WRITING the RESEARCH REPORT

This Manual was updated December 2021 for a Virtual Fair. If you find errors in this manual, please email webmaster@wwsef.ca.

Keep a detailed record or log of what you do throughout the work of your project in a **notebook** or **logbook** to bring to the fair as the judges will want to see it. Judges like to see a real notebook, where there may be scratched out bits, jotted notes, etc. Do not rewrite the records on a computer because when you print them they will look "perfect" and not like the actual notes you made as you did the project. If you choose to do some of this recording on a computer, do not edit or format the document so it is different than what you recorded over time; print it out "as is" to make it look as much as possible like a notebook or logbook.

The **research report** is separate from your ongoing notebook or logbook and demonstrates your ability to write a <u>summary</u> of your project using a standard scientific style of reporting. It requires that you select only what is important and state that in a succinct way. Use as much of the 600 word limit as you can. It is a <u>report</u> about what you did, <u>not a detailed record</u> of what you did. It will be marked separately and will count for 5% of your overall score.

The research report is entered as part of the WWSEF Application/Registration in the Project Information section in the field labeled "Project summary". It must be between 100 and 600 words and may be written in a word processing application, such as MS Word, and copied into the "Project summary" field. You may return to your report and make additions or changes anytime up to the close of registration.

Research Report Requirements:

Use these guidelines for writing your report.

1. The style is clear and concise with correct spelling and grammar.
2. The report should be written in sections with appropriate headings. The sections can vary to suit the nature of the project. This chart indicates the acceptable formats:

EXPERIMENT	INNOVATION	STUDY
Background and Purpose (and/or Hypothesis)	Introduction and Background	Background and Problem
Procedure	Purpose	Purpose or Thesis
Results and Conclusions	Design Criteria	Evidence of Supporting Data
	Procedure or Methodology	Conclusion
	Results	
	Conclusions and Recommendations	
Acknowledgements	Acknowledgements	Acknowledgements

3. No raw data or detailed observations are included in the report or in any appendices to the report. These are the main material of the project notebook or logbook.

4. The maximum length of the report is 600 words with most reports usually being between 400 and 600 words. A counter below the "Report summary" field shows the number of words in the report as it is entered. If the number of words exceeds 600 it will not be possible to save and complete the Project Information section.

Explanatory Notes:

1. The *Background and Purpose, Introduction and Background* and *Background and Problem* sections are intended to describe information that explains why the project was done. It is not to be a theoretical discussion.

2. The *Purpose* and *Purpose or Thesis* sections are to describe the more specific objectives of the project.

3. The *Design Criteria* describes in some detail how one would know if the innovation is successful.

4. The *Procedure* and *Procedure or Methodology* must be a very brief outline of the materials and methods used in the experiment or development work on the innovation, not a detailed accounting.

5. The *Evidence of Supporting Data* summarizes sources and information brought together to support the *Purpose or Thesis*.

6. The *Results and Conclusions* and *Results* sections summarize what you found and show how that relates to the purpose. A brief discussion of the limitations, or suggestions for further research, may be included for experiments.

7. The *Conclusions and Recommendations* and *Conclusion* sections briefly answer the problem posed in the *Purpose* and *Purpose or Thesis* sections*.

8. In the *Acknowledgments* paragraph, recognition should be given to all who provided <u>significant</u> assistance to the researcher in development of the project, in the form of guidance, materials, or facilities. The judges may use this information when formulating questions for the interview with you and when deliberating on the quality of your work. This section of the report will not be marked.

Displaying Your Research Report:

The online report will be judged by a professional marker and will not be seen by the judges who assess your project. You should have another copy of your report visible at your display during judging. It should follow the same requirements as above however you may add a cover page.

Display of the report during other times is at your discretion.

The marked copy of your report will be returned before the conclusion of the Fair.

How the Research Reports are graded:

The written reports are assigned 5, 4, 3, or 2 marks. They are evaluated on overall approach, organization, content, writing skills (grammar, spelling and punctuation) and style (clarity, precision and economy). A mark of zero will be assigned if no report is submitted with the application.

We have included some report samples in this manual to give you a start.

Note: The Project Title, your Name and School are entered automatically into the report.

Experiments

Hurry Up, I Need Some Water!
<name> <school>

Background, Purpose, Hypothesis:

Chlorine is one of the best ways to ensure safe drinking water. Chlorine was discovered in 1774 and became the seventeenth element on the periodic table of elements. It was discovered when Carl Scheele mixed pyrolusite, which is a mineral containing manganese dioxide, with muriatic acid. In time, it became widely known for its ability to purify water. When the chlorine first hits the water, it turns into hypochlorous acid and hypochlorite acid, both of which kill disease-causing bacteria and viruses. The acids react with the biomolecules, destroying the cell walls and effectively killing the bacteria in the water. After one puts excessive amounts of chlorine in the water, it is important to let the chlorine dissipate. Dissipation is the process in which the chlorine levels drop, because the excess chlorine has done its job and purified the water. The chlorine leaves the water and is released as a gas. The purpose of this experiment is to discover what increases the rate of dissipation. Variations in water temperature, light levels, and air movement will be tested throughout the experiment. These will be tested by putting four individual water bottles in the refrigerator, on top of a heater, in a cupboard and on a window sill. Two additional water bottles will be tested at room temperature in a typical room, but one will have a lid on it and the other will be kept open. My hypothesis is that all three factors -warmer water, higher light levels and increased air movement--will all increase the rate of chlorine dissipation.

Procedure:

In this experiment, I filled 6 water bottles with 1 liter of water. To each water bottle, I added 30 drops of chlorine and tested the initial chlorine levels. Every 5 minutes for the first hour, I tested the chlorine levels. During the next 30 minutes, I tested the water every 10 minutes. For the remaining 7.5 hours, I tested the water every 30 minutes. For each chlorine test, a sample from the bottle was removed and placed in the test tube. Four drops of OTO were added to the water, turning the water a shade of yellow. The shade of yellow was compared the standardized scale provided with the test kit.

Results and Conclusions:

This experiment proved that hot water significantly speeds up the dissipation rate. As well, I discovered that, when it comes to light levels, no significant change in the dissipation rate was detected. This is likely because the winter sunlight did not heat the water sufficiently; however, it is possible that on a sunny day in July the dissipation rate would increase because of the heat generated by the sun. In addition, I found that the amount of air movement in my test did not affect the dissipation rate. My initial hypothesis was correct in that I predicted that increased water temperature would lead to faster dissipation rates. However, I had predicted that increased light levels and air movement would have a similar effect. My experiment did not, however, show this to be the case.

Acknowledgements:

I would like to thank my parents for bringing me to the store to purchase items that were necessary for the experiment, as well as answering any questions that I had. I would also like to thank my teacher for his support.

Testing for Antibiotic Resistance
<name> <school>

Background and Purpose

The development of antibiotic resistance among pathogenic bacteria is a growing concern in medicine and food production. As antibiotics are used more frequently, bacterial colonies with antibiotic resistance become more prominent. As a result, it is becoming increasingly important to determine how frequently the use of an antibiotic will result in the growth of resistant mutants. As such, this experiment was created with the goal of determining how often certain antibiotics will produce bacterial colonies with resistance to that same antibiotic. The four antibiotics used were: Kanamycin, tetracycline, chloramphenicol, and ampicillin. All four are frequently used in medicine and other industries, and data from the experiment will help to determine which are the most likely to generate resistant bacteria when used in uncontrolled environments, like the human body. This knowledge can be used to limit the propagation of antibiotic-resistant bacterial colonies in the wild.

Procedure

First, four plates of Escherichia coli bacteria were exposed to a low concentration of one antibiotic using paper disks. This was accomplished by growing a lawn of E. coli on each plate, then soaking a disk of filter paper in a diluted antibiotic and placing it on the plate. The plates were then left in an incubator at 37 degrees Celsius for 8 hours to allow growth to occur. Then, colonies were harvested from inside zones of inhibition created by the antibiotic disks. These colonies were then incubated for 8 hours under the same conditions described above. Finally, the harvested colonies were placed in a test tube containing a higher concentration of the antibiotic than they were originally exposed to. Simultaneously, a control group of regular E. coli were exposed to each of the four high concentration antibiotics in the same way. The density of bacteria in each test tube was measured using a spectrometer after 24 hours.

Results and Conclusions

The results of the experiment have not yet been finalized, but the goal is to determine which antibiotics are most likely to produce resistant bacterial colonies. This data will be applicable in medicine, where it is preferable to use antibiotics, which produce fewer resistant colonies so that the antibiotic will remain effective over time. For example, if the resistant bacteria which grow in the inhibition range of tetracycline are shown to be highly resistant to high concentrations of the antibiotic, it would suggest that future use of tetracycline in uncontrolled environments could risk releasing resistant bacteria into the wild.

Acknowledgements

I would like to acknowledge <name> for granting me access to the University of Waterloo Applied Mathematics Biology Lab and its equipment so I could complete the experiment. Thanks also to <teacher> for answering questions and addressing concerns I had while planning the project.

Watch The Algal Bloom!

<name> <school>

Background, Purpose and Hypothesis:

Freshwater algal blooms occur when an increased quantity of algae colonizes a body of water. Last summer I observed green scummy water in a pond near my backyard, and after some research identified this as a bloom. The bloom is caused by excess nutrient runoff such as phosphorus, nitrogen and potassium compounds derived from fertilizers applied on lawns, fields, and gardens. This nutrient pollution causes algae to grow excessively. The purpose of this experiment is to determine if higher concentrations of fertilizer will increase algae growth. The hypothesis is that higher concentrations of nitrogen, phosphorus and potassium compounds will result in increased algae production.

Procedure:

Pond water was collected and categorized into 6 cups by concentration of fertilizer, one of which having no fertilizer. This was achieved by performing a dilution series by dividing each concentration of fertilizer in half. 0.06X, the lowest concentration of fertilizer, had a concentration of fertilizer 32 times smaller than the highest concentration of fertilizer: 1X. The pond water was then tested using a test kit to measure the pH, nitrite, ammonia, and phosphate levels to determine if the pond was suitable for algae growth. The algae was observed each day for fourteen days by recording the appearance of the algae and the pond water, as well as the temperature of the room and the amount of sunlight received each day. The area of the algae was then measured and recorded. This procedure was undergone 3 times.

Results, Conclusions and Applications:

The results of this experiment were that the highest concentration of fertilizer, 1X fertilizer solution, caused the most algae growth. However, the cup without fertilizer had a higher percentage than the three fewest concentrations of fertilizer; as a result, further testing would need to be done such as prolonging the trial lengths and increasing the temperature of the area where the algae grew to produce more reliable results. The results of this experiment could be used by farmers to inform them to not over fertilize their fields which could eventually wash off into bodies of water. Using natural fertilizers would be more effective since they are slow release and they don't filter away from the plants like chemical fertilizers, which would reduce the chance of an algal bloom. People who live near ponds, such as me and my neighbours, would also be informed to use the same advice on their lawns and gardens. Further testing would include determining the correlation between the temperature and algae growth using a scale to ascertain if this is also a cause that augments algae growth.

Acknowledgments:

I would like to thank my parents for funding this project and <teacher> for helping me decide how I would conduct this experiment.

Up, Up and Away
<name> <school>

Background, Purpose and Hypothesis:

Lift is one of the four forces, in addition to weight, thrust and drag, that affect the flight of an airplane. When an airplane takes off, lift is generated by thrust and the movement of air above and below the wings. Weight, on the other hand, opposes the lift and, together with gravity, draws the airplane back toward the earth. For an airplane to fly, there must be enough lift to overcome the weight. The reason I chose this experiment is because I love physics and am fascinated by how airplanes work. The purpose of this experiment is to find out which wing height (9.5mm, 12.7mm, 19.1mm, 25.4mm) can generate the most lift, if all other variables are kept constant. My initial hypothesis is that the 12.7mm wing will generate the most lift, and the 25.4mm wing will generate the least.

Procedure:

For this experiment, a wind tunnel must be constructed out of wood and Plexiglas. In order to do so, four trapezoids must be cut out of wood (Height--24"; Base--21"; Top--9"). These pieces of wood must be secured with L-shaped brackets, forming a cone into which a large fan can be placed. Three pieces of Plexiglas and one wooden base, each measuring 32x10", should be glued together, forming a long, box-shaped tunnel. A weigh scale should be placed in the middle of the wind tunnel. For each of the four wings, pieces of basswood should be cut and sanded to four distinct heights (9.5mm, 12.7mm, 19.1mm and 25.4mm). These wings must be attached to a stand and placed on the weigh scale. The initial weight should be recorded before turning on the fan. The lift created by the movement of air will reduce the actual weight of the wing and will indicate the amount of lift generated. This test should be done for all four wings, and the entire experiment should be conducted four times to establish verified results.

Results, Conclusion and Application:

My hypothesis was only partially correct. It was found that the smallest wing (9.5mm) generated the most lift. The results showed that the 9.5mm wing lost 7.44% of its weight. This was followed closely by the 12.7mm wing, which lost 6.165% of its weight. The 19.1mm wing lost 3.615% of its original weight. Lastly, the 25.4mm wing lost only 3.15% of its weight. The most likely reason that the the results turned out as they did is because the smaller wing was more proportional to the stand and wind tunnel. The larger wings, which had a higher profile and more blunt front end, generated greater impact force, which affected the lift generated. One variable that I could further test is how the wing's pitch affected its lift. This could inform us on how the lift changes when the airplane is taking off compared to when the airplane is in flight. A project like this can help us better understand lift and help us design more efficient wings.

Acknowledgments:

I would like to thank my parents for helping me and encouraging me along the way. I would also like to thank <teacher> for encouraging me to pursue science and asking difficult questions. He also gave good and knowledgeable advice.

Bacteria in Salmon with Varying Marinades

<name> <school>

Background and Purpose:

In the U.S. over 5,000 people die each year from food poisoning and over 300,000 people are hospitalized. The leading cause of food poisoning is bacteria and pathogens in food sources. Improper cooking methods are one of the causes. While meats are safe to ingest when cooked, raw fish found in popular dishes like sushi are on the rise. The purpose of this experiment was to see if three common food pairings, vinegar, wasabi, and mustard, could lower the risk of bacterial growth in salmon. A control group of salmon with no marinade was used to compare the effectiveness of the marinades. I hypothesize that the salmon samples with marinades will have less bacterial growth than the salmon samples without.

Procedure:

Fresh salmon, which had never been frozen before, was bought from the supermarket, and rinsed with cold water for half a minute. The salmon was sliced into 0.5 cm diameter by 0.2 cm thick, slices. Hereafter, the slices of salmon were divided into four groups, each containing 15 slices. Wasabi and mustard were coated on two groups of salmon specimens in a layer that was approximately 0.25 mm thick. White vinegar was used to completely submerge the third salmon group. The last sample of salmon had no coating, and acted as the control. All four fish samples were left for 24 hours in a 3 degrees Celsius environment. Then, they were lightly rinsed with cold water in a bowl three times each. A swab from each sample was taken and left to grow in a petri dish with an agar-based growth medium at 37 degrees Celsius. After 48 hours, bacterial colonies were counted.

Results, Conclusions, and Applications:

The control group has the most bacterial growth, upwards of 5,000 bacterial colonies. The wasabi and salmon group, and the mustard and salmon group, had similar amounts of bacteria, approximately 70% and 60% of the control group's bacterial growth, respectively. The salmon sample with vinegar had little to no growth in bacteria.

Vinegar, which contains acetic acid, is the most effective at preventing bacterial growth. Mustard, whose main ingredient is vinegar, is the second most effective. Wasabi is the third most effective.

Applying some of the previously mentioned marinades to the fish can reduce the risk of raw fish in sushi and other related dishes. Wasabi and salmon, already a popular combination, can reduce the growth of bacteria by almost a third of the original. Rice vinegar, which is used in the making of sushi rice, can be an additional step in reducing the risks with raw fish. Companies and restaurants can take this information into account when preparing raw fish to reduce the number of people who fall ill due to food poisoning.

Acknowledgements:

I would like to thank <teacher> for valuable advice and for supplying tools and equipment.

Will different fonts and colours impact how well people can recall words?
<name> <school>

Background Information
The colour or font of a word could affect how well it is memorized in two ways. One way is if the colour in which the word is printed is associated with the meaning of the word. For example, if the word "apple"; is printed in red, a person can use that colour to help memorize the word. This is a mnemonic, which is a way to help memorize something. Another way the colour or font can affect how a word is memorized is if either the font or colour is a distraction. In other words, the person may be looking at the colour instead of memorizing the word, making it more difficult to memorize. This may also apply to fonts. Different colours and fonts can also impact readability.

Purpose
The purpose of this experiment is to determine whether different fonts and colours will impact how well people can recall words.

Hypothesis
I hypothesize that words in fancy fonts and in lighter colours will be harder to remember than words in standard fonts and in darker colours.

Materials and Apparatus
The materials used were blank paper, writing utensils, a stopwatch, and willing participants. The devices needed for this project were a computer, a colour printer, and a black and white printer.

Procedure
1. Create an informed consent sheet.
2. Write up a list of 20 simple three-letter words.
3. Make two copies of this list.
4. Make the words in copy 1 different fonts, keeping the size at 12point, and the words in copy 2 different colours, using the font Arial throughout.
5. Ask people to partake in the experiment and have them fill out the informed consent sheet then conduct the test, being careful to give the participants one minute to look at the words and 30 seconds to remember them and to give half of the participants one set of words and the other half, the other set of words.
6. Record observations and results.
7. Create a graph or table to represent the data.

Results
Font: "Cow" (Permanent Marker font) was the easiest to remember, as 88% of people remembered it. "Cow" was followed by "Wig" (Ultra font) and "Ice" (Gloria Hallelujah font) each at 75%. Colour: As with font, "Cow" (in blue) was easiest to remember, as 75% of people remembered it. "Cow" was followed by "Lie" (in red) at 63%.

Conclusion
As I hypothesized, most of the words in fancier fonts and in lighter colours were harder to remember while words in simpler fonts and darker colours were easier to remember. However, most participants did not remember the word in Times New Roman, which is a standard font. Only about half of the participants remembered the word in Arial, which is the font most used in school. Also unlike my hypothesis, only one participant remembered the word in black. Some participants remembered the colours the words were in, rather than the words themselves. Some variables are: whether the word has an emotional attachment, whether the participant was distracted, and whether the word was studied more than the other words. The applications of this project are that if you want people to remember text, use a legible font and do not use light colours.

Acknowledgments
I would like to thank my parents for helping me create the graphs and tables, the participants in this experiment, and my teacher for helping me get started with my project.

Innovations

Phixing Physio

<name> <school>

Introduction and Purpose

Many athletes like myself suffer from injuries requiring physiotherapy. The athlete is assigned exercises that must be performed regularly to accelerate recovery. Ensuring the correctness of these exercises, which is key to their effectiveness, is very challenging. This is the inspiration for my project; I created a device to help with the performance of the single leg squat, an important exercise which was identified "difficult" in an interview with Holli Schimus, PT. There are three main criteria of a correct single leg squat. (1) while going down, the bent knee should not pass the toes; (2) the pressure on the foot of the bent leg should be kept even; and (3) the unbent leg should be extended forward. The purpose of my device is to improve the form of this exercise, and increase the number of squats performed without compromising effectiveness. As a secondary goal, I aim to increase regularity through an intrinsic incentive that highlights the benefits of the exercise.

Design Criteria

To test the success of my invention, the form of the exercise with and without the device needed to be evaluated using the above criteria. I also needed to guarantee that the use of the device would not compromise muscle usage. Muscle stimulation is an indication of muscle usage and is a natural metric that can be obtained through electromyography. Hence, my invention should help guide participants to correct form, while the muscle stimulation with the device stays consistent with that of without.

Methodology

While building my device, I had to ensure that users were provided support, adjustable resistance, and a restricted vertical path (provides balance and guarantees an even pressure distribution preventing knee tears/dislocations). To construct a restricted path, I attached two concentric PVC pipes on each side of the device, which allowed one of the pipes to slide easily through the other. For adjustable resistance, I installed bungee cords to connect the seat and the back of the device. These provide resistance while going down in the squat, and support while going up. The resistance can be adjusted by changing the number of cords. To use the device, one must sit on the seat, pushing to move down, and using muscle and support from the seat to move up.

To assess form, the three criteria of a correct squat were explained to subjects who were then asked to perform a maximum of ten squats before losing balance, with and without the device. For each criterion, scores of zero (never), one (sometimes) or two (always) were given. Subjects were then asked if they would perform the exercise regularly without the device, and were asked again after introducing the incentive, to gauge how compelling it is.

To evaluate muscle usage, a MyoWare (electromyography device) was used to measure stimulation in the quadriceps femoris (the main muscle used in this exercise) over time. Three squats were performed with and without the device. A MyoWare was placed on the muscle, connected to an arduino, and readings were relayed to a connected computer for analysis.

Results and Conclusion

My device improved form and correctness, and increased the percentage of participants who could perform ten consecutive squats, from 10% without the device, to 80% with the device. Furthermore, none of the subjects said they would perform the exercise regularly without the device, but 95% said they would when the incentive was introduced. The MyoWare showed that the device did not compromise muscle usage during the exercise. In the future, more consecutive squats should be performed to identify trends in muscle stimulation.

A Novel Algorithm for Identifying Sequence Motifs
<name> <school>

Introduction and Background
DNA (deoxyribonucleic acid) is made from monomers (nucleotides) with three key components: a sugar, a phosphate group, and a nitrogenous base (adenine, cytosine, guanine or thymine). DNA is the hereditary material in all forms of life. It carries genetic instructions used for growth, development and reproduction.
Motifs are short sequence patterns that represent the fundamental units of biological function, and they encode protein, or can facilitate DNA, and RNA interactions, as well as catalytic functions. They are found in both the coding and non-coding parts of the genome. Motifs allow for the identification of genes that contribute to specific functions of an organism.
Motif discovery involves the finding of motifs within sequences through experimental or computational means. Finding these motifs experimentally is very expensive in terms of time and resources, which is why many algorithms have been developed to find motifs through computational means.

Purpose
The purpose of this project is to develop a novel algorithm, which would attempt to solve the problem of finding DNA sequence motifs in an original way in order to increase the efficiency and accuracy of motif discovery.

Design Criteria
A successful algorithm is one that can accurately identify motifs within known sequences i.e. the motifs have been experimentally determined. The algorithm should identify these motifs faster than current algorithms such as the MEME (Multiple Expectation-maximization for Motif Elicitation) or GLAM2 (Gapped local alignment of motifs).

Procedure
The first step in this project was to read the large data files containing sequences into a nice data structure for manipulating in Python. After reading the data, from files in FASTA format, into Python, different algorithms to identify the most prominent motifs were explored. The amount of times a k-mer (sequence of length k) appeared in the set of sequences was recorded and was the primary value used for ranking motifs. However, it became apparent that analyzing only one sequence for motifs was not returning accurate motifs. Next, the data set obtained from a cell was randomly shuffled to create another data set. Then, these two sets of sequences could be compared to determine which motifs were unique to the original sequence by using the ratio of the frequencies of the motifs in the two different sequences. After this, the p-value (using the binomial test) was calculated to test the statistical significance of motif occurrences and rank motifs more accurately.

Results
When analyzing the PITX1 (paired-like homeodomain 1) sequences, which were obtained experimentally, the target motif was the "GGATTA" binding motif. It was found to be prominent but was not the top ranked motif. However, many variants of the "CAGCTG" motif were found to have very high rankings. When further research was done into the cause of this abnormality, it was discovered that the "CAGCTG" motif is an E-box (enhancer-box) DNA response element that acts as a protein-binding site. Previous studies have experimentally confirmed that the E-box and PITX1 motifs co-occur due to protein-protein interactions between the proteins encoded by the genes containing these motifs.

Conclusion
In conclusion, a newly-designed algorithm for DNA motif discovery was created successfully and was found to be relatively fast when compared to more complex algorithms such as MEME since analyzing data sets of over 10,000 sequences took around five minutes. Such a method of DNA motif discovery could help find new motifs and connect them to their biological function.

Acknowledgements

The Healing Hat

<name><school>

Introduction and Background
People with concussions can be afraid to move their heads, and often experience symptoms of dizziness. Vestibular-Ocular physiotherapists often prescribe specific rotations of the head to help heal concussions, dizziness and vertigo. These specific head rotations are part of the Cawthrone-Cooksely set of exercises.

Purpose
The purpose of my project is to create a device to encourage people with head injuries to move their heads to the prescribed range as directed by their physiotherapist, to help the healing process.

Design Criteria
The device must: be able to accurately track head rotation up, down, left and right; provide feedback to the user; be comfortable; be easy to use; be untethered; be configurable to the needs of the user; be lightweight; and must not result in further injury. Most importantly, the device must ensure the user performs the up-and-down and side-to-side Cawthrone-Cooksely head rotations to the full prescribed range of motion. A typical range of motion prescribed is 40-45 degrees.

Procedure
An Arduino computer (LilyPad) wired to a digital gyroscopic accelerometer (SparkFun 9DoF), a buzzer, a momentary switch, and a battery were sewn into a baseball hat. The position of the digital gyroscopic accelerometer must be at the crown of the head. The orientation of the digital gyroscopic accelerometer must be such that when the hat is worn, the Z axis points straight up from the ground, opposing gravity; the Y axis points parallel to the horizontal line roughly extending from the center of the skull and the tip of the nose, parallel to the ground; the X axis points parallel to ground and parallel to the horizontal line extended from the points at the centres of both ears. Left-to-right rotations are measured purely around the Z axis. Up and down rotations are measured purely around the X axis.
After the hat is placed on the head, the user must press the switch to reset and recalibrate the device. Code written in Arduino C then reads the rotational information from the digital gyroscopic accelerometer and produces a different buzzer sound when the hat is rotated to the configured angles. When the rotation is less than the configured angles, the buzzer is silent. On every tenth successful rotation, a short tune is played via the buzzer.
The device was shown to a registered Vestibular-Ocular physiotherapist for her to review its suitability for patient use.

Results, Conclusions and Applications
The device successfully tracks head rotation up, down, left and right, with a slight drift in one direction that increases slowly over time. Resetting the hat resets the drift to zero. If the user resets the device just prior to performing the exercises promptly, the drift is insignificant. Further work is required to reduce or eliminate the drift.
The device is comfortable and easy to use, and provides good feedback to the user. The configured angles may be changed by modifying, compiling and uploading the Arduino C code to the device. The configured axis (Z for left and right; X for up and down) may be changed by modifying, compiling and uploading the Arduino C code to the device.
The registered physiotherapist indicated that the hat would be useful for her patients. Proper determination of the device's effectiveness would require clinical trials.

Acknowledgements
I would like to thank my mother and father for their assistance. I would also like to thank physiotherapist <name> from VOR (Vestibular and Orthopedic Rehabilitation) for her insight and feedback.

Studies

Who Likes Mild Winters?

<name> <school>

Background

Earth's temperature is increasing due to global warming. The change is due to an increase in greenhouse gas emissions. This affects ecosystems and climate patterns all over the world. In Canada the winters are becoming warmer, which will affect the ecosystems here as many species that were kept in check by the cold winters will now be able to increase substantially. In British Columbia the mountain pine beetle outbreak is being caused by the warmer winters there that aren't cold enough to stop the beetles from expanding their range. The change in winters will allow species in America, like the Kudzu vine and the Aedes Aegypti mosquito to expand their range into Ontario.

Purpose

The purpose of this study is to see when Ontarian winters will become mild enough to allow organisms that were kept out by the cold to expand their range into Ontario.

Evidence and Supporting Data

The current extreme temperature in southern Ontario ranges from -20°C in the warmest parts to -37°C (1981-2010). This is significantly warmer than the -23°C to -43°C (of 1961-1990). If this trend continues in another 10 years the minimum temperature will be another 3°C lower, around -17°C, which will be high enough to allow many species to survive here.

The Kudzu vine is able to survive in the American plant hardiness zones 5-10. These places have an extreme minimum temperature of -29°C. This is lower than the current minimum temperature in Ontario, but even though the minimum temperatures are decreasing relatively quickly, the average temperature is not changing significantly. It is projected to change by only about 2°C from 2011-2040 to 2041-2070. However in as few as 10 years, if the temperature stops going down to extremely low minimum temperatures, the Kudzu vine will spread into Ontario.

This will negatively impact the ecosystems in Ontario, as the vine will take nutrients and space that the other plants need. It will also be difficult to get rid of, as it will thrive in the fertile Ontario soil and will not have any predators. It will reduce the biodiversity here as it will eliminate competing species. Kudzu has also been known to blanket fences and road signs, and hydro poles have collapsed due to the weight of the vine growing on them.

The Aedes Aegypti is a mosquito than can transmit many diseases that are not present in Canada now, like Zika virus and Dengue fever. Its current northernmost range is in places with a minimum temperature of -20°C. As with Kudzu it has not expanded here yet due to the cold average winter temperatures. However, as with Kudzu, if there are less severe cold snaps it will be seen here in about ten years, sooner if more climate change speeds up are. However it will take longer for the mosquito to establish itself here as -20°C is the edge of the mosquito's range. Not many of them will be able to survive at first, but as time progresses the temperature will get warmer and they will adapt to the cooler climate.

Conclusion

So within ten years Kudzu and Aedes Aegypti are expected to begin appearing in Ontario. These are only some of the more well-known species that will appear here as climate change progresses and, within ten years the ecosystems in Ontario will look very different as more organisms spread into Ontario.

Acknowledgements

I would like to thank <teacher>, my geography teacher for the guidance he provided. I would also like to thank my friends and family for all the support they provided me with.

The Cure for Diabetes
<name> <school>

Background and Problem:

Diabetes mellitus is an autoimmune disease that affects millions of individuals. It is a chronic disease where the body cannot produce Insulin, or cannot use the Insulin it produces. Insulin is a hormone produced by the pancreas, controlling the amount of sugar in the blood. It's crucial to maintaining proper health, which is why Diabetes can be fatal. Without Insulin, sugar cannot be turned into usable energy by the body, and individuals experience high blood sugars, which result in damaging organs, blood vessels, and nerves. There are two types of Diabetes: Type 1 and Type 2. Type 1 (juvenile onset/insulin-dependent Diabetes) typically occurs in children, and it is the complete lack of Insulin production. On the other hand, Type 2 (adult onset/insulin independent) occurs in the instance of obesity or late adulthood, and it is the resistance of Insulin, and the pancreas gradually makes less and less Insulin as the disease gets worse.

Purpose/Thesis:

The purpose of this study is to explore the research that is currently being done to cure Diabetes mellitus, and to draw our own conclusions or predictions on future advancements.

Evidence and Supporting Data:

There are numerous ongoing studies and advancements regarding the cure for Diabetes. Firstly, medical researchers are exploring the use of immunology in efforts to find a cure. They are trying to find a way to transplant islet cells that produce insulin, without having the body's immune system destroy them. Additionally, the use of engineering embryonic or adult stem cells to somehow regenerate islet cells is an optimistic approach to finding a cure, assuming that most Type 1 Diabetics still have some islet cells left to regenerate.

Conclusion:

Overall, Diabetes is a severe disease where Insulin is no longer produced, but there is an ample amount of cutting edge research, in an effort to find a cure. The future of Diabetes lies in the hands of immunology, and stem cell research.

Acknowledgements:

Special thanks to <name> MD at the Hospital for Sick Children for answering our questions regarding Diabetes, and for educating us about her past and current research on the disease.

Stay Pawsitive

<name> <school>

Background and Problem
Sometimes you just feel so down in the dumps and you feel like nothing can make you happy again. Studies show that dogs can help you feel happy again, so I wanted to find out if this research is true.

Purpose or Thesis
I think that dogs can be very effective in improving a person's mood, no matter what age you are.

Procedure
On Tuesday November 29, 2016 I went to St. Andrews Terrace nursing home in Cambridge with a St John Ambulance Therapy Dog and her handler to visit some residents to see if the dog changed their mood. We went back for a follow-up visit without the dog on December 2, 2016 to see what their mood was like when the dog wasn't there. Residence staff suggested 10 residents that could answer questions and communicate well. On the first day the 10 residents were asked the same 4 questions about their mood. On the second visit the same 10 residents were asked 2 of the questions from the previous visit, and 2 new ones because the dog was not there and the questions would have been irrelevant.

National Service Dogs (NSD) in Cambridge was contacted for a possible interview with someone in charge of their PTSD and/or their Companion Dog programs. Due to work and school schedules they could only be contacted by email or phone, but provided helpful material.

Results
On the first visit to St. Andrews Terrace, the majority of the residents that were questioned were already having a good day, but 80% of them felt that their mood did change when the dog was there. Of those 80%, all of them said the dog made them feel happier. None of the residents questioned felt less happy when the dog was there. In comparison, on the second visit, only 60% of the residents questioned were already having a good day. Unfortunately, 80% of them were sad that the dog wasn't there. Those same residents said that they would have been more happy if they could have visited with the dog.

The PTSD and Autism Service Dogs trained by NSD are valued at $30,000 because of their intense 2-year training to help with major cases of anxiety, depression, and autism. The dogs that could not qualify to be one of these Service Dogs are used in NSD's Companion Dog program as a very well trained pet, to be a best friend to the person who needs them. They are usually matched with people 18 and under who have anxiety and/or depression; some who can't even get out of bed in the morning without the dog's help. These kids often weren't very healthy or active until receiving the dog to help them. The dogs are given to the family free of charge, and is theirs to keep forever, but they will now be financially responsible for the dog's care.

Conclusion
This research shows that what was hypothesized is correct: Dogs can help to improve a person's mood, regardless of their age. Whether it's a quick visit or a long-term investment of a pet in a home, dogs can bring joy to a person's life, but they need people who care to help make that happen.

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