SciTECH

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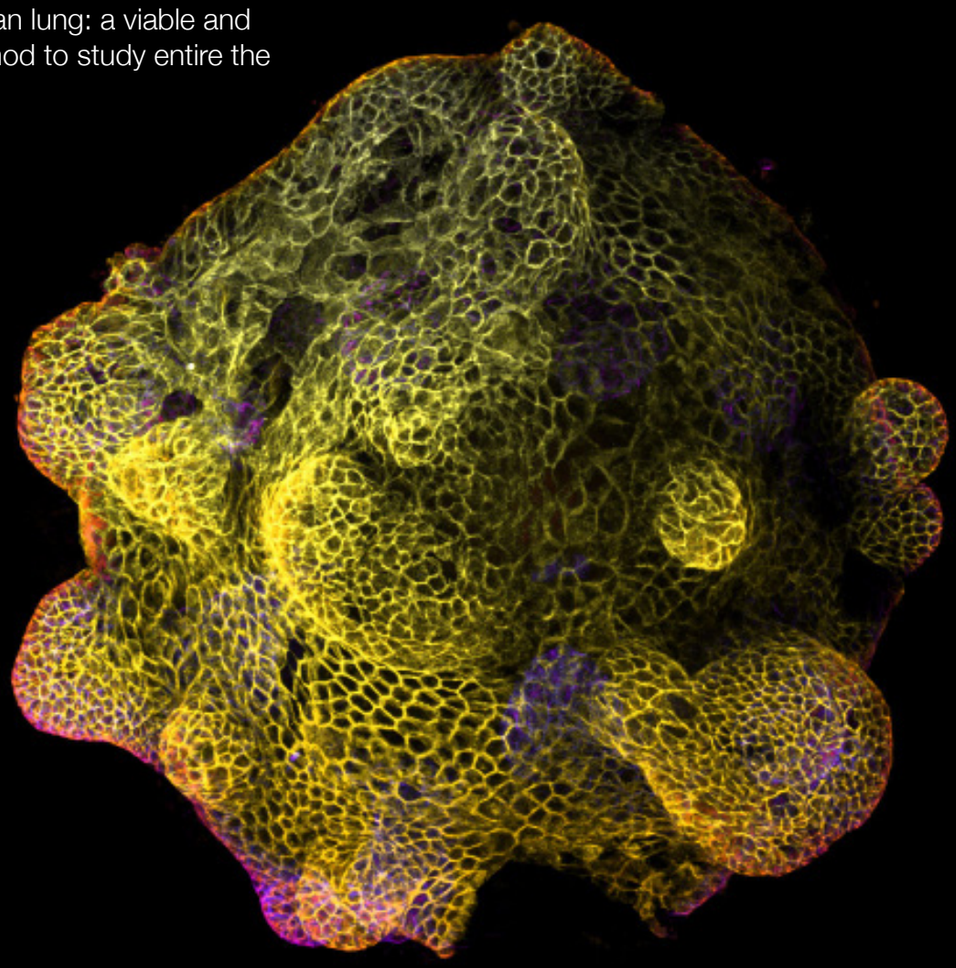
Vol. 1, Issue 1

3D ORGANOIDS

Researchers at UCLA discover ways to culture stem cells and manipulate them into a three-dimensional model of the human lung: a viable and effective method to study entire the organ.



The Current Reality of Virtual Reality

What's going on in the VR industry right now? Will Wu '19 can give you a rundown of the latest advancements and future implications of this promising technology.

What's the Big i.d.ea?

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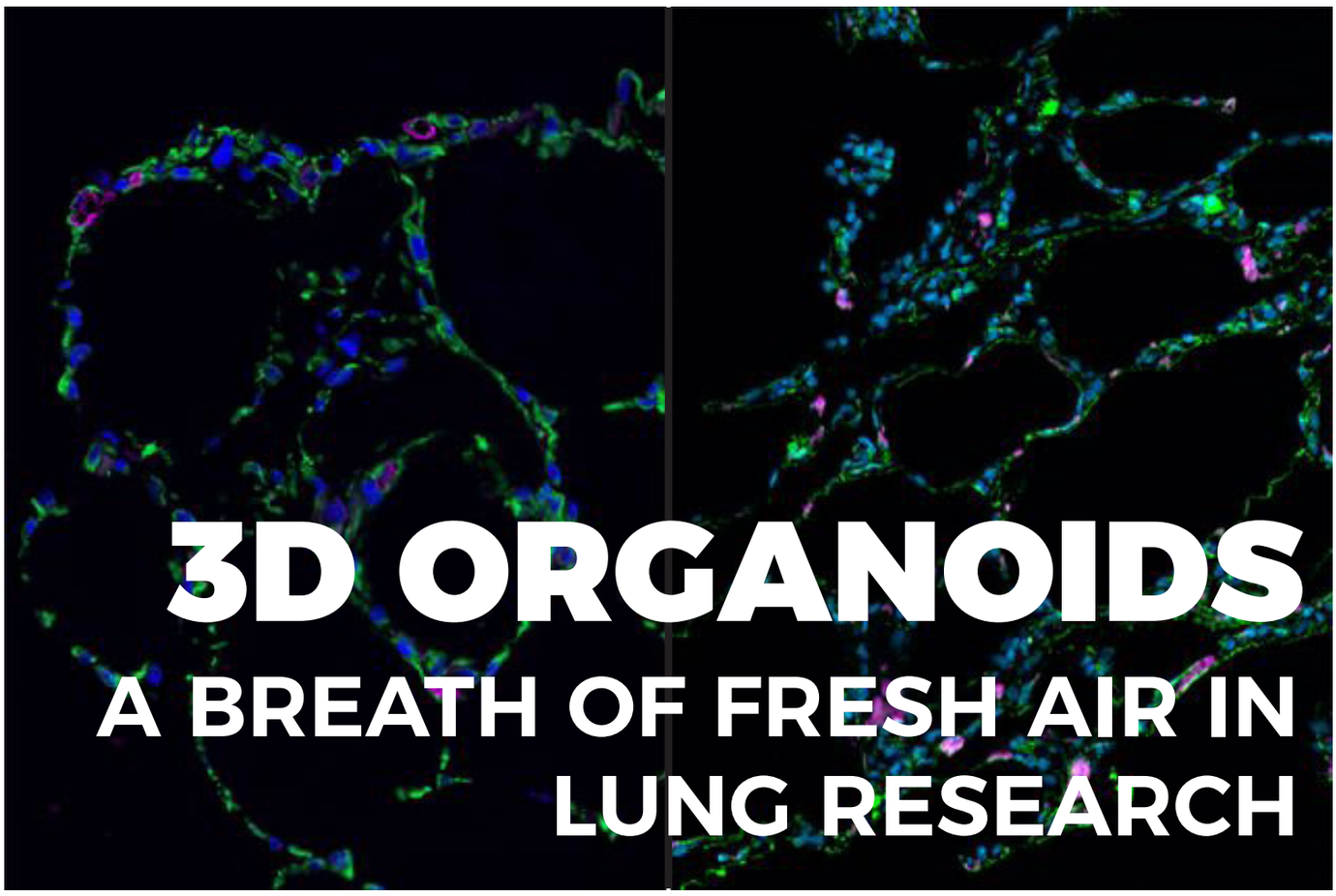


3D ORGANOIDS
A BREATH OF FRESH AIR IN LUNG RESEARCH

UCLA researchers use stem cells to grow 3-D lung-in-a-dish
3D bioengineered lung-like tissue (left) resembles adult human lung (right). *UCLA Broad Stem Cell Research Center.*

by KATE SPENCER '20

A recent advancement in the biomedical stem cell field has enabled scientists to synthesize 3D lung models. Researchers at the Eli and Edythe Broad Center of Regenerative Medicine and Stem Cell Research at UCLA discovered ways to culture stem cells into a three-dimensional model of the human lung. What was initially an experiment in improving medical therapies with self-assembled lung tissue ended in a viable and effective method to study entire organs.

Stem cells are integral in organ-modeling, as they have the ability to transform into more specialized cells. To produce the 3D human lung models, scientists covered hydrogel beads with lung-derived stem cells and organized them into small sections, each only seven millimeters across. The cells self-developed around the beads and linked to form an even 3D pattern. By means of self-assembly, the stem cells eventually formed air sacs called alveoli. In the article "Stem cells grown into 3-D lung-in-a-dish", researcher Dan Wilkinson stated, "The technique is very simple. We can make thousands of reproducible pieces of tissue that resemble lung and contain patient-specific cells."

> **"The technique is very simple. We can make thousands of reproducible pieces of tissue that resemble lung and contain patient-specific cells."**
>
> **- Dan Wilkinson**

After constructing these stem cell-derived models, called "organoids," researchers compared them to an actual adult human lung. While the initial organoid was harshly oversimplified, the team believes that it may provide an appropriate model of the lung that could be used in experimentation. Researchers are expected to continue advancing their work so that future organoids can more closely reflect the biological makeup of an actual human lung.

This advancement of 3D organoids has already assisted in identifying diseases and personalizing the diagnosis process—but this is just the beginning. The laboratory-grown lung tissue, while not yet perfect, can be used to study diseases that are difficult to imitate in 2D lung cell cultures. In the article "Development of a Three-Dimensional Bioengineering Technology to Generate Lung Tissue for Personalized Disease Modeling", Brigitte N. Gomperts, M.D. at David Geffen School of Medicine said, "While we haven't built a fully functional lung, we've been able to take lung cells and place them in the correct geometrical spacing and pattern to mimic a human lung." This application of

Successful 3D modeling could improve disease prognoses
A researcher works in his laboratory at the Institute for Stem cell Therapy and Exploration of Monogenic Diseases (I-Stem) in Evry, near Paris. November 27, 2009. *REUTERS/Garith Watkins.*

stem cells is expected to open doors for further research and the development of other organ models capable of being produced both efficiently and abundantly.

One of the main impacts of the turn towards 3D modeling is the improvement of disease prognoses. Idiopathic Pulmonary Fibrosis (IPF) is a severe and chronic disorder that involves major scarring of the lungs. Typically, symptoms include dry cough, chest pain, difficulty breathing, and shortness of breath. As a result, the patient's lungs become thick and stiff, limiting oxygen to the brain and other vital organs. Following diagnosis, most people tend to live only three to five years. In the past, researchers have relied on 2D cultures to further investigate the cause of IPF. The downside to this approach is that lung cells often appear healthy in a 2D model, making it a challenge to study the biological makeup of IPF. As explained by Dr. Joana Fernandes in the article "Stem Cells from IPF Patients Used to Create Working Lungs to Aid in Research, Personalized Treatment", "When certain molecular factors were added to these cultures, the 'lungs' also developed scars similar to those observed in the IPF lungs, a finding that supported this technique providing a more realistic and reliable environment for future IPF studies." In addition, using the new lung organoids, researchers will be able to uncover more about diseases that were difficult to study using conventional methods. Theoretically, clinicians could also collect cells from patients and use them in a 3D culture to personalize drug testing and diagnosis.

As to the true impact of this project on the scientific community, Dr. Brigitte Gomperts said, "This is the basis for precision medicine and personalized treatments." As more factors are tested, scientists can expect to see major growth in knowledge of disease modeling. •

BIBLIOGRAPHY

1. Fernandes, J., PhD. (2016, September 26). IPF Patient Stem Cells Create '3D Lungs' for Research, Therapy. From http://pulmonaryfibrosisnews.com/2016/09/26/stem-cells-ipf-patients-used-to-create-3d-lungs-for-research-personalize-therapy.
2. University of California, Los Angeles. (2016, September 15). Stem cells grown into 3D lung-in-a-dish. ScienceDaily. From www.sciencedaily.com/releases/2016/09/160915132225.htm.
3. Wilkinson, D. C., Alva-Ornelas, J. A., Sucre, J. M., Vijayaraj, P., Durra, A., Richardson, W., . . . Gomperts, B. N. (2016, September 15). Development of a Three-Dimensional Bioengineering Technology to Generate Lung Tissue for Personalized Disease Modeling. Stem Cells Translational Medicine. doi:10.5966/sctm.2016-0192The Atlantic (16 November 2014).

SYNESTHESIA

Seeing Beyond Sight

by SE RI LEE '19

The human brain is an extremely complex, multifaceted organ that serves as a hub for communication for the entire body. Every second, billions of brain cells, called neurons, send and receive information around the body. For most people, the flow of information between one sensory organ and the brain is restricted to a specific region. For instance, when one sees a fire truck, one's eyes send the signal of the color red to the visual cortex of the brain. For people with synesthesia, however, the sight of a fire truck would not only cause them to perceive the color red, but also, for example, smell chocolate chip cookies.

As demonstrated by the aforementioned example, synesthesia is a phenomenon in which an experience in one sensory or cognitive pathway involuntarily causes perception in an unrelated sensory or cognitive modality. Synesthetes may associate musical notes with shapes, numbers with colors, and even inanimate objects with personalities.

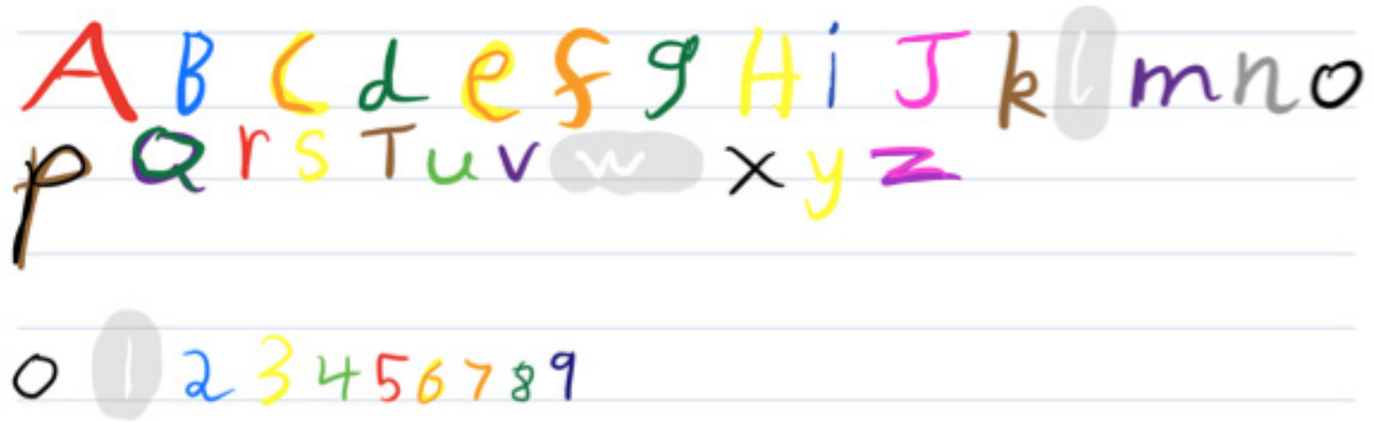
Synesthesia exists in many different forms. With only the five basic senses, there are over twenty combinations of senses. The most common types of synesthesia are: grapheme-color synesthesia, associations between a specific letter or number and a certain color; sound-to-color synesthesia, associations between color and sound; number-form synesthesia, three-dimensional arrangements of numbers, months, and years; and personification, associations of letters with unique personalities.

Based on a study conducted by the Emory News Center, one to four percent of Americans are diagnosed with synesthesia. Julia Dubel '20 experiences two of the most common types of synesthesia: grapheme-color and number-form. Like most other grapheme-color synesthetes, Julia associates the letter "A" with the color "red." However, she always sees the letter "B" in blue and the letter "C" in orange, whereas her grandmother, who also has synesthesia, sees them differently. Dubel commented, "It bothers me to see something written in another color than the color to which I'm accustomed, often when teachers correct tests or make comments in my essays in certain colored pens." Dubel also views numbers and months in certain colors and organizes them in a number map. For example, she arranges months in a cycle, "like a hula hoop," and years in "an outwardly bending chart."

I cannot even imagine what it would be like seeing every single word in uniform color as others do.
- Julia Dubel '20

She also uses a number map to add and subtract numbers. She explained, "When adding five to five, I would start with the number five, which is red, and highlight five boxes to the right in red to reach ten." When asked whether her synesthetic attributes distracted her in academic settings, she replied, "Not at all. In elementary school, I thought everyone else did math problems the same way as I did. All my life—as far as I can remember—I have been associating letters and numbers with their same corresponding colors. I cannot even imagine what it would be like seeing every single word in uniform color as others do." Like Dubel, most synesthetes state that their ways of thinking do little to no damage in their everyday lives.

For years, neurologists struggled to draw the line between synesthesia

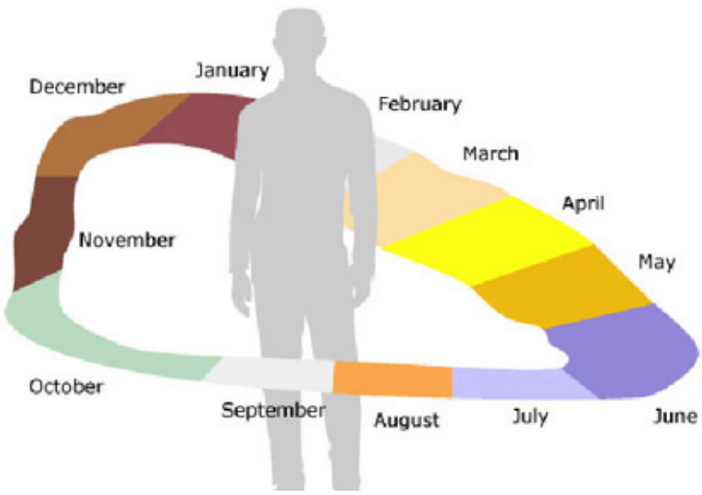


This is how Julia Dubel '20, who is a synesthete, sees numbers and the letters of the alphabet.

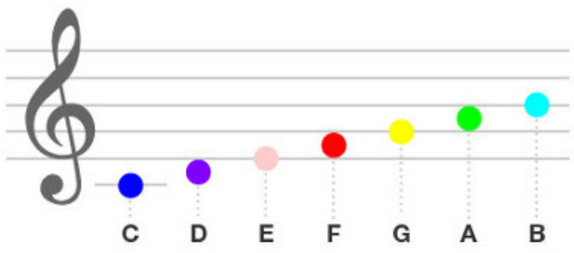
and cross-modal correspondences, the universal mixing of the senses. Examples of cross-modal correspondences include associations between letters like "k" and "t" and angular shapes, and between high and low pitched notes and their relative "locations" in space. While some researchers argue that synesthesia is simply an exaggerated version of a cross-modal correspondence, others claim that the two are unrelated—mainly because the symptoms of synesthesia vary among individuals whereas cross-modal correspondences generally occur between two seemingly related senses.

As of now, little is known regarding the causes of synesthesia. Many researchers agree that the brains of synesthetes are wired differently than those of non-synesthetes. Among researchers, some claim that the cells in different regions of the brain "cross-talk," or spill information into each other involuntarily. Scientists are also exploring potential genetic components behind the condition. Although the consensus is that synesthesia is hereditary, the specific genes that cause the phenomenon have not yet been discovered.

Discoveries regarding synesthesia are increasing due to intensive research, allowing scientists to learn more about the complexities of the human brain. Whether synesthesia stems from connections between different parts of the brain or from certain genes that contain synesthetic features, one thing is certain: the brain contains a myriad of secrets that have yet to be unearthed. •



Spatial Sequence Synethesia
A patient may perceive months in a ring surrounding their body and rotating clockwise throughout the year. *American Synesthesia Association/Carol Steen.*



Chromesthesia
Chromesthesia or sound-to-color synesthesia is a type of synesthesia in which heard sounds automatically and involuntarily evoke an experience of color.

BIBLIOGRAPHY

1. Cell Press. "Synesthesia: Brain study explores what makes colors and numbers collide." ScienceDaily. ScienceDaily, 23 January 2012.
2. "Sensory Connections Spill over in Synesthesia." Emory News Center, 12 Sept. 2016. Accessed 6 Oct. 2016.
3. Lacey, Simon, et al. "Synesthesia Strengthens Sound-symbolic Cross-modal Correspondences." Wiley.
4. Online Library, 15 Sept. 2016, onlinelibrary.wiley.com/doi/10.1111/ejn.13381/abstract. Accessed 6 Oct. 2016.

DR. MARISSA HOLMBECK

FUELING A LOVE FOR MITOCHONDRIA FOR EIGHT YEARS

by TRUELIAN LEE '17

Two people walk in with the same disease-causing mutation, but one has more severe symptoms than the other. Why? According to Dr. Marissa Holmbeck, who is currently researching mitochondria regulation, a potential reason for these differences may lie in the powerhouse of the cell—the mitochondria.

Mitochondria play important roles in disease research; Dr. Holmbeck explained, "For example, in cancer cells, because mitochondria are metabolic hubs, the mitochondria metabolism is altered, and, in certain cases, that can help the cancer cell metastasize. Mitochondria also seem to play a large role in any age-related disease, like Alzheimer's and Parkinson's."

Mitochondria are double-membrane organelles that produce energy in the cell. It is widely believed that mitochondria were cells that merged with a eukaryotic cell in a symbiotic relationship that has lasted through the ages. In the process, the mitochondria maintained its own circular genome, which it stores in the matrix, or inside the inner membrane. In humans, the mitochondrial genome encodes 13 proteins that are involved in energy production. Though it codes for various RNAs that are involved in transcription and translation, it doesn't code for all the components needed for these processes. Thus, mitochondria have to import over a thousand proteins from the nucleus to actually function.

Given their importance in the cell, mitochondria have their own regulatory systems to help maintain function. Currently, Dr. Holmbeck is looking at the impacts of one of these regulatory mechanisms: microRNAs (miRNAs).

These microRNA (miRNA) molecules play a large role in regulating transcription and translation. In order for a cell to produce a protein from the blueprints in DNA, it must first make a copy in the form of messenger RNA (mRNA) in a process called transcription. Then, the cell reads the information in the mRNA and produces proteins in a process called translation. If a cell doesn't need to produce a certain protein, it can use miRNAs to destroy the mRNA that carries the information for that protein. In order to do this, miRNAs must bind to a protein.

> "I think one of the other challenging things is that our lab is smaller; I'm the only one really working on this project, and that means I'm doing everything, unless I outsource it to other labs."
>
> **- Dr. Marissa Holmbeck**

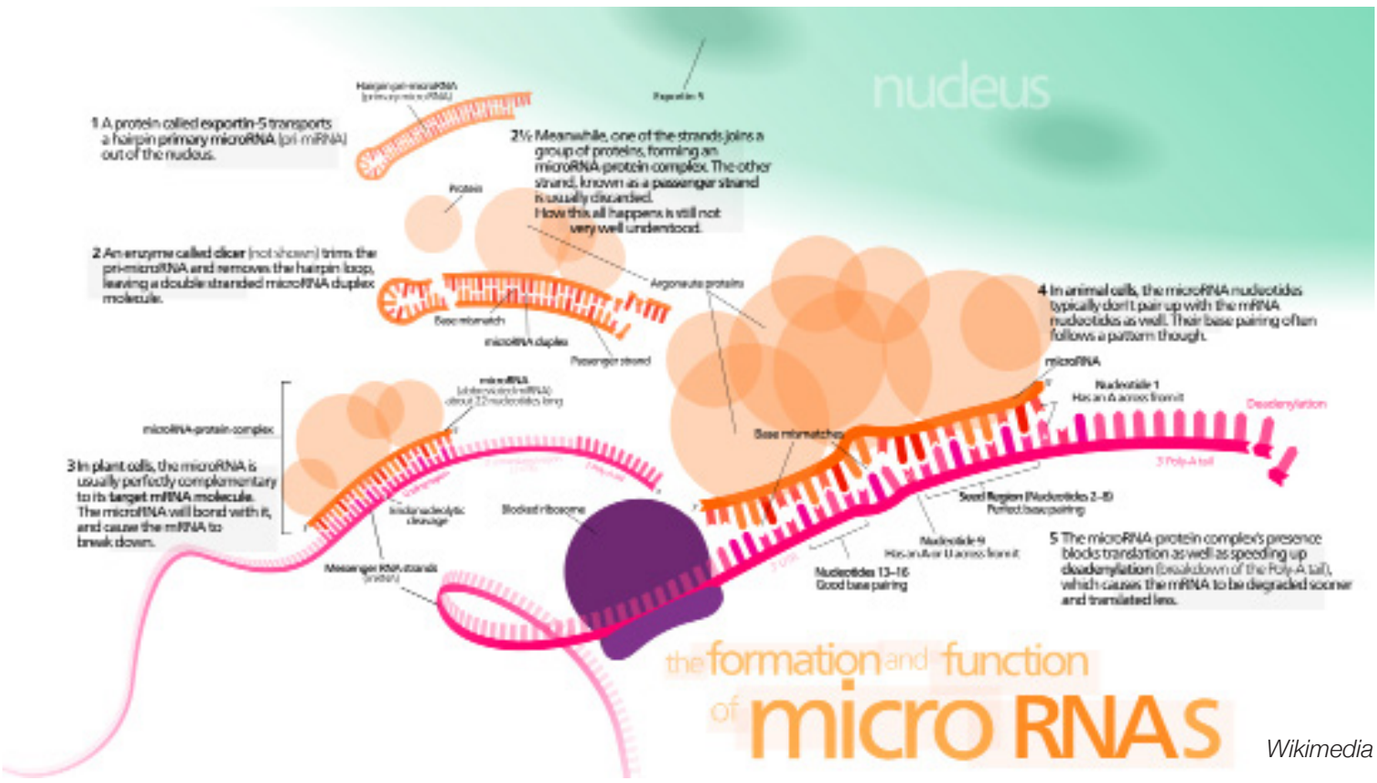
Dr. Holmbeck is focusing specifically on one of those proteins, Ago2, which can bind to miRNAs to destroy mRNAs. Dr. Holmbeck conjectured that the protein could be processing mitochondrial DNA or regulating the translation process. She said, "What I'm really trying to figure out is what miRNAs are doing in the mitochondria. Are some of the microRNAs complementary to mRNAs that are made by the mitochondria, and are they possibly silencing them?"

This research has various applications to diseases. Dr. Holmbeck said, "We're not actually sure if there's an imbalance of these miRNAs in disease states. Their balance can be disrupted as they regulate the mitochondria. In addition, miRNAs can be potential targets for disease therapies. Let's say you need to dampen down a specific subunit of the complex; you might be able to do that with a miRNA targeted to the mitochondria."

Dr. Holmbeck's research question dives into a field largely unexplored. She has realized she has more questions than answers. "The biggest challenge is trying to figure out where to go, because there is not a lot known about Ago2. We have some base hypotheses, and so we have to go in and test all of them," she remarked.

First, Dr. Holmbeck had to confirm that Ago2 was in the mitochondria through a technique called hypotonic swelling, which used the fact that mitochondria are double-membrane organelles. When mitochondria are placed in water, they swell so much that the outer membrane can be removed. Dr. Holmbeck analyzed the remaining inner membrane, discovering that Ago2 was present.

After that step, Dr. Holmbeck started isolating the functions of Ago2. She has genetically constructed cells lacking Ago2 through a genome-editing technique called CRISPR/Cas9, and she hopes to analyze these cells during the next few months.



Wikimedia

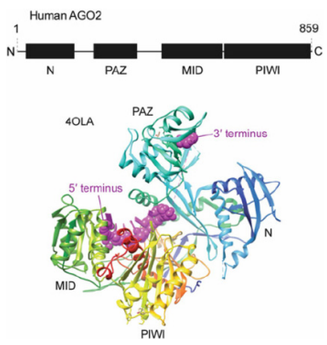
Regarding the timeline, Dr. Holmbeck noted, "I think one of the other challenging things is that our lab is smaller; I'm the only one really working on this project, and that means I'm doing everything, unless I outsource it to other labs. The pace of research moves a little more slowly, but it's neat because you have full ownership of it, and I like that."

Dr. Holmbeck has been working with mitochondria for eight years — since her freshman year in college. However, her interest in science started much earlier.

The California native noted that her science teachers in high school influenced her. "I had really awesome science teachers, and I really excelled in science. I really liked asking questions that no one had the answer to," she shared. "I was also really drawn to the scientific method, to the idea that you could use these tools to figure things out that no one had ever seen before."

Dr. Holmbeck went to the University of California, earning a B.S. in Biology and working in a mitochondria lab for over three years. She said, "The PI was so enthusiastic about her work, she convinced me within the first couple of months that mitochondria were the coolest things in the world." Dr. Holmbeck worked on projects trying to dissect the mechanisms of diseases associated with mitochondria dysfunction.

For graduate school, Dr. Holmbeck decided she needed a bit of an adventure. "I decided to jump coasts and go to Brown, since I hadn't really been outside California before that. There were a couple of different labs I was interested in— not necessarily mitochondrial ones."



A mitochondrion (plural mitochondria), a double membrane-bound organelle found in all eukaryotes that is responsible for the production of ATP. *Research Gate.*

Nevertheless, she soon found herself back in a mitochondrial lab. "The lab was really interesting because it looked at mitochondria from the perspective of evolutionary genetics, which was something I had no real exposure to before. Evolutionary genetics is really useful, because if you're looking at diseases or anything like that, if you don't put it back into the context of evolution, you're missing a piece of the puzzle." She added, "Being in the lab changed the perspective I started looking at science with."

After receiving her Ph.D. in Molecular Biology, Cell Biology, and Biochemistry, Dr. Holmbeck went to Yale. Looking forward, "the big decision in my upcoming career is whether or not I want to stay in academia and pursue a research career teaching or go into the pharmaceutical and biotech industries, into drug development, which I think would also be very fulfilling."

She added, "If you had talked to me a year ago, I would have probably said that I would definitely stay in academia. Now, I'm actually leaning more toward going into industry. I think there are a lot of reasons to go in that direction; it helps you feel as if your research is really making a difference, and you can actually have an impact with what you're doing. With basic science, it's very interesting in a lot of different ways, but I think more translational research may be what I'm more drawn to."

Dr. Holmbeck noted that her experience researching mitochondria has been invaluable to her thus far. "I've been able to conduct research in a variety of other fields, such as miRNAs and evolutionary genetics, while still working in the context of mitochondria. It's cool that I get to learn about whole other fields this way." •

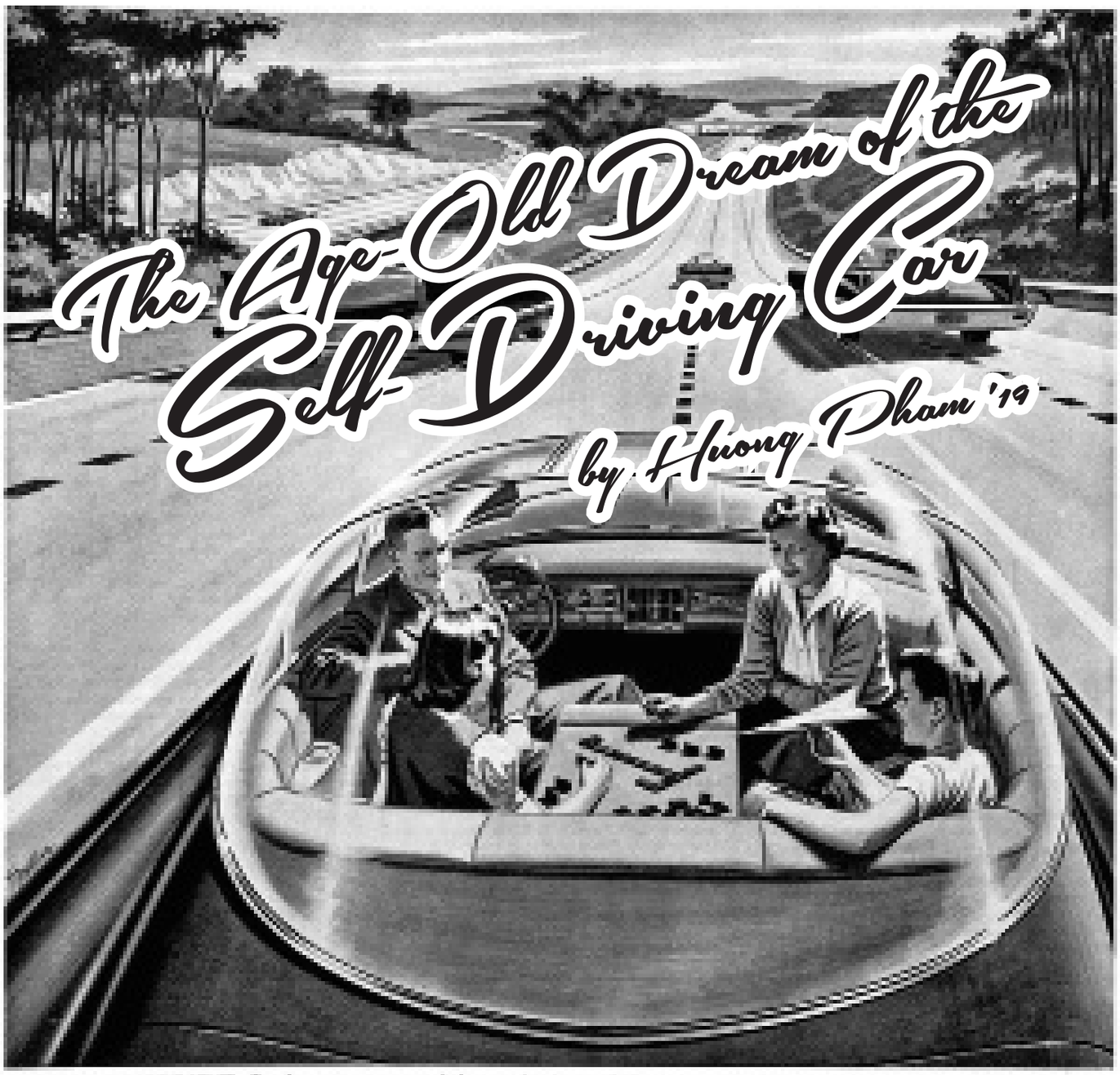
STUDENT SCIENCE RESEARCH AT THE KOHLER ENVIRONMENTAL CENTER

by ZEV NICOLAI-SCANIO '18

Students in the Environmental Immersion Program (EIP) at the Kohler Environmental Center (KEC) have the unique opportunity to dedicate a full academic year to conducting environmental research in an area of interest. The research hypotheses and project designs are student generated, and the students are responsible for data collection, analysis, and presentation as well. Most research projects are in the areas of the natural and social sciences. Students have chosen to explore topics in environmental economics, consumer theory, state and national environmental policy, chemical pollution of aquatic ecosystems, biofuels, invasive species, and factors influencing species diversity and distribution. Last year, Arielle Landau '17 and Myles Stokowski '17 chose to focus their work on ecosystems surrounding the KEC. Both of their studies will be continued as part of the long term ecological research at the KEC and will provide valuable data for years to come.

Arielle Landau '17 studied the effects of deer exclusion and invasive species on old field biodiversity and native plant reproductive success in southern Connecticut. Although there have been many studies on the effects of deer foraging in forest ecosystems, few studies have been done on the effects of deer browsing in New England old field systems. The purpose of her study was to identify the specific role invasive species play in either increasing or decreasing the effects of deer browsing on native species, measured in terms of biodiversity and reproductive success. Landau and fellow EIP student Sam Madden '17 helped to build 10m x 10m deer excluding structures in the fields near the KEC to control herbivore access to plants. Landau then identified native and invasive herbaceous plant species in the study plots. Her study plots included three replicates of four treatments: deer access and naturally occurring invasive species, deer access and invasive species removed, no deer access and naturally occurring invasive species, and no deer access and invasive species removed. Measurements were taken two weeks after deer exclusion began. As expected, the initial measurements of biodiversity, as measured by species richness and the Simpson's Reciprocal Index—a measure that quantifies the biodiversity of a habitat by taking into account the number of species present, as well as the abundance of each species—did not differ among treatments ($p>0.05$). Reproductive success, measured as the average number of flowering bodies per bedstraw individual, also did not differ among treatments ($p>0.05$). Since initial biodiversity and reproductive success measurements did not differ among treatments and replicates, changes in the future can more surely be attributed to the effects of invasive species and deer browsing on the plant community, and not location or habitat. Data collection from this experiment in the coming years will provide valuable insights on the roles that deer browsing and invasive species play in old field succession in New England.

Myles Stokowski '17 studied earthworm distribution, and the potential correlation between the diversity and abundance of earthworms and plant community type in the habitats surrounding the KEC. Invasive earthworms have spread through many of New England's forests and fields, but their populations differ with ecological community and biotic and abiotic factors such as pH, food availability, and soil moisture. Both directly, through consumption of seeds and fine roots, and indirectly, by mixing soil layers and accelerating decomposition, earthworms alter plant populations, often decreasing biodiversity and density of understory vegetation, and facilitating invasive plant species growth. Stokowski's study compared plant and earthworm populations in a red maple-hardwood swamp forest, an Appalachian oak-hickory forest with an established understory, an Appalachian oak-hickory forest without substantial understory plant populations, and a hayfield. Stokowski established ten 0.5 m^2 earthworm sampling sites across these habitats and surveyed all tree species with a diameter greater than ten centimeters within a 4.5 meter radius of the center of each forest sampling site. He determined that plant species richness did not differ significantly with earthworm biodiversity, number of individuals, or total biomass ($p>0.05$). However, earthworm populations differed significantly between ecological communities. Notably, all hayfield sites had higher earthworm biodiversity than forested sites. Overall the number of earthworms was greatest in the region of Appalachian oak-hickory forest with substantial understory, and no earthworms were found in the region with minimal understory. However, the lack of an earthworm population in this area is not likely to be the driving factor for the lack of understory vegetation. All forest sites with worms were dominated by invasive Amynthas species. Furthermore, Stokowski noted that collected Amynthas species individuals had greater body lengths as the season progressed, supporting the idea that these worms have annual life cycles in temperate climates and overwinter as egg capsules. •



The Age-Old Dream of the Self-Driving Car

by Huong Pham '19

A 1950s advertisement published by the Central Power and Light company boasted, "One day your car may speed along an electric super-highway, its speed and steering automatically controlled by electronic devices embedded in the road. Highways will be made safe—by electricity! No traffic jams, no collisions, no driver fatigue." Even though at the time, the advertisement was nothing more than speculation, this ambition of creating autonomous vehicles has inspired innovations for decades. From transmitting antennas in the 1920s to artificial intelligence in the 2010s, the path to the self-driving car has been long but worthwhile.

The idea of self-driving cars has been around since the 1920s. Early on, General Motors created different models of more independent cars with receivers that performed automatic steering, braking, and accelerating. Subsequently, many universities and corporations started their own specialized projects in this field. Notably, Carnegie Mellon University created a series of projects starting in 1984 that resulted in the Navlab vehicles. By 1995, its car completed a 3,100 mile cross-country journey that was almost entirely automatically controlled.

However, corporations and educational institutions are not the only groups taking an interest. After the turn of the millennium, the government sought to develop self-driving cars for military purposes. The Defense Advanced Research Projects Agency (DARPA) Grand Challenges were held in 2004, 2005,

and 2007 as competitive searches for successful self-driving cars, with millions of dollars awarded to the winning design.

But how do self-driving cars work? The car operates under a hardware system with a myriad of sensors and processors. To picture how these tools function, imagine you are in the car. As the car moves out to the road, it is able to keep a safe distance from the other cars as the radar sensors emit signals detecting vehicles in a 100-meter range. The car keeps moderate speed and never slides away from the lane thanks to sensors that release pulses of light, which bounce off surroundings and provide a system of detection for the vehicle.

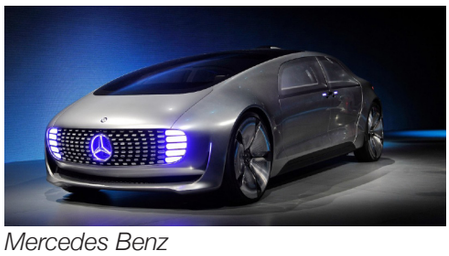
Suddenly, you reach a red traffic light, and school children are crossing the road. You start to panic but are quickly reassured because of the car's built-in video camera. Similar to your eyes, it builds a 3-D model of the landscape, reads traffic lights and road signs, identifies pedestrians and obstacles, and responds to these obstacles accordingly. Relieved, you realize the car has safely brought you to your destination. The ultrasonic sensors implemented in the wheels detect the curb and other vehicles; the car parks, and the ride is over.

Although the self-driving car industry has long been dominated by motor industry giants, such as Ford and Toyota, two relatively novice but outstanding players, Google and Tesla, have recently entered the field. Google has been developing its own driverless car secretly since 2009 and did not publicly announce the project until recently. Google's vehicles are actually Toyota, Audi, and Lexus cars upgraded with specialized components. Led by the winner of the 2005 DARPA Grand Challenge, the Google car has managed to cover an impressive distance of 2 million miles through the span of 6 years and is on course to be released publicly by 2020.

Google

Tesla

Uber



Mercedes Benz

Current models of self-driving cars.

Tesla Motors, founded by Elon Musk, is currently Google's strongest rival. In contrast to Google, Tesla builds electric cars equipped with autopilot mode—which meant only to assist drivers, not to replace them. Another difference between the two companies is that Tesla's cars are produced in its own factories.

However, both firms have recently been facing safety concerns. On May 7, 2016, a man named Joshua Brown was killed in a fatal crash while his Tesla car was in autopilot mode. The car failed to apply the brakes when a tractor made an unexpected left turn in front of the vehicle. In a recent release, Google also reported an incident that sent an operator to the hospital. The accident was not entirely the car's fault because it was struck by another car that ran a red light. Since it was travelling at a low speed of 22 miles per hour and the operator took on manual control in time, there weren't any severe injuries. The operator checked out of the hospital after a few examinations. However, according to Google, the damage on the car itself was pretty "substantial," as it was disfigured on the right side. Nonetheless, when compared to the accident rates of non-autonomous cars, these isolated incidents pale in comparison.

The next obstacle is making these cars a feasible investment for the average consumer. As technology improves, these cars will become cheaper to manufacture and the increased competition will also drive the price down. With rapid developments in the industry, it seems that self-driving cars will soon dominate the roads. •

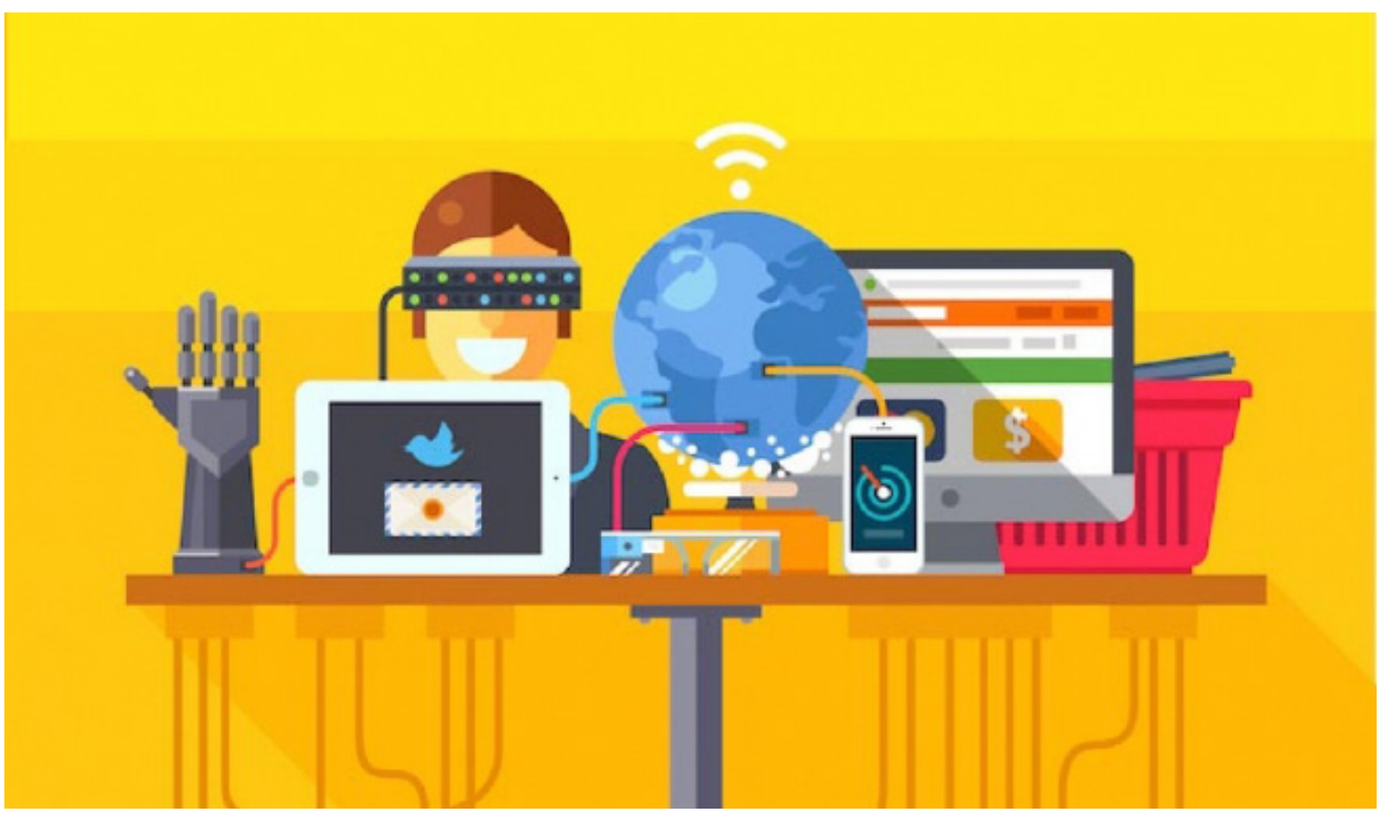
Cover by American Power and Light Companies.

The Current Reality of VIRTUAL REALITY

by WILL WU '19

Oculus started a global trend in virtual reality gaming and simulation with the release of its first generation virtual reality helmet, Oculus Rift DK1. Virtual Reality (VR) involves both hardware and software in order to provide an immersive simulated experience. The computer software generates realistic scenes and animations that imitate the real world and are displayed with specialized hardware, most notably VR headsets. However, like any consumer electronic devices, VR headsets are supported by auxiliary technologies, rendering the headsets just the tip of an iceberg.

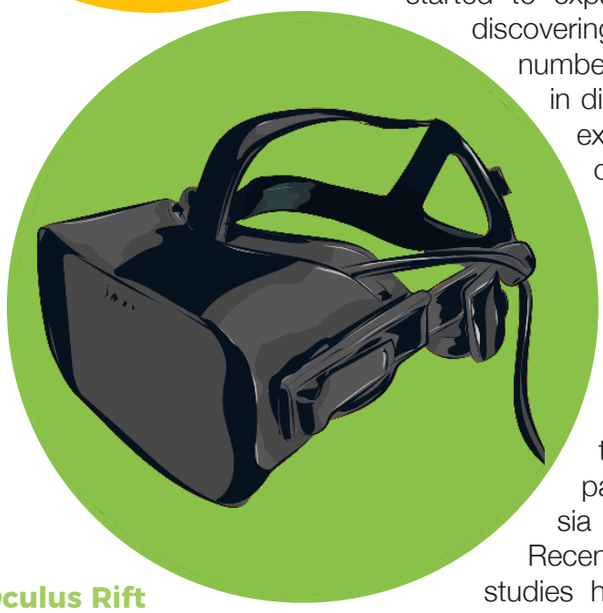
A variety of headsets exist on the market. However, the most popular are manufactured by three companies: HTC, Oculus, and Sony. These manufacturers have focused on the production of two kinds of headsets. The first category consists of headsets with an enclosed display screen. This type of headset is renowned for displaying stunning graphics but requires a connection to a console, which can be either a computer or a gaming system. Users generally agree that headsets with built-in displays tend to create a more immersive experience. The most popular examples of this



type of headset include Oculus Rift (including DK kits), HTC Vive, and Sony PlayStation VR. The second category does not have a built-in screen and requires a smartphone to serve as the display. With the use of a phone to serve as the screen, the embedded lens of this type of headset creates the VR experience and allows the user to play games and watch movies. This category of headsets usually costs less, making it more accessible to the public. Notable examples include Google Daydream View or Samsung Gear VR.

Headsets, especially those with built-in displays, require powerful central processing units (CPUs) and graphics processing units (or GPUs). If a developer wants to make the game experience as real and interactive as possible, then an emphasis must be placed on how the graphics of the game are rendered. A stunning 60 frames per second (fps) graphic can mimic the movement and fluidity of real-life. For example, truly breathtaking graphics of aquatic environments require real time interaction between a gamer's position and the gamer's reflection on the water, with adjustments to account for wind and waves. Immersive, sharp graphics require a GPU with high computing power and graphic memory. Otherwise, the scene becomes frustratingly slow and a section of the animation may become stuck on the screen. If the primary goal of VR is to mimic the real world, optimizing the realism of the graphics is necessary. Consequently, hardware manufacturers have responded by providing consoles and computers capable of delivering the required amount of power to process and generate vivid graphics. The foremost producers of the most popular CPUs on the market are Intel (generally Core i5) and AMD, while the two major producers of GPUs are Nvidia (GTX 970 or above) and AMD (AMD 290 or above). Of course, a complete VR experience requires additional technology such as peripheral interaction devices, made by companies such as Leap Motion or Microsoft.

HTC Vive


Oculus Rift

Recent cognitive psychology studies have shown that VR works well for directing patient's attention away from pain. VR games can decrease at least 40% of patients' pain without using pain medication.

The popularity of virtual reality has resulted in a growing number of developers joining the industry and contributing both software and useful libraries to the community. The two major platforms for developing games and simulations on VR are Unity3d and Unreal Engine, and the biggest distributing platform is Steam.

This summer, I was fortunate enough to visit the headquarters of HTC Vive in Shenzhen. Given that the VR industry has just started to expand, people are discovering an increasing number of applications in different fields. For example, a group of developers in Shenzhen are exploring the possibility of deploying VR headsets in a local hospital to be used by patients receiving partial anesthesia during surgery. Recent psychological studies have shown that VR works well for directing patient's attention away from pain. VR games can decrease at least 40% of patients' pain without using medication.

The virtual reality industry is still expanding, and there seem to be plenty of potential uses for the technology. Smarter tools have lowered the barricade to creating software, and even amateurs with minimal training can now make decent VR games. With a vast amount of applications that are still being discovered, VR truly has the potential to change the world. •

Cover illustrations by EdTech.

THOUGHT EXPERIMENT

Life is But a Dream (so Should You Row the Boat?)
Robert Nozick's Experience Machine

It's the news of the decade. Scientists have invented a technology called the Experience Machine that allows you to experience your ideal life. The machine is guaranteed to work flawlessly.

Anything is possible. You can construct a reality in which you are drowning in wealth, fame—whatever your heart desires.

In order to use this machine, you need to go to a lab. You'll be placed in an eternal coma, with electrodes hooking you up to the machine in a dark chamber. You will not have the memory of signing up to use the Experience Machine in the first place—you'll experience your perfect life, with no knowledge that it is all a machine simulation.

You'll never wake up from the coma and interact with the real world ever again, but you are living out your wildest dreams. Would you sign up to use this machine?

Submit your thoughts to tlee17@choate.edu for a chance to be featured in the next issue!

Selected Answer from Last Issue

Identity Crises (and Not the Angsty Teenager kind)
Derek Parfit's Teletransporter

A teletransporter, a machine able tio instantly transport you to any place with a corresponding teletransporter by replicating your atoms, glitches. Your atoms have been duplicated, but your original atoms have not been destroyed. Is destroying your atoms now equivalent to dying?

"How do we define death? Sure, scientifically, we die if we stop breathing for long enough that oxygen isn't delivered to our cells and they can't complete their functions. But once we plug resurrection into the equation, stuff gets complicated. The reason we fear death is probably an intrinsic repulsion we have to permanent change and the unknown. So, culturally, death means an irreversible change in state. But, if that's the case, scientifically dying and then resurrecting equates to not dying at all, since the change was reversed. But wait–was the change actually reversed, or are we different now that we're resurrected? To answer this, we first need to define what makes up our identities. Every decision we make is directly influenced by a combination of our past experiences and our genetics (i.e. personality traits). If we assume that the teletransporter recreates our molecular structure so perfectly that we retain all our memories and genes, then we are fundamentally the same person before and after teletransporting. Therefore, we experience no net change after using teletransporter, so we don't actually die. At least not under the cultural definition–which is really the only definition that matters to us in this scenario. Our fear is irrational."

-Kristen Andonie '17

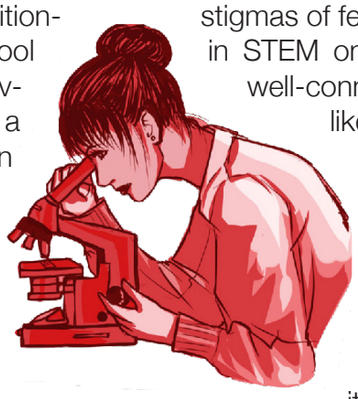
Women in STEM

by ELYSE CORNWALL '18

It seems impossible to talk about women in the professional workforce without using the words "minority" and "underrepresentation." Despite this, 51% of Americans employed in professional positions with at least an associate's degree are female. So where does gender inequality come into play in the American workforce? STEM (science, technology, engineering, and mathematics) fields. Within the United States Department of Labor's list of the 25 most common professions for women in 2014, the only STEM-related occupations are nurses and health aides, both of which are traditionally female dominated.

Critical STEM fields such as engineering and computer science are failing to utilize all possible employees, and thus are missing out on a major opportunity to further their own development. A study conducted between 2001 and 2004 by nonprofit organization Catalyst revealed that return on equity (ROE), return on sales (ROS), and return on invested capital (ROIC) within Fortune 500 companies were substantially higher for companies with more gender diversity. ROE increased by 53% for companies with the highest portions of female board directors compared to that of the lowest. Additionally, ROS increased by 42% and ROIC increased by 66% for these companies with more gender diversity. Women are crucial in the workplace, and even within the nation's most successful companies, a lack of female representation can dramatically reduce profit. Employment of women, especially in STEM fields that lack gender diversity, could revolutionize the workforce.

Underrepresentation occurs even though females perform similarly, if not better, compared to males in STEM subjects in high school. A study conducted by the National Science Foundation in 2016 reports that female and male students scored similarly on science and math standardized tests in 2012. Additionally, female high school students took high-level science courses at a slightly higher rate than their male peers; 22% of female students took these classes while only 18% of male students did. Unfortunately, this is the point where female interest and pursuit in STEM topics begins to decline. Women receive less than 20% of computer science and engineering bachelor's degrees and around 40% of physical science and math degrees. Class enrollment data from 2014 revealed that for Choate students, this gender gap in STEM occurs even earlier than college. At Choate, 46 out of the 59 students that had taken AP Computer Science from 2010 to 2014 were male. Enrollment in AP Physics C showed similar disproportion; 95 out of 122 students were male. Even at a distinguished preparatory school like Choate, young women aren't sufficiently encouraged to pursue higher level STEM courses.



Choate students must recognize that underrepresentation of women in STEM fields is an extremely relevant problem in their lives. Students cannot wait until they are employed to confront diversity issues within the professional workforce. Choate students and faculty can take initiative by consciously promoting female participation and achievement in high-level math and science courses and by confronting any stigmas of female incompetence in STEM on campus. A small, well-connected community like Choate is an optimal environment to tackle the issue of underrepresentation of women in STEM; an individual can be heard at Choate, whether it is during a Choate Talk, at a hosted discussion, or in a dorm with peers. STEM-related clubs and publications at Choate are ideal platforms to broadcast the accomplishments of female students. Whatever form this encouragement may take, it is critical that Choate students act now to improve both the future of women in STEM and the workforce as a whole. An investment in the diversification of STEM students on a scale as small as one campus is an investment in the future of STEM. •

Cover illustration by Monica Ramos.

A MORAL ABORTION: Perspectives from Various Religions

by CLAIRE STOVER '17

In the second installment of her three-part series on the nation's debate on abortion, Claire Stover '17 explores the varying religious views on the topic. The following article is not meant to categorize an individual's beliefs based on his or her religion—rather, it shows some common viewpoints among followers of different religions.

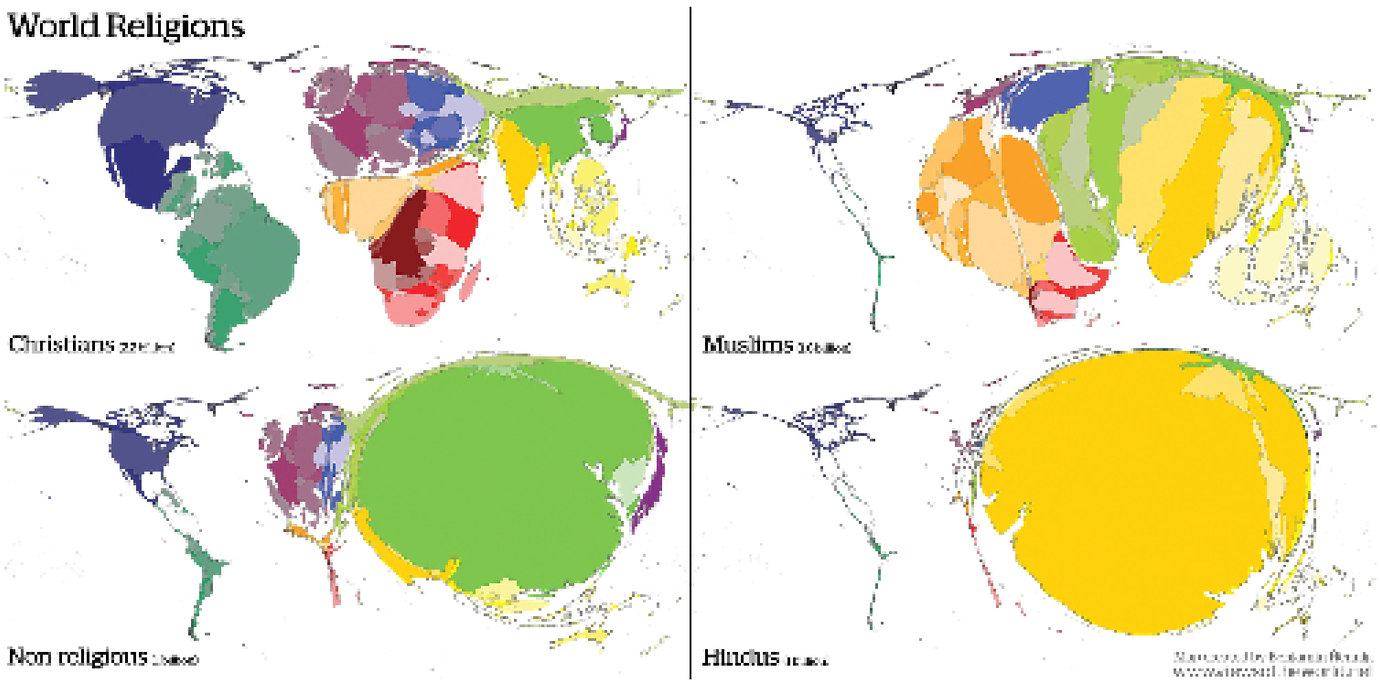
Abortion is one of the most polarizing topics in the nation. For some, it conjures up images of evil doctors selling dismembered fetuses for profit. Others imagine a scared teenager walking into a Planned Parenthood clinic, bombarded by hateful screams. But where do these passionate opinions come from? Though many religions emphasize the value of human life, they frequently differ in their stances on abortion. This adds to the complexity of the discourse surrounding the topic.

Roman Catholicism has 1.2 billion adherents worldwide and 69 million in the United States alone. It is characterized by an extensive body of dogma, dictating the beliefs of its constituents in nearly all matters, including abortion. In 1987, the Church codified its views in Donum Vitae (The Gift of Life), a document of the Congregation for the Doctrine of the Faith. Pope Benedict XVI stated, "Human life is sacred because from its beginning it involves the creative action of God." He added, "God alone is the Lord of life from its beginning until its end: no one can under any circumstance claim for himself the right directly to destroy an innocent human being." The Church is very active in protecting what it calls "innocent lives." Congregations organize and participate in conferences, clubs, and rallies calling for respect for life in Washington and across the globe. Their views align with pro-life political candidates, and they offer prayers and counseling to women contemplating abortion.

In contrast, pro-life Protestant churches, including the Southern Baptist Convention, The Church of Jesus Christ of Latter-Day Saints, the Episcopal Church, and the National Association of Evangelicals, all believe that abortion should only be an option in the first trimester of pregnancies resulting from rape or incest, or when the mother's life is in danger, according to the Pew Research Center. Otherwise, to them, abortion is a sinful act. They cite Jeremiah 1:5, "Before I formed you in the womb I knew you, before you were born I set you apart; I appointed you as a prophet to the nations," and Isaiah 49:15, "Can a mother forget the baby at her breast and have no compassion on the child she has borne? Though she may forget, I will not forget you," among others, as proof that life begins at conception. Furthermore, these churches apply the Commandment "thou shalt not kill" to solidify the sinfulness of the act.

Other pro-choice Protestant branches, including the United Church of Christ, the Presbyterian Church, and the Assembly of God, feel that woman deserve the right to an affordable, accessible, safe abortion. The bedrock of these churches is the personal relationship each follower has with God, and thus each is entitled to her own interpretation of the Bible and His teachings. In the Eighth General Synod of the United Church of Christ in 1971, they state that God "has called us to share the work of creation with him, giving us the privileges and responsibilities of fellowship in the family and in the wider units of society." They continue, "Inevitably, therefore, a judgement will be made or assumed as to when personal human life begins and at what point society has an interest in it and affirms an obligation towards it," and eventually conclude that while an embryo "is human in origin and potentially human in character, the integration of bodily functions and the possibility of social interactions do not appear until later." In other words, Christians have the freedom to create life and the responsibility to nurture it. However, scientifically, the point at which life begins is not at conception but is actually between the 20th and 28th weeks of pregnancy. Therefore, abortion before that point is entirely permissible.

Likewise, Judaism has a pro-Choice stance on abortion. Various movements in Judaism, such as the Reform and Conservative movements, cite the Torah as evidence for their beliefs. Exodus 21:22-23 states, "When men fight, and one of them pushes a pregnant woman and a miscarriage results, but no other damage ensues, the one responsible shall be fined." However, "if other damage ensues, the penalty shall be life for life." Therefore, a fetus is not a life according to the law, and thus can be terminated. The accompanying midrash, or ancient commentary on the law, confirms that man does not include a fetus. Furthermore, a collection of oral law, Mishnah Ohalot 7:6 says that if a woman is in danger of dying from giving birth, "one cuts up the fetus within her womb and extracts it limb by limb, because her life takes precedence over that of the fetus."



The geographic distribution of the practitioners of four major systems of belief.

Thus, the Jewish traditions affirm reproductive rights.

Similarly, Islam is fairly liberal with regards to abortion. Since the Qur'an does not specifically address abortion, different schools of Muslim law have different opinions on the issue. While it is considered haram, or wrong, it is not punishable. The further along in the pregnancy one is, the more wrong the abortion becomes, and after the soul, or "Ruh," is given to the fetus, it is no longer permissible to abort. Depending on the set of laws, Ruh occurs either at 40 days, 120 days, or 12 weeks. There is an importance placed on choosing the lesser of two evils; consequently, terminating the pregnancy for the sake of the mother is okay because she is an established being with a family and duties, while the fetus may die anyways if the mother is in danger.

In contrast, other religions do not have official doctrines on abortion, complicating the discussions regarding the practice in the religious community. While Buddhism and Hinduism lack official doctrine on the validity of abortion, the majority of practitioners believe that it is wrong. The portion of Buddhists believe that life begins at conception, and therefore termination of a pregnancy is equivalent to murder. However, Buddhism emphasizes the importance of the individual's choice, and thus each case is treated independently. Likewise, Hindus believe that abortion is permissible if the mother's life is in jeopardy. Still, Hinduism stresses the idea of ahimsa, or nonviolence in all facets of life, which dictates a pro-life stance in many situations.

The major religions of the world—Christianity, Judaism, Islam, Buddhism, and Hinduism—all differ in their beliefs on abortion. Additionally, there is a lot of variance in opinion within each religion, with followers ranging in their views on abortion. However, these religions' doctrines all align in agreement that there is an inherent value in a human life that demands respect. While these competing views contribute to the mosaic of opinions present, they all affirm the unity of the human race. •

Bibliography

1. Congregation for the Doctrine of the Faith. "Instruction on Respect for Human Life." Instruction on Respect for Human Life. The Holy See, 22 Feb. 1987. Web. 09 Oct. 2016.
2. Pew Research Forum. "Religious Groups' Official Positions on Abortion." Pew Research Centers Religion Public Life Project RSS. Pew Research Center, 16 Jan. 2013. Web. 09 Oct. 2016.
3. Pfeiffer, Richard C. "United Church of Christ General Synod Statements and Resolutions Regarding Freedom of Choice." United Church of Christ. United Church of Christ, 1971. Web. 09 Oct. 2016.
4. Oakley, Francis Chrisopher, Michael Frassetto, and Lawrence Cunningham. "Roman Catholicism." Encyclopædia Brittanica. N.p., 2016. Web. 9 Oct. 2016.
5. Rabinnical Assembly. "Resolution on Reproductive Freedom in the United States." The Rabbinical Assembly |. The Rabbinical Assembly, 2016. Web. 09 Oct. 2016.

WHAT'S THE BIG i.d.EA?

by ALYSSA SHIN '18

The new i.d.Lab is a resource available to all Choate students. However, many students do not know how to use the machines and tools to bring their ideas alive. Fortunately, some students on campus are taking the initiative and utilizing the machines of the i.d. Lab outside of the confines of the classroom. These students can be relied on to pave the way for increased usage of the i.d.Lab. Alan Luo '18 , interviewed here, is one of these students.

1. What inspired you to start using the i.d.Lab?

I first started using the i.d.Lab before there really was an actual i.d.Lab. We got a laser cutter very shortly after switching to the new building, and I was taking a robotics class at the time, so I was stationed in the classroom directly next to it. This also meant that I was often around finishing up classwork. For some arbitrary reason, I decided to laser cut some photos one day, and had pretty positive results. It was then that I asked Alyssa Shin for some of her photos. My decision to use the lab wasn't particularly surprising since I had always been a bit of a tinkerer and builder at home.

2. How frequently do you visit?

I probably visit at least once a day, for various reasons. It's a good place for homework, club meetings, and classes.

3. Is there anything you do regularly in the i.d.Lab?

I used to laser cut things every Friday, but not as frequently anymore. It's fun to laser engrave electronic devices.

4. Is there one particular project that you are proud of creating?

Not really, as I haven't done anything particularly substantial. I'm hoping to change that soon.

5. For those who are intimidated/scared of using the i.d.Lab for the first time, do you have any tips?

Don't be scared! The only way to learn anything is by failing. If you're not scared to fail while practicing a musical instrument or learning a new concept in class, then you have no reason to be scared to fail while using the machines. Just remember, Google can be your best friend.

6. Any plans for future projects?

I want to build an electroencephalogram (EEG), essentially a device that can monitor brainwave activity. It's not that hard; I actually built one at home a few years ago. I will need to purchase some extra materials (about $20 worth). I think one way that my experience creating the EEG here will differ from my experience creating the EEG at home is that I am three years smarter and I have smart peers that can help me this time around. •