HWJS

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Graphene: The Miracle Material

The Quantum Dance

The Thermal Vacuum Trap

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Out of the *Classroom*

By Kenny Gotlieb '06

It was during Studies in Scientific Research class that I first realized I can look at the world around me and ask how we can do things better. My team's woefully misguided attempts to improve the efficiency of refrigerators showed me that I could learn from tinkering. I wish I had tried this sooner—it was a thrilling new way of thinking that I hope to continue to carry with me.

I went to Harvard thinking I wanted to study physics because it was fun and presumably useful, though I wasn't sure for what. I was very lucky to have the math and science (and writing!) background from Harvard-Westlake that provided sure footing freshman year. While physics classes certainly can be very challenging, a steady stream of research talks on topics from string theory to robotics reminded me why this field was energizing to me and worth studying.

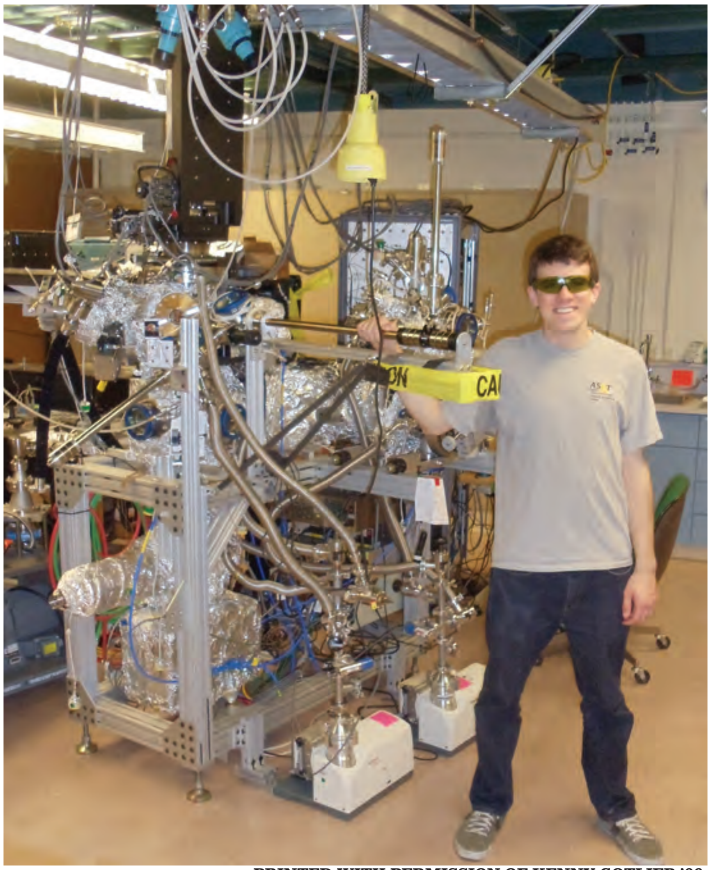
I enjoyed many of my classes in college and had the chance to TA a few (a lot of fun!), but the best part of my college experience was the people surrounding me. While hanging out in the dining hall, I talked with my friends about their ideas for tech startups and public health and education charities. Since graduation, I have seen these friends actually put their ideas into action. My classmates encouraged me to see the problems you learn about in classes or read about in the news as fertile ground for new ideas and action.

Early on in college, I took an alarming class on Earth's climate that made me want to contribute my best to the effort to prevent dangerous shifts in climate. It eventually became clear that many of the technologies that will help us mitigate and cope with climate change—not just solar cells, but energy storage, smart grid, and water management technologies—will require scientists and engineers with a strong physics background. Maybe the long nights working on problem sets were worth it.

I was very lucky to work in an observational cosmology research group in college. The group tracked exploding stars billions of light years away to study the accelerating expansion of the universe and the dark energy that is driving it. The highlight of this experience was traveling to an international observatory high in the mountains of Chile to test a device I had helped build that would gauge how much the atmosphere was distorting measurements of stars.

While there, my advisor explained to me that what makes a scientist successful is picking a big problem to work on and surrounding oneself with a talented team. He said you should always pursue whatever seems like the biggest question out there that we are now developing the capability to study. Hopefully, one's research experience has allowed her to develop skills that are worthwhile in new collaborations to tackle new problems.

I took a year off after college to work on a technological application of physics I never would have thought of: a brain imaging device. The professor for a healthcare



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class I took told me about a team of doctors seeking to design a faster and cheaper way to see into the brains of stroke victims. While the project didn't go according to plan, I saw that collaboration with people in other fields can lead to unexpected and exciting opportunities. Among other things, a collaborator of ours brought me on board to mentor some of his freshman MIT students on a research project of theirs.

I decided to go to applied physics graduate school at UC Berkeley because I felt like I needed to learn more before I could contribute to the problems I found interesting. I'm still not sure what I'll want to do after, but I figured that for many of the possibilities, experience doing science would be very valuable. Grad school is great—you get paid to do exciting research, hear thought-provoking talks from all the other scientists around, and take classes that are mostly for your own benefit rather than evaluation. I just recently got the exciting news that I was awarded a National Science Foundation Graduate Fellowship. Carrying my own funding will hopefully allow me a great deal of intellectual independence as I explore possible projects.

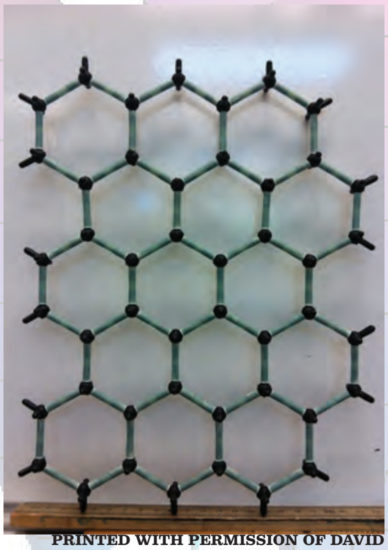
I work on condensed matter physics—basically studying the properties of exotic materials. My research group doesn't build the computer chips of tomorrow, but the group tries to understand the materials that—who knows?—could end up in any number of advanced devices in several decades.

My goal for now is to learn to be a scientist and any technological application that comes out of it would be a nice bonus. While I was fascinated by outer space when I was younger, it was in several classes I took in high school that I began to see science as something a real person could do. SSR was a very valuable experience in learning by playing that more students should have.

Graphene: The Miracle Material

By Connor Pasich and David Olodort

What if something was stronger than most every other material, lighter than most every other material, and passed electricity through it like it wasn't even there? You would have graphene.



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What it is:

Graphene is being heralded as the "miracle material" of the future because of these incredible properties. Andrew Geim and Konstantin Noselov exemplified its strength and lightness by the assertion that a three foot by three foot hammock of single-sheet graphene could hold the weight of a house cat and weigh less than a single whisker from that cat! The discovery that electrons pass through this material unimpaired is destined for great importance in the rapidly evolving worlds of semi-conducting and quantum computing industries. It is 98% transparent which is very exciting for electronics companies who are heavily investing in transparent screens and electronics for consumers. Samsung has even gone as far as promising a transparent screen by the end of 2012. This proves the establishment's dedication to such a radical, mysterious material, a rarity in the precarious environment of global electronics production.

To Date:

In order to work and experiment with our material, we first needed to isolate and observe it. We did so using the simple pencil-and-tape method. This can be done by simply scribbling on a sheet of paper, using a piece of scotch tape to pick up the graphite, then using successive piece of tape to "thin out" the graphite sample. After doing this several times and getting a good sample, we used the most powerful optical microscope at our disposal to observe the structure of the graphene molecules, and try to learn why it has the unique properties listed above.

Our work this semester is focused on researching graphene applications and qualities that can be studied in an environment less well-equipped than a national laboratory. We are attempting to conduct this project using the most basic of materials: a graphite pencil, scotch tape, and a scrap of paper. Amazingly enough, this is exactly the set up Dr. Geim and Dr. Noselov used in producing their Nobel prize-winning work. With this in mind, we should be able to make discoveries of the same magnitude with very basic equipment at hand. The goal of our experiment is not only to learn about the material and make new discoveries about it, but to also show that anyone with even the most basic resources at a high-school level can study this wonderful material and break new grounds in the scientific world.

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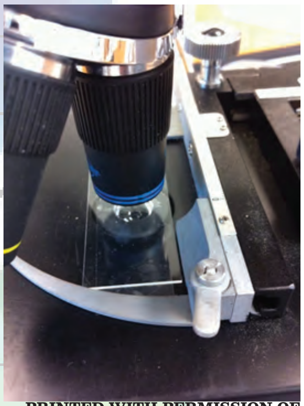
Intentions:

Our work will be based around possible applications for this amazing material. One field that we will purusue is the emerging development of solar technology using graphene. Due to its high conductivity and low thermal radiator, it is very power efficient; therefore, this is an ideal material for solar technology where squeezing every ounce of energy out of the sun's rays is crucial. It could also prove to be a more convenient alternative to modern solar panels, as it would result in a wait reduction and higher flexibility. This could allow us to shape them in different ways and place them in more locations, helping the use of solar power to spread and expand. Another interesting aspect to this will be studying its properties at temperature extremes. We currently have the capabilities to super freeze graphene but are working on ways to superheat it. These tests could show if there is a breaking point in graphene's qualities and how these possible characteristic changes affect our view of this as an industrial material. This is definitely a factor for any space equipment, a probably one-day destination for graphene. It could also give us some interesting physical properties like those seen in a frozen superconductor. The cooler, denser structure that may result from cooling could make the material even stronger and more stable, or give it more rigidity and inspire uses of the product that would solve major dilemmas.



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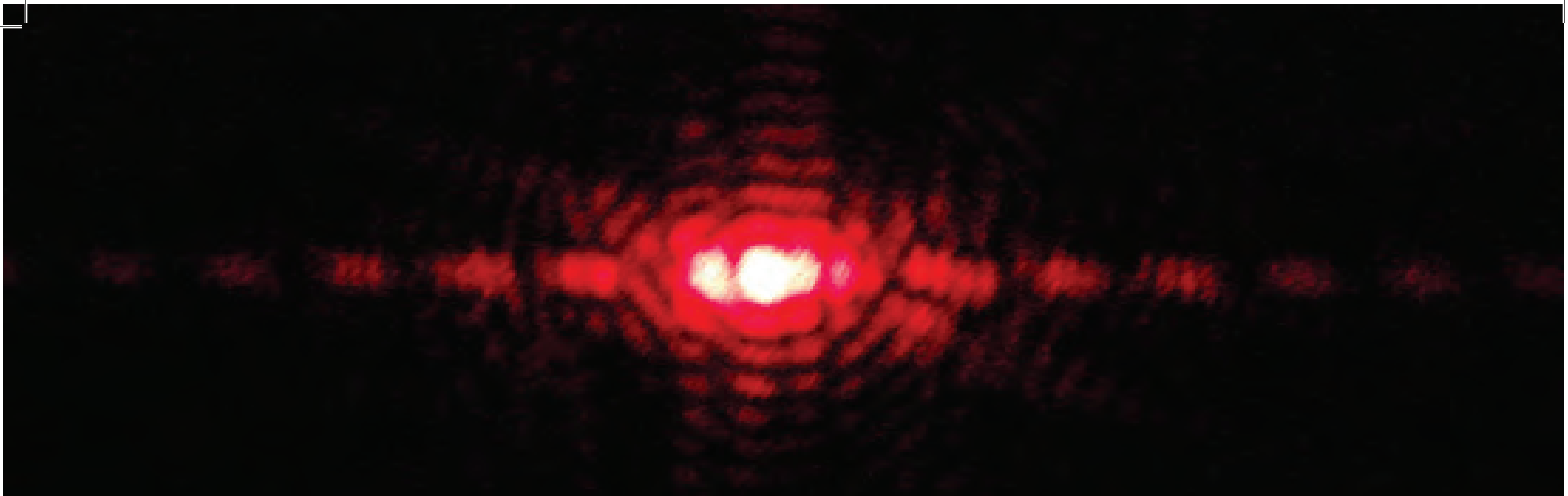
Who knows what we are going to discover and how it might change the world...

PAUL WENK



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The Quantum Dance

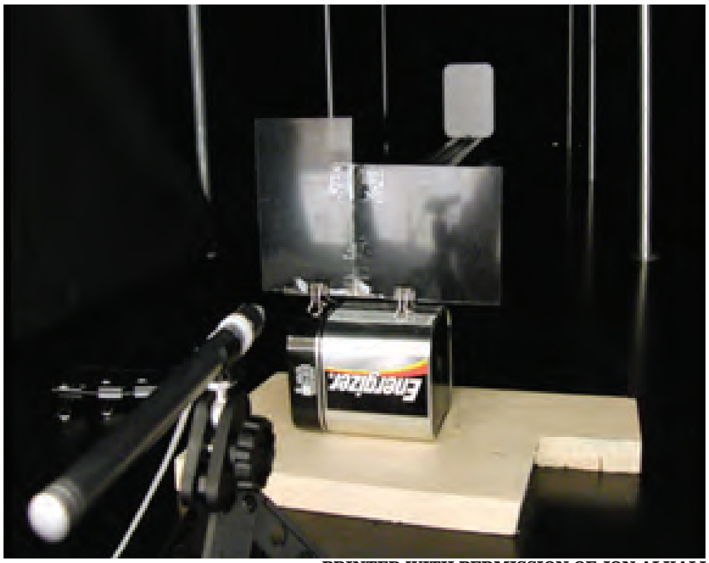
By Jon Alkalai, Michelle Choi, David Feinerman

Introduction

The Quantum Eraser experiment is one that has baffled both physicists and high school amateurs for years. Although a member of the latter, our group will use our makeshift experiment to somewhat contradictorily reinforce our knowledge of photons by defying commonsense laws of reality. Our experiment will dispute the logical understanding that an object cannot occupy two separate positions at the same time, thereby highlighting that the behavior of photons and quantum particles seems to defy traditional laws of time, motion, and place.

Summary

When the polarizers are held at a 45º angle in front of the path of the laser, it seems as if the photons "chose" which side of the wire to travel past based on what they encounter *after* they've twisted around the obstacle. Furthermore, as the information of each photon's path is erased, it becomes clear that the photon seemingly travels past *both* sides of the wire simultaneously and interferes with itself. In an incredibly puzzling series of events, the path of the photon, and the "quantum dance" that it performs as it travels around wires and through polarizers, allows us to come to a few conclusions: First, under specific quantum circumstances, the experiment shows that it is in fact possible to influence events in the past. Second, we found that an object can occupy two positions at once. To use Schrodinger's analogy, the photon acts as if it were a cat scampering around both sides of a tree concurrently.



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Experiment setup, with view of the duvetyn tent, display screen, red laser, and path labeler

Setup

In order to properly observe the behavior of photons from a laser, we needed to create a workspace that blocked out external light. Also, the experiment required that we keep the laser and our viewing screen at a distance. Thus we built a tent (approximately six-feet long) covered in lightproof duvetyn. To determine the direction each photon from the laser travels, we first needed to create a "path labeler". The path labeler is a set of polarizers angled 90° relative to each other and taped together. A straightened staple is then placed at the junction of the two polarizers, forcing individual photons to go either to the right or left of the staple. Next, we set up a viewing screen six feet from our polarizers so we could observe the pattern made by the diffracted photons.

Conclusion

Now a few months into the experiment, we have been able to complete our setup and successfully begin to see results. Manipulation of the red laser beam has produced the expected interference patterns in the presence of a path labeler. We have also s that interference disappears when a second polarizer is placed in either a vertical or horizontal position in addition to the path labeler — both expected results. In order to complete the experiment itself, we would like to have a clearer image of the eraser, or the pattern created when the second polarizer is placed at a 45° angle with the ground. This is perhaps the most meaningful part of the experiment, as it gives us the most valuable information as to the behavior of the photon as it dances around the staple.

For that reason, producing and documenting a clearer eraser pattern has been our focus for the last few weeks.

In order to test whether or not our laser is the source of the problem, we have recently produced a 5mw 532nm green astronomy laser pointer. With a more powerful, higher frequency laser, we hope that all of our patterns, including the one produced by the eraser, will become clearer and more defined. We have also begun to use the Visual Arts Department's cameras for higher-resolution imagery.

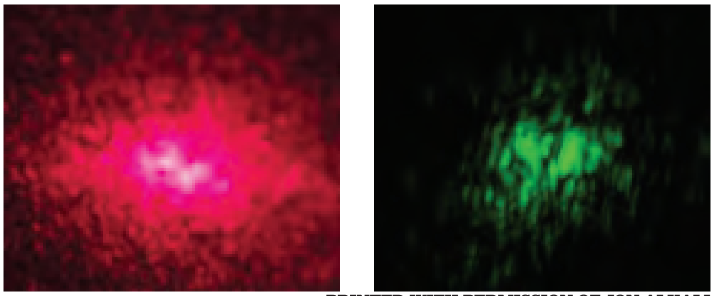
In conducting our experiment, we observed that the green laser produced far less clear diffraction patterns than the 671 nm red laser. This conclusion is related to the following equation, which relates the distance of the light from the slits to the wavelength of the laser:

$$x = \frac{m\lambda L}{d}$$

x= distance from the center of the pattern to the light
m= order of the bright spot
l= wavelength
d= distance between screen and polarizer
L= distance between slits

Because the wavelength is shorter in the green laser, the x value is smaller. This causes the light spots in the pattern to be closer together, causing the patterns to be less visible in the camera.

In conclusion, our experiment allows us to venture into the uncharted depths of quantum nature, and successful conclusions made about the nature of the photon would have wide-ranging effects on the world of quantum mechanics and physics.



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Pattern produced by the horizontal polarizer, left. A similar pattern was produced by the vertical polarizer. "Eraser" pattern produced by the 45^{O} *polarizer, right.*

The Thermal Vacuum Trap

By Aaron Strauss and Matthew Heartney

Problem

Currently, the transportation of heated or refrigerated objects is a very inefficient science. Although final temperatures are not particularly difficult or energy inefficient to reach, sustained cooling and heating require significant amounts of energy and the transportation of bulky temperature control units. This energy cost is magnified at extreme temperatures, putting unnecessary holes in one's wallet and the earth's ozone.

Idea

Three different kinds of heat transfer exist: convection, conduction, and radiation. A thermal vacuum trap negates or massively reduces all three types. A metal sphere (in which the desired sample is placed) is suspended by insulated wiring in a vacuum bell jar. The vacuum aspect of our design negates convection, as no heat is transferred through the air if there is no air, which is otherwise known as a vacuum. The insulated wire will be the only point of conduction, as the inner sphere will not be in contact with the sides of the jar. By insulating the wire against heat, the conduction, the largest form of heat transfer, would be reduced to a minimal amount. Finally, radiation will be negated by heat-reflective covers. By reducing heat transfer to a minimum, the temperature of the object cannot change, and will remain virtually constant if a strong vacuum is created.

Preliminary testing

In order to prove that vacuums do reduce heat transfer, specifically convection, we designed an experiment in which two Erlenmeyer flasks filled with water were heated to similar temperatures. One flask was fully sealed and placed in a vacuum, while the other flask was placed in an identical bell jar under standard atmospheric pressure. We allowed the two samples to cool towards room temperature, recording the temperature of each in three minute intervals. The resulting data table and graphs prove our concept.

Results from Preliminary Test

Graph 1 shows the overall temperatures of the samples with the red data points being the atmospheric pressure sample and the blue data points being the vacuum pressure sample. Even though the atmospheric sample started with a higher temperature, it ended with a lower temperature. This means that it lost more heat than the vacuum sample. To better demonstrate this greater loss of heat, Graph 2 shows the drop in temperature during each interval. Apart from the very first data point, which was most likely a badly timed point, the vacuum sample lost about .3 degrees less during each interval and had a more stable decrease. This suggests that conceptually, a vacuum decreases heat transfer. Furthermore, both graphs shared a general trend for heat decrease, albeit the atmospheric drop was faster. This uniform decrease most likely occurred due to contact heat transfer with the base, which suspension with insulated wiring would remove. In short, preliminary tests show that the idea of a thermal vacuum trap should reduce heat transfer.

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HANDS ON: *Matt Heartney '12 watches his partner Aaron Strauss '12 push down on the lid of the bell jar as a vacuum is created within it. Heartney and Strauss conducted experiments on the insulated properties of vacuums for the research project.*

Building Process

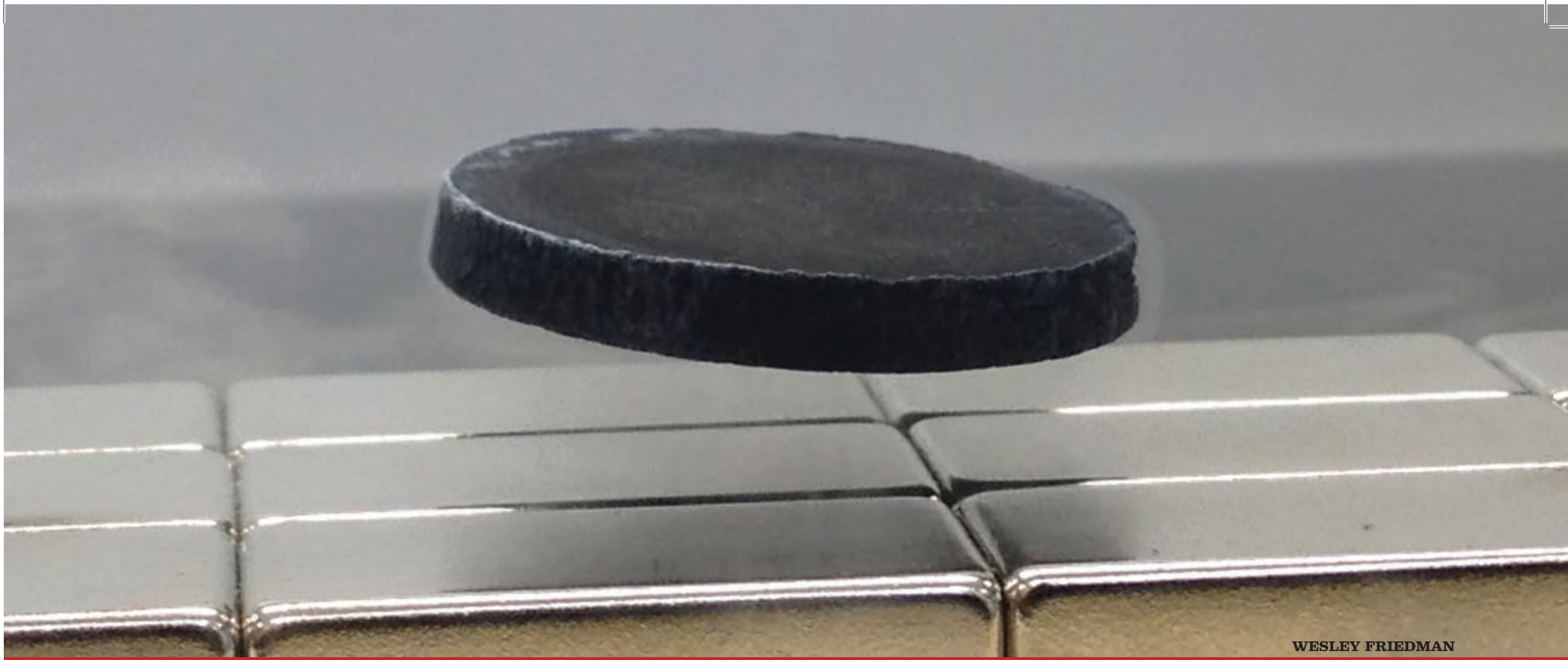
We are already in possession of two vacuum pumps and a vacuum chamber. In order to expedite the air evacuation process, we are attempting to combine the vacuuming powers of two pumps through a plastic Y-joint, essentially turning two vacuum pumps into a single, more powerful pump. If there is less air in the chamber, there will be less convection and therefore less heat transfer.

We have also completed the metal inner sphere. We purchased a small aluminum sphere, four inches in diameter, and split down the middle by hand using a hacksaw. Due to the rudimentary nature of our saw, the edges of our hemispheres were rough and we sanded them down using an angle grinder. The most important part of the inner chamber is the cage. One half of the cage sits on each half of the sphere. Each half has three metal protrusions with holes through the center. Each protrusion has a corresponding protrusion on the other cage. When a bolt is placed through each hole and tightened, the sphere halves will be forced together, creating and maintaining the pressure within the inner chamber while allowing for a vacuum in the bell chamber outside.

etween the halves of the sphere are soft plastic O-rings. These are rings that, when pushed together, have enough give to create a vacuum seal. They have been notched and affixed to the sphere halves with a high powered metal epoxy. The notching was done very precisely to make sure that the two halves fit together without gaps. A gap between the two halves would compromise the vacuum seal and any extremely small gaps or irregularities in the O-rings or hemispheres will be corrected when the halves are compressed together.

Future Plans and Current State

The inner chamber (with cage attachments) is completed and can be affixed to the bell chamber with insulated wiring. Several future possibilities for improvement exist for our thermal vacuum trap. For instance, to truly reduce heat transfer through conduction, a system of neodymium magnets can be affixed to the cage and outside of the bell chamber. In preparation for this possible step, we have constructed the inner chamber and cage entirely out of aluminum, a non-magnetic metal. We would need to construct a base which will accommodate magnets. It would have to be able to contain the vacuum while having enough spaces to place magnets to generate a magnetic field of a controlled magnitude. Also, we plan on using electromagnets on the base because it would give us the ability to modify the magnetic field, allowing us to account for small shifts in the sphere's location.



WESLEY FRIEDMAN

Experimenting with Quantum Levitation

By Wesley Friedman and Daniel Bai

Introduction:

In terms of classical physics, a magnetic field is described as a vector field that represents the Lorentz Force it exerts on moving electric charges. The magnetic field lines are commonly known to be straight, but as seen through experiments involving superconductors and neodymium magnets, the magnetic field is able to bend around the superconductors. This phenomenon is called the Meissner effect, where the magnetic field lines are completely repelled by the superconductor and the superconductor becomes locked in the x and y-axis. The purpose of the Quantum Levitation Project is to analyze the Meissner Effect, and ideally construct a circular ramp of magnets where the superconductor can freely levitate around this magnetic path uninterrupted by any change in the magnetic field of the track.

Experiment:

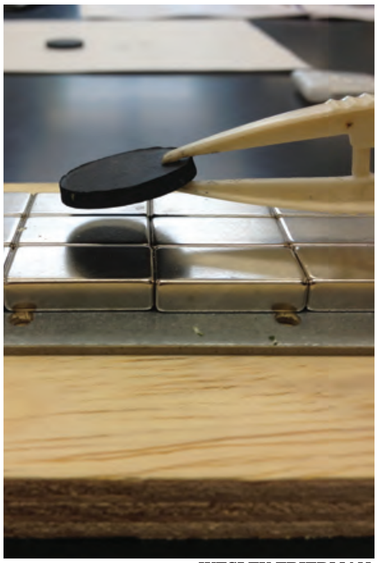
In this experiment, we used high temperature Bismuth superconductors, neodymium magnets, and liquid nitrogen. First, we made the ramp by magnetically attaching the neodymium magnets to sheet metal. We then cooled the superconductors by immersing them in liquid nitrogen because these ceramic disks can only act as superconductors when they are below their critical temperatures. Since the superconductors are high temperature superconductors, meaning they have a low critical temperature, they need to be cooled to approximately -196°C or 77K. After the superconductors reached their critical temperatures, we gently placed them on top of the magnetic ramp as they are diamagnetic.

Results:

So far in the experiment, we were successfully able to observe a glimpse of the Meissner Effect. When the superconductors levitated above the ramp, they levitated in place and we were even able to tilt them in different angles. However, we were not able to tilt the superconductors a lot because the magnetic force was not strong enough to hold the superconductor in place. This is because the superconductor we have is impure and a purer superconductor can surely provide better results for our experiment.

Future Plans:

Since superconductivity is a quantum mechanical phenomenon, there are many aspects of this experiment that we can explore. There are still many theories to be made and tested. In the future, we hope to get a purer and stronger superconductor in order to analyze the Meissner Effect more. We also hope to make a circular ramp rather than a simple straight path so that the superconductors can float in a circular path.



WESLEY FRIEDMAN

The Fractal Model of Plants and Trees

By Wiley Webb

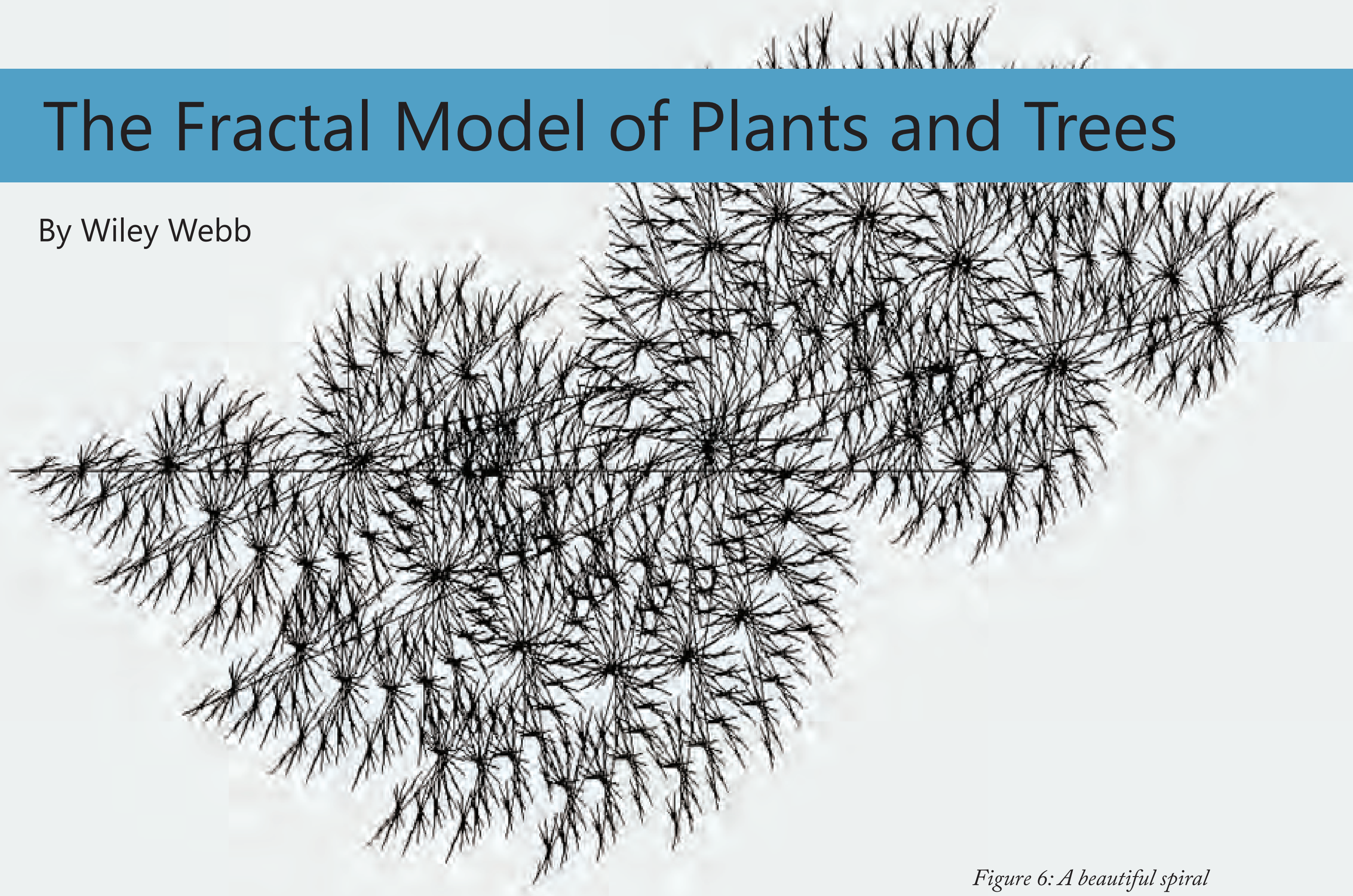


Figure 6: A beautiful spiral

Introduction and Purpose

In nature, there is no more prevalent mathematical form than the fractal, which can be found almost everywhere from a tree's branching pattern to its leaf structure. A fractal is, essentially, a pattern that is self-similar and identical on every scale at which the fractal is observed, no matter how big or small. I sought to create a simple yet flexible way to mathematically model one clear example of self-similarity: the branching pattern of plants and trees.

Using Java, an easy Object Oriented programming language, and Eclipse, an Integrated Development Environment (IDE), I built a piece of software that calculates the form of a fractal tree, displays the data, and freely allows the user to play with all the parameters involved. By tweaking just a few easy parameters, we can compare how well my software's model compares to the flora of the real world.

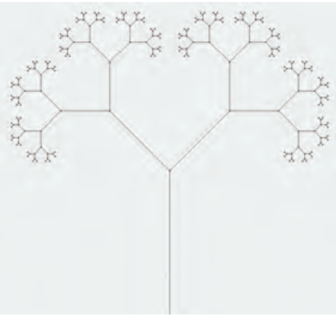


Figure 1: The default, simple tree: two sub-branches per parent branch, each bent at 45° from center and scaled to 75% of the parent's length, without randomness.

Designing an Elegant Mathematical Model

The data set, which consists of something between 1,000 to 65,000 points in the x-y plane, is generated recursively. A plant "knows" where to grow a new branch not because a central brain tells it where, but because each branch itself is "responsible" for growing its sub-branches and each of those sub-branches is responsible for its sub-sub-branches, etc. A recursive process works the same way – each branch of the data set calls a function on itself to create other branches, which inherently results in a self-similar model – perfect for generating fractals.

To make this data set look like a tree, the recursive function, when creating two or more sub-branches of a given parent branch: 1. bends the sub-branches away by a certain angle, 2. shortens them by a certain scaling factor, 3. emphasizes the left or right or middle branch more, 4. adds randomness to it (Fig. 1).

The Variable Parameters of Tree Formation

Since the user can vary every parameter — number of branches, angle, scaling, left/right, verticality and randomness — involved in the generation process, we can observe each variable's effects on the plant's form.

Angle varies the degree to which sub-branches are bent away from their parent. Low angle (0-30°), mid angle (30-45°) and high angle (45-90°) plants look like grasses, trees and bushes, respectively (Fig. 2).

Just for fun, at unrealistic angle settings above 90°, especially when combined with a high L/R setting, the plant spirals back upon itself, creating amazing geometric fractals (Fig. 3).

Scaling varies the scaling factor by which the length of

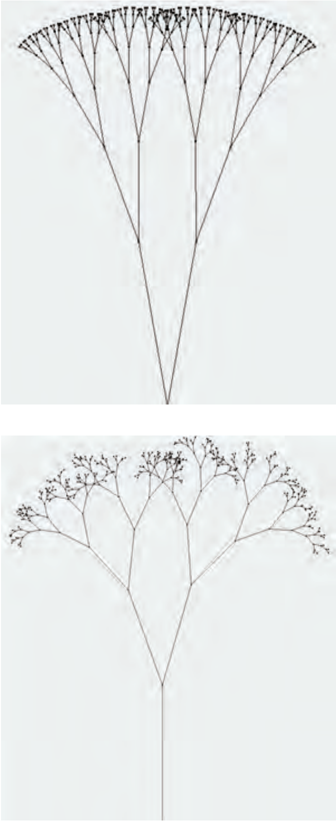


Figure 2: A small variation in angle is the difference between this papyrus grass, top, and this tree, above.

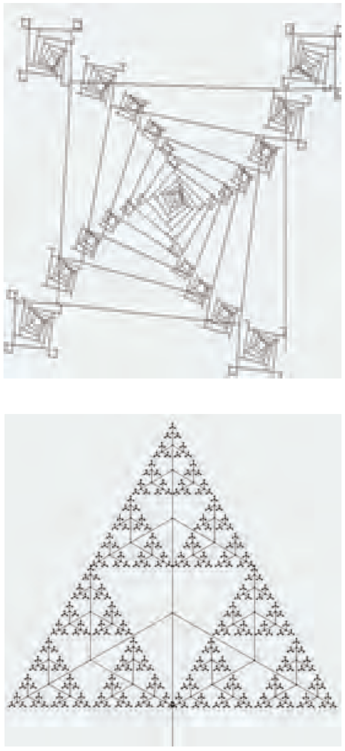


Figure 3: Squares composed of squares, top, and even the famous Sierpinski triangle, above.

sub-branches is reduced. Low scaling values mean stubbier plants with less dense foliage.

Left/Right scales the left or right branch harder than the other, essentially skewing the plant to one side. Low L/R ratios create trees wind-blown to one side whereas high ones result in fern fronds.

Verticality doesn't apply to the Two Sub-Branch mode because its function is to stress the length of the middle branch. This creates a lot of new plant varieties.

Randomness makes things interesting. Nature is neither perfect nor capable of being summed up in a mere few parameters. But just by adding some noise to all of our generated data, we can create some incredibly realistic looking plants (Fig. 4).

I noticed that adding too much randomness produces plants that look dry and dying (possibly because a sickly plant loses its ability to regulate its self-similarity) (Fig. 9).

Adding incredibly high amounts of randomness for fun creates shapes that cease to resemble plants but nevertheless still have corolaries in the natural world.

Conclusion

These few parameters allow the user to generate reasonably accurate models for a variety of plants, proving that most grasses, bushes, ferns, and trees are mathematically similar. The effectiveness of my recursive generation method shows that the rules of self-similarity apply; therefore, most plants are fractal in form. Another important note: a small amount of randomness makes a surprisingly vital contribution to how real our mathematical plant looks but too much randomness makes it sickly looking.

But since I designed the mathematical model and the software packaging around it to be flexible, we can study much more than just the intended subject of plants and trees. Using the same rules as nature, but with inputting unnaturally drastic values into those rules, gives us fantastical looking spirals that one would typically associate with much more complex mathematics than mere iterative addition and multiplication (Fig. 10).

Further Steps

My modeling system can be further improved in many ways, especially regarding the branching process. Not all plants have a parent branch split into two or three branches at one junction. Instead, a branch will stem off one child and continue on its own merry way, stemming off other children later on. There is also a lot of variety to how those child stems are placed, which deserves some study. And of course, every change to the tree model results in new ways to view its fundamental rules in the form of amazing mathematical spirals because we've proven how interconnected the worlds of math and nature are.

Figure 4: Some grasses, ferns and trees

Figure 5: A dead, muted fern.

ALL GRAPHICS BY WILEY WEBB

Multiple Resonances of a Spring-Magnet in a Solenoid

By Marissa Lepor

Introduction

Scientists have studied and analyzed magnetic forces and spring forces for centuries, but the relationship between magnetic forces and spring forces have not yet been fully investigated.

The shaker flashlight, a common household item, utilizes the concept of electromagnetic energy. Upon shaking, a neodymium magnet travels through a tightly wound copper coil and generates energy. A diode converts the energy from an alternating current (AC) to a direct current (DC), which is then stored in a capacitor. Upon flipping a switch, the electrical current travels through the wires and lights up the bulb.

Expanding the structure of a shaker flashlight to a contraption (the magnet is attached to a spring that vertically oscillates through a copper solenoid) allows one to investigate the qualitative and quantitative relationship between spring forces and magnetic forces.

Concepts

Electromagnetic Induction

As the neodymium magnet runs back and forth through the coil, it generates energy through electromagnetic induction. Due to the chemical structure of a copper atom, its valence electrons are loosely held. Thus the electrons in the copper solenoid are easily induced to move in response to the approaching magnet. The movement of electrons generates an electric current, which causes more electrons to move. The strength of the magnetic force and the distance between the magnet and the coil affects the amount of energy generated. In order to maximize the energy generated, a powerful neodymium magnet is used, and the distance between the magnet and the coil is minimized.

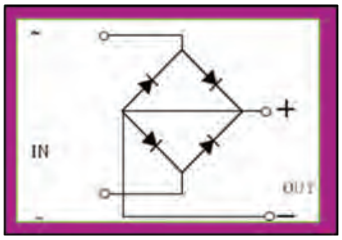


Figure 1: Full Wave Bridge Rectifier

Function of a Diode

The purpose of a diode is to convert the alternating current (AC) into a direct current (DC). To maximize the energy stored, the current must flow in one direction, but when the magnet runs in and out of the coil, it generates a current in two directions. Therefore, if the current were not rectified, the device would be half as productive. A full-wave bridge rectifier (four diodes arranged together) converts the alternating current to a direct current (figure 1). Both currents enter, but only a direct current exits.

Apparatus

A copper solenoid is connected to a push board that has the diodes and capacitor attached (figure 3). A neodymium magnet is attached to a spring, which is then tied to a string. The string is fed through a pulley and attached to an oscillator, which is also connected to a power supply. The oscillator operates at adjustable frequencies and amplitudes. A voltmeter is then connected to the solenoid and measures the voltage of the current.

Experiment

To determine the relationship between magnetic force and spring force, everything in the system remains constant except the frequency at which the magnet oscillates. As the frequency increases, the voltage generated is recorded. The current was then graphed versus the amplitude (figure 2).

Conclusion

By analyzing the "Voltage vs. Frequency" graph, the relationship between electromagnetic forces and spring forces becomes evident. The combination of both forces causes multiple resonances.

If the magnet solely oscillated through air (without the solenoid), then it would only experience a spring force and a gravitational force. Furthermore, because gravity remains constant, the only varying force is the spring force since, according to Hook's Law, it is displacement

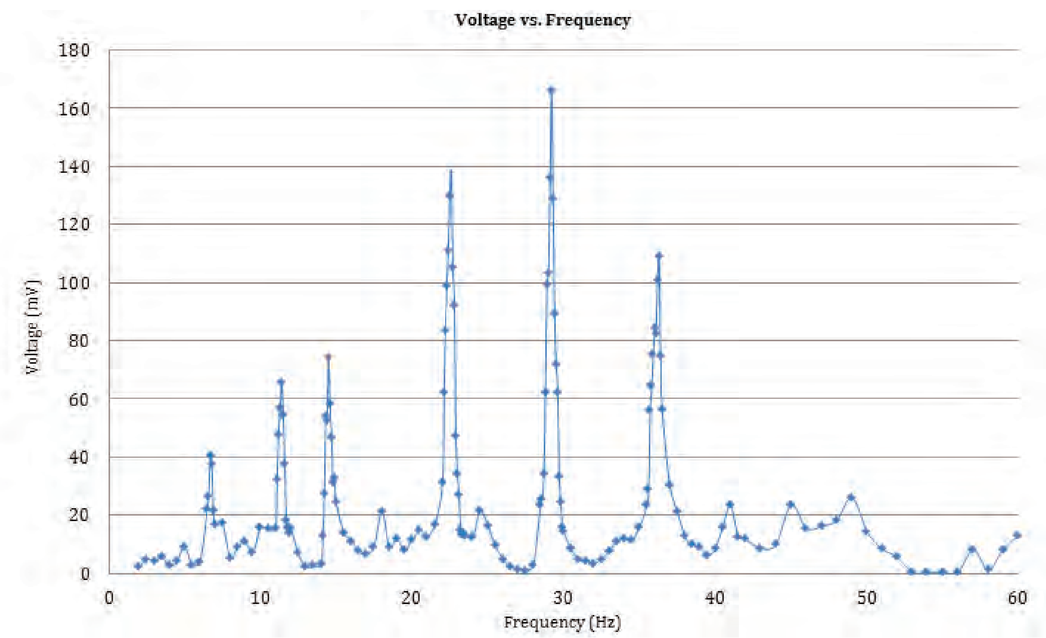


Figure 2: Voltage vs. Frequency graph for a magnet attached to a spring oscillating through a copper solenoid.

dependent. In a graph of amplitude versus frequency of a spring without a solenoid, there is one peak and therefore one resonant point (figure 3).

In contrast, when the magnet attached to a spring oscillates through a coil, it experiences a gravitational force, a spring force, and an electromagnetic force. The electromagnetic force is induced when the magnet runs through the coil and the current reacts upon the magnet. Unlike the displacement dependent spring force, the electromagnetic force is velocity dependent. Thus, the graph is a highly non-linear multiple-resonant graph. Interestingly, the trend of the multi-resonant graph is extremely similar to that of figure 6, but the resonant points create a linear response curve. Additionally, the graph in figure 6 exhibits a periodicity of about 3.5-4 Hz between successive peaks. This underscores the unique relationship between the forces and the inherent symmetry within the multi-peaked graph.

Upon further analysis, the relationship between the two forces can be expressed mathematically. By manipulating the formulas for gravitational force, spring force, and magnetic force, an equation relating the three forces together is generated.

$$F_g = mg \qquad F_s = k\Delta x \qquad F_B = \frac{B^2L^2}{R}v$$

m = mass of the object; g = gravitational force; k = spring constant; Δx = displacement; B = magnetic field strength; L = length of solenoid; R = radius of solenoid; v = velocity of magnet through solenoid

When the magnet moves down through the solenoid, both the spring force and the magnetic force oppose the gravitational force. Contrastingly, when the magnet moves up through the solenoid, the net force is the sum of the three forces.

$F_B+F_s-mg=F_{net}$ (down)
$F_B+F_s+mg=F_{net}$ (up)

The net force can be expressed as $F_{net}=F_0 sin(\omega)t$
Where F_0 is the driving force and $\omega=2\pi f$.

After manipulating the above equations, the relationship between the three forces can be expressed in the following manner:

$$\frac{B^2L^2}{R}\frac{dx}{dt} + k\Delta x \pm mg = F_0 \sin(\omega)\, t$$

Applications

This relationship has an infinite number of practical applications. By simply utilizing the kinetic motion we create on a daily basis, we can easily generate energy.

For example, a device can be inserted into a purse so that it generates energy as a person walks and stores it until a cellphone or other portable electronic device is plugged into it and charged. By constructing a similar apparatus to that of a shaker flashlight and replacing the action of shaking with walking, the magnet moves up and down and generates and electric current.

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http://scitation.aip.org/getpdf/servlet/GetPDFServlet?filetype=pdf&id=PHTEAH000045000008000492000001&idtype=cvips&doi=10.1119/1.2798361&prog=normal&bypassSSO=1

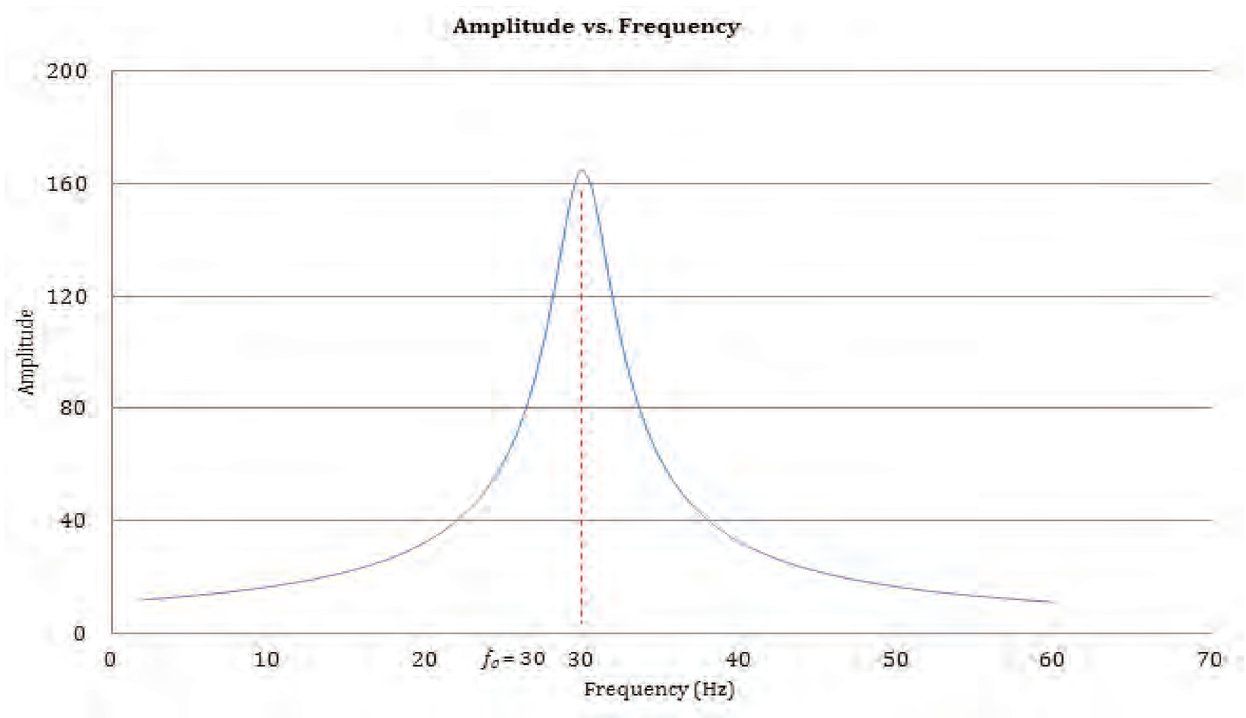


Figure 3: Amplitude vs. Frequency graph for theoretical magnet attached to a spring oscillating through air (no solenoid). There is one peak at $f = f_0$. The equation of the graph is given by $\frac{1}{\sqrt{(f-f_0)^2+d^2}}$.

Effects of Temperature on Pure Metals to Generate Electricity

By Connie Lee

Introduction

The direct conversion of temperature differences to electric energy, *the thermoelectric effect*, is on the edge of studies in the field of ecologically friendly energy sources. Since the early 1800s, many innovative pioneers have studied the specific properties of the thermoelectric effect and thermopower. Two of the most established effects are the Seebeck and Peltier effects.

Thomas Johann Seebeck, in 1821, found that a circuit comprised of two different metals at different temperatures would deflect a magnet; the temperature difference produced an electric current within the closed circuit. This is known as the Seebeck effect and is the basis for the idea of a thermocouple. The voltage produced is proportional to the temperature difference between the two junctions, and is known as the Seebeck coefficient.

Conversely, in 1834, Jean-Charles Peltier discovered that an electrical current created a cooling or heating effect, depending on the direction of current flow, at each respective junction. This is known as the Peltier effect.

My experiments focus on the principles that comprise the Seebeck effect.

Experiment Set One

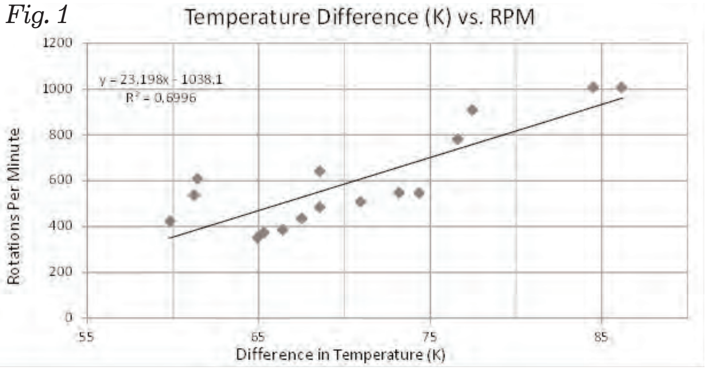
I began by exploring the thermoelectric effect by using a demonstrative device. The device consists of two aluminum ends that sandwich a semiconductor, which is connected to a motor that spins the illusion.

When one aluminum end is placed in hot water and the other end is placed in cold water, the temperature difference allows charge carriers to move across the junction of the semiconductor, creating a current. The current, then, flows to the motor and the thermoelectric effect can be observed when the attached illusion spins.

Using a strobe light set up, I first attempted to observe the temperature limitations of this particular thermoelectric device. I placed one end in boiling water and the other end in ice water, measured the temperature of the water at both ends and shone a strobe light on the set up. When the illusion seemed to appear still, I recorded the rotations per minute (RPM) that the strobe light was flashing at. The temperatures were read by electric thermometers and were, therefore, straightforward and easy to record. However, the RPM was harder to record due to the sensitivity of the strobe light and constant changes in RPM resulting from the slightest temperature changes. These factors affected my collected data, which I used to graph the difference in temperature over the number of rotations per minute (Fig. 1).

Although I did not experimentally reach any limiting temperature differences, I can conclusively say that the illusion spins faster when the temperature difference is greater.

Fig. 1



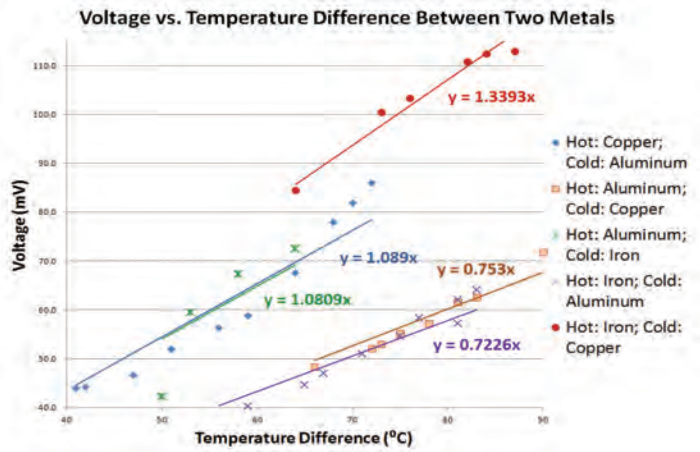
Experiment Set Two

I continued my experimentation with the demonstrative device by using different metals in different combinations. I went to an industrial metal supplier where I bought aluminum, copper, and iron sheets of approximately the same thickness. I then cut, bent, and drilled holes in the sheets so that I could reproduce similar experiments to those of Experiment Set One.

I then conducted experiments with each pair of metals. Instead of measuring the RPM, I constructed the same set up with the exception of the strobe light. Also, I connected a voltmeter to the terminal ends of the semiconductor to measure the output. Experiment Set Two is meant to test the thermal conductance of each metal and find the most efficient pair.

I tested the following sets: Hot: Copper; Cold: Aluminum, Hot: Aluminum; Cold: Copper, Hot: Aluminum; Cold: Iron, Hot: Iron; Cold: Aluminum and Hot: Iron; Cold: Copper.

When all the data collected is graphed together (Fig. 2), it is clear from a comparison of the equations of each trend line that the metal pair with Iron in hot water and Copper in cold water produces the greatest voltage/ degree of temperature difference.



Resources:

http://ocw.mit.edu/courses/mechanical-engineering/2-997-direct-solar-thermal-to-electrical-energy-conversion-technologies-fall-2009/audio-lectures/MIT2_997F09_lec02.pdf

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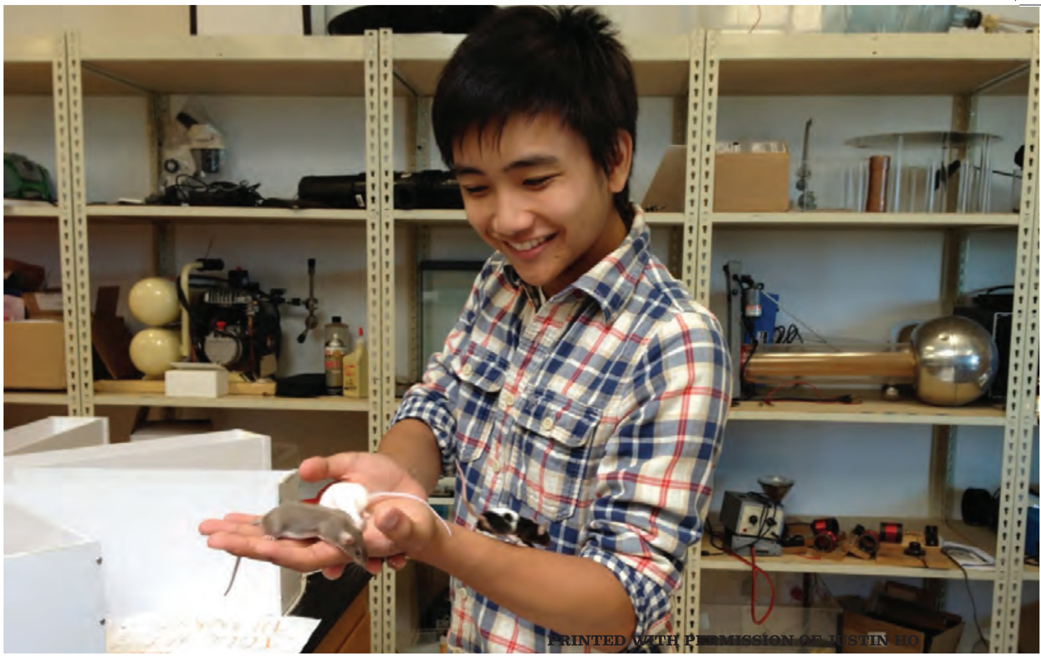
http://www.engineeringtoolbox.com/thermal-conductivity-metals-d_858.html

Can Music Make You Smarter?

By Justin Ho



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1. Introduction:

1.1 Music and Memory

Recently, fMRI studies of musicians show that areas of the brain associated with memory and specifically, spatial reasoning, are enlarged in people who have been exposed to music all their lives, when compared to laypeople. This can perhaps be attributed to music's ability to activate huge portions of the brain, essentially "exercising" it, making it stronger and larger.

1.2 Mice and the Radial Arm Maze (RAM)

In this experiment, I wanted to test whether music could affect mice's spatial reasoning abilities. Mice might give us a hint as to how a study on a larger scale might affect humans.

The radial arm maze was developed in 1976 by Olton and Samuelson to test spatial memory in rats. There is a central platform, and multiple arms are attached to it, much like the spokes of a wheel. Using the RAM, memory is inferred from trial to trial improvement in performance in the RAM.

2. Experiment Procedure

2.1 Treatment Group

2.1.1 Subjects

I started with a group of 3 mice, who have no prior experience with this kind of experiment. They will be housed together, kept in a 12/12hr light/dark cycle, light given from 8:00 am to 8:00 pm.

2.1.2 Treatment

To see if playing music has any effect on spatial ability, I will loop Mozart's Sonata in D Major for Two Pianos K 448, to be played through speakers, for 10 hours a day, starting from 10 am to 8 pm.

2.1.3 Testing protocol

I have set up the maze so that there are various shapes printed on a sheet of paper taped to each end of the arm. I then placed food rewards underneath one of the arms. The task is to see how long it takes before the mice are able to choose the arm that has the food in it. To prevent the mice from merely working in a systematically clockwise or counter clockwise direction, when they first are placed inside the maze, they are restrained for 10 seconds. After each entry into an arm, I restrain the mouse again for 5 seconds. The point of this is to force them to create a spatial map based around the shapes they've seen in each arm, and so they are not just circling until they find the food.

2.2 Control Group

This is the exact same as with the treatment group, the only difference being that there is no music playing at any time.

3. Results

3.1 Treatment Group

3.1.1 Time it took to find the food

From the graph, we can see that over time, all 3 of the mice improved in their times to complete the maze. This is perfectly normal, since you would expect them to learn over time. If you average out the data from all three mice, we find that given this sample size, the average mouse improved at about 3.5 seconds per trial to find the food.

3.1.2 Entries into an Arm

From this, we can see that the number of entries did not go down by much. Your average mouse improved by 0.1 arms per trial. The mice are completing the maze faster, but they are not necessarily becoming more efficient at completing it; they are only running faster into the same number of arms.

3.2 Control group

3.2.1 Time to completion

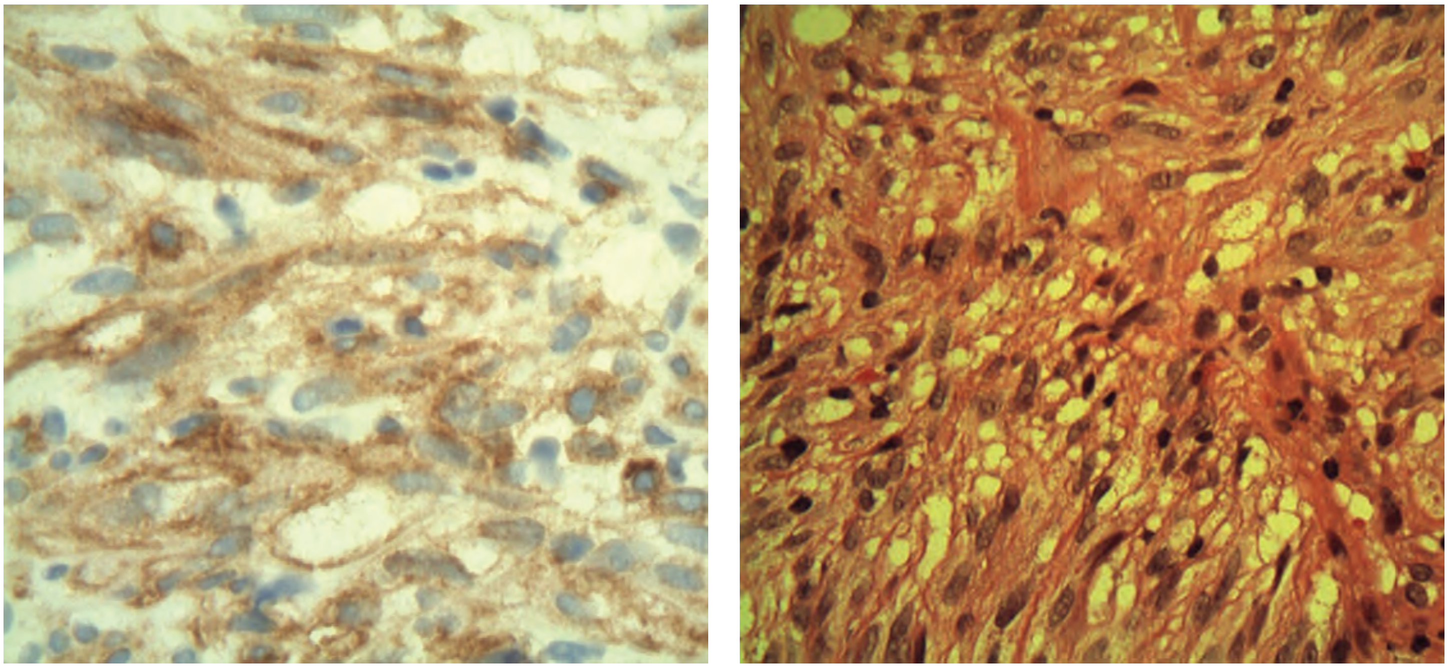
Results varied; Oreo actually had a very level trend line, meaning that she did not improve very much over time. Shaniqua seemed to have massive amounts of improvement over time, greater than any other mouse in the study. Our average control mouse improved by 2.9 seconds per trial. This is lower than the 3.5 seconds per trial from our experimental group, and would suggest that perhaps music does improve a mouse's ability to complete a spatial maze.

3.2.2 Number of Entries to an Arm

Just like with the experimental group, there is not a huge amount of improvement. Our linear trend line shows us that from the beginning to the end, our average mouse did not improve by much; 0.14 arms per trial. Again, this would seem to suggest that the mice are not choosing the arms more efficiently, but perhaps they are running a memorized route faster, using the shapes as checkpoints to guide their path to the food.

4. Conclusion

Initial results would seem to suggest that the mice do improve faster at finding the food when they have been exposed to significant amounts of music. However, the differences in improvement (3.5 vs 2.9 seconds per trial) are very small, so perhaps it can be attributed to sampling error. I only had 7 mice total, which is not very many, and not nearly enough to assume a normal distribution. These results are suggestive, but not nearly conclusive enough for us to determine whether music has any significant effect on spatial reasoning. As a result, if we were to want a more conclusive result, we would need many more mice, and to scale up this experiment, both in size and in time scale.



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GIST stained with hematoxylin and eosin (H&E), left, and GIST stained with CD117 (C-KIT) immunohistochemistry (brown), right.

Gastrointestinal Stromal Tumor, a Four Mutation Tumor

By Jeffrey Bu

Abstract

Cancer is a leading cause of death worldwide, with about 7.6 million cancer deaths in 2008. Cancer is a monoclonal disease and harbors multiple genetic aberrations, such as point mutations, deletions, or chromosomal translocations.

All cancers start from a single cell in a given individual. A single normal cell must accumulate one to several genetic abrasions in multiple discrete stages before developing into cancer, a process called the multistage model for carcinogenesis. This model has been applied to and tested on many cancers with success. Retinoblastoma, a malignant eye tumor mostly seen in young children, is the best example. It contains two such mutations (two hits model).

In this study, we choose the gastrointestinal stromal tumor (GIST) to test this multistage model for carcinogenesis and to find out how many rate-limiting mutations there are for GIST. We utilize the incidence data of GIST from the Surveillance, Epidemiology, and End Results (SEER) registries (1973-2007) to perform our analysis. GISTs are a rare cancer, but they are the most common mesenchymal tumor of the gastrointestinal tract. The majority of GISTs show characteristic mutations in the Kit gene or PDGFRA gene on chromosome 4 and are positive for the C-Kit immunohistochemical stain, which is one of the key diagnostic tools.

By analyzing the SEER incidence data, we obtain a significant linear regression line with an estimated intercept of 3.1, thus indicating three additional hits/mutations besides the C-Kit/PDGFRA mutations for GIST ($F=928.95$, $p=0$). Ninety-nine percent of the variation in the GIST incidence rate can be explained by age (R^2 = 0.99).

In summary, by applying the multistage model of carcinogenesis to the incidence data obtained from the SEER registries, we find statistical evidence of three additional rate-limiting mutations for GIST.

Introduction

Carcinogenesis and the multistage model for carcinogenesis: Each year, there are millions of new cancer cases and deaths worldwide. The more we know about cancer, the better we can fight it. We now know that every cancer starts from a single normal cell. Over time, this single cell accumulates one or more genetic aberrations or mutations in multiple discrete stages before it develops into a deadly cancer—so called the stochastic multistage model for carcinogenesis. In other words, the cancer occurs as a consequence of one to several genetic aberrations or mutations. For a given cancer, the incidence of this cancer, I, can be expressed as

$$I = k(\text{age})^{n-1}$$

where k is a rate constant and n is the number of required mutations or rate-limiting mutations in the multistage model. Finding the exact number of mutations needed for a given cancer is important and will help us in laboratory-based research on this cancer.

Cancer to be studied: Gastrointestinal stromal tumor (GIST).

GISTs are rare, but they are the most common mesenchymal tumors of the gastrointestinal tract (Figure 1a). They account for approximately 1-3% of all gastrointestinal tumors. There is no clear gender preference, but there are slightly more male patients. The most common locations in the body for GISTs are in the stomach. GISTs can also occur in the esophagus, small and large intestines, and rarely the gallbladder. GISTs originate from gastrointestinal pacemaker cells called interstitial cells of Cajal. Cajal cells send signals to the GI tract to help move food and liquid through the system. The majority of GISTs show a characteristic gain-of-function mutation in the C-Kit receptor tyrosine kinase (KIT) gene or a gain-of-function mutation in the PDGFR-alpha gene. This gene contains the code for platelet-derived growth factor receptor (PDGFRA) on chromosome 4 and is positive for C-Kit immunohistochemical stain (Figure 1b), which is one of the key diagnostic tools. GISTs can be either benign or malignant. Surgical resection and targeted therapy by imatinib (Gleevec) are the two main treatments of choice for GIST. Imatinib also is a tyrosine kinase inhibitor developed to treat chronic myeloid leukemia.

Hypothesis: Four mutation model of carcinogenesis to explain the SEER incidence data obtained from the National Cancer Institute for GIST.

Materials and Methods

Data: Obtained a CD-ROM which contains the incidence rates of GIST in Surveillance, Epidemiology, and End Results (SEER) registries, 2000–2007, from the National Cancer Institute.

Methods: Log-log plot of incidence rate of gastrointestinal stromal tumor (GIST) vs. age of onset in years. Linear regression analysis by Excel: to fit a straight line to the log-log plot of incidence rate of GIST vs. age of onset. Both slope and intercept are estimated by the least-squares approach. The correlation coefficient and R^2 are also calculated. The significance of the linear regression line is statistically tested by the analysis of variance (ANOVA Program in Excel).

Results

Age-specific incidence rates of GIST and the number of GIST cases (males and females) in the 17 SEER registries providing data for the years 1973 to 2007 are presented in Table 1. Figure 2 shows a typical power curve of the incidence rate from ages 5 to 84 years. Figure 3 shows the log-log plot and linear regression analysis of incidence rate of GIST, SEER registries, 2000-2007. The linear regression equation is

```
Incidence (GIST) = 3.1368(Age)-5.4896
(2)
```

Analysis of variance (ANOVA) revealed a statistically significant linear regression relationship between the incidence rate and age (F=928.95 and p=0). Ninety-nine percent of the variation in GIST incidence was explained by age (R^2 = 0.99).

Table 1 Age-specific and adjusted incidence rates of gastrointestinal stromal tumor in Surveillance, Epidemiology, and End Results (SEER) registries, 2000–2007

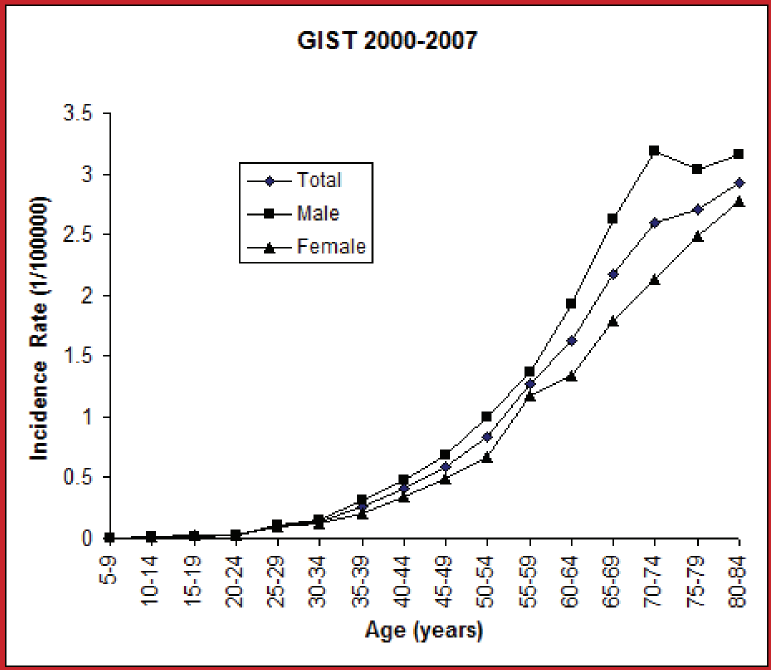


Figure 1 Incidence rate of gastrointestinal stromal tumor (GIST), SEER registries, 2000-2007

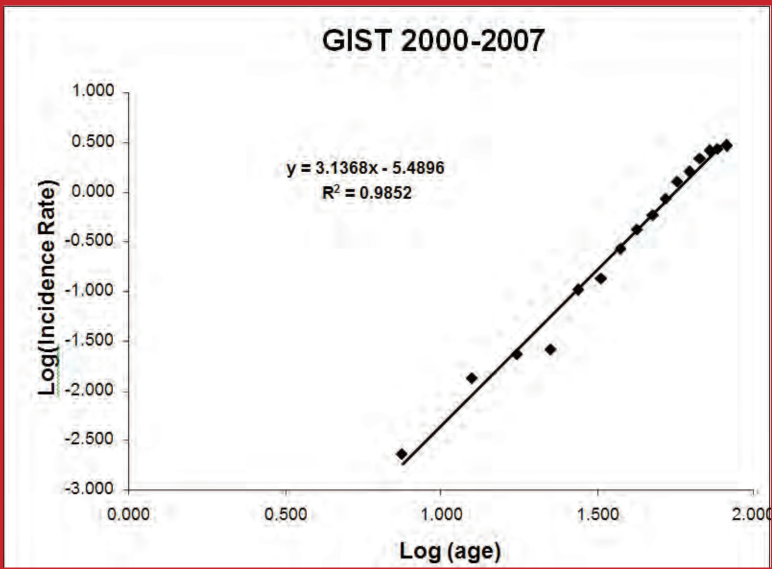


Figure 2 Log-log plot and linear regression analysis of incidence rate of gastrointestinal stromal tumor (GIST), SEER registries, 2000-2007

Figure 2 Incidence rate of gastrointestinal stromal tumor (GIST), SEER registries, 2000-2007

Conclusion

By applying the multistage model of carcinogenesis to the incidence rate data obtained from the Surveillance, Epidemiology, and End Results registries, we find statistical evidence of three additional rate-limiting mutations for gastrointestinal stromal tumor.

Can chemicals cook an egg?

By Leland Frankel

Introduction

There are thousands of creatures that lay eggs, but when a cookbook says "Add Four Eggs," there is no need for clarification. What is being asked for is the egg of the common chicken, the domesticated fowl, *Gallus gallus domesticus*. It is an essential ingredient in almost every form of cooking and baking. The vitality of the egg is rarely questioned, save by vegans. What makes one of the most common foodstuffs in the entire world, one that is present in nearly every American home, so remarkable? What does it do?

The answer ends up being "Quite a lot, actually." It starts with the fact that nearly the entirety of an egg is made of water. This liquid bonds with starches, causing them to swell into a more solid structure, and the steam produced acts as an incredibly powerful leaven. A single portion of liquid will actually burst into 1600 parts steam.[1] The protein in egg is another leaven; it becomes elastic as heat is applied, catching air bubbles and expanding to multiple times its original size. And that's just in pastry! Whether it causing a cake to rise or enmeshing a sauce, binding or smoothing, the egg is one busy little ingredient that is often overlooked.

LELAND FRANKEL

Eggs were "cooked" in sugar syrup, acetic acid and ethyl alcohol

It is the cooking of the egg itself, though, which fascinates me. Whether you're boiling an egg, frying it, baking it, or just leaving it on a hot sidewalk to sizzle in the sun, heat is the key factor in transforming an egg from raw to edible. Heat denatures the proteins of an egg, causing them to unwind and expand, eventually linking up with other proteins in strong covalent bonds that force the water out of the egg (hence getting harder and less liquid). I wondered why heat had to be used to accomplish this: after all, it's a relatively basic chemical reaction. Exploring further, I found several substances that seemed to cause similar effects in an egg as heating it. With this new knowledge in mind, I set out to learn the best method to "cook" an egg without cooking it. Can a chemically "cooked" egg ever match a traditionally cooked one?

LELAND FRANKEL

The equipment used for Frankel's testing of if sugar syrup, acetic acid or ethyl alcohol could "cook" eggs.

Experiment

I intend to take raw egg and immerse it in several different substances, both chemical and natural, to determine which is superior at "cooking" the egg over various periods of time. When I have determined my answer, I intend to explore why it is what it is, and then continue testing from there to try and figure out if an egg can be cooked without heat with the same efficiency as heat.

The substances I am going to use are:

1. 20 milliliters (ml) of Sugar Syrup
2. 20 ml of Acetic Acid distilled from White Vinegar
3. 20 ml of 70% Proof Alcohol

There will also be a test egg to show the standard, non-experimental condition of the subject. All tests will be repeated as necessary until the best "stimulant" of the egg is discovered. Ultimately, I will test and compare this method of cooking with actually applying heat to an egg.

Testing and Results

The first round of experimentation was, to say the least, a failure. While I was waiting for my results overnight, the refrigerator that I was using suffered a break down and my samples were moved to another, ruining the experiment.

Several days later, I tried again. This time I allowed the samples to sit for 48 hours in a 5.6 degree Celsius refrigerator. My results were interesting. As predicted, the test egg was almost completely unchanged. The alcohol had produced almost instant change on contact with the egg, forming thin filaments in the egg white and hardening the yolk to the point of near-solidity. The sugar syrup condensed the egg white into a firmer, translucent jelly that sat below the remainder of liquid. The acetic acid produced similar results to the syrup, but more extreme and visible without a dye test.

For my next test, I combined 10 milliliters of each solution together and immersed the raw egg in this combined fluid. Letting this sit for 48 hours, I found that they collectively did not produce as distinct a result as each did on their own, as opposed to reacting more powerfully. Adding a little more alcohol, I observed that it produced almost instant coagulation. Some more research showed that alcohol is responsible for breaking the weaker hydrogen bonds in egg protein, while acid has to break the more powerful ionic bonds.[2] The issue, therefore, most likely lay in the fact that my acetic acid was too weak. I replaced it a more powerful, concentrated glacial acetic acid. This proved to produce more results than the alcohol, practically cooking the egg through. Now I wanted to see what would happen if I combined the two to try and break both kinds of bonds and compare the results to an actual cooked egg.

Conclusion

Even though the combined alcohol and acid cooked the egg more efficiently than any combination before, it still paled in comparison with the actual cooked (alright, burned) egg. The chemicals that I used were highly toxic to drink and not so good to touch either, yet they could not thoroughly cook an egg. As none of my natural, non-dangerous substances cooked the egg with any real efficiency, this leads me to believe that there is no chemical way to properly cook an egg that is not highly poisonous.

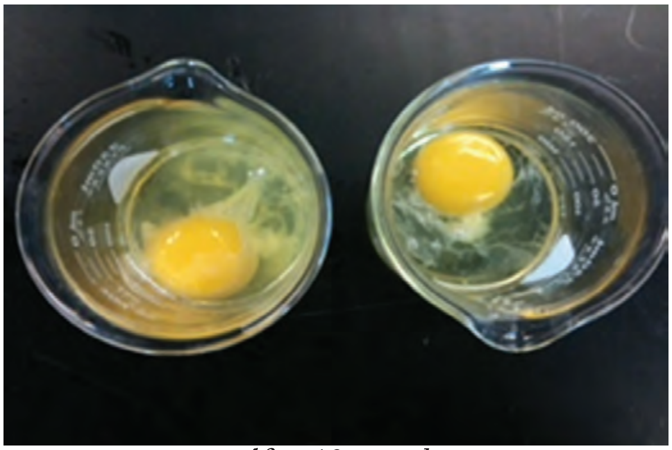
Although theoretically it should be possible, none of my tests produced results that cooked an egg thoroughly, quickly, or left them in an edible state. My chemicals could not break the molecular bonds within the egg's yolk and white with the same power that a flame can, at least not without tainting the results with dangerous toxins.

Endnotes

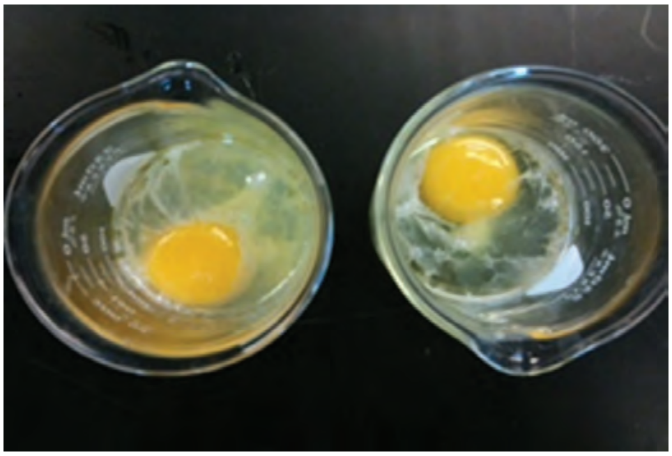
1 Gardiner, Anne, and Sue Wilson. "Science of Cooking: Ask the Inquisitive Cooks!" Exploratorium: the Museum of Science, Art and Human Perception. Web. 25 Oct. 2011. <http://www.exploratorium.edu/cooking/icooks/article_5-03.html>.

2 "TLC Cooking "Why Do Eggs Turn Hard When You Boil Them?"" TLC Cooking "Food and Recipes" Web. 25 Oct. 2011. <http://recipes.howstuffworks.com/menus/question616.htm>.

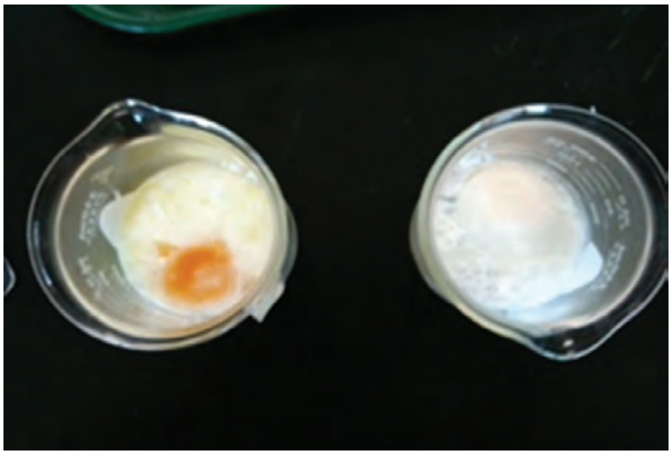
Effects of glacial acetic acid, left, and ethanol, right, on "cooking" an egg



After 10 seconds



After 30 minutes



After 24 hours

GRAPHIC BY ELI HAIMS
PHOTOS BY LELAND FRANKEL

Remote Controlled Car

by Brian Gross

Introduction:

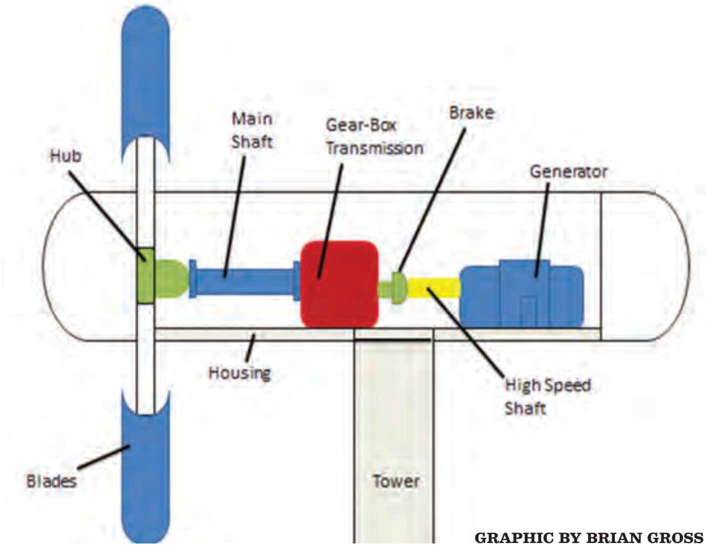
The vertical wind turbine was created in the 7th century in Afghanistan. A wind turbine works by a rotating propeller spinning the turbine. The circular motion of the turbine then induces a current and thus produces electricity. In today's society, efficiency is one of the most important aspects of innovation. The internal combustion engine of automobiles is only 9% efficient. My idea is to use a wind turbine to improve the energy efficiency of an automobile. In my experiment I am specifically using the harvested electricity to charge a battery as the remote controlled car moves forward.

Experiment:

My experiment will involve testing the efficiency of the car by velocity and maximum distance. By April, I hope to have a car and propeller that will be 10% more efficient than the base line model. Again, this will be measured in the overall distance covered by the car. Once I have achieved a sufficient maximum range, I will try to recreate the project on a larger scale, such as an electric go-kart.

To help the propeller create less drag I will test angles, the size, and the shape of the propeller. One of my designs includes a vertical propeller that is in a modified wind foil to decrease the surface area. With the decrease in surface area, the drag coefficient will also be reduced.

BRIAN GROSS



GRAPHIC BY BRIAN GROSS

Once I find the optimal setup of the wind turbine, I will design the circuit for the remote controlled car so that the battery can charge and discharge simultaneously. This will be a circuit that will remotely switch between the two batteries. One battery would charge, while the other discharges. My other circuit design would charge and discharge one battery simultaneously. The up side to using the circuit with two batteries is that it is easier to measure exactly how much electricity the wind turbine is producing. However using two batteries adds extra weight to the car, which would reduce my maximum distance.

Inefficiencies:

As mentioned previously, the propeller and battery adds weight to the car. The propeller also adds drag and I will have to account for this inefficiency. The electrical energy the battery gains from the wind turbine will have to be greater than the distance lost by the drag and weight for this experiment to be proven successful. Once I have tested a control for the car, with no turbine, I can use the velocity and distance to calculate the gains and losses from the car with the added turbine. Once this has been calculated, I will try to maximize the efficiency of the rig. I will use weight reduction, test different propeller angles, and try different aerodynamics to maximize efficiency.

The turbine had two rotating main shafts to power the generator. The two shafts were geared together, so the large shaft rotated slower than the small shaft. I only needed the fast moving small shaft for the test I am conducting, for the propeller does not fit on the large shaft. I took the whole turbine apart, and rebuilt the gearing of the turbine so there was no large shaft. As a result, the small shaft spun faster, and more smoothly.

Results:

The graph below illustrates the data for my control test of my car. The car drove for six complete 400m laps, with an average lap time of 94 seconds. The time per lap increased as the batteries drained.

In the test with the propeller, the car only ran for four 400m laps. However, the car had an average lap of 89 seconds. The propeller may add stability to the car while it drives, which may prevent it from crashing.

I also tested the Voltage the turbine produced versus the wind speed. The turbine was tested with the gear connecting to the large input shaft and without.

No Gear

Wind Speed (MPH)	*Volts*
4.5	*0*
6.2	*0.05*
14.2	*0.09*
22	*0.45*
25	*0.41*

Gear

Wind Speed (MPH)	*Volts*
5	*0*
5.9	*0.07*
14.4	*0.1*
19	*0.36*
21	*0.36*

The turbine without the gear produced a maximum of .45 volts instead of a maximum of .36 volts, and the propeller started moving at 4.5MPH instead of 5.0MPH. The turbine without the gear was most efficient at 22MPH, while the turbine with the gear was most efficient at 19MPH. The turbine without the gear is more efficient, for it produced more volts, and started producing electricity at a lower speed.

Problems:

The first propeller was shattered during a test. I carved the shattered propeller into a smaller one, so I could continue testing while I waited for the replacement propeller to arrive.

During one of my control tests, I crashed the car, and broke the axle on it. Luckily I was able to mend the broken axle without replacing the axle or the car.

I also broke my original turbine, which basically meant I had to start over from point A. The new turbine had a different wattage rating than the old one, which changes my results of the test. The new turbine also spins at a different revolution than the old one, for the new turbine has more friction as it spins. (All data in this experiment is from data with the new turbine).

The biggest problem in this experiment is that the turbine does not produce enough voltage for the battery to charge. The battery requires 7.2volts to charge. I have tried numerous alternatives to make the turbine more efficient, including regearing the turbine, and changing the propeller size, but nothing seems to make it efficient enough to charge the battery.

Solutions:

To make sure I wired the turbine correctly I connected it to an LED light. As expected, the light lit up.

To reduce the weight I will change from a metal mount for the turbine to a lighter plastic or wood mounting system.

To reduce the air resistance I will put the propeller on a lower mount, so the bottom of the propeller moves just above the ground.

Lastly, I will try to change the gearing ratio within the turbine so the propeller can spin with higher revolutions per minute.

BRIAN GROSS

Conclusion:

My experiment involves attaching a wind turbine to a battery operated remote controlled car to test its efficiency. I am measuring the efficiency both by the maximum distance and the velocity of the automobile. I will achieve this by reducing the drag, the weight, and maximizing aerodynamics. In the long term I plan to create a circuit to charge and discharge the battery or batteries simultaneously. I will modify my propeller to be vertical, and minimize drag. I will try to change the gearing ratios of the propeller, reduce the weight, and increase aerodynamic wind flow. I will then put my design on a large scale go-kart or car. My goal is to make the car travel 10% farther than stock, and I will modify my project until I can come close to that goal. Even though my experiment was unsuccessful, I was able to increase the efficiency of the turbine, and correctly wire it to a light bulb. This experiment should be done on a larger scale so one can truly see the electrical power a larger wind turbine could produce, and compare this to the weight and drag created by the propeller and the turbine.

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An Understanding of Genetic Diseases

By Bradley Wachtell

Genetics has always been of great interest to scientists. The way traits are passed on from parents to offspring fascinated all those who studied the subject. Until relatively recently neither the true process of DNA replication nor the genome was fully understood. Genetics has made great strides in the last century. It was only in 1953 that James D. Watson and Francis Crick discovered the structure of DNA. Before these two not much was known about DNA at all: how it replicated, how it passed on from generation to generation, or what could go wrong within the molecule itself. Since then genetics has expanded to become one of the fastest growing fields in science. More is discovered in genetics every day than in any other field. Today a person can pay to have their entire genome sequenced.

Genetic diseases were always known about, but became more fully understood with the discovery of DNA. As technology and analyzing techniques improved with regards to DNA so did the knowledge of genetic disease. Today a new genetic disorder is discovered every month. The research currently being done in this field is amazing.

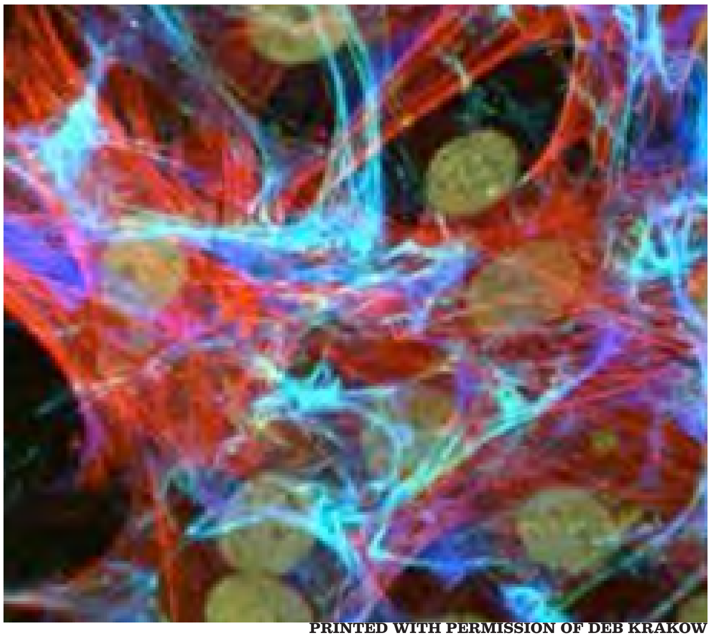
For my project I will work in Deborah Krakow's genetics lab in the orthopedics department at UCLA. I will focus on understanding the clinical and molecular basis of genetic diseases. Her work mainly focuses on dwarfism. I will assist her and her associates, Sulin Wu PhD, Stuart Tompson, PhD, Anna Sarukhanov, Margarita Ivanova, and Ashley Kim research and discover new mutations that cause genetic diseases.

Methods

Some of the main methods I will use will include polymerase chain reaction (PCR), cell cultures, and western blots. These all provide valuable information about the DNA itself or a protein for which the DNA codes.

PCR is a technique used to isolate and mass replicate portions of a person's genome. To do this you introduce a portion of the patient DNA with many other proteins and enzymes that are then all put into a PCR machine. This annealing machine changes temperatures in order to separate the double helix of the DNA and allow for the other added enzymes to make complimentary strands. This process of heating and cooling is repeated many times in order to mass replicate the DNA. Once the portion of interest on the DNA is copied multiple times, the sequence can be further studied.

Cell culture is the process of growing either mice or patient cells under controlled conditions in order to observe how the cells function. Once the cells are grown they can be observed in many ways ranging from immunofluorescence to creating vaccines. These cells are normally used to see how proteins are used within the cell. Once the function of the protein is discovered we can begin to have a better understanding of what a mutated form of the protein will cause.



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Immunofluorescence is one of the more interesting applications of cell culture. The cultured cells are introduced to an antibody that attaches itself to a specific site on a specific protein. Then a secondary antibody is introduced into the cell and this antibody attaches to the primary antibody. The secondary antibody has a florescent tip on it. Once both antibodies have had the chance to attach to the protein or to the other antibody, respectively, the cells are put under a florescent microscope. Under this special microscope the path of a single protein throughout the cell can be visualized as it glows a certain color. The ability to trace a protein through the cell allows for us to see where the protein is going and what other proteins or systems it is interacting with. Information like this is invaluable to determine what the implications of a mutation on a protein are.

Western blotting identifies, using specific antibodies, proteins that have been separated from one another according to their size by gel electrophoresis. The proteins are run through a gel, driven by an electrical current, in order to separate them. Then the protein is transferred onto a filter paper and probed with antibodies in order to be able to locate the proteins of interest. These proteins can then be isolated and further studied.

My Project

First I will find the mutation in the gene that codes for Fibrillin 1 in 20 patients with acromicric dysplasia. Then I will determine if all the patients have the mutation in Fibrillin 1 or if there are other mutations responsible for their disorder. Once I have found patients with the mutation of interest I will use their DNA and amplify the exons of Fibrillin 1 using PCR and then perform sequence analysis of these exons using the process described above. Furthermore I will use cells from the patients with both acromicric and geleophysic dysplasias. I will culture cells using the cell culture method highlighted above. Then I will look at how the cells respond to stimulation with growth factors to see if they respond the same way because clinically they look extremely similar.

The Disease I Will be Studying

The diseases I will be studying will be a group called acrofacial dysplasias. Specifically I will be dealing with geleophysic dysplasias and acromicric dysplasia.

Geleophysic dysplasia was initially documented in 1971.

This is a well know form of dwarfism, noted at birth by small hands and feet of the baby. It is a progressive growth-failure form of dwarfism. It is characterized by bone disorders predominantly affecting stature, facial features, hands and feet.

Acromicric dysplasia is a recently found disorder caused by mutations in the Fibrillin 1 gene. My main task this year will be to determine why these two disorders, geleophysic dysplasia and acromicric dysplasia, are clinically so similar and to see if both diseases respond to the same treatments the same way.

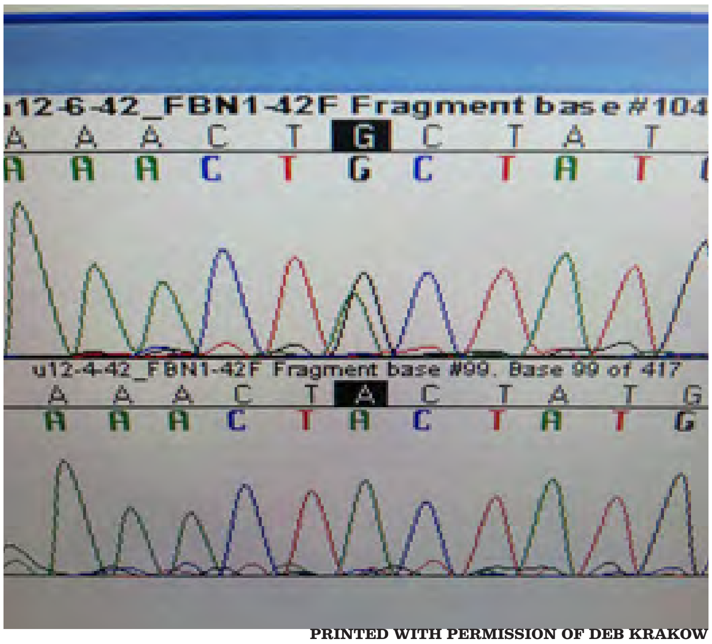
My Progress in the Lab

So far during my time in the lab I have sequenced a new set of patients genomes using PCR techniques and sent them to an external company for sequencing. The lab receives back a report that can then be read to find mutations in the genome. Once we receive the report back I scan through the image in order to check for mutations. A sample on one of these reports can be found on the next page. The highlighted nucleotide and corresponding peak in the picture show a mutated nucleotide. The double peak in the chromatogram shows this. The surrounding nucleotides are non-mutated nucleotides and the single dominant peak in the chromatogram demonstrates this. This along with a comparison to control DNA, of a known non-mutant genome, allows the lab to tell what the mutation is and where it is in the genome.

Once the mutation was discovered I began to culture mutated patient's cells in incubators. During this process the cells actually continue to grow and replicate in the medium they are placed. Once the cells are significantly cultured I extracted patient cells and introduced them to a series of drugs or growth factors and observed how the mutation effects the cells and their growth.

Conclusion

During my time at the lab I expect to gain a full understanding of inheritance of mendelian disorders, a clinical understanding of a disorder or group of disorders, the exon-intron gene structure, fundamentals of PCR and protein analysis, basic concepts of cell biology including protein localization and function, and the ability to present and articulate my research. I will also learn much more about the similarities and or differences between these two forms of dwarfism.



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The applications of my project have the potential to be very interesting. This project will further the research in acromicric dysplasia and help doctors understand how the mutation leads to the phenotypic symptoms. This will allow for a deeper understanding of what is happening on the cellular level for patients with acromicric dysplasia and could lead to treatments that will help them manage their disease.

Behavioral neurobiology *of zebrafish*

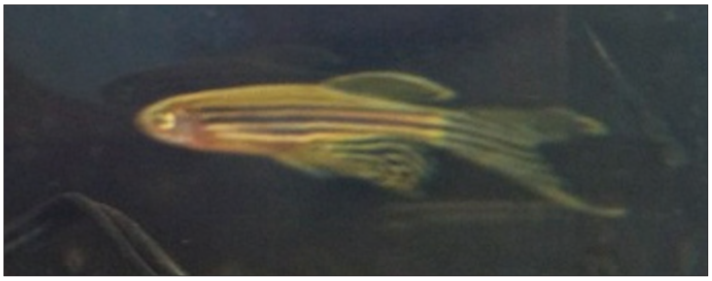
By Taylor Yang

In recent years, the Zebrafish species has been gaining momentum and is on its way to becoming a new model organism, particularly in the field of neuroscience.

Introduction:

In the past, studies have used traditional model organisms, such as mice and dogs, to test everything from addiction to memory capacity. However, in recent years, the Zebrafish species has been gaining momentum and is on its way to becoming a new model organism, particularly in the field of neuroscience. This is due to several reasons – they are small, inexpensive, easily managed, and their clear spinal cord allows for the uncomplicated observance of embryonic development. Previous studies with different stimulus have been completed, allowing for a certain environment to be shaped very easily.

When Studies in Scientific Research began, I planned to try and observe the development of the spinal cord of a model organism. I thought about using chicks, mice, or drosophila, but they were all too complicated for me to be able to manage during a school day and through the weekends. In addition, after the cost of all the materials needed for their upkeep, such as food, shelter, and decorations, was added up, I realized that the experiment



TAYLOR YANG

Fig. 1: Typical Danio Rerio, commonly known as Zebrafish

would be too expensive. Thus, I knew that I would need to alter my original experiment, as well as to finding a new model organism to observe. After discovering several articles and research papers that discussed Zebrafish, I decided that these organisms' best suited my needs and that my experiment would be both beneficial and relevant if I were to contribute to the current line of Zebrafish model organism research.

After realizing these two things, I determined what my objective would be for this class. By teaching two separate groups of fish to associate a straight apparatus with feeding, via Pavlovian Conditioning, I measured their times of reaction over the course of several weeks. The timing of their reactions helped me to construct a graph based on their reaction times versus number of weeks of training. This graph, in turn, assisted me in determining whether or not the learning capacity of Zebrafish is distinctive or stagnant.

Learning Capacity

It has been previously established that fish do have the ability to learn – in Japan even fish have been taught to do tricks. However it is difficult to measure the extent of said learning ability. I approached this issue by recording the time it takes the fish to begin consuming the food. My theory was that if, over time, the fish become faster and faster, then that result would suggest that they do indeed need time to recognize and learn from a stimulus. On the other hand, if the fish initially became faster and faster but eventually responded to the food at a constant rate, that result would be indicative of a limited learning capacity.

Studies have not yet shown the time frame in which fish learn to adjust to a stimulus such as this, and so I was not sure how much time would pass before a clear pattern could be seen in their reactions. However, though my results did become more constant, a clear point of recognition by the fish was not defined.

Apparatus

The Zebrafish are the main focus of the experiment, but in order to maintain a comfortable environment for them, several pieces of equipment are needed. Firstly, I needed a tank to house the fish. Attached to the tank is a filter that keeps the water clean and the number of nutrients stable, a water heater which maintains a steady temperature for the Zebrafish (a tropical species), and a light bulb which provides both constant light and a little bit of heat for the fish.

TAYLOR YANG

Fig. 2: Classic tropical fish tank

Experimental Plan

There were two tanks of five Zebrafish each. Each tank was exactly identical, except for the color of gravel used. The reason for the different gravel is to prevent the two groups from getting mixed up if, for some reason, the tanks are jostled.

One tank's fish was fed and taught to associate feeding with an apparatus for a period of several weeks. After that time period, I began training the second group and timed both groups. This allowed me to see if the original reaction times were different and how long it took for the second group to catch up with the first.

Actual Experiment

On a daily basis, I had a stable routine that I conducted in order to eliminate as many confounding variables as possible. Every feeding, I stood in front of the fish tank and waited several minutes until the fish calmed down. When you first approach the tank, the fish become aware of a human presence and become excited, swimming rapid in circles in their tank. I know that they have relaxed once their swimming patterns return to normal. After they calmed down, I randomly chose an area to stick the straight apparatus (I used a thermometer, as it allows me to take the temperature and has a colored tip) in. After placing it in the water, I quickly added food to that same area and time the reactions of the fish. After timing, I was sure to record the data for the formation of a graph that will later allow me to better show a reaction trend.

Current Results of Experiment

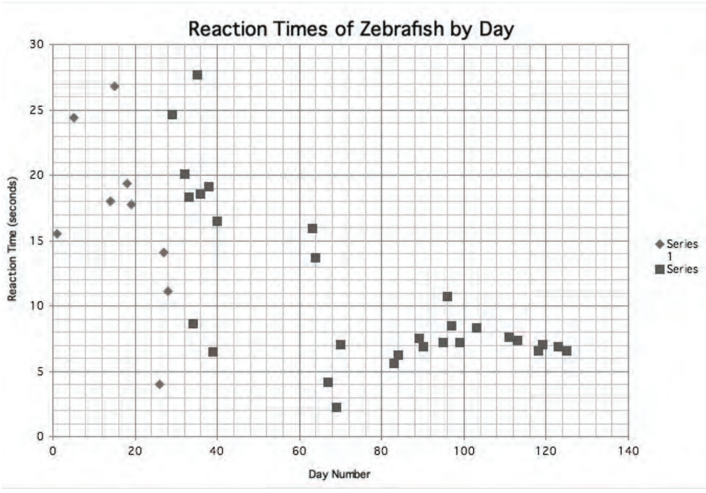
After consistently training group 1 for a period of almost four weeks, I began to train group 2. Though there are many sources of possible lab error (discussed later), overall the results were indicative of increasingly fast reactions. This suggests that zebrafish may indeed have the capacity to learn, for they have, presumably, begun to associate food with the thermometer. Group 2 also seemed to be following that same trend. Though group 1 has unfortunately passed away, I continued the steady experimentation with group 2.

Lab Error

As I have conducted the experiment, many unforeseen events have taken place that in some way may affected my data, and thus should be taken note of. The many pieces of equipment used to maintain the fish tanks are all very sensitive and are disturbed easily. For instance, group 1 was killed by hot water caused by the jostling of the heater. The loss of fish prevented me from taking further data from group 1 and my results are not taken from as long a period as ideal. Lastly, the placement of the thermometer in the water may impact the time in which the fish react and as of now, there was no easy way to determine that.

Conclusion

I found that, over time, the reaction times of both the



groups of Zebrafish leveled out at around 6-7 seconds. Though it would have been more accurate to continue experimentation for a couple more weeks, I am fairly confident that Zebrafish can indeed learn to associate feeding with an apparatus. In addition, I also conducted a control experiment in which I timed their reaction to food without the thermometer. This reaction time was significantly faster at around 2-3 seconds, implying that the reaction rate of the Zebrafish to the thermometer has the potential to be even faster.

The premise of this experiment was fairly simple, but current and future results may greatly impact the way Zebrafish are considered as model organisms in the world of behavioral neuroscience. In addition, I hope that the superficially misleading simplicity of the experiment allows others to easily understand the concepts at hand and gain an interest in this field of science.

References

For an excellent summary of previous experiments, please reference *http://www.ncbi.nlm.nih.gov/books/NBK5216/*.

Automated Quadrotor

By Joel Argueta and Matt Heartney

When we look at the sky, we see helicopters, airplanes, and other man-made objects that can fly, but most of us do not look at how complicated it is to build these aircraft in order to keep them in the air. These aircraft need to be stable and be able to maneuver themselves around, along with other things. To achieve this there are a lot of factors that need to be considered: weight, aerodynamics, size, etc.

We, Matt Heartney and Joel Argueta, are planning to build a small quadrotor, a helicopter with four rotors. The benefit of having four rotors is that it gives the aircraft more stability, making it easier for us to meet our objective of building an aircraft that can fly. Furthermore, rather than having to majorly tilt the aircraft in order for it to turn, move forward/ backwards, etc, decreasing/ increasing the speed of individual rotors will do that for us.

General Plan

To build this quadrotor we are first going to program a microcontroller, the brain of the quadrotor, to control the motors that will power the rotors. After the programming is complete, we are going to figure out a design that will make stable flight possible. We are going to consider the weight of the quadrotor and the speed at which the rotors rotate.

Specifics

A microcontroller is capable of rerouting and changing the electrical flow through a circuit. By hooking up a gyroscope to the quadrotor, we should be able to get data about how it is oriented. Said data will be passed along to the microcontroller, which will interpret and modify the currents accordingly. For example, if the quadrotor is tilting too far forward due to a gust of air, the current to the front motors will be given more power and the back motors will be given less. This will cause the quadrotor to correct its tilt.

The quadrotor will have a central hub section which holds the microcontroller and gyroscope. From the hub will be four symmetrical motor hubs. Surrounding each rotor will be a duct to concentrate the lift force from the rotor down instead of out to the sides. This will maximize lift and reduce idle sway. This will finish the standard quadrotor design.

Progress

We have the microcontroller we plan to control the quadrotor with. We will use the Arduino 2560 Mega V3. We will program it using the standard Arduino IDE (Interactive Developer Environment). The IDE uses a C-based programming language which we have some experience with. Soon, we will hook up the motors we salvaged from the original quadrotor and attempt to control them with the Arduino Mega 2560.

We have also reinforced the original frame of the quadrotor. The original frame was breaking in three separate locations and easily bent when pushed on. We reinforced the ducts for the rotors and are replacing the rotors to decrease the space inbetween the ducts and the rotor, which will improve the lift. Also, the frame will now be more resistant to compressing when it strikes the ground, which will make it more difficult to damage it again.

We have the motors we plan to use. They were salvaged from the old quadrotor and are simple DC motors designed to be light and easy to work with. The new rotors we have ordered will more closely fit in the ducts, improving lift and stability without majorly increasing weight. The program can currently control the motors, but speed control is somewhat gimmicky. This should be resolved once a secondary power circuit is created solely to power the motors, instead of powering the microcontroller and the motors from that single source. Transistors will transform small bursts of current from the microcontroller into a speed control for the motors.

The Lissajous Curve and Its Acoustic Relationship

By Alex Goodwin

In 1815, Nathaniel Bodwitch discovered a system of parametric equations to explain complex harmonic motion as such:

$$x(t) = A\sin(at + \delta),\ y(t) = B\sin(bt)$$

The system allows for two inputs on an x-y plane such that δ is an angle in radians between the two inputs given by $\delta = \pi(N-1)/(2N)$ (where N is a natural number and *a/b* is rational. This combination yields a graph that changes with respect to time, and produces the figures that make up what is known as the Lissajous Curve.

The curve itself is named after Jules Antoine Lissajous who explored and expanded on Bodwitch's work in 1857 to develop a further understanding of harmonic motion. The graphical representation of these parametric equations is very sensitive to the ratio of *a/b*.

In acoustics, this ratio is very helpful in studying the relationship between frequencies. The visual representation of two frequency inputs playing simultaneously can be seen on an oscilloscope (as seen in Figure 1, and as *a/b* ranges from 0 to 1, the Lissajous figures produce complex curves and simple curves. It has been found that when the ratio of the two frequencies is a fraction involving any of the numbers of the set {16, 12, 9, 8, 6, 4}, the result is said to be simple and is synonymous with a discernable pattern to the eye and a pleasing sound to the ear. Naturally it follows that any ratio aside from those just mentioned would yield a complex curve, synonymous with a chaotic pattern to the eye and a discordant sound to the ear (Fig. 3).

Method:

The purpose of this experiment is to explore *why* these ratios are pleasing to us. What makes them appealing to the ear? How does our brain distinguish between a "nice" sound and an "ugly" sound?

In order to discover this, I have created a two-part experiment. The first part is a behavioral experiment and the second part is a scientific experiment. The first part of the experiment is underway and the most immediate action that will be taken as soon as the frequencies have been identified in their entirety will be the subjective survey (the second half of the behavioral part). In the meanwhile; I am identifying the frequency combinations that I will use for the scientific experiment. The simple patterns are going to be derived from various combinations of the set that I spoke of before, {16, 12, 9, 8, 6, 4}, and the complex patterns are going to be derived by combining one number from that set with one in the set of numbers between 1 and 16 that are not a part of the former set.

The first half of the behavioral experiment went as follows: I drew two abstract pictures (Figures 1 and 2) on the board for the class, one having jagged, sharp edges, and the other having circular, smooth curves. I then told the class that one of these objects is named Malouma and the other is named Tequité, completely arbitrarily. I had everyone in the class write down on a piece of paper which one they thought was which and the results were quite interesting: 13 out of 14 identified the curvy object as Malouma and the other as Tequité. This result is an answer to a broader question that includes the question of the brain's interpretation of sound. There are certain connections that the brain makes through the senses that are truly inherent in our biology and leave us asking why certain stimulations provoke varied responses in humans. The experiment I ran with Malouma and Tequité is compelling evidence that there is a true physical reason for these connections common to all humans. Now that this has been established, I am ready to apply this method specifically to the brain's interpretation of sound, and then hopefully yield concrete proof with the use of fMRI.

I found a book entitled *This is Your Brain on Music* that touches on several of the topics that are vital to my experiment. I am now reading it to learn more about the general topic and formulate new ideas as to how I can receive the best results from the project. Although this project is mainly addressing good sounds and bad sounds by using frequency combinations, there are several other test fields that can be useful in answering this same question: rhythmic patterns; harmonies and melodies; minor sounds vs. major sounds; chromatic increments vs. whole tone increments; diminished and augmented chords... these are just some examples of other elements of music that trigger various reactions in the human brain. This project has plenty of aspects to tackle already, but that said, these other questions about music and its interpretation by the human brain are things that I hope to address in the future, and I am expecting that my findings in this experiment will lead to many other discoveries on the topic.

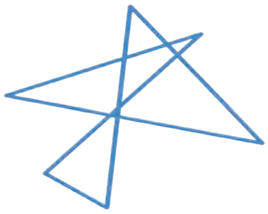
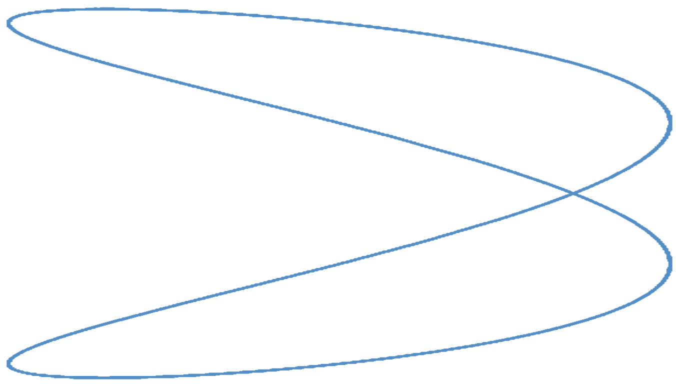


Fig. 1

Fig. 2



$x = A_x\sin(\omega_x t + \delta_x)$ $y = \sin(t)$ $0 \le t \le 2\pi$	Lissajous curve	
ω_x horizontal angular frequency	horizontal angular frequency	2
δ_x horizontal angular phase	horizontal angular phase	$\frac{\pi}{4}$
A_x horizontal amplitude	horizontal amplitude	1

GRAPHICS BY ALEX GOODWIN

Fig. 1: Go-Kart

Variables of Speed:

Studying the variables that effect the acceleration of a Go-Kart

By Ben Greif and George Natsis

Since Henry Ford created the Model T in 1908, the basics of automobile design have been improved upon, but still remain largely unchanged. The Go-Kart we are using for our experiment is the most basic and pure form of the car. In its essence, it is similar to Ford's Model T. We wish to discover what design improvements make the greatest difference on the acceleration and fuel efficiency of a car at its purest form.

Concept

We adopted the idea of testing the effects on acceleration and fuel efficiency of various alterations to the basic design of our Go-Kart. The variables we planned on testing are as follows: varying gear ratios, varying tire styles and inflation levels, and varying fuel types.

Apparatus

We used a "Stingray" Go-Kart (Fig. 1), Duramax 16 HP Engine (Fig. 2), varying gears and clutches (Fig. 3), and generic tools.

Experiment

We hoped to test acceleration in two ways. First, we planned on timing how long it took the Go-Kart to reach 60 mph for all alterations. Second, we wanted to measure the time for the Go-Kart to travel a quarter of a mile and the speed achieved at the end. To test the differences in fuel efficiency, we planned on adding a specific amount of fuel to the gas tank and running the Go-Kart at a set speed for two miles. We would then measure the amount of fuel consumed.

Fig. 2: Duramax 16 HP Engine

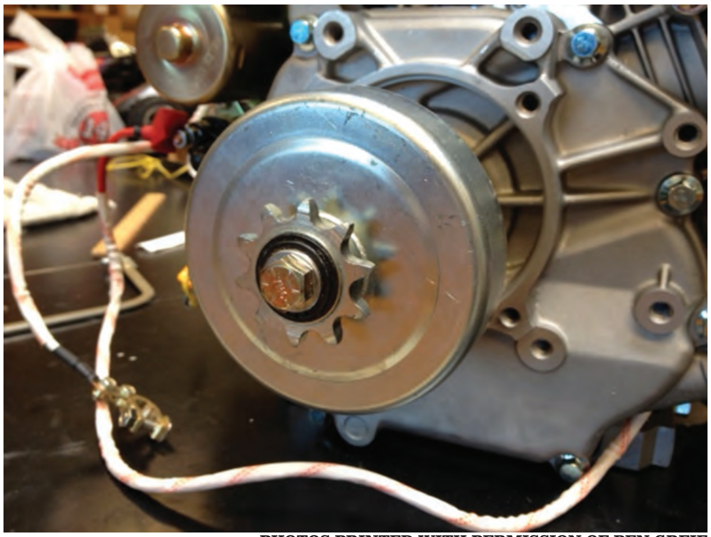


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Fig. 3: Clutch mounted to Engine Crankshaft

Traction is one factor of acceleration. We decided to try to test different tread patterns and tire compositions. The tires currently on the go kart are a hard compound rubber with relatively low surface area contacting the ground. If a tire has greater surface area contacting the road, it will have greater rolling friction, or grip, to propel the car to greater speeds. In order to achieve this increase in grip, we decided to buy softer compound tires with a higher surface area. Based on torque figures, the most efficient gear ratio can be determined for any system. By calculating the appropriate ratio we could determine the difference between various improper ratios and the proper ratio. A more efficient ratio means optimal power at the wheels. We were also looking to determine the best ratio of gasoline and ethanol for an efficient and powerful car.

Fig. 5: Welded engine mount plate

Fig. 6 Wired Electric Starter

Current Condition

In March, after finishing the Go-Kart and deciding to test it, we had an accidental collision of the Go-Kart which has severely set back our testing. On the first attempt to test out the Go-Kart, the Go-Kart only had enough battery charge to fill the combustion chambers of the engine with fuel but not enough to actually turn the engine over and start it. This caused the engine to begin an alarming noise and begin whirring.

After having the driver get out of the Go-Kart and disconnecting the battery, we decided to turn the engine over manually to clear the fuel out. This ended up starting the engine. However, this should not have been a problem except that our clutch failed. This meant that even while at idle the engine was still able to spin the wheels. With the engine spinning the wheels, the Go-Kart drove, without a driver, into a plastic fence and bent the left wheel spindle and two tie rod bearings. Since the Go-Kart is no longer made by the manufacturer we were unable to find replacement parts. This forced us to prematurely end our project late in the year. With our remaining two months we will be looking to find other ways to continue testing. Before the unfortunate collision, we welded plates to create a new engine mount (Fig. 5), mounted the engine, secured the battery, extended the wiring for the electric starter at the front (Fig. 6), hooked up the accelerator with the gas pedal and completed the chain drive system.

Preliminary Data

With some preliminary information we calculated that our Go-Kart has a power to weight ratio of 100.88 bhp/tonne. For comparison, a 2010 Volkswagen Jetta 1.4 TSI has a power to weight ratio of 110.18 bhp/tonne. With this value, the specs of our Go-Kart, and the assistance of an online simulator, we were able to simulate the Go-Kart's capabilities.

The maximum acceleration and speed graph shows that the Go-Kart could be capable of reaching speeds up to 80 mph, although this would be very unsafe in this Go-Kart.

The simulated quarter mile time is very respectable for a Go-Kart, considering that a 2011 Prius Hybrid has a quarter mile time of 17.4 seconds and crosses the line going 79.3 mph

If the simulations are true representations of the Go-Kart's performance, then the Go-Kart would beat the 2011 Prius by 0.3 seconds.

Conclusion

Although we cannot reach any conclusions at this point due to the aforementioned setbacks, we hope to have answered several of our questions about the effects of certain variables on speed by the end of the year once we have found a way to continue testing.

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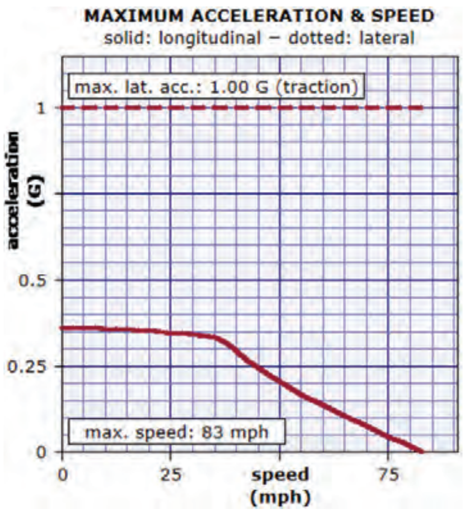
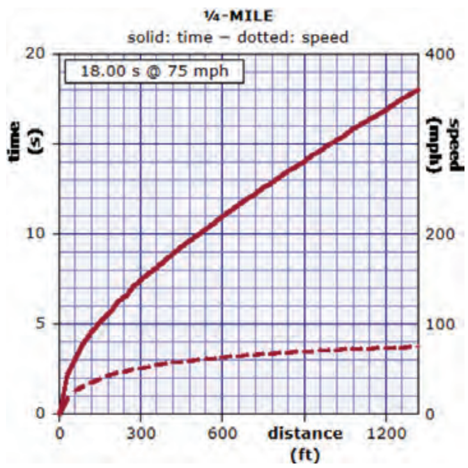
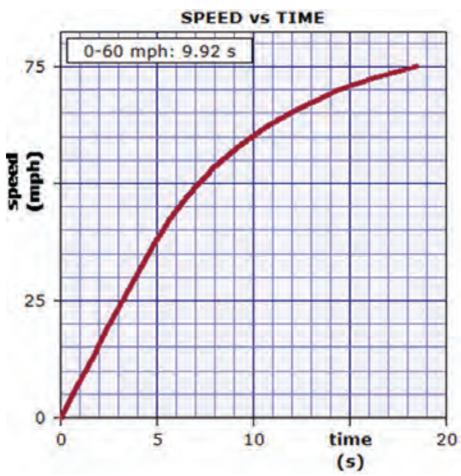






GRAPHICS BY BEN GRIEF AND GEORGE NATSIS

Wings in Ground Effect

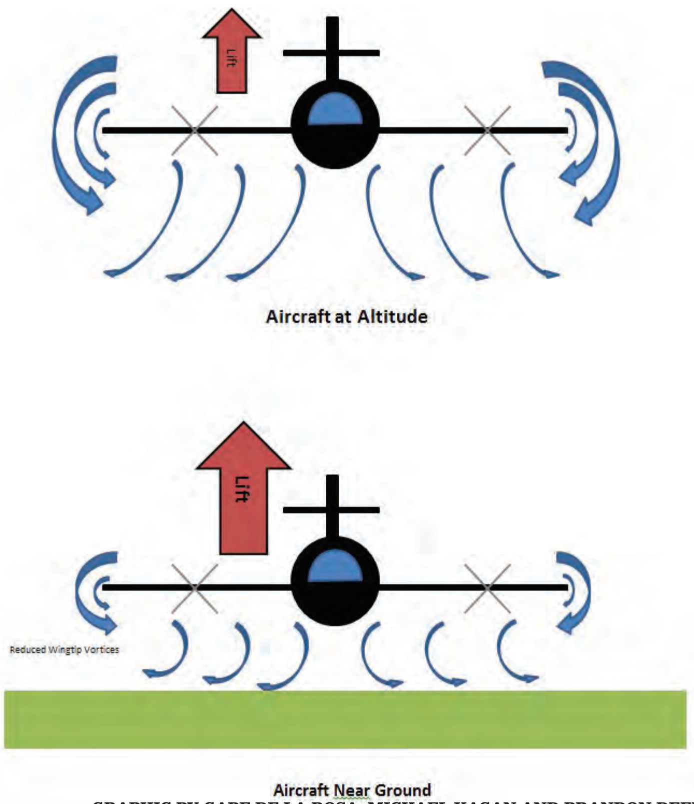
By Gabriel De La Rosa, Michael Kagan, and Brandon Deere

Lift is a fundamental concept in the everyday world. As air flows over a surface, like an airplane wing, it creates a pressure difference that causes a force on one side of the surface. The interaction between the said airplane wing and the air around it is fairly understood. But what happens when another surface, like the ground, is added?

While testing his vehicles, Dr. Alexander Lippisch, a German scientist who moved to America after World War II, found that they did not go over obstacles well. While this proved problematic for a land based craft, he moved his design to water. Lippisch found that when the plane was less than one wingspan above the water surface it could maintain a steady path. In America, Lippisch began designing Ground Effect Vehicles and harnessing the power of this effect.

With the added lift, the wing could use a lower angle of attack to generate the same amount of lift, and the aircraft needs less power to stay above the ground. In fact, one ground effect vehicle only needed 13 horsepower.

Lippisch found that the added lift comes from increased pressure under the wing. This is caused when the vortices created by the wing tips contact the ground and break up, extra air is shoved under the wing. As he further experimented with different wing designs, he found that he could generate even more lift by adding opposite dihedral to the wings and making the sides of the wing flush with the ground. The ideal wing also has even more curvature than a normal airplane wing, and it forms a pocket where air is trapped.



GRAPHIC BY GABE DE LA ROSA, MICHAEL KAGAN AND BRANDON DEERE

A diagram of the Ground Effect

With this new configuration, air gets trapped under the wing and increases the pressure, generating lift. This bubble of air eventually causes enough pressure that the trailing edge of the wing lifts off the ground to let air out. If the craft is moving, air is constantly flowing in and out from under the wing, and this allows the craft to hover along the ground.

Our Design

We built a scale balsa wood model of wings in ground effect vehicle. We tried to keep our design as close to Lippisch's as possible, but because we lacked desgin plans, we couldn't be 100% accurate. We used balsa wood because it is lightweight and easy to assemble, yet still fairly durable in a small scale. It has been a staple for any model airplane enthusiast, and its proven reliability in flight was exactly what we were looking for.

We found that our craft has a tendency to porpoise when thrown. The nose rises too high, and the ground effect is broken. To solve this problem, we added a tail with a flat wing to the back of our model. The wing has the same teardrop shape of a normal airplane wing, and generates its own lift. This added lift lifts the tail above the ground and allows the nose to drop slightly, keeping the plane from flipping backwards. This tail is present on many of Lippisch's designs, and can contain a rudder to steer the craft. In the pictures above, we took part of our design (the tail) and placed it in a model of a wind tunnel. Then we blew smoke into the machine to see how aerodynamic the balsa wood was. The smoke flowed easily over the balsa wood to create minimal friction and moderate lift. Strings are attached to show how the tail would respond with the weight added by the model itself. Without strings the tail would blow up into the roof of the wind tunnel.

Potential Outcome

Observing the way these vehicles travel using the air under the plane is in laymen's terms, a hovercraft.

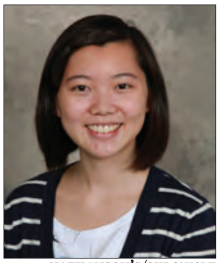
With the continual increase in gas prices, researchers are desperately looking for different ways of transportation. There are already hover crafts that can float over water, so there is a continual search to see whether they can hover over the ground. There is no question that this is an affective way to travel locally with out a significant cost attached to it. It is obvious that this prototypical vehicle is probably not going come to the markets soon. But this it's possibly the next generation's way of transportation with no need of foreign oil.

Conclusion

This model can be altered in many ways. The size, angles, and weight can be changed (within certain limits) to the point where the more models that are created, the better understanding researchers will have. It will take a while to execute the first using vehicle that runs on pushing air into the ground to generate lift. However, when it happens it will be one of the most revolutionary inventions of the generation.

Summer Research

Many students take advantage of research opportunties at local instituations over the summer. While some students continue to pursue interests they have studied in school, such as biology or mathematics, others venture into new fields, like plasma physics or dentistry.



NATHANSON'S/CHRONICLE

WuXI Apptec

Wendy Chen '13

The project was based off reports that green tea medicines caused liver damage. I studied the four main catechins in green tea by conducting in vitro tests.

NATHANSON'S/CHRONICLE

Clinical Neuroscience Lab at UCLA with Dr. Tyrone Cannon

Blake Nostratian '13

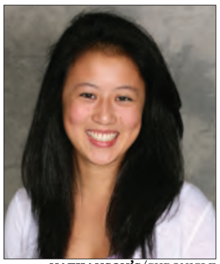
I assisted in research aims to discover causes of schizophrenia and bipolar disorder and to develop effective treatment and prevention strategies based on an understanding of the genetic and neural mechanisms that give rise to these disorders.

NATHANSON'S/CHRONICLE

UCLA Department of Psychiatry with Dr. Marcy Forgey

Divya Siddarth '14

I observed sessions at the Child and Adolescent Mood Disorders Clinic in UCLA, and accompanied her in visiting patients at the Ronald Reagan Hospital.



NATHANSON'S/CHRONICLE

City of Hope Cancer Research Institute - Eugene and Ruth Roberts Summer Student Academy with Dr. R.J. Lin

Meagan Wang '12

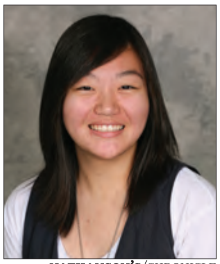
I worked in the molecular biology department on a project that was developing a reporter system to measure micro RNA levels in cancer cells.

NATHANSON'S/CHRONICLE

Hidden Markov Model with Dr. Li of Avid Academy for Gifted Youth

Larry Zhang '14

My project concentrated on using dinucleotide frequencies to calculate the locations of introns and exons. I compared dinucleotide frequencies between introns and exons, and used these frequencies to create a Java model. I used this model to try and figure out the locations of introns and exons on an unknown piece of DNA.

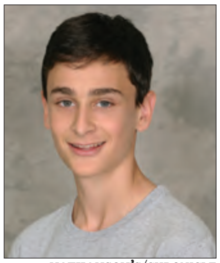


NATHANSON'S/CHRONICLE

Julie Ko '12

UCLA Undergraduate Research Consortium in Functional Genomics

Dr. John Olson

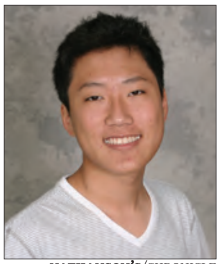


NATHANSON'S/CHRONICLE

Michael Rothberg '13

UCLA Department of Hematology/Oncology

Dr. John Timmerman



NATHANSON'S/CHRONICLE

Daniel Bai '12

UCLA Basic Plasma Science Facility

Dr. Gekelman

NATHANSON'S/CHRONICLE

Adit Gadh '12

UCLA Dentistry Deparment

Dr. Cun-Yu Wang

The Triumph of Playfulness in Creativity

By Dr. Antonio Nassar

NATHANSON'S/CHRONICLE
Antonio Nassar

One of the most amazing things that mankind has ever invented, was discovered by Dr. Andre Geim and his co-workers after hours. This resulted in the 2010 Nobel Prize in Physics.

At a Physics Conference at UCSB I attended this year, Dr. Geim said that he and his students discovered graphene during their so-called Friday-night experiments when they worked on projects outside the mainstream, experimenting with the "impossible" and having fun.

More than 70 years ago, two of the greatest names in Physics, Sir Rudolph Peierls and Nobel Prize Winner Lev Landau, argued that two-dimensional crystals (such as graphene) were thermodynamically unstable and could not exist. Nevertheless, not only graphene is possible but it is the strongest, yet thinnest possible material you can imagine. It's so strong that it would take something the size of an elephant, balanced on a pencil, to break through a sheet of graphene the thickness of a piece of paper. Graphene is so thin at molecular level that a stack of 7 million sheets would be only a millimeter thick.

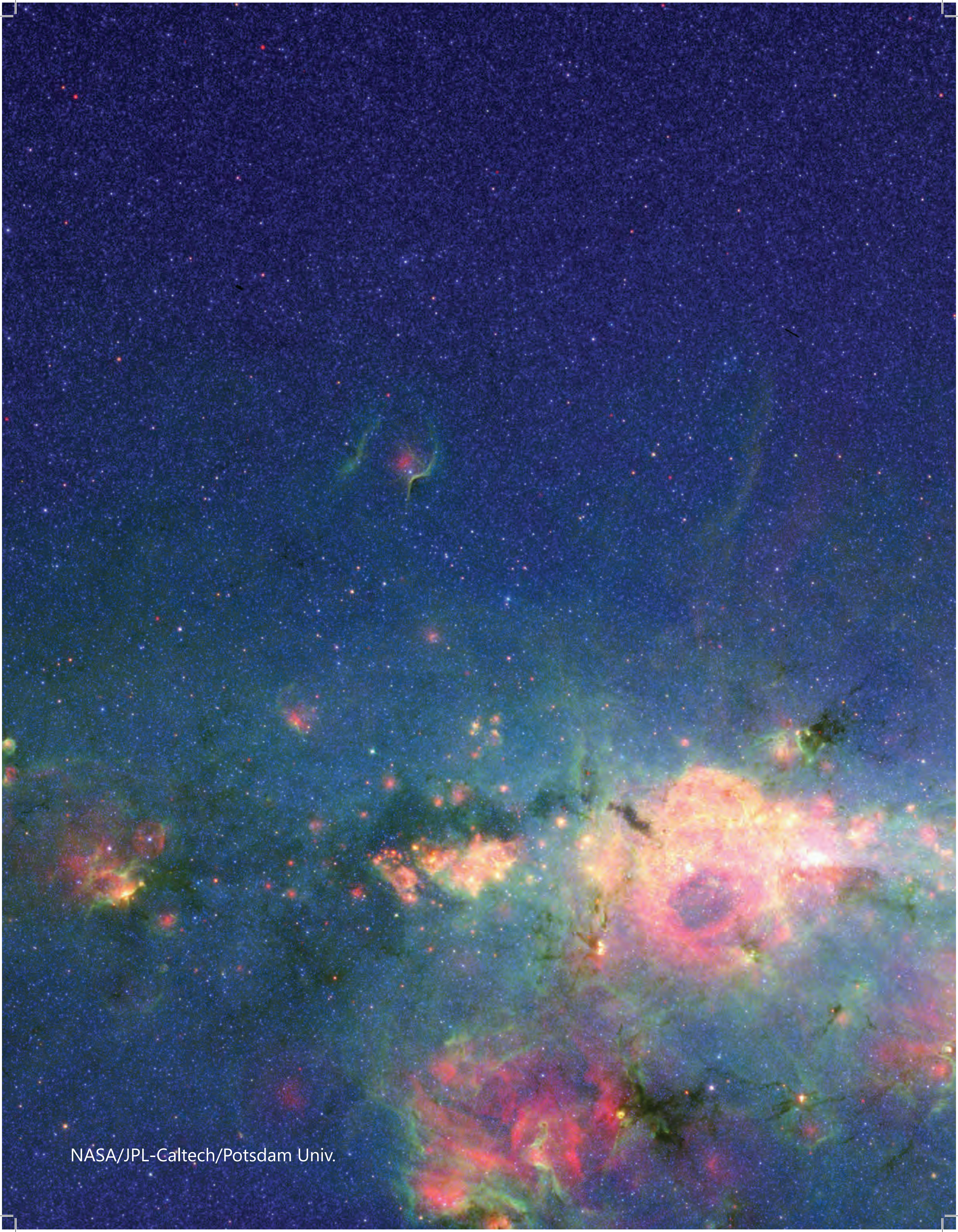
"One can confidently say that (just like the transistor last century) that graphene is the most remarkable invention in this century. We will see the difference between life before and after graphene.

One can confidently say that (just like the transistor last century) that graphene is the most remarkable invention in this century. We will see the difference between life before and after graphene.

Here is another example of how playfulness can be regarded as one type of creativity. One day in a cafeteria at Cornell University, the great Richard Feynman saw a student set a plate with a Cornell emblem on it spinning and then throwing it up in the air. The plate started wobbling in a way that caught Feynman's interest, and he succeeded in explaining the motion by the classical mechanical equations. This made him feel so elated that he went on to his quantum mechanical problem of spinning electrons and, lo and behold, solved the problem that he had been working on for a long time. This led him to the research that eventually resulted in his Nobel Prize.

Likewise, Andre Geim has always had the element of playfulness in his research. He became the first win a Nobel Prize and an Ig Nobel Prize. The Ig Nobel Prize is awarded by the Annals of Improbable Research (AIR) - This is a bi-monthly magazine devoted to scientific humor, in the form of a satirical take on the standard academic journal. AIR, has published six times a year since 1995, usually showcases at least one piece of scientific research being done on a strange or unexpected topic, but most of their articles concern real or fictional absurd experiments, such as a comparison of apples and oranges using infrared spectroscopy.

A colleague of Andre Geim said that his award shows that people can still win a Nobel by "mucking about in a lab with pencil and sticky tape and experimenting with the impossible."


NASA/JPL-Caltech/Potsdam Univ.