What Is Nanotechnology?” *What Is Nanotechnology? | Nano*, www.nano.gov/nanotech-101/what/definition.
Nanorobotics: “Nanorobotics.” *ScienceDaily*, ScienceDaily, www.sciencedaily.com/terms/nanorobotics.htm.

IV. Web Design

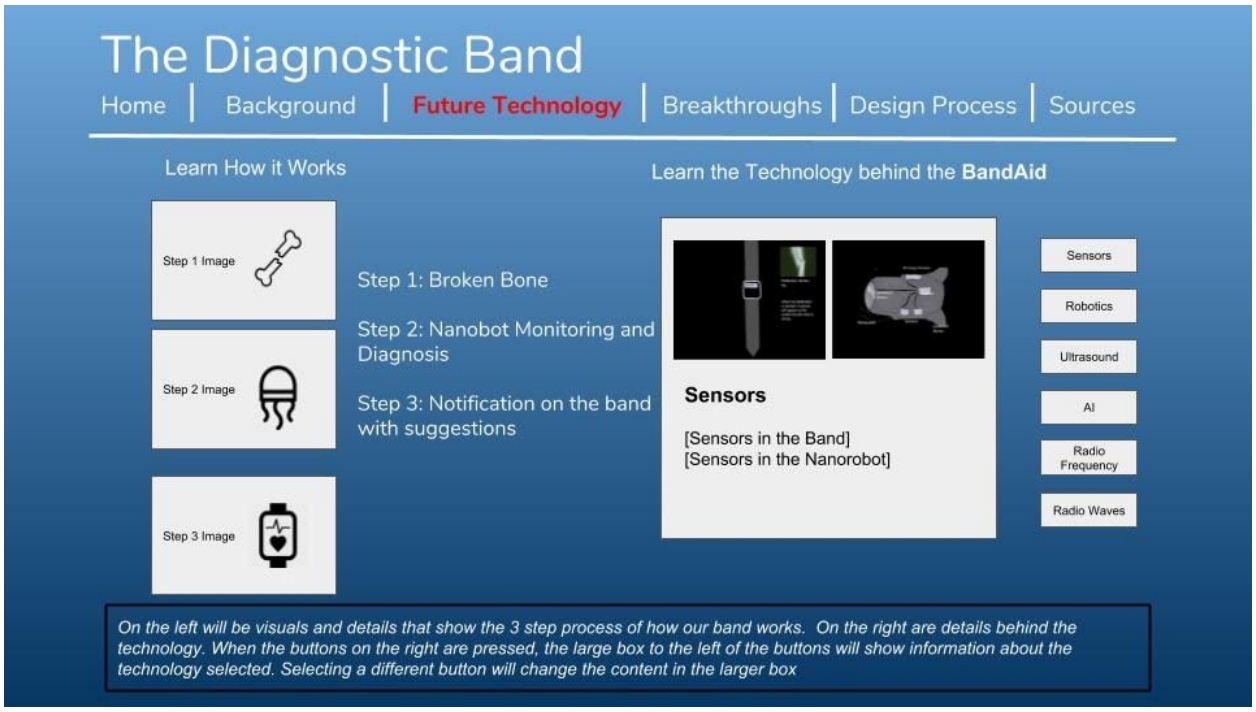
Page 1



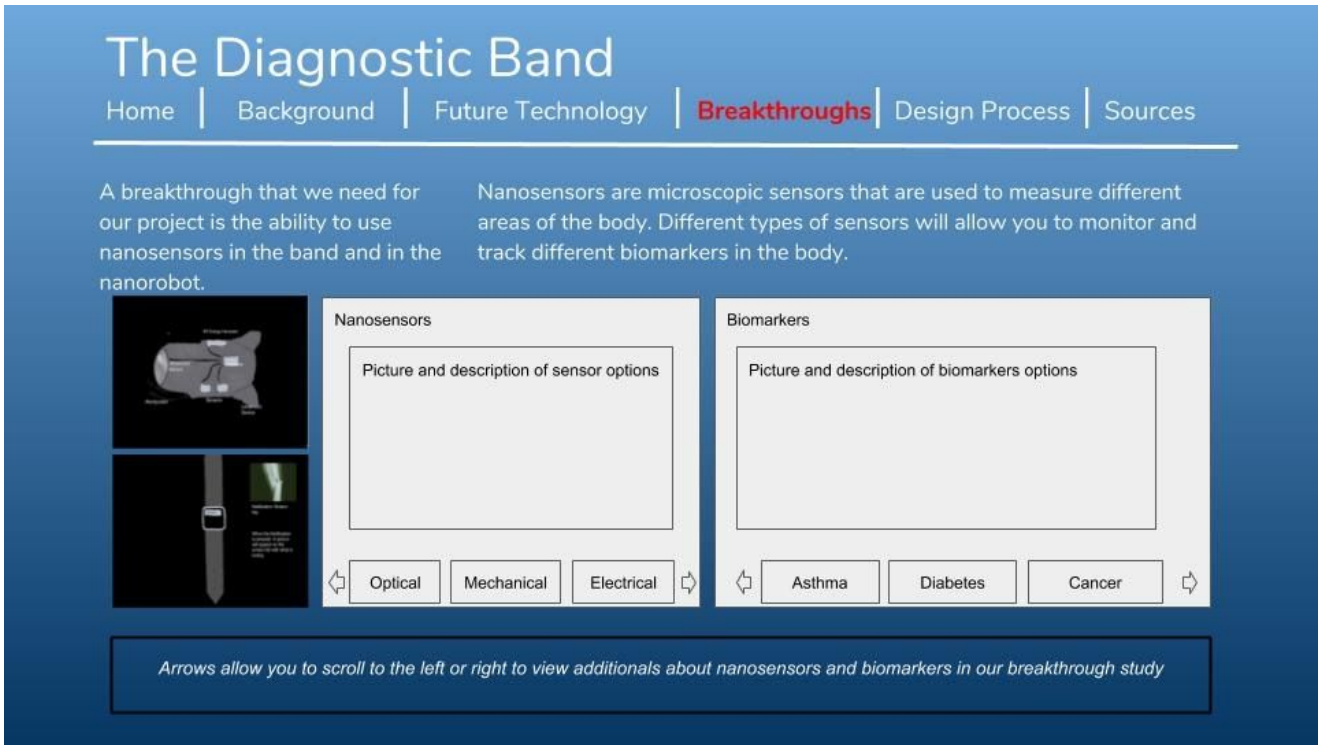
Page 2


The Diagnostic Band
Home | Background | Future Technology | Breakthroughs | Design Process | Sources
Today, there are many health devices and trackers, but they only have individual uses for only minor issues. In order to be able to be screened for illnesses or to be diagnosed, a trip to the doctor is needed. An appointment can be expensive for a minor home remedy problem, and also for a disease screening. Our device will be able to accurately diagnose minor and serious, and internal and external conditions.
What's available today
Medical devices
Blood Samples
Smart Watches
Sensors
Doctor Consult
Computers
History
Our Vision and limitations of today's technology
Video details of our vision
This page features a video of our vision. If the buttons under "What's available today" is clicked, a pop up will appear and explain the topic and its limitation. The arrows will allow you to scroll to all the additional technologies that exist today.

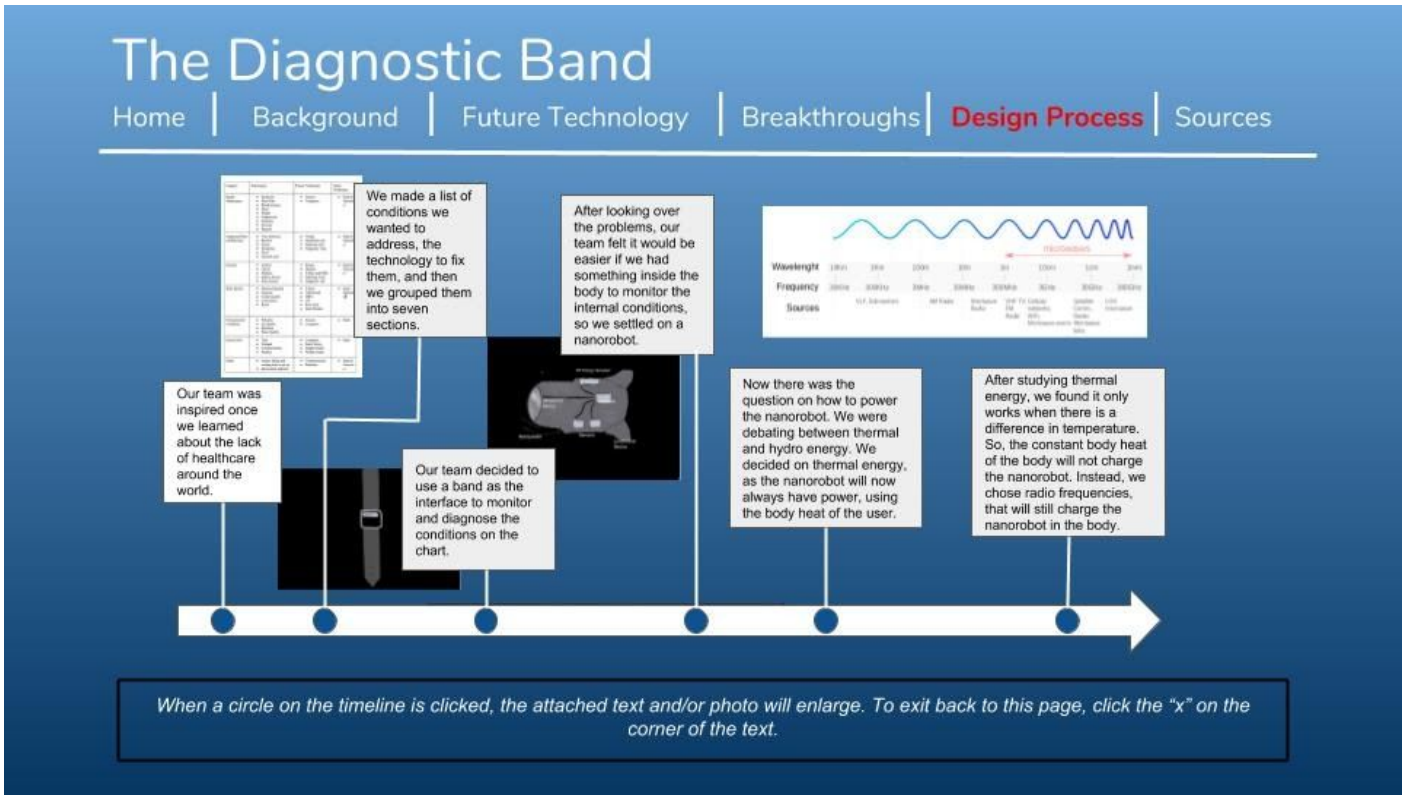
Page 3


The Diagnostic Band
Home | Background | Future Technology | Breakthroughs | Design Process | Sources
Learn How it Works
Step 1 Image
Step 2 Image
Step 3 Image
Step 1: Broken Bone
Step 2: Nanobot Monitoring and Diagnosis
Step 3: Notification on the band with suggestions
Learn the Technology behind the BandAid
Sensors
[Sensors in the Band]
[Sensors in the Nanorobot]
Sensors
Robotics
Ultrasound
AI
Radio Frequency
Radio Waves
On the left will be visuals and details that show the 3 step process of how our band works. On the right are details behind the technology. When the buttons on the right are pressed, the large box to the left of the buttons will show information about the technology selected. Selecting a different button will change the content in the larger box

Page 4


The Diagnostic Band
Home | Background | Future Technology | Breakthroughs | Design Process | Sources
A breakthrough that we need for our project is the ability to use nanosensors in the band and in the nanorobot.
Nanosensors are microscopic sensors that are used to measure different areas of the body. Different types of sensors will allow you to monitor and track different biomarkers in the body.
Nanosensors
Picture and description of sensor options
Optical
Mechanical
Electrical
Biomarkers
Picture and description of biomarkers options
Asthma
Diabetes
Cancer
Arrows allow you to scroll to the left or right to view additionals about nanosensors and biomarkers in our breakthrough study

Page 5


The Diagnostic Band
Home | Background | Future Technology | Breakthroughs | Design Process | Sources
We made a list of conditions we wanted to address, the technology to fix them, and then we grouped them into seven sections.
After looking over the problems, our team felt it would be easier if we had something inside the body to monitor the internal conditions, so we settled on a nanorobot.
Wavelenght
Frequency
Sources
Our team was inspired once we learned about the lack of healthcare around the world.
Our team decided to use a band as the interface to monitor and diagnose the conditions on the chart.
Now there was the question on how to power the nanorobot. We were debating between thermal and hydro energy. We decided on thermal energy, as the nanorobot will now always have power, using the body heat of the user.
After studying thermal energy, we found it only works when there is a difference in temperature. So, the constant body heat of the body will not charge the nanorobot. Instead, we chose radio frequencies, that will still charge the nanorobot in the body.
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