030210 Caroline Burchat • Anna Supryka

ON

030209

- Shade Is Cool -

Project # 030210 - By Caroline Burchat and Anna Supryka

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platine

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RESULTS & OBSERVATIONS

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Canada-Wide Science Fair
Expo-sciences pancanadienne

Prix platine

Background

Purpose

Hypothesis

Process

Chitosan Doped Graphene Sand Composite (GSC)

NOGOS

Materials

Procedure

Pre-Filtration Contaminants
Post-Filtration

Chocolate | Blood | MacConkey | Brucella
Pre-filtration Agar Plates
Post-filtration

Observations and Analysis: Dissolved Solids

Observations and Analysis: Bacterial Growth

Observations and Analysis: Raman Spectroscopy and SEM Analysis

Elemental Analysis | Raman Spectroscopy 532nm Laser | SEM Image (1600x Magnification)

Filter Container

CWSF ESPC
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Best
Meil

CWSF ESPC
Canada-Wide Science Fair
Expo-sciences pancanadienne

Best Project
Meilleur projet

Gold Medal
Médaille d'or

Special Award
Prix spécial

ABSTRACT

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EXTRACELLULAR ELECTRON TRANSPORT

MFC DESIGN

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INDIVIDUAL CLONE PERFORMANCE

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MFC THERMODYNAMICS

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CONCLUSIONS

ACKNOWLEDGEMENTS

REFERENCES

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Benford's Law

060120

David Tobias Holcer

BC

Purpose/ Problem

Hypothesis

I believed that after conducting multiple experiments in different fields, the results would conclude that the percentage of occurrence of leading digits would match the predicted percentages of Benford's Law.

Background

I myself am very interested in mathematics and to computers. Because of this, I knew that I wanted to pick a project that I would enjoy working on and studying. I was looking around for ideas and after contemplating multiple choices, I ended upon Benford's law

Procedure

For this experimental study I used few materials:

- A computer
- Specific applications - Mathematica, the Python programming language, Excel
- Data from the U.S. Census

What I did in this experiment is I took different kinds of data both in populations of countries and identified the leading digit for each of the entries of this data set. Using computer programming with Python and other powerful languages such as Mathematica I great for its data retrieval, I was able to gather data for this experiment.

Background Research

Benford's law states that leading digits in numbers of nature or numbers that we don't control turn out to be 1 more than they turn out to be 9. This seems counter-intuitive at first, wouldn't we expect all numbers to be seen the same amount of times as starting digits. This "random" sorting is not what occurs with Benford's law.

Ironically Frank Benford did not discover this law but in fact, a Canadian mathematician Simon Newcomb discovered this in 1881. While he was using a log book (log books were used in the old days as a shortcut to multiplication since it was simpler) he found that the earlier pages of the book were getting more worn than the later pages

Conclusions

Results and Observations

Future work

Sources of Error

Acknowledgements

Real World application

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Chill Out!

ON

Erika Dunn • Amy MacFarlane

BACKGROUND

PROCEDURE

Citric Acid Solution

Testing Endothermic Solution

PURPOSE

HYPOTHESIS

Tube Materials

Creating Tubes

MATERIALS

VARIABLES

Shirt Materials

and Degradation on Water Quality

030304 Theresa DeCola

ON

Localised Potential Implications of Dreissenid

Theresa DeCola, Bayside Secondary

Introduction

Invasive Dreissenid mussels, which originated in the Ukraine and Eurasia, have invoked major changes across the Great Lakes at both the micro and macro level. These creatures are now a predominant issue in the Bay of Quinte, and are most prevalent as Zebra and Quagga mussels. Like humans, Dreissenid mussels have spread from their original habitats to locations in which they do not natively exist. The presence of these invasive species changes the local environments due to their life cycles and minimal predation. Also, like humans the large communities that are created affect the native flora as they develop on and over the original mussel community by adding layers as well as changing the overall surface area for waste accumulation. As a result, the Dreissenid mussels will deplete the naturally occurring food sources and as their populations expand their waste streams will create entirely new eco-systems. These newly formed communities of aquatic biota rely on the nutrients that are excreted from the mussels and can cause localized water quality issues for both recreational and municipal uses.

The mussels themselves also change the nutrient concentrations in the bodies of water. The nutrient cycle becomes distorted and interrupted. Phosphorous is now being converted from soluble to particulate form in the water column. This conversion causes inland water to become more nutrient rich, or eutrophic, as the off shore water becomes more oligotrophic to even oligotrophic. These changes affect the nutrient cycle so that there is little deep water cycling and a lesser amount of biological activity in the shallow waters. The mussels clear the water resulting in native species being outcompeted by algae forming that can cause issues for those in the near shore waterways.

In the lower Great Lakes Basin the algal populations have transitioned from predominantly [illegible] to dominate Blue/Green Algae or Cyanobacteria. These phyla of bacteria are known to produce toxins and odours such as the hepa and neuro toxin Microcystin LR. These compounds are increasing the toxicity of potential drinking water as well as of the decay cycle of algae. These changes in the algal populations not only have a significant impact on the food web also on Dreissenid mussels. Bivalves such as Dreissenid mussel's intake water like a filter, and utilize the algae as their food. As a result the Dreissenid mussels are filtering toxins and taste and odour causing compounds through their bodies at a higher than ever before in the Great Lakes Basin. Despite the fact that it is known that these toxins are present in the water, the effect that Dreissenid mussels have an effect on their concentrations.

Purpose

The purpose of this study was to determine the role of Dreissenid mussels in the accumulation [illegible]

aims of this study are:

- To document the species, size and mass data of Dreissenid mussel [illegible]
- To determine the specific effect of Dreissenid mussels on the nutrient [illegible]
- To further study the effect of localized differences in Dreissenid [illegible]
- To determine whether bioaccumulation of Microcystin toxins is [illegible]

H

If the Dreissenid populations are exposed to [illegible] in which the organisms in the ecosystem interact with one another [illegible] metabolize, and therefore release concentrations of compounds [illegible] is also theorized that if a Dreissenid mussel is exposed to algae [illegible]

P

Dreissenid mussels and overlying water samples [illegible] apart, each with 2 varying depths. Sample Sites 1 and 2 A were [illegible] Site 1 and 2 B. Sample site 1 was from an open water Marina [illegible] samples were collected using a 900 cm³ template. Mussels [illegible] 1.0cm, 1.0 - 1.5cm, 1.5 - 2.0 cm and < 2.0 cm). All mature specimens [illegible] specimens to determine the mass ratio. The mixture mussels [illegible] decanted off. The same process was applied to a sub group [illegible] analyzed for particulate nutrients (P-phosphorus and N-nitrogen) [illegible] nutrients, Microcystin and chlorophyll A, to provide a water [illegible]

Ackn

Special thanks to Dustin Emms Turner for [illegible] Dundee Marine Services for in water support and Continental Ca[illegible]

Mussel Death and Degradation on Water Quality

School, Belleville, Ontario

Results

The results showed significant differences in the mussel communities' associated Microcystin and nutrient concentrations among sites. Higher densities of mussels were recorded in the sample 1 locations (13,000 vs. 7,300 animals/m²) while average mussel weight (0.8 vs. 0.9g) and size (1.6cm vs. 1.8cm) were consistent between depths and locations. It was observed that the population distribution was quagga (88%) and zebra (12%) mussels at sample site 1 while specimens at sample site 2 were 93% quagga mussels and 7% zebra. Mature mussels (greater than 2.0 cm in length) constituted between18 and 28% of the total sample mass but accounted for only 7 to 12% of the sample populations.

Analysis of overlying water, from all sites, indicate minimal levels of particulate phosphorus (P), nitrogen (N) and Microcystin. The samples from Sample Sites 1A & 1B showed significant degradation in Dissolved Oxygen (DO) dropping to 5.1 mg/L from 8.1 mg/L. The pH was recorded at 1 m intervals, with readings being higher than normal for surface water, as all but 3 readings were above 8.5, with the highest being a pH of 9.09. Laboratory analysis indicated that larger quantities of particulate P : N are present in the July 31st samples from Sample Sites 1A and 1B (85.1 : 1997.0 mg/L and 169.3 : 1350 mg/L respectively). Analysis also indicates that the highest recorded Microcystin levels occurred in the July 31st samples first run sample from Site 2A at 34.9 ug/L.

All lab analysis from Aug 29th samples indicate a significant reduction in all sampled parameters. this could be related to 2 large precipitation events that could have moved the particulate P and N from the surface of the benthic layer. Also although "Mature" mussels (>2.0cm) constituted only 18 to 28% of the total sample mass they consistently represented 40 to 50% of all measurable Microcystin.

Conclusion

occurrences of particulate P and N shunting and that these materials are not being fully integrated into

N concentrations mimicked the population mass distribution with the mature mussels representing mass and representing approximately 25% of the Particulate P & N.

ed approximately 25% of the population mass, but they contributed approximately 50% of the ecosystem. The results are indicative to the fact that Dreissenid mussels are bio-accumulating this

Potential Application

practical applications for this study. Dreissenid mussels are capable of bioaccumulation, so they may culture. What would set Dreissenid mussels apart from other bio-indicators is that they are in situ. vels of contamination would be known.

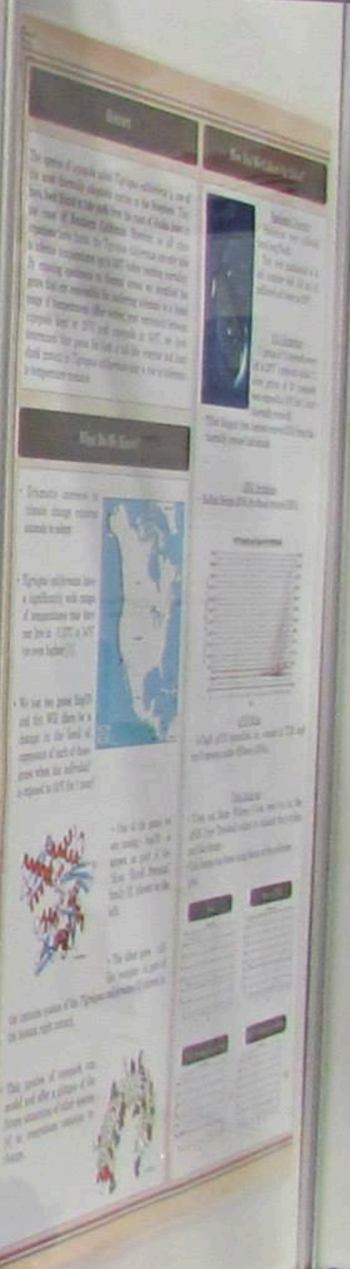
References

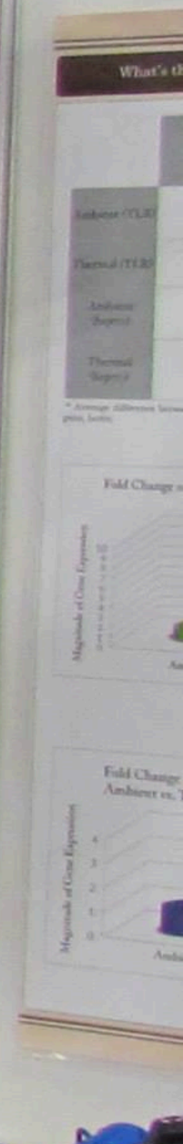
2003 JAWWA. 95: 113-118; Watson & Ridal 2004. *Wat. Sci Technol.* 49:33-39; Edge et al 2010.
CA; Watson et al 2011. Bay of Quinte RAP report. ; DeCola, Watson et al 2011. *Localized Differences in*

CWSF ESPC

Gene(s) to Survi

030303 Christabel





Canada-Wide Science Fair
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060205 Caroline Mahut

ON

060206

Gold Medal
Médaille d'or

Challenge Award
Prix de défi

Question

Can earlier work on a modified ground effect wing airfoil be used to design an innovative functional ground effect aircraft? How might this ground effect aircraft be used to help Greater Toronto area commuting challenges?

Engineering Objective

The engineering objective is to:

- Design and build a proof-of-concept ground effect aircraft model that will lift off at acceptable velocity and maintain that lift.
- Make total cost comparisons of commute cost, commute time and other geographically distinct cost of living expenses.

Background

"Ground effect" is the increase in lift relative to the induced drag that results when an aircraft flies close to the ground (or similar surface). The entire aircraft functions on the "ground effect". The aircraft takes off and flies only a couple of meters off of the ground in order to maintain increased lift (*Aerodynamics of a Double-Element Wing in Ground Effect*). The main components that render a ground effect aircraft to be so effective are stability, controllability and aerodynamic efficiency. These aircrafts are also much more lift and fuel efficient than conventional aircraft.

Today, ground effect aircraft range from two seat recreational vehicles to 500 ton war crafts. Many passenger ground effect aircraft are used in the Far East to transport people between places such as Australia and New Zealand. *(Wing in Ground Effect Craft Review)*

In my previous project, a modified ground effect wing was developed that was more lift efficient than both a conventional aircraft wing and a regular ground effect wing.

Project Approach/Procedure

The project was broken into the following steps:

1. Identify the Major Attributes of this Ground Effect Aircraft
2. Determine Sizes and Weights of the Aircraft Components
3. Design and Build a Flight-Worthy Proof-of-Concept model
4. Design and Build a Flight Test Rig
5. Undertake experiments to determine
   - The effect of the "Ground Effect altitude" (or Aircraft Posterior Clearance - APC)on take-off velocity.
   - The optimal axial alignment of engines on the fuselages to impart thrust.
6. Undertake Cost Comparisons for four Commuting Corridors

Taking the Flyway

Solution Development

Step 1: Design of the Major Attributes of the Ground Effect Aircraft:
The design of this ground effect aircraft consists of two fuselages on either end of a single connecting wing.

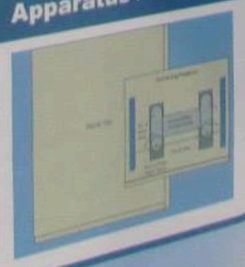
Step 2: Determination of the Size and Weight of the Ground Effect Aircraft:
The full-scale aircraft was designed to carry 200 people in each fuselage or 400 people per flight. The size of the fuselage was calculated to be 28 metres long, 3 metres high and 3.5 metres wide. The weight of the aircraft was determined to be 284 metric tons based on the wing size, fuselage size, engine size, tail size and payload. After a number of iterations, the final size of the wing was calculated to be 20 metres in length and 5.5 metres in chord.

Step 3: Building the Prototype:
To validate the ground effect aircraft design, a flight worthy concept model and airfoil was built, dimensionally proportionate to the designed aircraft.

Step 4: Design/Build a Test Rig:
An original test rig was then built on the back of a trailer in order to test the concept model. The time and velocity at which the aircraft took off to be observed. The takeoff time, landing time, takeoff velocity and landing velocity of the aircraft during the flight test were recorded. Environmental factors such as wind speed and direction were recorded to determine whether there were any crosswinds that could alter the results.

Aircraft Model

Apparatus / Test Rig

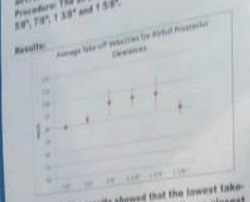


Flyway

Experiment 1

Purpose: To determine the effect of different airfoil posterior clearances (APC) on the takeoff speed of the aircraft .
Procedure: The aircraft was tested at APCs of 3/8", 5/8", 7/8", 1 3/8" and 1 5/8".

Results:



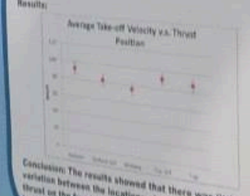
Conclusion: The results showed that the lowest take-off and landing velocity when the aircraft was closest to the platform, therefore at 3/8".

Experiment 2

Purpose: To determine the optimal axial alignment for the impart thrust on the back of the aircraft optimize engine placement.

Procedure: The impartment of thrust position was located by screwing in a screw at different elevations on the rear of the fuselage. Then a wire was placed underneath the two screws and attached to two posts on either side of the aircraft. When the aircraft was in flight the wire would restrain the aircraft, effectively imparting thrust. The thrust was imparted at the bottom, quarter elevation, midway, ¾ elevation and top on the rear of the fuselage.

Results:



Conclusion: The results showed that there was little variation between the locations of axial impartment of thrust on the fuselage however the midpoint had the lowest takeoff velocity.

Economic Analysis

An analysis was conducted to determine the economic feasibility of the St. Catharines to Toronto transportation route. While the annual cost of taking " the Flyway" is more than other commuter routes, savings in cost of living in St. Catherines help to reduce the net cost. While the total cost for the Flyway is apparently higher than other options, the time freed up by shorter commuter times can be used for family time and/or productive work. This may be seen as even more valuable by commuters.

Commute to Toronto					
Start Home	End	1 way commute	Cost Fuel	Cost of Living	
Barrie	Via	1 hr 15 min	16.500	$7,000	
St. Catharines	Via	1 hr 15 min	16.500	$7,000	
St. Catharines	Go Train	1 hr 15 min	16.500	$7,000	
St. Catharines	Flyway	22.5	16.500	$7,000	
St. Catharines	Flyway	22.5 min	16.500	$7,000	
			33.000	$7,000	
			33.000	$7,000	
			33.000	$7,000	

Conclusion

The engineering objectives were met.

- A novel proof-of-concept ground effects model aircraft was designed and built. It took off and stayed aloft at 70-80 km/h. Tests were completed using an original design test rig to determine optimal airfoil posterior clearance and axial thrust positioning on the fuselages.
- Cost comparisons for four competing commuting corridors were determined. The Flyway between St. Catharines and Toronto is more expensive in commute cost but offers significantly reduced commuting time and lower costs of housing compared to the other transportation routes considered.

Extensions

- Testing and recording the lift and drag on the aircraft while in flight in order to compare it to other conventional and ground effect aircrafts
- Adding weights to the aircraft in order to create a proportionate weight to size ratio equivalent to that of the aircraft design
- Determining the optimal ground effect height for the aircraft while it is at cruising speed
- Analyzing the infrastructural costs associated with introducing these aircraft into cities.

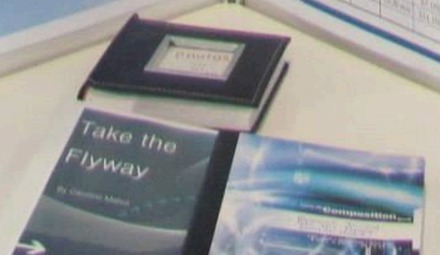
Applications

- Ground effect aircraft can fly over any flat terrain such as water, ice, snow, prairie, desert, marsh, lakes and rivers.
- The use of Ground Effect aircraft in commuter "Flyways" can be placed in other similar regions around the world.
  - Vancouver Island to the mainland
  - Across the Great Lakes
  - Sri Lanka to India
  - The Caribbean Islands

Acknowledgements

I would like to thank:

- my father, my mother and my little sisters for continuous help and support throughout my project
- Sue Olynyk for her effort to prepare me for CWSF and her advice on possible revisions to my project.
- all the members of BASEF who helped encourage me and helped me to improve my project.



William Aldan Aird

ON

Silver Medal
Médaille d'argent

MULTI-FUNCTIONAL WATER WHEEL CART

improving the quality of life in developing nations

Introduction

Challenges in Developing Nations

SAFE WATER

POVERTY

MALNUTRITION

PHYSICAL LABOUR

EDUCATION

ELECTRICITY

Design

Creating the Most Viable Design

Evolution of a Part

The Engineering Evolution of a Part

WHITE CAP

GREEN CAP

YELLOW CAP

RED CAP

The designs of a part are constantly evolving in an effort to make the best possible parts at an affordable price. The following is the evolution of the main cap of the water wheel drum.

Innovative Part

Built into the Design

TEG Handle Grip

Scientific Theory & Experiment Behind the Parts Design

Testing

Testing

Water Wheel Cart

Discussion

Sponsorship and Fundraising Concepts Built into the Design

Water Wheel Cart + Solutions

Conclusion

Extensions

Applications

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William Aldan Aird

ON

Silver Medal
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MULTI-FUNCTIONAL WATER WHEEL CART

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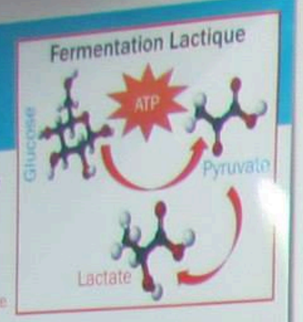
Fermentation Lactique



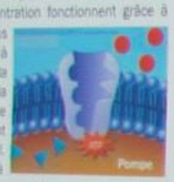
Crise acidotique

Les causes:

- Une infection
- Effort physique
- Une émotion forte
- Un stress quelconque

Dans ces conditions, la demande d'ATP s'élève brusquement. La chaine respiratoire étant défectueuse, la production d'ATP se fait par fermentation lactique. Cette voie palliative crée énormément de pyruvate issu du glucose qui se dégrade en lactate et, en se liant à des H^+ acidifie le sang. Le pH normal du sang est d'environ 7,4 alors que dans ce cas, il baisse à 6,8, une variation très considérable.

Les pompes de transports diffusant des ions et des petites molécules à travers les membranes contre leur gradient de concentration fonctionnent grâce à l'énergie fournie par le bris des liaisons phosphoanhydrides de l'ATP. Les pompes à sodium et à potassium sont essentielles à la santé de tout le corps, car elles permettent la dépolarisation de la membrane qui crée le potentiel d'action. Celui-ci permet le déplacement d'influx nerveux, des pieds à la tête (Reece et al. 2012). Les pompes à ions calcium (Ca^{2+}), quant à elles, se retrouvent dans les cellules des muscles squelettiques et permettent la contraction des muscles et le relâchement de ceux-ci (Lodish et al. 2005).



Conséquences

Le bilan énergétique étant réduit:

- Baisse de la qualité de la transmission des influx nerveux (Pompes Na^+/K^+)
- Baisse de la qualité de l'activité musculaire (Pompes Ca^{2+})
- Retards de développement physique et intellectuel
- Diminution de la vigueur musculaire

Lors d'une crise acidotique:

- Acidification du sang

Baisse du PH sanguin

Dysfonction des protéines

Apoptose, Nécrose, Fribrose

Hypoxie, Anoxie

Coma

Arrêt cardiaque

En somme, l'acidose lactique congénitale, une maladie autosomique récessive, est fatale lorsque l'enfant subit une crise acidotique. Jusqu'à ce jour, cette maladie n'est pas curable.

Question:
Si la mutation affecte principalement une protéine dans la mitochondrie, l'implantation d'une mitochondrie saine dans l'ovule avant la fécondation pourrait éventuellement éviter à l'enfant de développer la maladie

Cégep de Rimouski

0323 Beta-Blockers

Marjan Ghazi

QC

Gold Medal / Médaille d'or

Special Award / Prix spécial

Identifying the Problem

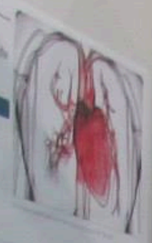
Cardiovascular diseases cause 19% of Canadian deaths. This ranking alerts the pharmaceutical industry to produce bearable medications.

Examples of Cardiovascular Diseases:

Hypertension: Increase in blood pressure

Cardiac Arrhythmia: Irregular heart beat

Postural Tachycardia Syndrome: Increase in heart rate



Purpose

It is understood that these medications occasionally fail. Cases show beta-blockers activating the β-ARs as opposed to blocking them, resulting in the physiological effects damaging to patients . In order to fix this problem, we must first identify the problem and answer to the question "Why are Beta-blockers failing?" The project defines the limitations of beta-blockers.

Unfavorable Effects of the Activated β-AR

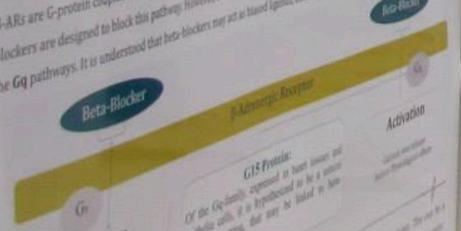
- heart muscle contraction
- increase in heart rate
- increase atrial cardiac muscle contractility
- dilation of the hepatic artery
- dilation of the coronary artery
- contractility of the ventricular cardiac muscle

Treatment Medications

This justifies the utility of beta-blockers in treatment. beta-blockers block the Beta-adrenergic receptors and to undesirable effects to restore safety to patients' cardiovascular systems.

Hypothesis Formulation:

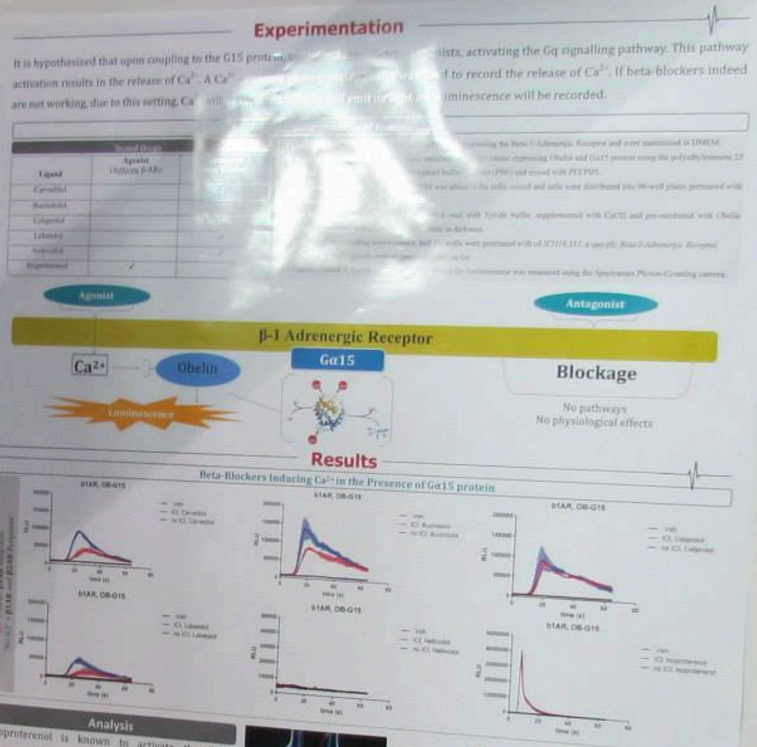
β-ARs are G-protein coupled receptors that generally couple to a **Gs**-family G-protein. Upon activation, the Gs pathway is activated and blockers are designed to block this pathway. However, beta-blockers have proven to induce the release of Ca^{2+}, a response generated the **Gq** pathways. It is understood that beta-blockers may act as biased ligands, blocking the Gs pathway while activating the Gq pathway.



Since β-ARs and G15 protein are expressed simultaneously in the cardiovascular system, three coupling is very probable. The red to possible scenarios where beta-blockers act as agonist of the Gq pathway. Instead of preventing the effects of the common beta-adrenergic receptors, the effects will be induced in patients, over time leading to further heart damage.

Experimentation

It is hypothesized that upon coupling to the G15 protein, [illegible] agonists, activating the Gq signalling pathway. This pathway activation results in the release of Ca^{2+}. A Ca^{2+} [illegible] used to record the release of Ca^{2+}. If beta-blockers indeed are not working, due to this setting, Ca^{2+} [illegible] luminescence will be recorded.

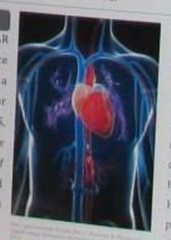


Results

Beta-Blockers Inducing Ca^{2+} in the Presence of Gα15 protein

Analysis

Isoproterenol is known to activate the β1AR receptor; the high-magnitude peak of luminescence is justified. All β-blockers are expected to result in a baseline luminescence; proving receptor antagonism. However, in the presence of Gα15, Carvedilol, Bucindolol, Celiprolol and Labetalol are inducing significant emissions of light as a result of Ca^{2+} release, which represents unpredicted activation of the β1AR receptor, as beta-blockers prove to act as agonists of the G_{aq} pathway.



Conclusion

The Gα15 protein in our experimental system represents a factor causing the β1AR's antagonism to fail. Performed in-vitro, this experiment may explain beta-blockers' occasional inefficiency. When the β1AR is coupled to Gα15, the antagonisms aren't expressed effectively. In treatment of cardiovascular diseases such as congestive heart failure, hypertension and other conditions, beta-blockers are often used. However, these drugs may act as agonists, in cases where Gα15 protein is present, as proven in this experiment, and over time this may lead to heart failure. When wondering "Why are Beta-blockers reporting failure?" this project justifies an answer, which is the first step in developing safer medications and making cardiovascular diseases less threatening.

Acknowledgements

Experiments were performed in the *Institute of Research in Immunology and Cancer* (IRIC) of l'Université de Montreal, with the mentoring of Viktoriya Lukashova Ph.D. and scientific sponsor Michel Bouvier Ph.D.

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040324

Un remède attirant

Simarjit Bilkhu

LE CERVEAU ET L'ÉLECTROMAGNÉTISME

GYRUS PRÉCENTRAL
STIMULONS-LE !

CHAMP MAGNÉTIQUE

LE TAUX DE RÉMISSION TOTALE EST DE 45% APRÈS UN AN DE TRAITEMENT.

NEURONE SCHÉMATISÉ

DENDRITES

SOMA

AXONE

TERMINAISONS AXONALES

DIFFÉRENCE DE POTENTIEL

TRANSMISSION SYNAPTIQUE

060118 Cameron Bourdeau

060117

Observations and Data

INTRODUCTION

Camellia, the genus more widely known by its common name - tea - is everywhere these days. We consume it; it consumes us. For nearly 5,000 years, it has been cultivated in mountainous, equatorial regions the world over. Whether utilized as an inexpensive source of nourishment, as a ceremonial or ritualistic tonic, as an ultimate comfort brew or catalyst for a multi-billion dollar wellness movement, tea has experienced a substantial rise to the top of the beverage charts, second only to water. Canadians spend almost $900,000,000 on tea per year which translates to a consumption figure of approximately 79L per person. The flavours, varieties, and content seem to differ endlessly in almost every store you visit. Most commercially available teas, however, fall into four basic categories.

Black tea - The most common type of tea in North America, it is oxidized (left in a room to dry/ferment) for the longest period of time. A common misconception is that this longer oxidation time increases the caffeine level of the end product. Although there are numerous factors that contribute to the caffeine level in tea, such as soil chemistry, altitude, or position of the leaf on the plant and cultivation practices, oxidation time is not one of them.

Green tea - The predominant choice of the tea lover in Central and East Asia, these leaves are picked very young in the spring, and are pan-fired or steamed before their quick drying process to preserve their delicate flavour and keep their appearance intact.

Decaffeinated tea- All varieties of tea can go through the most prominent industrial decaffeination process which involves the spraying of dichloromethane and ethyl acetate. The spraying and drying process occurs for up to ten hours and has only a slight effect on the taste of the leaf itself. Decaffeination still leaves 1-2% of the caffeine in the leaves, however.

Herbal tea – This is technically not a tea at all, rather a composition of flowers and other plant matter, fruit, herbs, spices, and sometimes other things like chocolate. Due to the fact that there is no tea in herbal "tea," it contains little to no caffeine.

BACKGROUND

On any given weekend afternoon or after dinner through the week, there are teapots and tea cups strewn about the house. Differing flavours: some with milk, some with honey, and some with sugar; each of us savouring a unique variation of our home-brewed favourite. By chance, what I observed and found very interesting was that, regardless of brand, type or ingredients, each member of my family had a different method of steeping tea to achieve their desired result. Did we all have our own precise and meticulously practiced methods, factoring in time and temperature? Or, were we simply and subconsciously, able to define the taste of our tea with our eyes? I decided to put this to the test and built a simple device to measure the strength of tea using a photoresistor. Project Tea Time, began.

QUESTION

Given the large array of tea types available, based on temperature and time, do four popular varieties strengthen equally?

HYPOTHESIS

I don't think that the teas will strengthen equa
however I think they will strengthen in similar patter
but at different levels of strength.

MATERIALS

- Multimeter
- Kettle
- Electrical Tape
- Water
- Spoon
- Measuring Cup

Clips

1. Use electrical tape to secu
through an opaque object
tape
2. Cover the outside
3. Place the cup u
4. Boil a kettle of
5. Drop a tea bl
into a clear plas
6. Repeat ste
7. Move the
8. Turn on th
the reading is
9. One at a
through the c
10. Repeat

RESULTS

The teas' strengths increased in a similar pattern: the strength went up sharply at 60 seconds, then steadily through 90 and 120 seconds, then sharply again at 240 seconds. The black tea showed the most variation from this pattern in that its strength did not rise as sharply at 240 seconds. The raspberry tea had the steepest rise in strength at 240 seconds: it rose from 790 ohms to 1100 ohms at 75 degrees, a total rise of 310 ohms.

CONCLUSION

The hypothesis was correct. Although the teas' strength levels were very different, the patterns in which they strengthened were similar. Please see graphs below.

If I were to perform this experiment again, I would consider using more varieties of tea (e.g. white or oolong, or even loose tea); a greater temperature range, and/or increased lengths of time. Although it is a subjective measurement, I would also consider having a focus group test the teas to determine which teas are preferred in terms of taste.

APPLICATION

Restaurants such as Starbucks or Tim Horton's could use this technology to make better tasting tea for customers, or allow the customers to choose the exact strength of tea they would like to purchase. Also, a teapot could have a built in photoresistor allowing people to remove the tea bags to obtain certain tea strength.

Introduction

- Non-small-cell Lung Cancer is the most prevalent cancer-related mortality with over 1.4 million deaths annually.
- More than 80% of Lung Cancers are classified as Non-Small Cell Lung Cancer (NSCLC).
  - NSCLC, encompass large tumors that develop in central and peripheral regions of the lung.
  - High Potential for metastasis via nearby lymph nodes (lymphoduct), vasculature and circulatory and highly vascularized tissue.
  - Low survival rates due to limitations in early diagnosis and treatment methods.
- NSCLC is characterized by: 1) Abnormally high levels of chromosomal aneuploidy, 2) Cell cycle dysregulation.
- The understanding of molecular mechanisms of NSCLC characteristics (Aneuploidy & Cell Cycle Dysregulation) will lead to more specific and targeted diagnosis and treatment methods.
- **This project focuses on CDK5RAP2 — a protein that is central to cell cycle regulation and spindle formation — and its possible contribution to NSCLC progression.**

Background Research

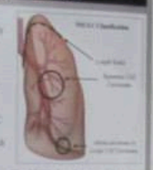
Cancer

- Cancer is blanket term that covers a collection of diseases which are characterized by unregulated proliferation of abnormal cells.
  - Cancer cells may be invasive or functional tissues and organs.
  - Cancer cells may metastasize through the lymphatic system or bloodstream – ultimately establishing neoplasms in other regions of the body.
- Cancer cells differentiate from functional normal cells:

Behavioral Differentiation	Physical Differentiation
Unregulated Cell Cycle	Multiple, large nuclei
Increased resilience against low nutrient levels	Coarse Chromatin
Angiogenesis	Small Cytoplasm
Anaplasia	Multiple Nucleoli
Loss of anchorage or density dependence in cell growth	Unregulated Cell Structure with various missing 'functional' organelles

- Unregulated cell cycle is predominantly caused by gene damage - Tumor Suppressor Genes and Oncogenes.
  - Tumor suppressor genes are downregulated, causing unregulated proliferation.
  - Oncogenes are upregulated which causes increased proliferation.
- **Treatments (radiotherapy, chemotherapy, angiogenesis inhibitors and surgery) prove to be invasive or non-targeted. Search for targeted and effective treatment and diagnostic methods, which molecularly target characterizations of cancer, prove to be invaluable.**

Non-Small Cell Lung Cancer

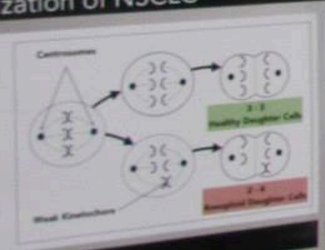


- NSCLCs are all lung cancers except SCLCs.
- NSCLC subtypes of large cell tumors that are relatively resistant to chemotherapy, found in peripheral or central regions of the lung.
- There are 3 main categories of NSCLC
  - Adenocarcinomas, squamous cell carcinomas and large cell carcinomas.
- Currently, 85% of patients are diagnosed with NSCLC after symptoms develop.
  - NSCLC late diagnosis leads to late treatment, which results in low survival rates.
- Genetic and Protein Biomarkers (KRAS, EGFR, ALK, p53 and TSLC1 - have been correlated to NSCLC, but they have low efficiency.
  - KRAS gene mutation have shown the highest correlation to NSCLC with 25% of NSCLC patients exhibiting this mutations.
- Treatments are not targeted and invasive:
  - Radiation Therapy and Chemotherapy – Insensitive treatment.
  - Surgery – Wedge Resection (One Region of Lung), Lobectomy (Removal of entire lobe)
- **More effective diagnosis and treatment methods must be developed in order to maximize survival rates. These diagnosis and treatments methods can come through the understanding of molecular mechanisms that contribute towards NSCLC characterization.**

Characterization of NSCLC

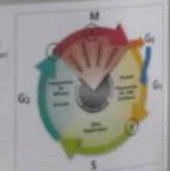
1) Aneuploidy

- The imbalance in chromosomes.
- Usually caused by chromosomal missegregation during mitosis.
- Referring to whole aneuploidy, **not partial aneuploidy.**
- Abnormally prevalent in NSCLC patients - 80%.



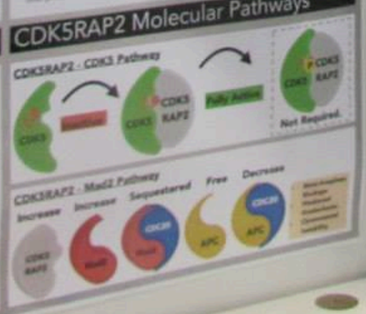
2) Cell Cycle Dysregulation

- The cell cycle is regulated by various proteins, within cancer cells, these checkpoint proteins are suppressed and unregulated.
- There are three distinct checkpoints within the cell cycle:
  - G1 - S Checkpoint
  - G2 - M Checkpoint
  - Mitotic Anaphase Checkpoint
- (Major contributors are Cyclin Dependent Kinases)
- Prevalent in all cancer types – main cause of over-proliferation.



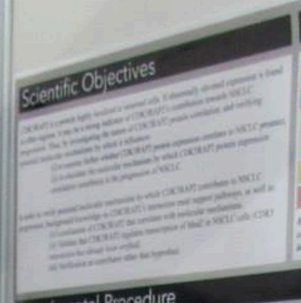
CDK5RAP2

- Cyclin Dependent Kinase 5 Regulatory Associated Protein 2 (CDK5RAP2) is an 215 kDa enzyme encoded by the CDK5RAP2 gene.
  - CDK5RAP2 is involved in brain development, neuronal differentiation and neuronal maturation.
  - CDK5RAP2 has been linked to primary microcephaly.
  - CDK5RAP2 has two major protein pathways.
- Involved in interactions with two major protein pathways.
  - Serves as an activator for CDK5 (Forming Maturation Promoting Factor - MPF) in rat cerebral cortex cells.
  - Serves as a transcription factor for Mad2 in yeast studied cells.

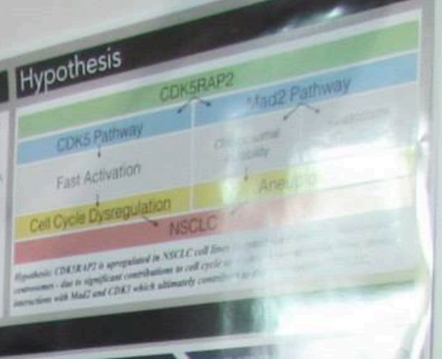


CDK5RAP2 Molecular Pathways

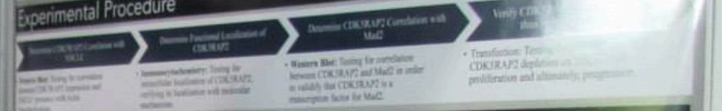
Scientific Objectives



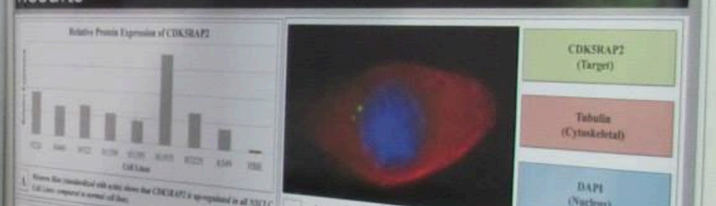
Hypothesis



Experimental Procedure

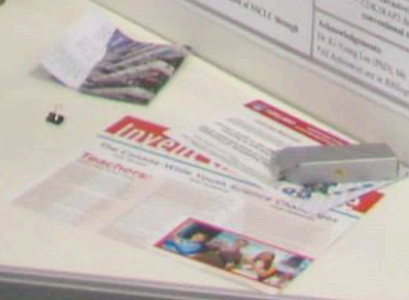


Results



Conclusion

Applications and Extension



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040231 Marianne Drolet-Sénéchal

QC

Le pouvoir d'un trésor pour le X

CHUS

INTRODUCTION

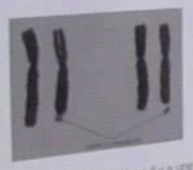
LE SYNDROME DE L'X FRAGILE

Le Syndrome de l'X fragile est l'une des plus importantes causes de retard mental d'origine génétique.

Prévalence
Un garçon sur 4000
Une fille sur 8000

Autres caractéristiques
- Retard de développement
- Difformités physiques

La cause du Syndrome de l'X fragile



La cause de l'X fragile est une anomalie sur le chromosome X.

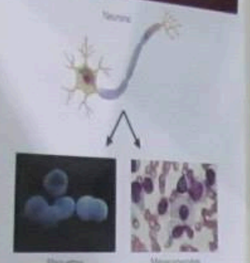
Chez les individus atteints, il y a une trop grande répétition du trinucléotide CGG (thréonine de la boucle) dans la région 5' non-traduite du gène FMR1. Cela mène à la méthylation du gène.

Mécanismes généraux de la cause du Syndrome

Méthylation du gène FMR1
↓
Absence de la protéine FMRP découlant du gène
↓
Impact sur l'activité des récepteurs mGluR de type 1 (mGluR-1 et mGluR-5)
↓
Anomalies induites principalement dans les neurones

PLAQUETTES : UN MODÈLE D'ÉTUDE

MARIANNE DRO



L'EXPÉRIENCE

Démarche scientifique

Le but de l'expérience
Le but de l'expérience était de détecter les récepteurs mGluR-1 et mGluR-5 dans des échantillons de mégacaryocytes (cellules de la lignée MES-01). Cette expérience s'est réalisée sur plusieurs jours et comportait plusieurs étapes.

Question de recherche
Est-ce que les perturbations synaptiques observées chez les patients ayant le Syndrome de l'X Fragile peuvent être étudiées sur les mégacaryocytes (précurseurs des plaquettes sanguines)? Autrement dit, est-ce que les mégacaryocytes vont exprimer les récepteurs mGluR-1 et mGluR-5 tels au Syndrome de l'X Fragile?

HYPOTHÈSE

L'hypothèse est que les mégacaryocytes (et donc les plaquettes) vont exprimer les récepteurs mGluR-1 et mGluR-5 parce que les mégacaryocytes expriment déjà la protéine FMRP et que les plaquettes sanguines ont plusieurs caractéristiques en commun avec les neurones.

TRÉSOR POUR LE X

LET-SÉNÉCHAL

PROTOCOLE EXPÉRIMENTAL

Préparation des échantillons de protéines

Gel d'électrophorèse et migration

Western Blot : α-primaire et α-secondaire

RÉSULTATS

Western Blot sur la présence de FMRP (04/02/2015)

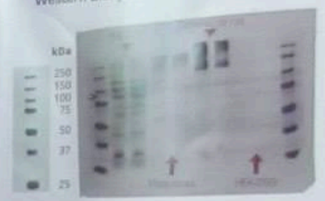
Western Blot pour le récepteur mGluR-1 (27/03/2015)

Nous pouvons observer un signal très clair autour de ce poids moléculaire.

SÉMINAIRE DE SHERBROOKE

RÉSULTATS (SUITE)

Western Blot pour le récepteur mGluR-5



Le récepteur mGluR-5 se trouve à 142kDa.
Nous pouvons observer un signal très clair autour de ce poids moléculaire.

DISCUSSION ET ANALYSE

Ces résultats démontrent l'expression des récepteurs mGluR-1 et mGluR-5 sur des mégacaryocytes et des plaquettes. Bien-sûr, d'autres expériences de confirmation et d'analyses en profondeur (test d'activation des récepteurs) sont prévues.

IMPACT DES RÉSULTATS

Ces résultats ont validé l'utilisation de mégacaryocytes et de plaquettes comme bon modèle d'étude pour le Syndrome de l'X fragile.

Du point de vue clinique, les expériences sur les plaquettes vont permettre l'élaboration d'un test plus performant pour diagnostiquer le Syndrome de l'X fragile axé sur la quantification de FMRP et peut-être des récepteurs mGluR-1 et mGluR-5.

CONCLUSION

Merci d'avoir pris le temps d'écouter ma présentation d'expo-sciences!

Marianne Drolet-Sénéchal
Secondaire 4 - Séminaire de Sherbrooke

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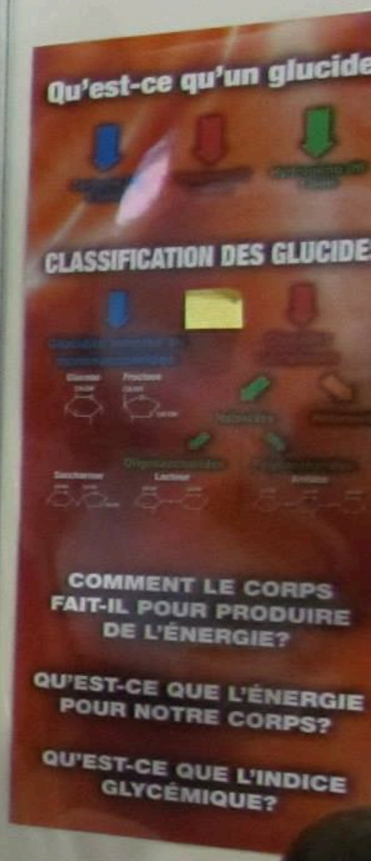
040232 Louis-Antoine Ge

Le pouvoir de



Welcome to

OME OF THE

FIRE

Searching for Sails

Introduction/Purpose

Background

Hypothesis

Materials

Procedure

Applications

Variables and
Possible Sources of Error

Things to Improve On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Disorders
Melody Song
I speak English
DIR DES GLUCIDES
Variables indépendantes
Background
Purposes
Hypothesis
Materials
Methodology
Results
Conclusion
Future Applications
Acknowledgements
References
Bronze Medal
Médaille de bronze
EBO
Problem
11,000
deaths
50%
Purpose
Discover the molecule with the highest probability of acting as a receptor antagonist for the Niemann-Pick C1 receptor (NPC1), a protein crucial to the survival of the Ebola Virus.
Hypothesis
Given the relatively small number of molecules tested, it is anticipated that such molecules will be unlikely to inhibit the NPC1 protein.

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030114

Can We Improve the Quality
Developing and Third World

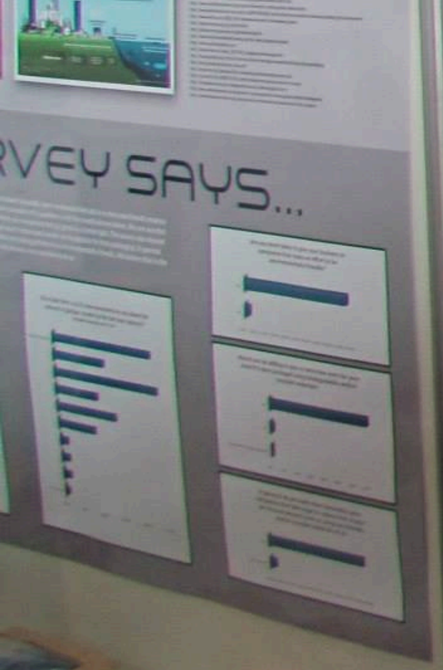
Rachel Brouwer

ON

TE CHANGE

CH A BIG DEAL?

RVEY SAYS...



Background

Potassium (K), Phosphorus (P) and Nitrogen (N) are the most important nutrients to the growth of every plant because of the help they provide to it's growth and health. Potassium improves drought resistance, increases chemical processes and is very important in water regulation. Phosphorus increases plant growth by promoting cell division and the development of new tissue. Nitrogen helps to produce proteins and nucleic acids, increasing plant growth and development.

Plants can only absorb Nitrogen in fixed form. Conversion of atmospheric to fixed Nitrogen, like Nitrates, occurs through a process called Nitrogen fixation. Nitrogen fixation can happen through artificial processes such as the Haber-Bosch process, which uses a chemical reaction to create ammonia or Nitrates (NO_3) - Nitrates are the only form of Nitrogen plants can intake for fertilizers. Consequences of these artificial processes include acid rain (due to an increase of ammonia in the atmosphere) and an increase of Nitrous Oxide (a greenhouse gas, the third largest contributor to global warming).

Fertilizers also cause other problems associated with the environment such as an increase of Nitrogen and Phosphorus levels in bodies of water. Nitrogen can be washed out of soil into rivers or streams leading to high levels of Nitrogen which are considered dangerous to human health. Phosphorus can not be separated from soil particles because of the bond it forms with the soil. However, it can be washed into bodies of water with soil. Although high levels of Phosphorus aren't considered dangerous to human health, they stimulate excessive growth of algae, leading to oxygen depletion and dead-zones in water bodies. Chemicals in fertilizers can also leak into groundwater resources, contaminating the water.

Natural Nitrogen fixing processes occur because of a bacteria that lives on the roots of legumes. Rhizobia have a symbiotic relationship with all legumes - they use atmospheric Nitrogen and fix it onto the roots of the legume in nodules, in exchange for sugars provided by the plant. When a Nitrogen fixing plant dies, the Nitrogen that it has stored in the nodules is released into the ground in the form of Nitrates. Plants growing there afterwards can use the Nitrogen released by the legume to grow.

On a recent podcast on CBC, the Nitrogen fixing abilities of clovers were discussed. This brought my attention to using clovers as natural fertilizers. Clovers can provide Nitrogen to crops through a natural process. Clovers are a better natural alternative to chemical fertilizers because it's natural, cheaper, and provides other environmental benefits such as increasing the population of honey bees by providing nector liked by the bees. It costs approximately $30 to plant an acre of clover and approximately $200 to fertilizer an acre. It costs 4 times more to use a chemical fertilizer.

The Nitrogen Cycle

The Nitrogen Cycle is a process in which different bacteria convert Nitrogen into different forms. Assimilation, Nitrogen fixation, and denitrification are some of the stages in the Nitrogen Cycle. Nitrogen can go into the soil through 3 different processes. Decomposers expels waste, the initial form of Nitrogen it expels is ammonia. Nitrogen fixing bacteria and fungi convert the organic Nitrogen into ammonium and Nitrogen fixation occurs through 2 different bacteria. One on the roots of plants, the other in the soil itself. Nitrogen fixing bacteria in soil (cyanobacteria) use atmospheric Nitrogen and fix it into soil in the form of Ammonium. Nitrogen fixing bacteria on the roots of legumes (rhizobia) convert atmospheric Nitrogen into nitrates and stores them on the roots in nodules. The stored Nitrogen is released when the plant dies.

Plants intake Nitrogen through Assimilation, a process in which plants intake Nitrogen in the form of Nitrates. Plants cannot assimilate Ammonia. Nitrification is the process which converts Ammonia into Nitrates. This process is very important in the Nitrogen Cycle because plants can not make any other forms of Nitrogen.

Denitrification is the last stage of the cycle, a process which converts Nitrates back into atmospheric Nitrogen.

Purpose

The purpose of this study was to determine if clovers were a viable natural alternative to chemical fertilizers. Regular top soil was used as a control. Miracle Gro was used as the chemical fertilizer because of it's proven ability to work. Nitrogen enriched soil (using clovers) was used as the natural alternative.

The aim of the experiment was to compare a natural fertilizer (clovers) to the benefits of chemical fertilizer, that has already been proven to work. The overall goal of this experiment was to change opinions in the agricultural world regarding chemical fertilizers by providing natural alternatives (such as clovers) as a cheaper, more natural, organic and less dangerous option.

Hypothesis

The plants in the topsoil naturally enriched by clover will grow better than the control because of the higher Nitrogen content. The plants in the topsoil treated with Miracle Gro will do better than the plants in the naturally enriched topsoil because of the additional nutrients.

Procedure: Experiment 1

The experiment was conducted in four different stages over a 40 day time period.

Stage 1, Germinating Clover Seeds:
3 containers were rinsed with water and dried to remove any contaminants or residue. 1 coffee filter was then inserted into each of the containers, where it was moistened and molded into place using 5mL of water. 80 clover seeds were placed into each of the containers and the lids were then closed. The containers were placed in an area which received consistent amounts of sunlight, for 1 days.

Stage 2, Growing Germinated Clover:
3 containers without lids were filled with approximately 1-1.5 in. of topsoil. 80 germinated clover seeds were sprinkled on top of each container. The containers were placed in an area which received consistent amounts of sunlight, for 14 days.

Stage 3, Germinating Fenugreek Seeds: This process began on day 13 of Stage 2. 12 small containers with lids were filled with 4 fenugreek seeds each. Each container was then filled with 10mL of water and the lids were closed. The containers were then placed in an area which received consistent amounts of sunlight for 7 days. This stage produced all germinated fenugreek seeds.

Stage 4, Growing Germinated Fenugreek:
After the clovers grew for 14 days, they were gently ripped out and laid on top of the soil. The clovers were left this way for 3 days before they were removed from the soil completely. 16 containers were filled with regular topsoil and labeled Nitrogen Enriched. 16 containers were filled with regular topsoil and labeled Fertilizer. 16 containers were filled with regular topsoil and labeled Control. One germinated fenugreek seed was planted into each container, a total of 48 specimens - 16 per test sample/control. 0.5 mL of Miracle Gro was mixed with 500mL of water per container daily. The Nitrogen Enriched and Control labelled samples were watered with 10 mL of the Miracle Gro mixture daily. The Fertilizer and Control were watered with 10 mL of water per container daily. The containers were placed in an area which received consistent amounts of sunlight. Observations were recorded daily for 14 days. Plant height and the visible health of individual plants were recorded.

Results: Experiment 1

The results showed differences between the control and test samples over a 14 day time period.

Fertilizer Results: By day 4, the plants watered with the fertilizer had started to turn yellow and dry out. By day 6 it was apparent the plants were the fertilizer weren't growing well. The leaves had disappeared completely and the plant had wilted. By day 14, the last day of my experiment, the plants in the fertilizer had dried out completely and had begun to decompose. On day 14, the average plant height for the Fertilizer was 3.712 cm.

Nitrogen Enriched Results: The plants in the Nitrogen enriched soil grew quickly and by day 4 them were 2 leaves visible on each plant. By day 10 the leaves had grown noticeably larger than day 4. By day 14, the last day of my experiment, the Nitrogen enriched plants had grown larger than the Control and the Fertilizer. On day 14, the average plant height for the Nitrogen Enriched was 7.802cm.

Control Results: The control grew at a steady pace and by day 4 them were 2 leaves visible on each plant. By day 6, 2 of the control plants were not growing. By day 10, the leaves were noticeably larger than on day 4. By day 14 (the last day) the remaining control plants looked healthy and showed no signs of problems. On the 14, the average plant height for the Control was 7.962cm.

Possible Errors

The results show the Fertilizer plants doing the worst. The may have occurred because too much of the fertilizer was introduced to the seeds and became toxic.

After further research I learned that the chemical fertilizer should only be used once every week and not every day. Excessive use of fertilizer can alter the soil's salinity and pH value. High levels of salinity make it difficult for plants to intake water and low levels of pH make nutrients less available, causing various nutritional deficiencies. If the plant had stopped taking in water and wasn't receiving enough nutrients, it could explain the stunt in growth and why the plant dried out.

Improvements

Because of the mistakes made the first time I executed my experiment (misuse of chemical fertilizer), I decided to repeat the experiment with more control over different variables such as: proper use of fertilizer, growth measurements of each plant, measurements of nitrogen levels in the different soil samples, and visual evidence (pictures).

Stage 1 and 2: Because of time restrictions, I was unable to germinate and grow new clovers. Instead, I decided to use clovers that had already been grown in our lawn for approximately one season. The clover roots were carefully sorted and cleaned to remove any soil contaminants.

Measurements: Because Nitrogen plays a large role in plant growth and development, I felt it was important to record measurements of each plant. This showed the growth rate of the different specimens, in turn, showing the effect the fertilizer and the naturally enriched soil had on the plants.

Nitrogen Testers: I decided to test each of the soil samples for Nitrogen because by finding out the Nitrogen content in the soil, I would have more evidence to support my conclusion. For my first experiment, I had no definite way of telling if Nitrogen was in the soil, and how much of it. By choosing to test each of the soil samples, I had conclusive evidence to support my final conclusion.

Visual Evidence: I decided to take daily pictures of each plant to provide visual proof of plant growth, instead of only using observations.

Procedure: Experiment 2

This experiment was conducted in 3 different stages over a 15 day time period.

Stage 1, Germinating The Fenugreek:
12 small containers with lids were filled with 4 fenugreek seeds each. Each container was then filled with 10mL of water and the lids were closed. The containers were then placed in an area which received consistent amounts of sunlight for 5 days. This stage produced 48 germinated fenugreek seeds. This stage was carried out at the same time as Stage 2 and lasted only 5 days due to time restrictions.

Stage 2, Making Nitrogen Enriched Soil:
Finding/Cleaning: 20 clover plants were dug up using a shovel. Each plant was rinsed with water and detangled from other roots (grass or other weed roots). The clovers were then washed more carefully in a tray of water to remove any excess dirt and contaminants from outside.
Cutting/Mixing: The tops of the clovers were cut off from the roots, and the roots were cut into small pieces, to prevent the plants from growing. Because, I planned on mixing the plants into the soil, I needed to take the necessary precautions to ensure they didn't grow back. I took a plastic 2L container and filled it with 4 cups of dirt. I placed the cut up roots inside and mixed the soil well. I sealed the lid and placed the container in an area with small amounts of sun light, for 5 days.

Stage 3, Planting The Fenugreek:
16 containers were filled with the naturally enriched (by clover) soil and labeled Nitrogen Enriched. 16 containers were filled with regular topsoil and labeled Fertilizer. 16 containers were filled with regular topsoil and labeled Control. One germinated fenugreek seed was planted into each container, a total of 48 specimens - 16 per test sample/control. 0.5 mL of Miracle Gro was mixed with 500mL of water, according to package instructions. The Nitrogen Enriched and Control labelled samples were watered with 10 mL of filtered water per container, daily. The Fertilizer labelled samples were watered with 10 mL of the Miracle Gro mixture on the first day, and regular water on all the other days. The containers were placed in an area which received consistent amounts of sunlight, observations were recorded daily for 10 days. Plant height and the visible health of individual plants were recorded.

Results: Experiment 2

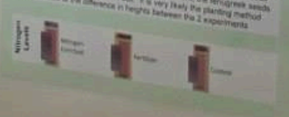
The results show differences between the control and test samples over a 9 day time period.

Fertilizer Results: By day 3, there were visible signs of growth in most of the plants. By day 4, there were 2 Fertilizer plants which had not sprouted, but the other plants had 2 visible leaves. By day 6, it was visually evident the Fertilizer plants were doing better than the Control and the N Enriched. By day 8, a third leaf had begun to grow on all plants except for 2. At day 9, the last day of my experiment, it was clear the plants in the fertilizer had grown the best. The final height average for the Fertilizer plants was 5.8cm.

Nitrogen Enriched Results: By day 3, there were visible signs of growth in most of the plants. By day 4, there were 5 Nitrogen Enriched plants which had not sprouted, but the other plants had 2 visible leaves. By day 6, it was visually evident the Nitrogen Enriched plants were doing better than the Control and 2 of the plants which had not sprouted originally, began to sprout. By day 8, a third leaf had begun to grow on all plants except for 1 plant. At day 9, the last day of my experiment, it was clear the plants in the Nitrogen Enriched had grown better than the control. The final height average for the Nitrogen Enriched plants was 5.4cm.

Control Results: By day 3, there were visible signs of growth in most of the plants. By day 4, there were 2 Control plants which had not sprouted, but the other plants had 2 visible leaves. By day 6, it was visually evident the Control was not growing a well as the N Enriched plants and the Fertilizer. By day 7, a third leaf had begun to grow on all plants except for 6. At day 9, the last day of my experiment, it was clear the Control had grown the worst. The final height average for the Control was 5.2cm.

Note: The plants grown in the second experiment far exceeded the height averages of those grown in the first experiment. This could have been because of the germination times, the way the fenugreek seeds were planted or the longer days of sunlight. In the first experiment, the fenugreek seeds were laid on top of the soil. In the second experiment, the fenugreek seeds were placed under the top of the soil. It is very likely the planting method was the cause of the difference in heights between the 2 experiments.



Conclusion

Based on the results for experiment 1 and 2, it can be concluded clovers leave behind a nutritional benefit once they die. The difference in heights and growth rates between the Control and the Nitrogen Enriched, indicate clovers can act as a viable, natural, alternative to a chemical fertilizer, therefore proving my hypothesis correct. Some of the main indications of plant health are the growth rates and the heights. By both standards, the Nitrogen Enriched plants surpass the Control.

The results from the first experiment show the plants in the fertilizer failing and dying, after fixing this problem, the plants in the second experiment show higher growth rates than the Control and the Nitrogen Enriched.

Because the results from the second experiment show the Fertilizer plants doing better than the Nitrogen Enriched, it can be concluded that fertilizer has additional nutritional benefits. Nitrogen fixation, although a very good method of fertilization, will not provide the same benefits as a chemical fertilizer. It is, however, environmentally safer, cheaper, more natural, and they provide other environmental benefits to the surrounding habitat.

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030113

Finding A Natural Fertilizer

Meera Moorthy

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Background

Potassium (K), Phosphorus (P) and Nitrogen (N) are the most important nutrients to the growth of every plant because of the help they provide in it's growth and health. Potassium improves drought resistance, increases chemical processes and is very important in water regulation. Phosphorus increases plant growth by promoting cell division and the development of new tissue. Nitrogen helps in producing proteins and nucleic acids, increasing plant growth and development.

Plants can only absorb Nitrogen in fixed form. Conversion of atmospheric Nitrogen (N2) to fixed Nitrogen, like Nitrates, occurs through 2 processes called Nitrogen fixation and Haber Bosch process, which uses a chemical reaction to create ammonia or Nitrates (NO3). Nitrates are the only form of Nitrogen plants can absorb for fertilizers. Consequences of these artificial processes include acid rain (due to an increase of ammonia in the atmosphere) and an increase of Nitrous Oxide (a greenhouse gas, the third largest contributor to global warming).

Fertilizers also cause other problems associated with the environment such as an increase of Nitrogen and Phosphorus levels in bodies of water. Nitrogen can be washed out of soil into rivers or streams leading to high levels of Nitrogen which are considered dangerous to human health. Phosphorus can not be separated from soil particles because of the bond it forms with the soil. However, it can be washed into bodies of water with soil. Although high levels of Phosphorus aren't considered dangerous to human health, they stimulate excessive growth of algae, leading to oxygen depletion and dead zones in water bodies. Chemicals in fertilizers can also leak into groundwater resources, contaminating the water.

Natural Nitrogen fixing processes occur because of a bacteria that lives in the roots of legumes. Rhizobia have a symbiotic relationship with all legumes: they use atmospheric Nitrogen and fix it onto the roots of the legume in nodules in exchange for sugars provided by the plant. When a Nitrogen fixing plant dies the Nitrogen that it has stored in the nodules is released into the ground in the form of Nitrates. Plants growing there afterwards can use the Nitrogen released by the legume to grow.

On a recent podcast on CBC, the Nitrogen fixing abilities of clovers were discussed. This brought my attention to using clovers as natural fertilizers. Clovers can provide Nitrogen to crops through a natural process. Clovers are a better natural alternative to chemical fertilizers because it's natural, cheaper, and provides other environmental benefits such as increasing the population of honey bees by providing nectar liked by the bees. It costs approximately $50 to plant an acre of clover and approximately $200 to fertilizer an acre. It costs 4 times more to use a chemical fertilizer.

The Nitrogen Cycle

The Nitrogen Cycle is a process in which different bodies, mixed Nitrogen into different forms. Assimilation, Nitrogen fixation, and decomposition are some of the stages in the Nitrogen cycle. Nitrogen can go into the soil through 2 different processes.

Nitrogen fixation: Nitrogen fixing bacteria, found in the roots of legumes, convert the organic Nitrogen into ammonia and fungi convert the organic Nitrogen to organic compounds. Plants can only absorb Nitrogen in these 2 forms. Decomposers, bacteria, one of the roots of plants, like what is in the soil itself. Nitrogen fixing bacteria is not synthesized like what is in the soil itself. Nitrogen in the soil is in the form of Ammonium ions. Atmospheric Nitrogen and is in roots of legumes (rhizobia) convert atmospheric Nitrogen into Nitrates and stored there on the roots in nodules. The stored Nitrogen is released when the plant dies.

Plants make Nitrogen through Assimilation, a process in which plants slowly Nitrogen in the form of Nitrates. Plants cannot absorb Ammonia. Nitrification is the process which converts Ammonia into Nitrates. The process is very important in the Nitrogen cycle because plants can not obtain any other forms of Nitrogen.

Denitrification is the last stage of the cycle. A process which converts Nitrates back into atmospheric Nitrogen.

Purpose

The purpose of this study was to determine if clovers were a viable natural alternative to chemical fertilizers. Regular fig soil was used as a control. Miracle Gro was used as the chemical fertilizer because of it's proven ability to work. Nitrogen enriched soil using organic was used as the natural alternative.

The aim of this experiment was to compare a natural fertilizer concern to the benefits of chemical fertilizer, that has already been proven to work. The overall goal of this experiment was to change opinions in the agricultural world regarding chemical fertilizers by providing natural alternatives (such as clovers) as a cheaper, more secure, organic and less dangerous option.

Hypothesis

The plants in the topsoil naturally enriched by clover will grow better than the control because of the higher Nitrogen content. The plants in the topsoil treated with Miracle - Gro will do better than the plants in the naturally enriched topsoil because of the additional nutrients.

Procedure: Experiment 1

The experiment was conducted in four different stages over a 45 day time period.

Stage 1. Germinating Clover Seeds
2 containers were rinsed with water and dried to remove any contaminants or residue. 1 coffee filter was then inserted into each of the containers, where it was moistened and molded into place using tins. 40 clover seeds were placed onto each of the containers and the lids were then closed. The containers were placed in an area which received consistent amounts of sunlight, for 7 days.

Stage 2. Growing Germinated Clover
2 containers without lids were filled with approximately 1.13 cu. of topsoil. 20 germinated clover seeds were sprinkled on top of each container. The containers were placed in an area which received consistent amounts of sunlight, for 13 days.

Stage 3. Germinating Fenugreek Seeds
2 - 1/2 wheat containers with lids were filled with 4 fenugreek seeds each. Each container was then placed in an area which received consistent amounts of sunlight for 7 days. This stage produced 48 germinated fenugreek seeds.

Stage 4. Growing Germinated Fenugreek
After the clovers grew for 14 days, they were gently, tipped out and set on top of the soil. The clovers were left this way for 7 days before they were removed from the soil completely. 16 containers were filled with regular topsoil and labeled Control. 16 containers were filled with regular topsoil and labeled Fertilizer. 16 containers were filled with naturally enriched (by clover) soil and labeled Nitrogen Enriched. The Control and Nitrogen Enriched containers were filled with 1 cup of Miracle Gro mixed with 500mL of water, according to package instructions. The Fertilizer labeled containers were filled with 10 mL of the Miracle Gro mixture per container daily. The containers were placed in an area which received consistent amounts of sunlight, observations were recorded daily for 14 days. Plant height and the visible health of individual plants were recorded.

Results: Experiment 1

The results showed differences between the control and soil samples over a 14 day time period.

Fertilizer Results: By day 3, the plants watered with the fertilizer had started to turn yellow and dry out. By day 6 it was apparent the plants in the fertilizer weren't growing well. The leaves had disappeared completely and the plant had wilted. By day 14 all the soil in the experiment was gone in the fertilizer bowl and had not completely sprouted. The plants in the fertilizer had died not completely and had begun to decompose. On day 14, the average plant height for the Fertilizer was 2.712 cm.

Nitrogen Enriched Results: The plants in the Nitrogen enriched soil grew quickly and by day 6 were about 7 leaves visible in each plant. By day 14 all the plants in the Nitrogen enriched soil were still growing. By day 14 the plants had grown substantially larger than they were on day 6. By day 14 the remaining Nitrogen might have been used up. The plants grew taller than the Control and the Fertilizer. On day 14, the average plant height for the Nitrogen Enriched was 3.96cm.

Control Results: The control grew at a steady pace and by day 6 they were 5 leaves visible on each plant. By day 14 the control plants were still growing. By day 14, the leaves were substantially larger than on day 6. By day 14 the plants in the Control were taller than the Fertilizer, but shorter than the Nitrogen Enriched. On day 14, the average plant height for the control was 3.963cm.

Possible Errors

The molds show the Fertilizer plants dying the worst. This may have been because too much of the fertilizer was introduced to the seeds and several from.

After further research I learned that the chemical fertilizer should only be used once every week and not every day. Excessive use of fertilizer can also ruin soil's salinity and pH value. High levels of salinity make it difficult for plants to intake water and low levels of pH make nutrients less available, causing various nutritional deficiencies. If the plant had stopped taking in water and wasn't receiving enough nutrients, it could explain the short in growth and why the plant died out.

Improvements

Because of the mistakes made the first time I executed my experiment (misuse of chemical fertilizer), I decided to repeat the experiment with more control over different variables such as: proper use of fertilizer, growth measurements of each plant, measurements of nitrogen levels in the different soil samples, and visual evidence (pictures).

Stage 1 and 2: Because of time restrictions, I was unable to germinate and grow new clovers. Instead, I decided to use clovers that had already been grown in our lawn for approximately one season. The clover roots were carefully sorted and cleaned to remove any soil contaminants.

Measurements: Because Nitrogen plays a large role in plant growth and development, I felt it was important to record measurements of each plant. This showed the growth rate of the different specimens, in turn, showing the effect the fertilizer and the naturally enriched soil had on the plants.

Nitrogen Testers: I decided to test each of the soil samples for Nitrogen because by finding out the Nitrogen content in the soil, I would have more evidence to support my conclusion. For my first experiment, I had no definite way of telling if Nitrogen was in the soil, and how much of it. By choosing to test each of the soil samples, I had conclusive evidence to support my final conclusion.

Visual Evidence: I decided to take daily pictures of each plant to provide visual proof of plant growth, instead of only using observations.

Procedure: Experiment 2

This experiment was conducted in 3 different stages over a 15 day time period:

Stage 1. Germinating The Fenugreek:
12 small containers with lids were filled with 4 fenugreek seeds each. Each container was then filled with 10mL of water and the lids were closed. The containers were then placed in an area which received consistent amounts of sunlight for 5 days. This stage produced 48 germinated fenugreek seeds. This stage was carried out at the same time as Stage 2 and lasted only 5 days due to time restrictions.

Stage 2. Making Nitrogen Enriched Soil:
Finding/Cleaning: 20 clover plants were dug up using a shovel. Each plant was rinsed with water and detangled from other roots (grass or other weed roots). The clovers were then washed more carefully in a bay of water to remove any excess dirt and contaminants from outside.

Cutting/Mixing: The tops of the clovers were cut off from the roots, and the roots were cut into small pieces, to prevent the plants from growing. Because, I planned on mixing the plants into the soil, I needed to take the necessary precautions to ensure they didn't grow back. I took a plastic 2L container and filled it with 4 cups of dirt. I placed the cut up roots inside and mixed the soil well. I sealed the lid and placed the container in an area with small amounts of sun light, for 5 days.

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16 containers were filled with the naturally enriched (by clover) soil and labeled Nitrogen Enriched. 16 containers were filled with regular topsoil and labeled Fertilizer. 16 containers were filled with regular topsoil and labeled Control. One germinated fenugreek seed was planted into each container, a total of 48 specimens - 16 per test sample/control. 0.5 mL of Miracle Gro was mixed with 500mL of water, according to package instructions. The Nitrogen Enriched and Control labelled samples were watered with 10 mL of filtered water per container, daily. The Fertilizer labelled samples were watered with 10 mL of the Miracle Gro mixture on the first day, and regular water on all the other days. The containers were placed in an area which received consistent amounts of sunlight, observations were recorded daily for 10 days. Plant height and the visible health of individual plants were recorded.

Results: Experiment 2

The results show differences between the control and test samples over a 8 day time period.

Fertilizer Results: By day 3, there were visible signs of growth in most of the plants. By day 4, there were 2 Fertilizer plants which had not sprouted, but the other plants had 2 visible leaves. By day 8, it was visually evident the Fertilizer plants were doing better than the Control and the N Enriched. By day 8, a third leaf had begun to grow on all plants except for 2. All day 8, the last day of my experiment, it was clear the plants in the fertilizer had grown the best. The final height average for the Fertilizer plants was 8.9cm.

Nitrogen Enriched Results: By day 3, there were visible signs of growth in most of the plants. By day 4, there were 5 Nitrogen Enriched plants which had not sprouted, but the other plants had 2 visible leaves. By day 8, it was visually evident the Nitrogen Enriched plants were doing better than the Control and 2 of the plants which had not sprouted originally, began to sprout. By day 8, a third leaf had begun to grow on all plants except for 1 plant. All day 8, the last day of my experiment, it was clear the plants in the Nitrogen Enriched had grown better than the control. The final height average for the Nitrogen Enriched plants was 8.4cm.

Control Results: By day 3, there were visible signs of growth in most of the plants. By day 4, there were 2 Control plants which had not sprouted, but the other plants had 2 visible leaves. By day 8, it was visually evident the Control were not growing as well as the N Enriched plants and the Fertilizer. By day 7, a third leaf had begun to grow on all plants except for 6. All day 8, the last day of my experiment, it was clear the Control had grown the worst. The final height average for the Control was 6.2cm.

Note: The plants grown in the second experiment far exceeded the height averages of those grown in the first experiment. This could have been because of the germination times, the way the fenugreek seeds were planted or the longer days of sunlight. In the first experiment, the fenugreek seeds were laid on top of the soil. In the second experiment, the fenugreek seeds were placed under the top of the soil. It is very likely the planting method was the cause of the difference in heights between the 2 experiments.

Conclusion

Based on the results for experiment 1 and 2, it can be concluded clovers were behind a nutritional benefit since they did. The difference in heights and growth rates between the Control and the Nitrogen Enriched, indicate clovers can act as a viable, natural, alternative to a chemical fertilizer, therefore proving my hypothesis correct. Some of the cons to a chemical fertilizer, therefore proving my hypothesis correct. Some of the cons to a chemical fertilizer are the growth rates and the heights. By both standards, the Nitrogen Enriched plants surpass the Control.

The results from the first experiment show me plants in the fertilizer falling and dying, after doing this problem, the plants in the second experiment show higher growth rates than the Control and the Nitrogen Enriched.

Because the results from the second experiment show the Fertilizer plants doing better than the Nitrogen Enriched, it can be concluded that fertilizer has additional nutritional benefits. Nitrogen fixation, although a very good method of production, will not provide the same benefits as a chemical fertilizer. It is, however, environmentally safer, cheaper, more natural, and they provide other environmental benefits to the surrounding habitat.

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Can We Improve the Quality of Developing and Third World

Rachel Brouwer

ou gauche?

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"The Strength of Dogs' Olfactory System Among Different Breeds".

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Take Your Best Shot

010112 Seamus Stears

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"The Strength of Dogs' Olfactory System Among Different Breeds".

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Alex Schneider

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Take Your Best Shot

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Seamus Stears

Verulam Ordovician Fossils vary due to composition and level of Strata?

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Small But Mighty-The Environmental Impact of Microbeads

030211 Holly Tetzlaff

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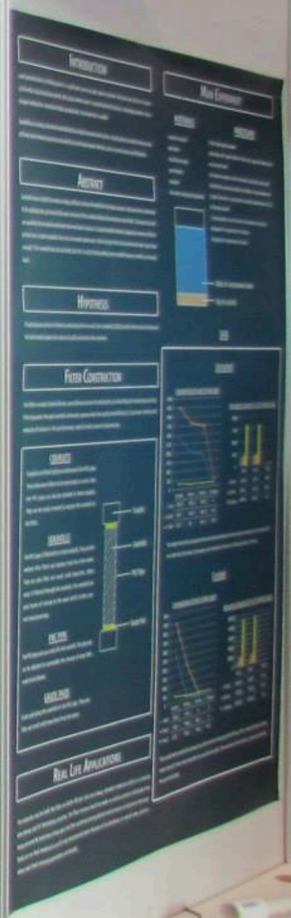
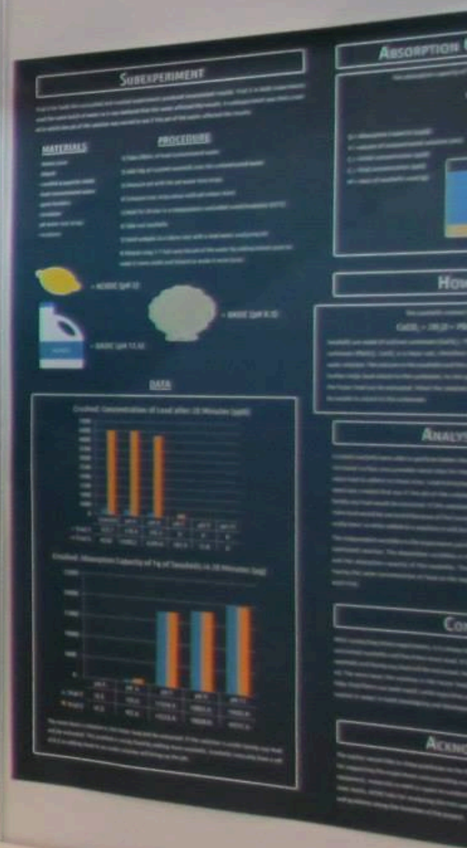
Lead it Go: Purifying Lead Co
Water with Common Seashell

030212 Olivia Li





Do Verulam Ordovician Fossils vary due to the composition and level of Strata?

210 Dylan Rowe

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Small But Mighty-The Environmental Impact of Microbeads

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Lead it Go: Purifying Water with Common

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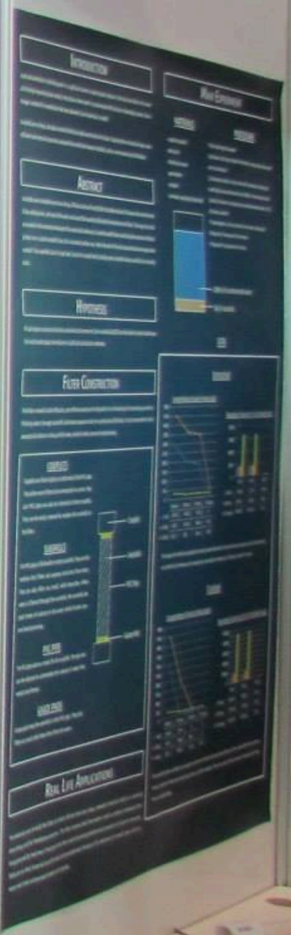
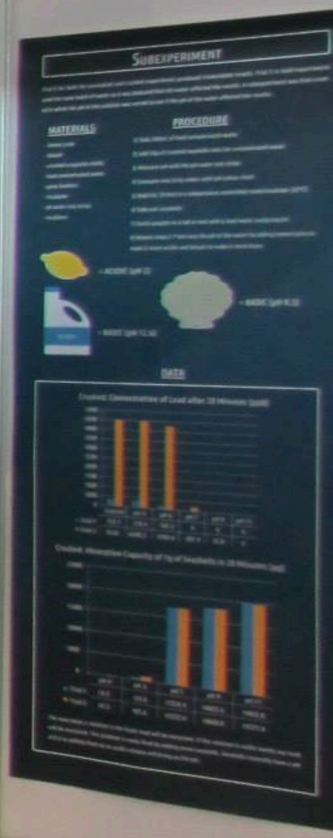




CWSF ESPC

Shade is Cool

030210 Caroline Burchat • Anna Supryka

AB

ON

Tea Time

060118

Cameron Bourdeau

ON

INTRODUCTION

Camellia, the genus more widely known by its common name - tea - is everywhere these days. We consume it; it consumes us. For nearly 5,000 years, it has been cultivated in mountainous, equatorial regions the world over. Whether utilized as an inexpensive source of nourishment, as a ceremonial or ritualistic tonic, as an ultimate comfort brew or catalyst for a multi-billion dollar wellness movement, tea has experienced a substantial rise to the top of the beverage charts, second only to water. Canadians spend almost $500,000,000 on tea per year which translates to a consumption figure of approximately 79L per person. The flavours, varieties, and content seem to differ endlessly in almost every store you visit. Most commercially available teas, however, fall into four basic categories:

Black tea - The most common type of tea in North America, it is oxidized (left in a room to dry/ferment) for the longest period of time. A common misconception is that this longer oxidation time increases the caffeine level of the end product. Although there are numerous factors that contribute to the caffeine level in tea, such as soil chemistry, altitude, or position of the leaf on the plant and cultivation practices, oxidation time is not one of them.

Green tea - The predominant choice of the tea lover in Central and East Asia, these leaves are picked very young in the spring, and are pan-fired or steamed before their quick drying process to preserve their delicate flavour and keep their appearance intact.

Decaffeinated tea- All varieties of tea can go through the most prominent industrial decaffeination process which involves the spraying of dichloromethane and ethyl acetate. The spraying and drying process occurs for up to ten hours and has only a slight effect on the taste of the leaf itself. Decaffeination still leaves 1-2% of the caffeine in the leaves, however.

Herbal tea – This is technically not a tea at all; rather a composition of flowers and other plant matter, fruit, herbs, spices, and sometimes other things like chocolate. Due to the fact that there is no tea in herbal "tea," it contains little to no caffeine.

BACKGROUND

On any given weekend afternoon or after dinner through the week, there are teapots and tea cups strewn about the house. Differing flavours; some with milk, some with honey, and some with sugar; each of us savouring a unique variation of our home-brewed favourite. By chance, what I observed and found very interesting was that, regardless of brand, type or ingredients, each member of my family had a different method of steeping tea to achieve their desired result. Did we all have our own precise and meticulously practiced methods, factoring in time and temperature? Or, were we simply and subconsciously, able to define the taste of our tea with our eyes? I decided to put this to the test, and built a simple device to measure the strength of tea using a photoresistor. Project Tea Time, began.

QUESTION

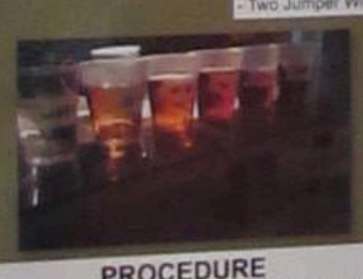
Given the large array of tea types available, based on temperature and time, do four popular varieties strengthen equally?

HYPOTHESIS

I don't think that the teas will strengthen equally, however I think they will strengthen in similar patterns, but at different levels of strength.

MATERIALS

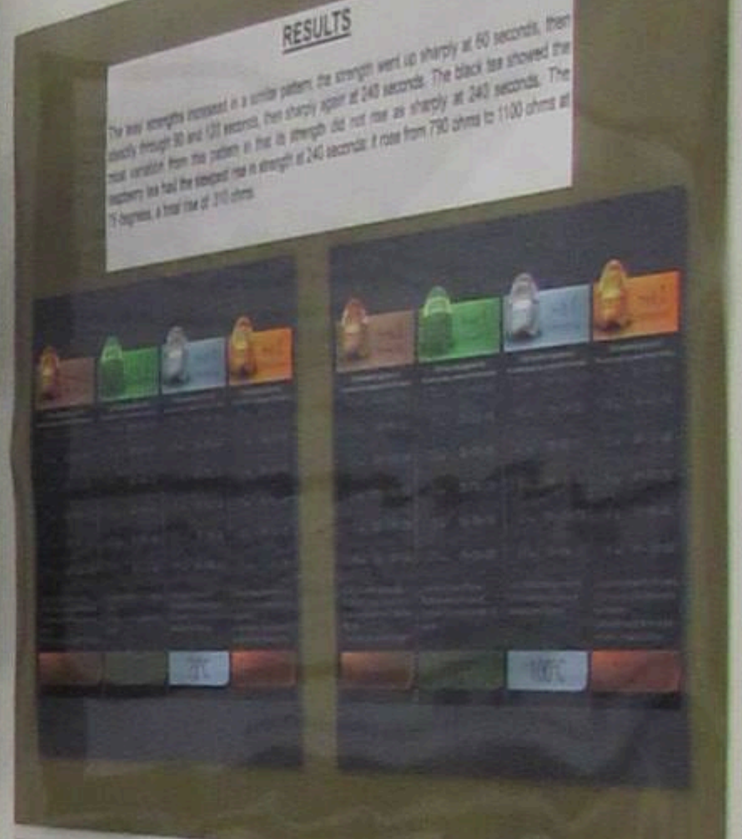
- Clear Plastic Cup
- Aluminum Foil
- Cadmium Sulfide Photoresistor
- Cooking Surface
- Timer
- Two Jumper Wires, with Clips
- Multimeter
- Kettle
- Electrical Tape
- Water
- Spoon
- Measuring Cup



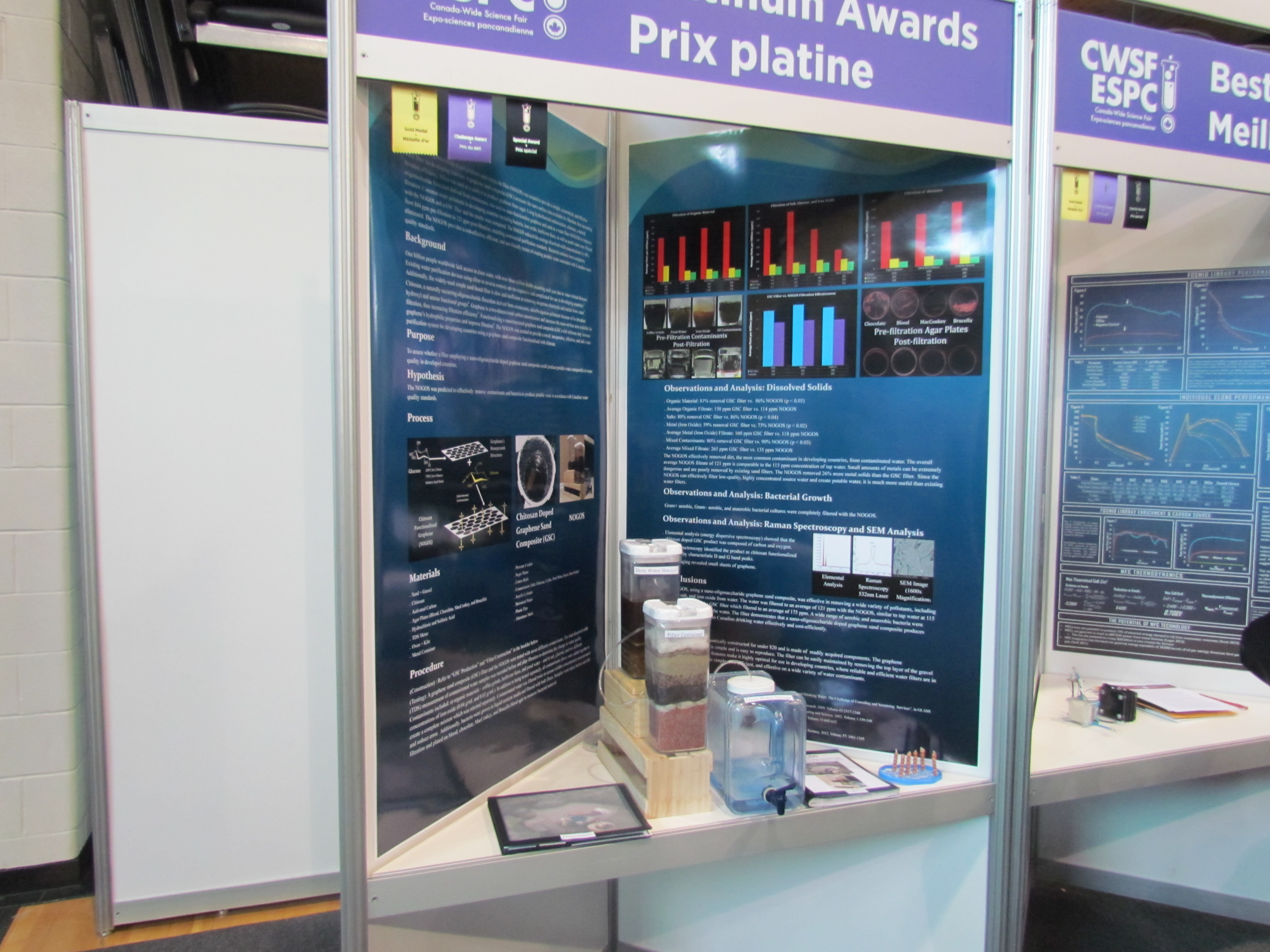
PROCEDURE

1. Use electrical tape to secure the photoresistor to the bottom of a clear plastic cup. The clear cup is needed because light cannot pass through an opaque object. Once the photoresistor has been placed (squiggly line facing the cup), cover the bottom with the electrical tape.
2. Cover the outside of the cup with aluminum foil so the light shining into the cup is reflected towards the photoresistor.
3. Place the cup under the lamp. Make sure the lamp is directed into the cup.
4. Boil a kettle of water at 100°C and pour 500 mL into the measuring cup.
5. Drop a tea bag into the water and start a four-minute timer. Remove the tea bag with a spoon when the timer is done. Pour the tea into a clear plastic cup, filling it three-quarters of the way, and discard the rest of the tea.
6. Repeat steps 4-5 with 30 second, 60 second, 120 second and 240 second increments.
7. Move the teas to the testing device.
8. Turn on the multimeter and set it to resistance mode. If you do not have an auto-ranging multimeter, set it to the 2000-ohm range so the reading is an exact number of ohms with no decimal places.
9. One at a time, place the tea cups into the testing device (This is where the clear tea cups become important: the light must pass through the cups before hitting the photoresistor), wait for a stable multimeter reading, and record the reading.
10. Repeat steps 4-10 with the other three tea types; then repeat steps 4-10 with water at 75°C.

RESULTS



CONCLUSION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Awards
Prix platine
CWSF
ESPC
Gold Medal
Médaille d'Or
Challenge Award
Prix du défi
Special Award
Prix spécial
Background
Purpose
To assess whether a filter employing a nano-oligosaccharide doped graphene sand composite could produce potable water comparable to water quality in developed countries.
Hypothesis
The NOGOS was predicted to effectively remove contaminants and bacteria to produce potable water in accordance with Canadian water quality standards.
Process
Glucose
Chitosan Functionalized Graphene (NOGOS)
Chitosan Doped Graphene Sand Composite (GSC)
NOGOS
Materials
Procedure
Filtration of Organic Material
GSC Filter vs. NOGOS Filtration Effectiveness
Pre-Filtration Contaminants
Post-Filtration
Chocolate
Blood
MacConkey
Brucella
Pre-filtration Agar Plates
Post-filtration
Observations and Analysis: Dissolved Solids
. Organic Material: 81% removal GSC filter vs. 86% NOGOS (p < 0.05)
. Average Organic Filtrate: 150 ppm GSC filter vs. 114 ppm NOGOS
. Salts: 80% removal GSC filter vs. 86% NOGOS (p < 0.04)
. Metal (Iron Oxide): 59% removal GSC filter vs. 73% NOGOS (p < 0.02)
. Average Metal (Iron Oxide) Filtrate: 160 ppm GSC filter vs. 118 ppm NOGOS
. Mixed Contaminants: 80% removal GSC filter vs. 90% NOGOS (p < 0.03)
. Average Mixed Filtrate: 265 ppm GSC filter vs. 135 ppm NOGOS
The NOGOS effectively removed dirt, the most common contaminant in developing countries, from contaminated water. The overall average NOGOS filtrate of 121 ppm is comparable to the 115 ppm concentration of tap water. Small amounts of metals can be extremely dangerous and are poorly removed by existing sand filters. The NOGOS removed 26% more metal solids than the GSC filter. Since the NOGOS can effectively filter low-quality, highly concentrated source water and create potable water, it is much more useful than existing water filters.
Observations and Analysis: Bacterial Growth
Gram+ aerobic, Gram- aerobic, and anaerobic bacterial cultures were completely filtered with the NOGOS.
Observations and Analysis: Raman Spectroscopy and SEM Analysis
Elemental Analysis
Raman Spectroscopy 532nm Laser
SEM Image (1600x Magnification)
Dirty Water Storage
Filter Container

CWSF ESPC
Canada-Wide Science Fair
Expo-sciences pancanadienne

Best Project
Meilleur projet

Gold Medal / Médaille d'or

Special Award / Prix spécial

ABSTRACT

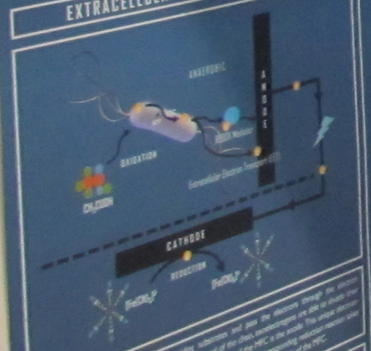
In this study, a novel procedure was utilized to identify genes with roles in power output of exoelectrogenic bacteria in microbial fuel cells (MFCs). An *E. coli* fosmid library constructed from microorganisms in a bioreactor fed with metal-contaminated water was incubated into dual-chamber, batch operated MFCs. The MFCs incubated with the fosmid clones performed significantly better than the MFCs incubated with a *E. coli* DH5α control strain generating almost 4 times more peak power in a 48 hour incubation period. Biofilm samples were extracted from the MFCs and individual clones isolated. Incubation with the isolated clones revealed four clones with significant improvements in power output over the control strain. The results of this study demonstrate that using a gain of function approach to rapidly screen a wide array of genes in gene libraries may be an efficient and feasible method to identify genes that enhance power generation of exoelectrogenic microbes in MFCs.

INTRODUCTION

Microbial fuel cells (MFCs) are bioelectrochemical systems (BESs) that convert chemical energy into electrical energy by utilizing microbes to oxidize organic or inorganic substrates to generate power (Ismail et al. 2013). Recently, new developments have been made in mediatorless MFCs. These exploit the electron transferring capabilities of exoelectrogens, which have the ability to transfer electrons directly to an external electron acceptor without the assistance of exogenic redox mediators (Logan 2009).

Although the design and operation of MFCs are fairly advanced, our current understanding of the biological functions and the role of certain genes in driving the mechanisms of electron transfer of exoelectrogens are lacking (Fedorovich et al. 2009).

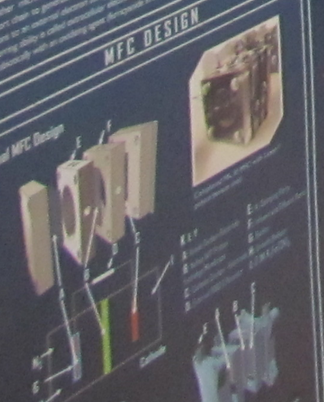
EXTRACELLULAR ELECTRON TRANSPORT



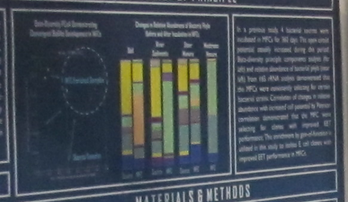
Like other microbes, exoelectrogens require nutrients and the electron acceptor for cellular maintenance. Due to the nature of their metabolism, exoelectrogens are able to shuttle electrons to an external electron acceptor, such as the anode of the MFC, a process known as extracellular electron transferring during a cellular respiration process. The electrons then flow through the circuit to the cathode where they combine with an oxidizing agent, commonly oxygen in the diagram on the outside of the MFC.

MFC DESIGN

Final MFC Design

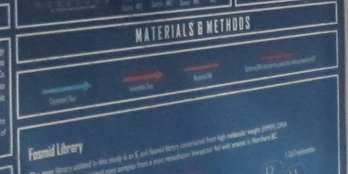


PROOF OF PRINCIPLE



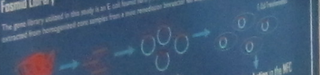
In a previous study 4 bacterial species were incubated in MFCs for 192 days. The open circuit potential steadily increased during the period. Biodiversity gradually progressed, despite the pH and relative abundance of bacterial phyla (over 48). From 16S rRNA analysis demonstrated that the MFCs were extremely selective for certain bacterial species. Conversion of changes in relative abundance with increased cell potential by Pearson correlation demonstrated that the MFC were selecting for clones with improved EET performance. This environment for gene discovery is utilized in this study to isolate 5 *E. coli* clones with improved EET performance in MFCs.

MATERIALS & METHODS



Fosmid Library

The gene library isolated in this study is an *E. coli* fosmid library constructed from high molecular weight (HMW) DNA extracted from homogenized core samples from a mine remediation bioreactor fed with arsenic in Northern BC.

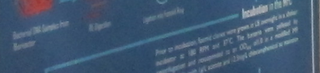


Performance Evaluation

MFCs were connected to a 1K Ω external resistor and the voltage measured continuously using a data acquisition device (Omega Engineering Inc.). Once voltage stabilized, polarization and power curves were generated. Cell voltage and current were recorded using the same instrument. Incubations were conducted in duplicate MFCs using *E. coli* DH5α as a control strain (Kirchhoff, Hamelers).

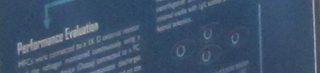
Clone Isolation

Prior to incubation, fosmid clones were grown in LB overnight in a 96-well plate and subsequently frozen in 15% glycerol at -80 °C. The bacteria were pelleted by centrifugation and resuspended in 1x PO_4 at 0.5 in a modified 96-well plate. Fosmid clones were isolated by incubating the MFCs with 1g/L acetate and 0.25g/L chloramphenicol to maintain fosmid selection.



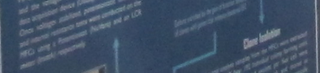
DNA Extraction

DNA was extracted from clones in 1.5 mL MFC effluent using a plasmid extraction kit (Qiagen). Plasmid DNA was then digested with restriction enzyme Sau3AI from New England Biolabs. The digested DNA was then run on a 0.8% agarose gel and the DNA fragments between 30 and 40 kb were extracted using a gel extraction kit (Qiagen).



Library Construction

Extracted DNA was ligated into the pCC1FOS vector using the EPICENTRE CopyControl™ Fosmid Library Production Kit. The ligated DNA was then packaged into lambda phage particles using MaxPlax™ Lambda Packaging Extract. The packaged phage particles were then transduced into *E. coli* EPI300™ cells and plated on LB agar plates containing chloramphenicol (12.5 μg/mL) and X-gal (40 μg/mL). Fosmid clones were picked using a sterile toothpick and inoculated into 96-well plates containing LB broth with chloramphenicol (12.5 μg/mL) and 15% glycerol. Fosmid libraries were stored at -80 °C.



Sequencing

Fosmid DNA was extracted from clones using the Qiagen Plasmid Purification Kit. Sequencing was performed by the Genome Sequencing Centre at the BC Cancer Research Centre using the Illumina HiSeq 2000 platform.

Bioinformatics

Sequences were assembled using Velvet (Zerbino and Birney 2008) and annotated using the RAST server (Aziz et al. 2008). Open reading frames (ORFs) were identified using MetaGeneMark (Zhu et al. 2010). Sequences were compared to the NCBI database using BLAST (Altschul et al. 1990).

FOSMID LIBRARY PERFORMANCE

Figure 1

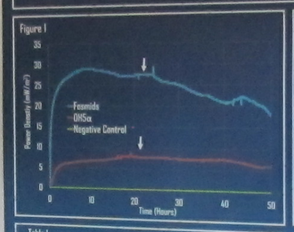


Figure 2

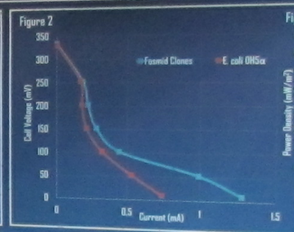


Figure 3

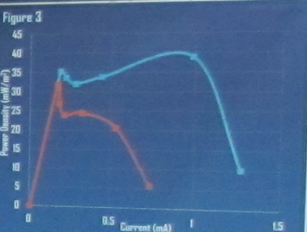


Table 1	Parameter	Fosmid-Library MFC	E. coli DH5α MFC
	Peak Cell Potential	502mV ± 7.78mV	130mV ± 4.24mV
	Peak Power Density	77.5mW/m² – 7.22mW/m²	7.58mW/m² ± 0.635mW/m²
	Internal Resistance	65.2Ω	65.5Ω
	Rint Power	38.8mW/m²	31.8mW/m²
	Current at Rint power	8.888mA	9.71mA
	Open Circuit Potential (OCP)	505mV	505mV
	Rint	43.8%	48.7%

Fig 1. Power density of the MFCs incubated with the fosmid library (FMFC), *E. coli* DH5α control strain (DMFC), and GPS only (NC) across a 10000 Ω resistor normalized to the surface area of the anode. Arrows indicate feeding.

Fig 2. Polarization curve for FMFCs and DMFCs derived from potentiostatic discharge 1-V curves (not shown). Note the three overpotential regions: η_{act}, η_{ohm} and η_{conc}.

Fig 3. Power curves for the FMFCs and DMFCs derived from the polarization curve (Fig.2). Note the improved power output of the FMFCs across the operable current range.

Fig 4. Comparison of power density of fosmid clones running on mineral incubated in pure culture.

Fig 5. Polarization curve for individual fosmid clones compared to *E. coli* DH5α.

Fig 6. Power curves for individual fosmid clones compared to *E. coli* DH5α.

Table 1. Performance summary of MFCs incubated with fosmid clones and *E. coli* DH5α.

Table 2. Performance summary of MFCs incubated with fosmid clones in pure culture. P-values were determined using a two-tailed unpaired t-test conducted on the peak power output of the library or each fosmid clone against that of the *E. coli* DH5α control.

INDIVIDUAL CLONE PERFORMANCE

Figure 5

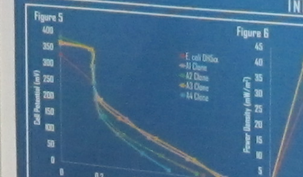


Figure 6

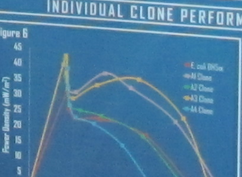


Figure 4

Table 2	Clone	A1A1	A1A2	A1A3	A1A4	A2A1	A2A2	A2A3	A2A4	DH5α	Fosmid Library
	Peak Cell Potential (mV)	504 ± 10.1	515 ± 15.6	508 ± 3.45	174 ± 70.7	177 ± 25.9	133 ± 13.2	169 ± 4.24	169 ± 4.24	130 ± 4.24	497 ± 7.78
	Peak Power Density (mW/m²)	70.1 ± 4.6	65.0 ± 3.78	70.1 ± 0.849	21.8 ± 5.47	8.7 ± 4.68	7.59 ± 1.73	7.58 ± 6.35			27.5 ± 2.72
	% Improvement in P	256 ± 87.1	228 ± 53.9	270 ± 25.29	-209 ± 79.6	148 ± 83.1	105 ± 24.5				284 ± 42.4
	P-value	0.0039	0.0016	<0.0001	0.0197	0.1653	0.7035				<0.0001
	R_{Int} (Ω)	51.3	54.7	52.1	42.8			48.7			47.5

FOSMID LIBRRAY ENRICHMENT & CARBON SOURCE

Fig. 7. Comparison of power density of MFCs incubated with fosmid clones and an empty vector control with ferricyanide as the terminal electron acceptor.

Figure 7

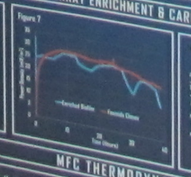
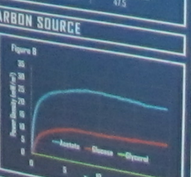


Fig 8. Power density comparison of MFCs incubated with fosmid clones with acetate, glucose and glycerol as the carbon source. All MFCs were incubated with 1g/L glycerol were inoculated.

Figure 8



MFC THERMODYNAMICS

Max Theoretical Cell *Emf*

Oxidation at Anode

$CH_3COO^- + 4H_2O \rightarrow 2HCO_3^- + 9H^+ + 8e^-$

$E^\circ_{anode} = -0.296V$

Reduction at Anode

$2O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

$E^\circ_{cathode} = +0.805V$

$E^\circ = 1.000$

$E^\circ_{cathode} = \frac{RT}{nF} \ln \frac{[O_2]^2[H^+]^4}{[H_2O]^2}$

$E^\circ_{cathode} = 0.410V$

Max Cell Emf

$Emf = E^\circ_{cathode} - E^\circ_{anode}$

$= 0.410V - (-0.296) =$

0.706V

Thermodynamic Efficiency

$\eta_{MFC} = \frac{V_{measured}}{E_{emf}}$

THE POTENTIAL OF MFC TECHNOLOGY

- MFCs have the potential to produce 10% of electrical energy demand in US from wastewater treatment (Scott 2012)
- MFCs can generate as much as 600 GW power from waste biomass (Logan 2012)
- MFCs have the potential to create $30 billion in new income for farmers
- The US has the potential to create 830 billion in new income for farmers (Scott 2012)
- The US has the potential to create 830 billion in new income for farmers (Scott 2012)

CONCLUSIONS

The MFCs incubated with the fosmid clones produced significantly more power than the MFCs incubated with an *E. coli* DH5α control strain, generating approximately 4 times more peak power during a 48 hour incubation period. Results from the polarization and power curves demonstrated enhanced performances in the mid to high current ranges; this suggests that the fosmid clones may carry genes that code for extracellular proteins that improve EET or enhance biofilm structures. Four individual clones isolated from the enriched media demonstrated significant improvements in power output over the control strain.

Polarization and power curves for the individual clones revealed clones with enhancements in both upper and lower current ranges, suggesting that the different gene inserts are conferring different advantages to the clones. The A2 and A3 clones demonstrated enhancements in the lower current ranges, suggesting enhancements in charge-transfer kinetics or substrate metabolism.

The results of this study demonstrate that using a gain of function approach to rapidly screen a wide array of genes in a gene library may be an efficient method to identify genes that enhance power generation of exoelectrogenic microbes in MFCs. Further work is needed to narrow down the gene responsible for the performance enhancement. This includes plasmid library construction of the fosmid inserts and further screening steps.

ACKNOWLEDGEMENTS

The researcher would like to thank the following for their contributions: Andy Hoh, faculty Dr. Steve Baldwin, for providing lab space and guidance; Dr. Yinghui Zhang for assistance in the lab; Dr. Jeff Gostomski, for providing the mine water; and graduate students Dr. Yinghui Zhang, Dr. Jeff Gostomski, and Mr. Robert Cheng, for their contributions and encouragement.

REFERENCES

- Logan, B.E. and J.M. Regan. Electricity-producing bacterial communities in microbial fuel cells. Trends in Microbiology, 2006. 14(12): 512-518.
- Logan, B.E., Microbial Fuel Cells. 2008: John Wiley & Sons.
- Logan, B.E., Exoelectrogenic bacteria that power microbial fuel cells. Nature Reviews Microbiology, 2009. 7(5): 375-381.
- Logan, B.E., et al., Microbial Fuel Cells: Methodology and Technology. Environmental Science & Technology, 2006. 40(17): 5181-5192.
- Rabaey, K. and W. Verstraete, Microbial fuel cells: novel biotechnology for energy generation. Trends in Biotechnology, 2005. 23(6): 291-298.
- Rabaey, K., et al., Biofuel cells select for microbial consortia that self-mediate electron transfer. Applied and Environmental Microbiology, 2004. 70(9): 5373-5382.
- Rabaey, K., et al., Microbial ecology meets electrochemistry: electricity-driven and driving communities. The ISME Journal, 2007. 1(1): 9-18.
- Rabaey, K., et al., Continuous microbial fuel cells convert carbohydrates to hydrogen and lactic acid. Biotechnology and Bioengineering, 2005. 93(4): 784-788.
- Rabaey, K., et al., Microbial Fuel Cells for Sulfide Removal. Environmental Science & Technology, 2006. 40(17): 5218-5224.
- Rabaey, K., et al., Microbial Phenazine Production Enhances Electron Transfer in Biofuel Cells. Environmental Science & Technology, 2005. 39(9): 3401-3408.
- Rabaey, K., et al., Tubular microbial fuel cells for efficient electricity generation. Environmental Science & Technology, 2005. 39(20): 8077-8082.
- Rabaey, K., et al., Biofuel cells select for microbial consortia that self-mediate electron transfer. Applied and Environmental Microbiology, 2004. 70(9): 5373-5382.
- Rabaey, K., et al., Microbial ecology meets electrochemistry: electricity-driven and driving communities. The ISME Journal, 2007. 1(1): 9-18.
- Rabaey, K., et al., Continuous microbial fuel cells convert carbohydrates to hydrogen and lactic acid. Biotechnology and Bioengineering, 2005. 93(4): 784-788.
- Rabaey, K., et al., Microbial Fuel Cells for Sulfide Removal. Environmental Science & Technology, 2006. 40(17): 5218-5224.
- Rabaey, K., et al., Microbial Phenazine Production Enhances Electron Transfer in Biofuel Cells. Environmental Science & Technology, 2005. 39(9): 3401-3408.
- Rabaey, K., et al., Tubular microbial fuel cells for efficient electricity generation. Environmental Science & Technology, 2005. 39(20): 8077-8082.

CWSF ESPC
Canada-Wide Science Fair
Expo-sciences pancanadienne

Benford's Law

060120 David Tobias Holcer

BC

Silver Medal
Médaille d'argent

Purpose/ Problem

It seems like this problem or "Law" is ridiculous. How and why in the world is this possible? I set out to try to show that this law really does work and isn't all a myth.

Frank Benford
American engineer and physicist, accredited for Benford's Law.

Hypothesis

I believed that after conducting multiple experiments in different fields, the results would conclude that the percentage of occurrence of leading digits would match the predicted percentages of Benford's Law.

Background

I myself am very interested in mathematics and in computers. Because of this, I knew that I wanted to pick a project that I would enjoy working on and studying. I was looking around for ideas, and after contemplating multiple choices, I ended upon Benford's law.

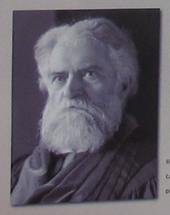
Procedure

For this experimental study I used few materials:
- A computer
- Specific applications : Mathematica, the Python programming language, Excel.
- Data from the U.S. Census.

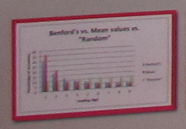
What I did in this experiment is I took different kinds of data (such as population of counties) and identified the leading digit for each of the entries of this data set. Using computer programming with Python and other powerful languages such as Mathematica (great for its data retrieval), I was able to gather data for this experiment.

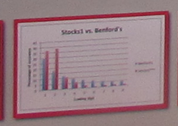
Background Research

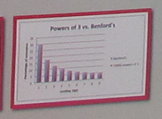
Benford's law states that leading digits in numbers of nature or numbers that we don't control turn out to be 1 more than they turn out to be 9. This seems counter-intuitive at first, wouldn't we expect all numbers to be seen the same amount of times as starting digits. This "random" sorting is not what occurs with Benford's law.
Ironically Frank Benford did not discover this law, but in fact, a Canadian mathematician Simon Newcomb discovered this in 1881. While he was using a log book (log books were used in the old days as a shortcut to multiplication since it was simpler), he found that the earlier pages of the book were getting more worn than the later pages.

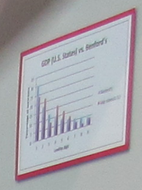


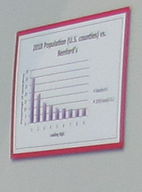
Simon Newcomb
Canadian mathematician and astronomer.
Discovered Benford's Law in 1881.











Conclusions

I can conclude with this project's results that Benford's law is truly a law I can support this through the results of my data sets, which closely match Benford's predicted percentage of leading digits and after running statistical analysis (T-tests) I was able to show that there was a significant correlation between given data sets. Much of the relevance of these conclusions has to do with real world applications (assessing if a data representation in today's world such as populating stock prices or values).

Results and Observations

The results of my experiment were mostly positive and followed what I had predicted in my hypothesis. Given the data sets I tested for I was able to find out that in general, Benford's law worked, and was apparent in the results I got and in the bar graphs I drew.

Sources of Error

Time frames, and unit of measurement could have created small errors in my project. While looking at my data, I found a few outliers because of these reasons.

Future work

If I were to develop this project further in the future, I would be interested looking out the relationship between time and the leading digit that occurs. I would pose the question:
"Is there a correlation between the percentage of occurrence of the leading digit in 1 field that will be consistent after a lengthy time period?" For example, I would be interested in researching if words that are used in the year 1900 would have the same percentage of occurrence of leading digits as words used in the year 2000.

Real World application

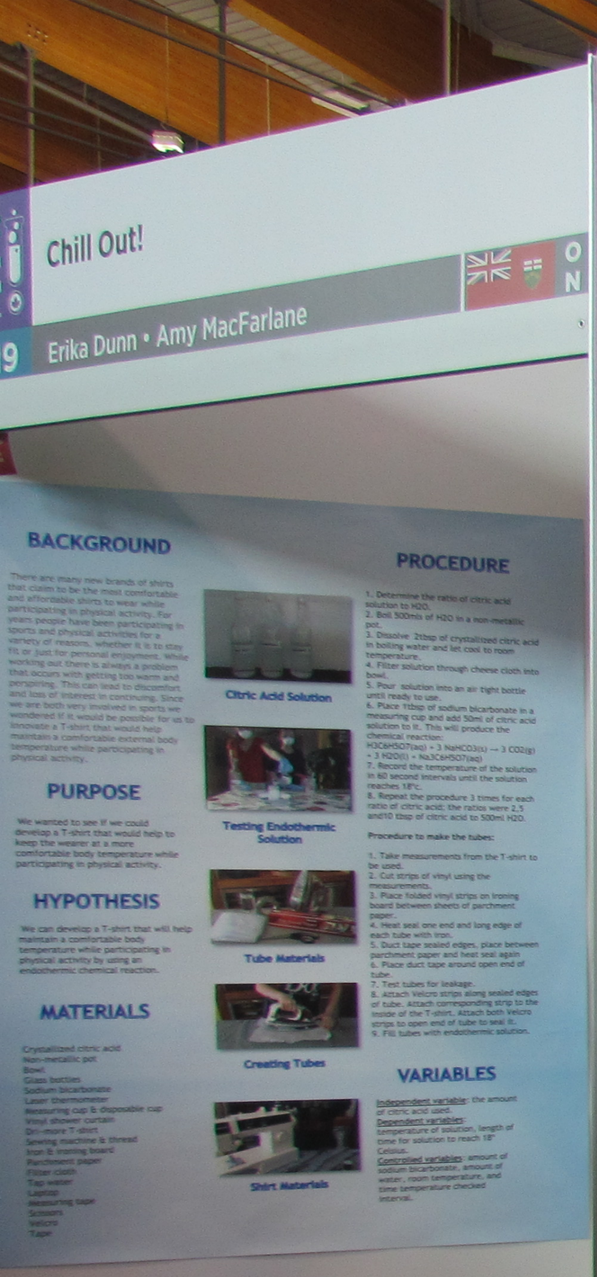
This project can and is affecting the real world today. This information of predicting leading digits in data is so precise that it can be used to detect frauds especially in finance. In fact, it was used multiple times already in courts to detect fake or fraudulent tax reports which resulted in a sentence for the accused person.

Acknowledgements

I would like to thank my mom and dad for their support and my parents friends and for my project and helping me with various other things.

Bibliography/References

"Benford's Law." Data Analysis Mathematical. N.p., n.d. Web. 28 Apr. 2015.
"Benford's Law." Wikipedia. Wikimedia Foundation, n.d. Web. 28 Apr. 2015.
"Benford's Law: Theory and Applications." Benford's Law: Theory and Applications. N.p., n.d. Web. 28 Apr. 2015.
"Frank Benford." Wikipedia. Wikimedia Foundation, n.d. Web. 28 Apr. 2015.
"Simon Newcomb." Wikipedia. Wikimedia Foundation, n.d. Web. 28 Apr. 2015.
"The Significant-Digit Phenomenon." The American Mathematical Monthly. N.p., n.d. Web. 28 Apr. 2015.



Canada-Wide Science Fair
Expo-sciences pancanadienne

060205 Caroline Mahut

ON

Gold Medal
Médaille d'or

Challenge Award
Prix du défi

Question

Can earlier work on a modified ground effect wing airfoil be used to design an innovative functional ground effect aircraft? How might this ground effect aircraft be used to help Greater Toronto area commuting challenges?

Engineering Objective

The engineering objective is to:

- Design and build a proof-of-concept ground effect aircraft model that will lift off at acceptable velocity and maintain that lift.
- Make total cost comparisons of commute cost, commute time and other geographically distinct cost of living expenses.

Background

"Ground effect" is the increase in lift relative to the induced drag that results when an aircraft flies close to the ground (or similar surface). The entire aircraft functions on the "ground effect". The aircraft takes off and flies only a couple of meters off of the ground in order to maintain increased lift (*Aerodynamics of a Double-Element Wing in Ground Effect)*. The main components that render a ground effect aircraft to be so effective are stability, controllability and aerodynamic efficiency. These aircrafts are also much more lift and fuel efficient than conventional aircraft.

Today, ground effect aircraft range from two seat recreational vehicles to 500 ton war crafts. Many passenger ground effect aircraft are used in the Far East to transport people between places such as Australia and New Zealand. *(Wing in Ground Effect Craft Review)*

In my previous project, a modified ground effect wing was developed that was more lift efficient than both a conventional aircraft wing and a regular ground effect wing.

Project Approach/Procedure

The project was broken into the following steps:

1. Identify the Major Attributes of this Ground Effect Aircraft
2. Determine Sizes and Weights of the Aircraft Components
3. Design and Build a Flight-Worthy Proof-of-Concept model
4. Design and Build a Flight Test Rig
5. Undertake experiments to determine
   - The effect of the "Ground Effect altitude" (or Aircraft Posterior Clearance - APC)on take-off velocity.
   - The optimal axial alignment of engines on the fuselages to impart thrust.
6. Undertake Cost Comparisons for four Commuting Corridors

Taking the Flyway

Solution Development

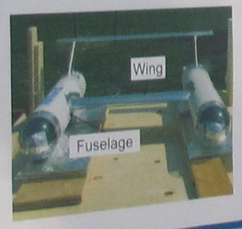
Step 1: Design of the Major Attributes of the Ground Effect Aircraft:
The design of this ground effect aircraft consists of two fuselages on either end of a single connecting wing.

Step 2: Determination of the Size and Weight of the Ground Effect Aircraft:
The full-scale aircraft was designed to carry 200 people in each fuselage or 400 people per flight. The size of the fuselage was calculated to be 28 metres long, 3 metres high and 3.5 metres wide. The weight of the aircraft was determined to be 284 metric tons based on the wing size, fuselage size, engine size, tail size and payload. After a number of iterations, the final size of the wing was calculated to be 20 metres in length and 6.5 metres in chord.

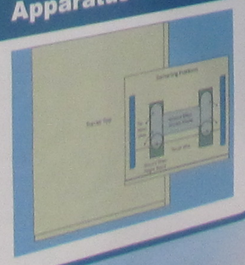
Step 3: Building the Prototype:
To validate the ground effect aircraft design, a flight worthy concept model and airfoil was built, dimensionally proportionate to the designed aircraft.

Step 4: Design/Build a Test Rig:
An original test rig was then built on the back of a trailer in order to test the concept model. The time and velocity at which the aircraft took off to be observed. The takeoff time, landing time, takeoff velocity and landing velocity of the aircraft during the flight test were recorded. Environmental factors such as wind speed and direction were recorded to determine whether there were any crosswinds that could alter the results.

Aircraft Model



Apparatus / Test Rig

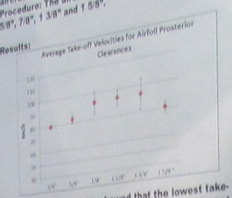


Flyway

Experiment 1

Purpose: To determine the effect of different airfoil posterior clearances (APC) on the takeoff speed of the aircraft .
Procedure: The aircraft was tested at APCs of 3/8", 5/8", 7/8", 1 3/8" and 1 5/8".

Results:



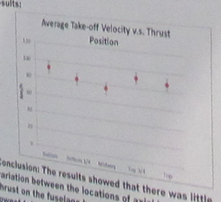
Conclusion: The results showed that the lowest take-off and landing velocity when the aircraft was closest to the platform; therefore at 3/8".

Experiment 2

Purpose: To determine the optimal axial alignment for the impart thrust on the back of the aircraft optimize engine placement.

Procedure: The impartment of thrust position was located by screwing in a screw at different elevations on the rear of the fuselage. Then a wire was placed underneath the two screws and attached to two posts on either side of the aircraft. When the aircraft was in flight the wire would restrain the aircraft, effectively imparting thrust. The thrust was imparted at the bottom, quarter elevation, midway, ¾ elevation and top on the rear of the fuselage.

Results:



Conclusion: The results showed that there was little variation between the locations of axial impartment of thrust on the fuselage however the midpoint had the lowest takeoff velocity.

Economic Analysis

An analysis was conducted to determine the economic feasibility of the St. Catharines to Toronto transportation route. While the annual cost of taking "the Flyway" is more than other commuter routes, savings in cost of living in St. Catherines help to reduce the net cost. While the total cost for the Flyway is apparently higher than other options, the time freed up by shorter commuter times can be used for family time and/or productive work. This may be seen as even more valuable by commuters.

Commute to Toronto					
From Home	Via	3 way commute			
Barrie		Time (min)	Cost ($/year)	Cost of Living $/year	
St. Catharines	Car	115; 30 min	$8,800	$4,700	
St. Catharines	Car	115; 15 min	$8,800	$3,000	
St. Catharines	Go TRAIN	135; 30 min	$7,150	$3,000	
St. Catharines	Flyway	135; 30 min	$11,150	$3,000	
Toronto				$3,000	
				$8,000	

Conclusion

The engineering objectives were met.

- A novel proof-of-concept ground effects model aircraft was designed and built. It took off and stayed aloft at 70-80 km/h. Tests were completed using an original design test rig to determine optimal airfoil posterior clearance and axial thrust positioning on the fuselages.
- Cost comparisons for four competing commuting corridors were determined. The Flyway between St. Catharines and Toronto is more expensive in commute cost but offers significantly reduced commuting time and lower costs of housing compared to the other transportation routes considered.

Extensions

- Testing and recording the lift and drag on the aircraft while in flight in order to compare it to other conventional and ground effect aircrafts
- Adding weights to the aircraft in order to create a proportionate weight to size ratio equivalent to that of the aircraft design
- Determining the optimal ground effect height for the aircraft while it is at cruising speed
- Analyzing the infrastructural costs associated with introducing these aircraft into cities.

Applications

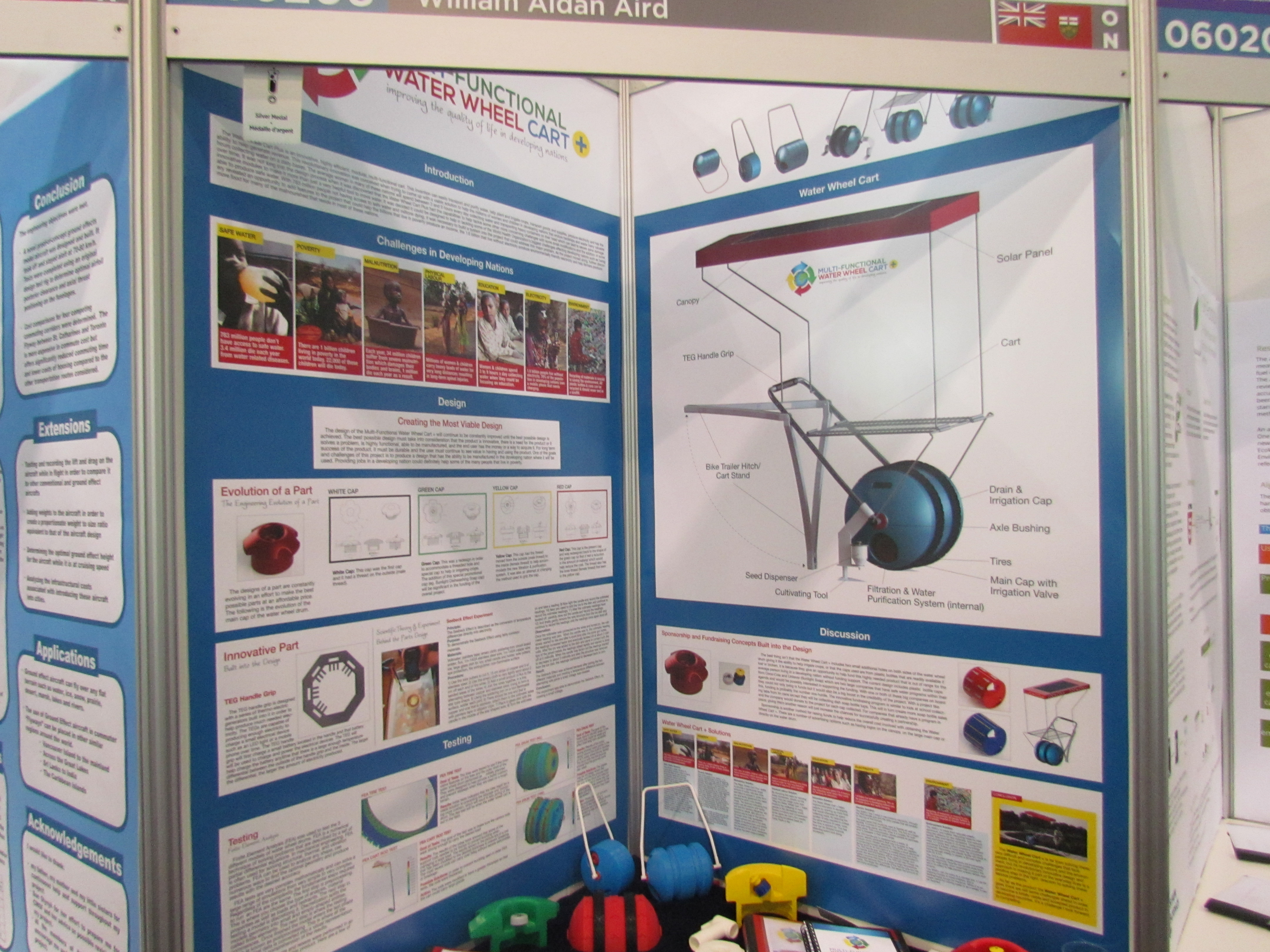
- Ground effect aircraft can fly over any flat terrain such as water, ice, snow, prairie, desert, marsh, lakes and rivers.
- The use of Ground Effect aircraft in commuter "Flyways" can be placed in other similar regions around the world.
  - Vancouver Island to the mainland
  - Across the Great Lakes
  - Sri Lanka to India
  - The Caribbean Islands

Acknowledgements

I would like to thank:

- my father, my mother and my little sisters for continuous help and support throughout my project
- Sue Olynyk for her effort to prepare me for CWSF and her advice on possible revisions to my project.
- all the members of BASEF who helped encourage me and helped me to improve my project.

060206



William Aidan Aird
ON
Silver Medal
Médaille d'argent
MULTI-FUNCTIONAL WATER WHEEL CART +
improving the quality of life in developing nations
Introduction
Challenges in Developing Nations
SAFE WATER
POVERTY
MALNUTRITION
EDUCATION
ELECTRICITY
783 million people don't have access to safe water. 3.4 million die each year from water related diseases.
Design
Creating the Most Viable Design
Evolution of a Part
The Engineering Evolution of a Part
WHITE CAP
GREEN CAP
YELLOW CAP
RED CAP
Innovative Part
Built into the Design
TEG Handle Grip
Seebeck Effect Experiment
Testing
Conclusion
Extensions
Applications
Acknowledgements
Water Wheel Cart
Solar Panel
Canopy
Cart
TEG Handle Grip
Bike Trailer Hitch/
Cart Stand
Drain &
Irrigation Cap
Axle Bushing
Tires
Seed Dispenser
Cultivating Tool
Filtration & Water
Purification System (internal)
Main Cap with
Irrigation Valve
Discussion
Sponsorship and Fundraising Concepts Built into the Design
Water Wheel Cart + Solutions
CONCLUSION
06020

Beta-Blockers

Marjan Ghazi

Gold Medal · Médaille d'or

Special Award · Prix spécial

QC

Identifying the Problem

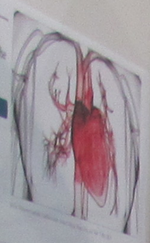
Cardiovascular diseases cause 19% of Canadian deaths. This ranking alerts the pharmaceutical industry to produce favorable medications.

Examples of Cardiovascular Diseases

Hypertension: Increase in blood pressure

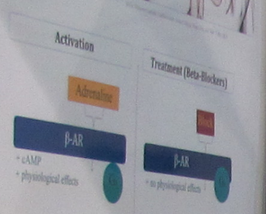
Cardiac Arrhythmia: Irregular heart beat

Postural Tachycardia Syndrome: Increase in heart rate



Purpose

It is understood that these medications occasionally fail. Cases show beta-blockers activating the β-ARs as opposed to blocking them, resulting in the physiological effects, damaging to patients . In order to fix this problem, we must first identify the problem and answer to the question "Why are Beta-blockers failing?" The project defines the limitations of beta-blockers.



Unfavorable Effects of the Activated β-AR

- heart muscle contraction
- increase in heart rate
- increase atrial cardiac muscle contractility
- dilation of the hepatic artery
- dilation of the coronary artery
- contractility of the ventricular cardiac muscle

The Beta-Adrenergic Receptors

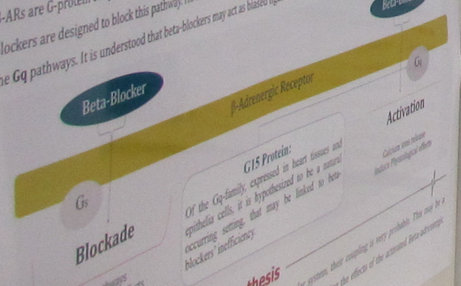
The listed cardiovascular disease symptoms are due to the activation of the Beta-adrenergic receptors. These receptors are naturally activated by hormones such as adrenaline and their activation results in unfavorable effects, to patients. This justifies the utility of beta-blockers in treatment.

Treatment Medications

This justifies the utility of beta-blockers in treatment. beta-blockers block the Beta-adrenergic receptors and its unfavorable effects to ensure safety to patients' cardiovascular systems.

Hypothesis Formulation

β-ARs are G-protein coupled receptors that generally couple to a **Gs**-family G-protein. Upon activation, the Gs pathway is activated and beta-blockers are designed to block this pathway. However, beta-blockers have proven to induce the release of Ca^{2+}, a response upon activation of the **Gq** pathways. It is understood that beta-blockers may act as biased ligands, blocking the Gs pathway while activating the Gq pathway.



Hypothesis

Since β-ARs and G15 protein are expressed simultaneously in the cardiovascular system, their coupling is very probable. The real life possible scenario where beta-blockers act as agonist of the Gq pathway. Instead of preventing the effects of the activated beta-adrenergic receptors, the effects will be induced in patients, over time leading to further heart damage.

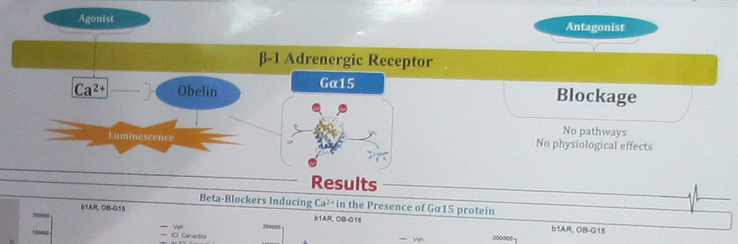
Experimentation

It is hypothesized that upon coupling to the G15 protein, [illegible] antagonists, activating the Gq signalling pathway. This pathway activation results in the release of Ca^{2+}. A Ca^{2+} sensitive photoprotein, Obelin was used to record the release of Ca^{2+}. If beta-blockers indeed are not working, due to this setting, Ca^{2+} will [illegible]. Obelin will emit its light and luminescence will be recorded.

Preparation of Procedure

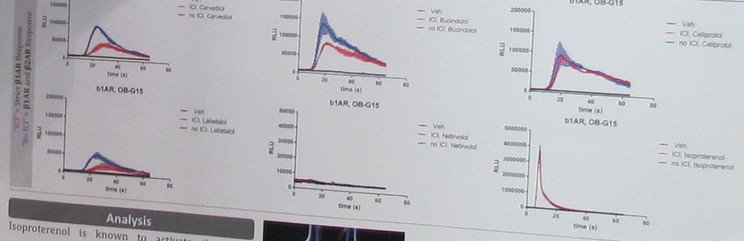
Tested Drugs		
Ligand	Agonist (Adrenic β-AR)	Antagonist (Beta-Blocker)
Carvedilol		✓
Bucindolol		✓
Celiprolol		✓
Labetalol		✓
Nebivolol		✓
Isoproterenol	✓	

[illegible] expressing the Beta-1-Adrenergic Receptor and were maintained in DMEM. [illegible] vector expressing Obelin and Gα15 protein using the polyethylenimine 25 [illegible] sphate buffer [illegible] (PBS) and mixed with PEI/PBS. [illegible] was added to the cells; mixed and cells were distributed into 96-well plates pretreated with [illegible] ence with Tyrode buffer, supplemented with CaCl2 and pre-incubated with Obelin [illegible] ture in darkness. [illegible] according bioluminescence, half the wells were pretreated with of *ICI118,551, a specific Beta-2-Adrenergic Receptor.* [illegible] ligands were re-[illegible] ction on ice. [illegible] ligands, diluted in tyrode [illegible] and the luminescence was measured using the Spectramax Photon-Counting camera.



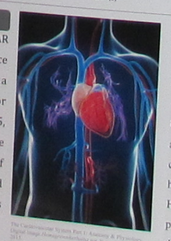
Results

Beta-Blockers Inducing Ca^{2+} in the Presence of Gα15 protein



Analysis

Isoproterenol is known to activate the β1AR receptor; the high-magnitude peak of luminescence is justified. All β-blockers are expected to result in a baseline luminescence; proving receptor antagonism. However, in the presence of Gα15, Carvedilol, Bucindolol, Celiprolol and Labetalol are inducing significant emissions of light as a result of Ca^{2+} release, which represents unpredicted activation of the β1AR receptor, as beta-blockers prove to act as agonists of the G_{aq} pathway.



The Cardiovascular System Part 1: Anatomy & Physiology. [illegible] Image. Available from: [illegible]. N.p., n.d. Web. 15 Dec. 2015.

Conclusion

The Gα15 protein in our experimental system represents a factor causing the β1AR's antagonism to fail. Performed in-vitro, this experiment may explain beta-blockers' occasional inefficiency. When the β1AR is coupled to Gα15, the antagonisms aren't expressed effectively. In treatment of cardiovascular diseases such as congestive heart failure, hypertension and other conditions, beta-blockers are often used. However, these drugs may act as agonists, in cases where Gα15 protein is present, as proven in this experiment, and over time this may lead to heart failure. When wondering "Why are Beta-blockers reporting failure?" this project justifies an answer, which is the first step in developing safer medications and making cardiovascular diseases less threatening.

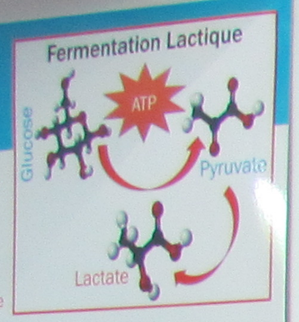
Acknowledgements

Experiments were performed in the *Institute of Research in Immunology and Cancer* (IRIC) of l'Université de Montreal, with the mentoring of Viktoriya Lukashova Ph.D. and scientific sponsor Michel Bouvier Ph.D.

Crise acidotique

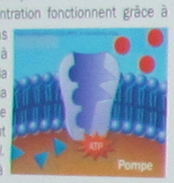
Les causes:

- Une infection
- Effort physique
- Une émotion forte
- Un stress quelconque



Dans ces conditions, la demande d'ATP s'élève brusquement. La chaine respiratoire étant défectueuse, la production d'ATP se fait par fermentation lactique. Cette voie palliative crée énormément de pyruvate issu du glucose qui se dégrade en lactate et, en se liant à des H^+ acidifie le sang. Le pH normal du sang est d'environ 7,4 alors que dans ce cas, il baisse à 6,8, une variation très considérable.

Les pompes de transports diffusant des ions et des petites molécules à travers les membranes contre leur gradient de concentration fonctionnent grâce à l'énergie fournie par le bris des liaisons phosphoanhydrides de l'ATP. Les pompes à sodium et à potassium sont essentielles à la santé de tout le corps, car elles permettent la dépolarisation de la membrane qui crée le potentiel d'action. Celui-ci permet le déplacement d'influx nerveux, des pieds à la tête (Reece *et al.* 2012). Les pompes à ions calcium (Ca^{2+}), quant à elles, se retrouvent dans les cellules des muscles squelettiques et permettent la contraction des muscles et le relâchement de ceux-ci (Lodish *et al.* 2005).



Conséquences

Le bilan énergétique étant réduit:

- Baisse de la qualité de la transmission des influx nerveux (Pompes Na^+/K^+)
- Baisse de la qualité de l'activité musculaire (Pompes Ca^{2+})
- Retards de développement physique et intellectuel
- Diminution de la vigueur musculaire

Lors d'une crise acidotique:

- Acidification du sang

Baisse du PH sanguin

Dysfonction des protéines

Apoptose, Nécrose, Fribrose

Hypoxie, Anoxie

Coma

Arrêt cardiaque

En somme, l'acidose lactique congénitale, une maladie autosomique récessive, est fatale lorsque l'enfant subit une crise acidotique. Jusqu'à ce jour, cette maladie n'est pas curable.

Question:
Si la mutation affecte principalement une protéine dans la mitochondrie, l'implantation d'une mitochondrie saine dans l'ovule avant la fécondation pourrait éventuellement éviter à l'enfant de développer la maladie

Références

MORIN, Charles (Dr.), 2012, « Acidose lactique congénitale type Saguenay Lac-Saint-Jean », Sur [illegible] Saguenay, le portail des maladies rares et des médicaments orphelins

REECE, Jane et al. 2012, Campbell - Biologie, 4e édition, Québec, Editions Pearson, 1408 pages.

OUELLETTE, Gaï et al. [illegible] Association de l'acidose lactique du Saguenay Lac-Saint-Jean - Trousse d'information sur l'acidose lactique.

LODISH, Harvey et al. 2005, Biologie moléculaire de la cellule, 5e édition, Paris - Editions De Boeck Université, 1053 p.

Remerciements

Maxime Gelgoh pour son aide dans la recherche

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Richard Cloutier pour tous les précieux conseils

Le Cégep de Rimouski pour la généreuse aide financière

Cégep de Rimouski

CWSF ESPC
Canada-Wide Science Fair · Expositions pancanadiennes

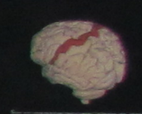
040324

Un remède attirant

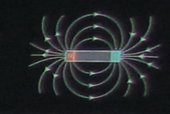
Simarjit Bilkhu

LE CERVEAU ET L'ÉLECTROMAGNÉTISME

GYRUS PRÉCENTRAL
STIMULONS-LE !



CHAMP MAGNÉTIQUE



LE TAUX DE RÉMISSION TOTALE EST DE 45% APRÈS UN AN DE TRAITEMENT.

NEURONE SCHÉMATISÉ

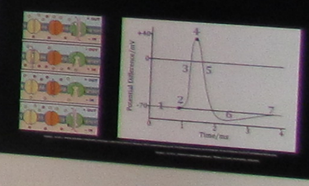
DENDRITES

SOMA

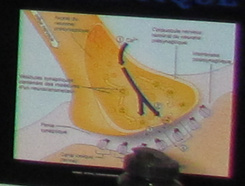
AXONE

TERMINAISONS AXONALES

DIFFÉRENCE DE POTENTIEL



TRANSMISSION SYNAPTIQUE



or Foe?

SK

Je parle français

POTHESIS:

VARIABLES:

OBSERVATIONS:

REFERENCES:

NO SMOKING

CONCLUSION:

CWSF ESPC
Canada-Wide Science Fair
Expo-sciences pancanadienne

Phenylalanine Self-Diagnostic Test for Phenylketonuria Patients

040317

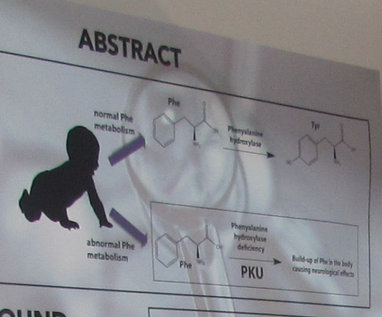
Nathan Kuehne

BC

Gold Medal
Médaille d'or

ABSTRACT

This project developed an at-home test for patients suffering from phenylketonuria (PKU). PKU is a genetic condition in which patients cannot metabolize phenylalanine, leading to a buildup of this compound in their tissues, causing neurological defects. At-home monitoring can help patients evaluate their phenylalanine intake, thus reducing the negative effects. A urine sample is filtered to isolate the biomarking phenylalanine, followed with the synthesis of gold nanoparticles, initiating a colour-change. A 3D-printed device was then developed to simplify the filtration process, requiring minimal user-interaction and expediting the results. A visible colour change indicates the presence of harmful levels of phenylalanine.

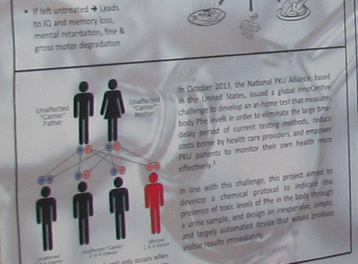


BACKGROUND

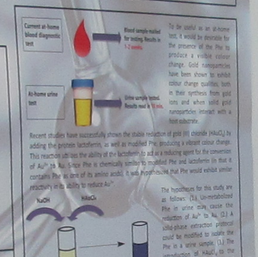
Phenylketonuria (PKU) =

- Genetically inherited metabolic disorder
- Usually diagnosed at birth
- Deficiency in the enzyme phenylalanine hydroxylase
- If left untreated → Leads to IQ and memory loss, mental retardation, fine & gross motor degradation

PKU can be successfully treated with a diet low in phenylalanine (Phe). However, damage done by excess Phe is irreversible, meaning early detection and strict adherence to diet is crucial.



PKU is genetically inherited, and only occurs when both parents carry the gene and it is passed onto the offspring.



Recent studies have successfully shown the visible reduction of gold (III) chloride ($HAuCl_4$) by adding the amino butterfly, as well as modified Phe, producing a vibrant colour change. This reaction utilizes the ability of the butterfly to act as a reducing agent for the conversion of Au^{3+} to Au^0. Since Phe is chemically similar to modified Phe and butterfly (in that it contains Phe as one of its amino acids), it was hypothesized that Phe would exhibit similar reduction ability to reduce Au^{3+}.

Fig. 1: Reaction for the synthesis of gold nanoparticles by Phe oxidation of Phe to Tyr

$$5\ OH^-_{(aq)} + 1\ Phe_{(s)} + 2\ Au^{3+}_{(aq)} \rightarrow 1\ Tyr_{(s)} + 2\ Au_{(s)} + 3\ H_2O_{(l)}$$

The hypothesis for this study are as follows: (1) Un-metabolized Phe in urine does cause the reduction of Au^{3+} to Au^0, (2) A solid-phase extraction protocol could be modified to isolate the Phe in a urine sample, (3) The introduction of $HAuCl_4$ to the remaining solution and the resulting reduction to gold nanoparticles would indicate the presence of Phe, with a visible colour change indicative of the presence of harmful levels of Phe.

COLOUR-CHANGE ANALYSIS

Analysis of the reaction between $HAuCl_4$ and Phe:

The ratio between ($HAuCl_4$) and ($NaOH$) was varied, with qualitative and quantitative measurements collected using a UV-Visible spectrometer to assess the optical density of the samples. Once the appropriate concentrations were determined, a kinetic analysis was completed (Fig.2)

Fig. 2: Kinetic absorbance spectrum of the reduction of $HAuCl_4$ showing the increase in absorbance as a function of time. The overall colour change was from colourless to black-purple.

After establishing the appropriate ratio for colour change with chloroauric acid, the addition of other ions was tested. Specifically, the ions commonly found in urine (NaCl, KCl, K_2SO_4, urea and creatinine) were tested separately, creatinine and the Au^{3+}, resulting in a colourless solution (Fig. 3). This indicated that a filtration process would be necessary to isolate the Phe from the competing components in urine.

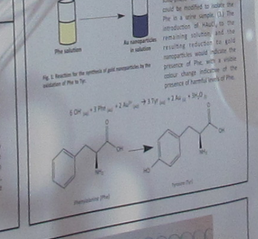


Fig. 3: Visible-colour assay calibration curve for the reduction of gold (III) chloride with Phe at 550 nm. Level of detection calculated to be 0.018 mM.

SOLID PHASE EXTRACTION

Urine Filtration:

To determine if a filtration process would be necessary to identify the presence of Phe in a urine sample, colour-change tests were run with other molecules also in urine. When Phe was tested with salts commonly found in urine (NaCl, KCl, K_2SO_4), urea and creatinine separately, creatinine and the Au^{3+}, resulting in a colourless solution (Fig. 3). This indicated that a filtration process would be necessary to isolate the Phe from the competing components in urine.

SPE Optimization:

A SPE protocol was followed to filter Phe out of a urine sample. However, a wash containing methanol caused the immediate reduction of $HAuCl_4$ regardless of whether Phe was present in the urine sample (Fig. 4.1). The protocol was successfully modified to function without methanol, filtering the salts, creatinine and urea out of urine, so that the Phe remained in the solid-phase of the filter. When $HAuCl_4$ and NaOH were added to the filter, a colour change occurred when Phe was present (Fig. 4.2).

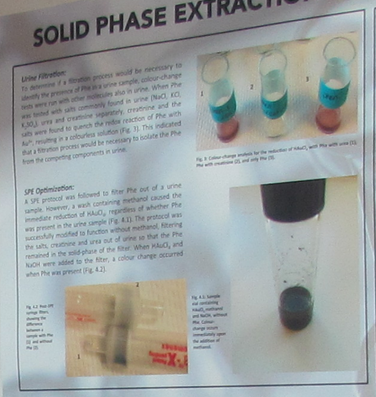


Fig. 4.1: Sample vial containing $HAuCl_4$, methanol and NaOH, without Phe. Colour change absent, methanol successfully ignor the addition of methanol.

LOD DETERMINATION

Limit of detection determination:

After establishing that Phe does initiate a colour-change reaction with $HAuCl_4$ (see Fig. 1), a calibration curve was calculated by varying the concentration of Phe (Fig. 5 and 6). This allowed for the determination of the limit of detection (LOD) of Phe in this assay. Analysis of the visible light emission spectra at 550 nm revealed the LOD to be 0.018 mM with an r^2 of 0.996. As a concentration above 0.0602 mM would indicate abnormal Phe levels, this LOD successfully fulfils the requirements of this assay.

Fig. 5: Absorbance spectrum of varying concentrations of Phe complexed with gold nanoparticles. This data was used to generate the calibration curve for the determination of LOD for Phe.

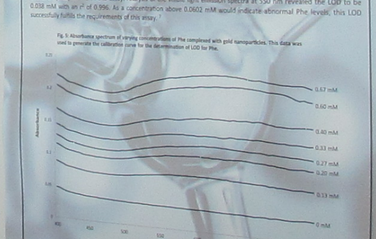


Fig. 6: Visible-colour assay calibration curve for the reduction of gold (III) chloride with Phe at 550 nm. Level of detection calculated to be 0.018 mM.

DEVICE PROTOTYPE

A handheld device was designed and prototyped, enabling the chemical processes to be encapsulated and contained in an easy-to-use, at-home test. This project fills a void identified by the National PKU Alliance as critical for the future of PKU treatment and management: a simple, rapid, and inexpensive at-home Phe assessment device for patients to manage their treatment, and to prevent serious symptoms and health consequences.

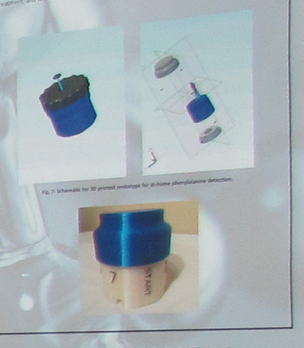
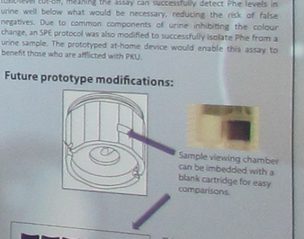


Fig. 7: Schematic for 3D printed prototype for at-home phenylalanine detection.

CONCLUSION

The reduction of $HAuCl_4$ when in the presence of base was optimized so the introduction of the biomarker, Phe, produced a rapid, vibrant colour change from colourless to black-purple. A LOD was determined to be lower than the toxic-level cut-off, meaning the assay can successfully detect Phe levels in urine well below what would be necessary, reducing the risk of false negatives. Due to common components of urine inhibiting the colour change, an SPE protocol was also modified to successfully isolate Phe from a urine sample. The prototyped at-home device would enable this assay to benefit those who are afflicted with PKU.

Future prototype modifications:



References
Mayo Clinic Staff. (2014). Phenylketonuria (PKU). Retrieved March 2, 2015, from National PKU Alliance website: http://npkua.org/Education/Newborn-Screening/PKU-Overview
Mayo Clinic Staff. (2014). Phenylketonuria (PKU): Symptoms. Retrieved from mayoclinic website: http://www.mayoclinic.org/diseases-conditions/phenylketonuria/basics/symptoms/con-20033091
Ng, K., Liu, Y., & Lu, Y. (2007). Oligonucleotide-Modified Gold Nanoparticles for Colorimetric Detection of Mercuric Ion in Real Water Samples. Journal of the American Chemical Society, 129(5), 1014-1019. doi:10.1021/ja067155+
Nicolas, A. L., Nicolas, C., Kotlar, H. K., & Knudsen, I. (2002). Improved 10S complement quantum yield for gold nanoparticle conjugates. Journal of Immunological Methods, 263(1-2), 165-176. doi:10.1016/s0022-1759(02)00044-7
Sharma, J., Chhabra, R., Cheng, A., Brownell, J., Liu, Y., & Yan, H. (2009). Control of self-assembly of DNA tubules through integration of gold nanoparticles. Science, 323(5910), 112-116. doi:10.1126/science.1165943
Storhoff, J. J., Elghanian, R., Mucic, R. C., Mirkin, C. A., & Letsinger, R. L. (1998). One-pot colorimetric differentiation of polynucleotides with single base imperfections using gold nanoparticle probes. Journal of the American Chemical Society, 120(9), 1959-1964. doi:10.1021/ja972332i
Tsai, D., Denkova, A. G., Nikoobakht, B., Tsai, M., Mahmoud, M. A., Walsh, M. J., . . . Van Der Zande, M. (2014). Two-Dimensional Self-Assembled Monolayers and Their Theoretical Simulations of Gold Nanorods. ACS Nano, 8(9), 9332-9340. doi:10.1021/nn503284x
Wang, Y., Wei, H., Li, B., Ren, W., Cheng, Y., Li, N., & Yang, F. (2014). Rapid and Sensitive Homogeneous Detection of Avian Influenza Virus Using Target-Responsive Hairpin DNA Probe and Unmodified Gold Nanoparticles. PLoS ONE, 9(1), e85693. doi:10.1371/journal.pone.0085693
Wilhelm, S. V., & Kane, A. B. (2013). Synthesis of Monodisperse Gold Nanoparticles. Current Protocols in Toxicology, 4.14.1-4.14.11. doi:10.1002/0471140856.tx0414s56

Revolution 3D Printers

Introduction

- Internationally, Lung Cancer is the most prevalent cancer-related mortality with over 1.4 million deaths annually.
- More than 80% of Lung Cancers are classified as Non-Small Cell Lung Cancer (NSCLC).
  - NSCLC involves large tumors that develop in central and peripheral regions of the lung.
  - High Potential for metastasis via nearby lymph nodes (intrapulmonary, mediastinal and extrathoracic) and highly vascularized tissue.
  - Low survival rates due to limitations in early diagnosis and treatment methods.
- NSCLC is characterized by: 1) Abnormally high levels of chromosomal aneuploidy, 2) Cell cycle dysregulation.
- The understanding of molecular mechanisms of NSCLC characterizations (Aneuploidy & Cell Cycle Dysregulation) will lead to more specific and targeted diagnosis and treatment methods.
- **This project focuses on CDK5RAP2 – a protein that is central to cell cycle regulation and spindle formation – and its possible contribution to NSCLC progression.**

Background Research

Cancer

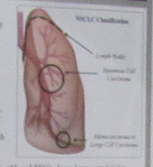
- Cancer is blanket term that covers a collection of diseases which are characterized by unregulated proliferation of abnormal cells.
  - Cancer cells may be invasive or functional tissues and organs.
  - Cancer cells may metastasize through the lymphatic system or bloodstream – ultimately establishing neoplasms in other regions of the body.
- Cancer cells differentiate from functional normal cells:

Behavioral Differentiation	Physical Differentiation
Unregulated Cell Cycle	Multiple, large nuclei
Increased resilience against low nutrient levels	Coarse Chromatin
Angiogenesis	Small Cytoplasm
Anaplasia	Multiple Nucleoli
Loss of anchorage or density dependence in cell growth	Unregulated Cell Structure with various missing functional organelles

- Unregulated cell cycle is predominantly caused by gene damage - Tumor-Suppression Genes and Oncogenes.
  - Tumor suppression genes are downregulated, causing unregulated proliferation.
  - Oncogenes are upregulated which causes increased proliferation.
- **Treatments (radiotherapy, chemotherapy, angiogenesis inhibitors and surgery) prove to be invasive or non-targeted. Search for targeted and effective treatment and diagnostic methods, which molecularly target characterizations of cancer, proves to be invaluable.**

Non-Small Cell Lung Cancer

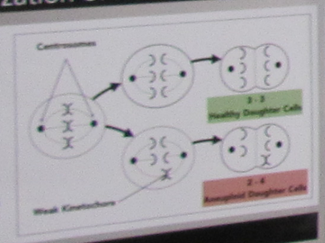
- NSCLCs are all lung cancers except SCLCs.
- NSCLC consists of large cell tumors that are relatively resistant to chemotherapy, found in peripheral or central regions of the lung.
- There are 3 main categories of NSCLC:
  - Adenocarcinoma, squamous cell carcinomas and large cell carcinoma.
- Currently, 85% of patients are diagnosed with NSCLC after symptoms develop.
  - NSCLC late diagnosis leads to late treatment, which results in low survival rates.
- Genetic and Protein Biomarkers –(KRAS, EGFR, ALK, p53 and TSO) –have been correlated to NSCLC, but they have low efficiency.
  - KRAS gene mutation have shown the highest correlation to NSCLC with 25% of NSCLC patients exhibiting this mutations.
- Treatments are not targeted and invasive:
  - Radiation Therapy and Chemotherapy – Insensitive treatments
  - Surgery – Wedge Resection (One Region of Lung), Lobectomy (Removal of entire lobe)
- **More effective diagnosis and treatment methods must be developed in order to maximize survival rates. These diagnosis and treatments methods can come through the understanding of molecular mechanisms that contribute towards NSCLC characterization.**



Characterization of NSCLC

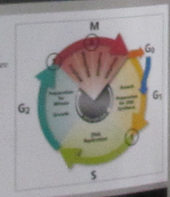
1) Aneuploidy

- The imbalance in chromosomes.
- Usually caused by chromosomal misregregation during mitosis.
- Referring to whole aneuploidy, **not partial aneuploidy.**
- Abnormally prevalent in NSCLC patients – 95%.



2) Cell Cycle Dysregulation

- The cell cycle is regulated by various proteins, within cancer cells, these checkpoint proteins are mutated and manipulated.
- There are three distinct checkpoints within the cell cycle:
  - G1 – S Checkpoint
  - G2 – M Checkpoint
  - Mete-Anaphase Checkpoint
- (Major contributors are Cyclin- Dependent Kinases)
- Prevalent in all cancer types – main cause of over-proliferation.



CDK5RAP2

- Cyclin-Dependent Kinase 5 Regulatory Associated Protein 2 (CDK5RAP2) is an 215 kDa enzyme encoded by the CDK5RAP2 gene.
  - CDK5RAP2 is involved in brain development, neuronal differentiation and neuronal maturation.
  - CDK5RAP2 has been linked to primary microcephaly.
  - CDK5RAP2 has two major protein pathways.
- Involved in interactions with two major protein pathways.
  - Serves as an activator for CDK5 (Forming Maturation Promoting Factor – MPF) in all studied cells.
  - Serves as a transcription factor for Mad2 in most studied cells.

Independent of CDK5 and Mad2

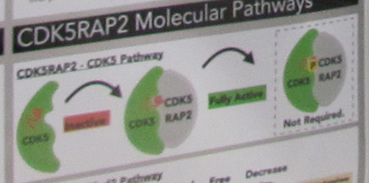
- Neuronal maturation, differentiation, development, cell region localization, nuclear membrane, etc.).
- No significant contribution to non-neuronal cells.

CDK5

- Activated by CDK5RAP2 in G1 cycle.
- Activated by CDK5RAP2, without **phosphorylation**.
- CDK5 complex is involved in G1 and G2-M checkpoint regulation.

CDK5RAP2 Molecular Pathways

CDK5RAP2 - CDK5 Pathway



CDK5RAP2 - Mad2 Pathway

Scientific Objectives

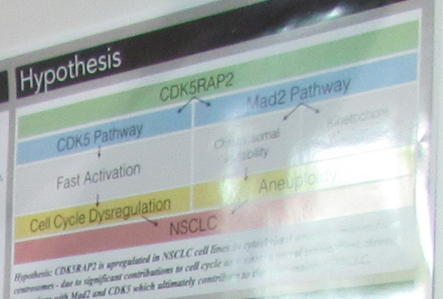
CDK5RAP2 is a protein highly localized in neuronal cells. If abnormally elevated expression is found in other regions, it may be a strong indicator of CDK5RAP2's contribution towards NSCLC progression. Thus, by investigating the nature of CDK5RAP2 protein correlation, and verifying potential molecular mechanisms by which it influences:

(i) to examine further whether CDK5RAP2 protein expression correlates to NSCLC presence,
(ii) to examine the molecular mechanism by which CDK5RAP2 protein expression correlation contributes to the progression of NSCLC.

In order to verify potential molecular mechanisms by which CDK5RAP2 contributes to NSCLC progression, background knowledge on CDK5RAP2's interaction must support pathways, as well as:

(i) Localization of CDK5RAP2 that correlates with molecular mechanisms.
(ii) Validate that CDK5RAP2 regulates transcription of Mad2 in NSCLC cells (CDK5 interaction has already been verified).
(iii) Verification as contributor rather than hyperfoci.

Hypothesis



Hypothesis: CDK5RAP1 is upregulated in NSCLC cell lines [illegible] ***centrosomes - due to significant contributions to cell cycle*** [illegible] ***interactions with Mad2 and CDK5 which ultimately contribute*** [illegible]

Experimental Procedure

Determine CDK5RAP2 Correlation with NSCLC

Western Blot: Testing for correlation between CDK5RAP2 expression and NSCLC presence with Actin Standardization.

Determine Functional Localization of CDK5RAP2

- **Immunocytochemistry:** Testing for intracellular localization of CDK5RAP2, verifying its localization with molecular mechanisms.

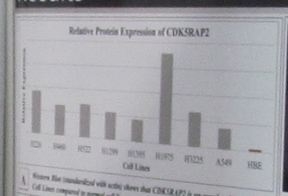
Determine CDK5RAP2 Correlation with Mad2

- **Western Blot:** Testing for correlation between CDK5RAP2 and Mad2 in order to validify that CDK5RAP2 is a transcription factor for Mad2.

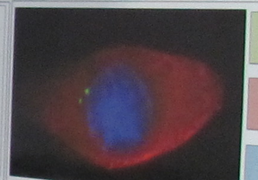
Verify CDK5 [illegible] **thus**

- Transfection: Testing [illegible] CDK5RAP2 depletion on [illegible] proliferation and ultimately, progression.

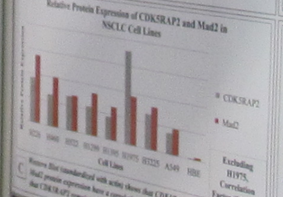
Results



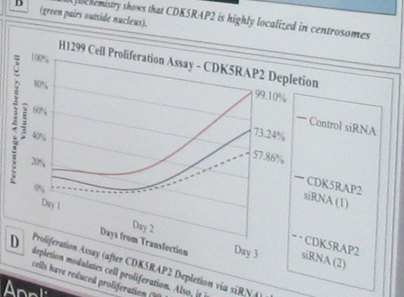
A. Western Blot standardized with actin) shows that CDK5RAP2 is up-regulated in all NSCLC Cell Lines compared to normal cell lines.



B. *Immunocytochemistry shows that CDK5RAP2 is highly localized in centrosomes (green pairs outside nucleus).*



C. Western Blot standardized with actin) shows that CDK5RAP2 protein expression and Mad2 protein expression have a correlation factor of 94.49%, which strongly indicates that CDK5RAP2 contains to a transcription factor for Mad2 in NSCLC cell lines.



D. *Proliferation Assay (after CDK5RAP2 Depletion via siRNA) shows that CDK5RAP2 depletion modulates cell proliferation. Also, it is evident that CDK5RAP2-depleted cells have reduced proliferation (99.10% vs. 73.24% vs. 57.86%).*

Conclusion

In our hypothesized, CDK5RAP1 expression was higher in NSCLC cell lines compared to normal cell lines, which strongly suggests the presence of a correlation between CDK5RAP1 expression and NSCLC presence. More specifically, CDK5RAP1 is upregulated in 100% of NSCLC cell lines. As was hypothesized, all overexpression strongly supports the molecular mechanisms that were [illegible]

1) CDK5RAP1 was highly localized to centrosomes in NSCLC cell lines. Centrosomal [illegible] supports abnormal pathways. a) CDK5 is also largely localized [illegible] centrosomes. This protein interaction is viable. b) Mad2 is also prominent [illegible] CDK5RAP2 and Mad2 interaction. Overexpression of opposite dominant supports [illegible] CDK5RAP2 and Mad2 pathways.

2) Western Blot results [illegible] CDK5RAP2 existed as 94.49% correlation factor Hence, CDK5RAP2 [illegible] a transcription factor for Mad2 in NSCLC cell lines. Overall, CDK5RAP2 [illegible] significantly reduced proliferation rates. Thus, it can be concluded that CDK5RAP2 serves as a transcription factor for Mad2 in NSCLC cell lines, which directly contributes towards the progression of NSCLC – and a contributor to NSCLC cells which directly contributes towards the progression of NSCLC (Overall 1).

Therefore, it can be concluded that CDK5RAP2 contributes to the progression of NSCLC through [illegible] and Mad2 interaction.

Applications and Extension

Two **major discoveries** were made in this project. Firstly, CDK5RAP2 was found to be **up-regulated in 100% of NSCLC cell lines**. Secondly, CDK5RAP2 depletion was found to **significantly impede NSCLC cell proliferation**. Thus,

1) **Diagnosis methods** utilizing CDK5RAP2 are viable. With a) Understanding of CDK5RAP2 **upregulation translation** to serum, sputum and blood and b) **Comparative CDK5RAP2 levels** in all regions of the body.
   - Early biomarker diagnosis methods can utilize CDK5RAP2 to **evaluate presence of neoplasms**. **(Non-invasive)**
   - Tumor homing can utilize CDK5RAP2 to **determine localization of malignant** tissue. **(Non-invasive)**
2) **Treatment methods** utilizing CDK5RAP2 are viable. With a) Understanding of **CDK5RAP2 depletion effect** on normal cells.
   - Targeted inhibition of CDK5RAP2 may significantly **reduce NSCLC cell proliferation.**
   - CDK5RAP2 depletion of malignant neoplasm region can aid in **localized conventional therapies** (surgery, radiation therapy)

Acknowledgements:
Dr. Ke-Young Lee (PhD), Mr. Xidi Wang (MSc) – University of Calgary – SACRI
* All References are in Bibliography Booklet

Canada-Wide Science Fair
Expo-sciences pancanadienne

040231 Marianne Drolet-Sénéchal

QC

Gold Medal
Médaille d'or

CHUS

INTRODUCTION

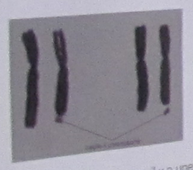
LE SYNDROME DE L'X FRAGILE

Le Syndrome de l'X fragile est l'une des plus importantes causes de retard mental d'origine génétique.

Prévalence
Un garçon sur 4000
Une fille sur 8000

Autres caractéristiques
- Retard de développement
- Difformités physiques

La cause du Syndrome de l'X fragile



La cause de l'X fragile est une anomalie sur le chromosome X.

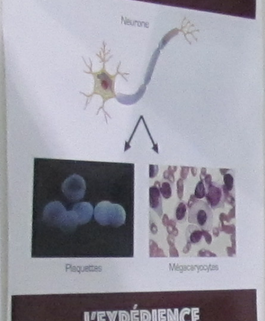
Chez les individus atteints, il y a une trop grande répétition du trinucléotide CGG (théorie de la boucle) dans la région 5' non-traduite du gène FMR1. Cela mène à la méthylation du gène.

Mécanismes généraux de la cause du Syndrome

Méthylation du gène FMR1
▼
Absence de la protéine FMRP découlant du gène
▼
Impact sur l'activité des récepteurs mGluR de type 1 (mGluR-1 et mGluR-5)
▼
Anomalies induites principalement dans les neurones

PLAQUETTES : UN MODÈLE D'ÉTUDE

MARIANNE DRO



L'EXPÉRIENCE

Démarche scientifique

Le but de l'expérience
Le but de l'expérience était de détecter les récepteurs mGluR-1 et mGluR-5 dans des échantillons de mégacaryocytes (cellules de la lignée MEG-01). Cette expérience s'est étalée sur plusieurs jours et comportait plusieurs étapes.

Question de recherche
Est-ce que les perturbations synaptiques observées chez les patients ayant le Syndrome de l'X Fragile peuvent être étudiées sur les mégacaryocytes (précurseurs des plaquettes sanguines)? Autrement dit, est-ce que les mégacaryocytes vont exprimer les récepteurs mGluR-1 et mGluR-5 liés au Syndrome de l'X Fragile?

HYPOTHÈSE

L'hypothèse est que les mégacaryocytes (et donc les plaquettes) vont exprimer les récepteurs mGluR-1 et mGluR-5 parce que les mégacaryocytes expriment déjà la protéine FMRP et que les plaquettes sanguines ont plusieurs caractéristiques en commun avec les neurones.

TRÉSOR POUR LE X

LET-SÉNÉCHAL

PROTOCOLE EXPÉRIMENTAL

Préparation des échantillons de protéines

Gel d'électrophorèse et migration

Western Blot : α-primaire et α-secondaire

RÉSULTATS

Western Blot sur la présence de FMRP (04/02/2015)

Western Blot pour le récepteur mGluR-1 (27/03/2015)

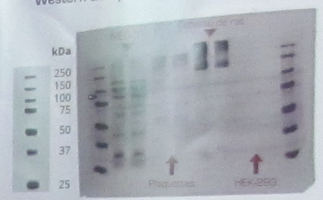
Le récepteur mGluR-1 se trouve à 132kDa.

Nous pouvons observer un signal très clair autour de ce poids moléculaire.

SÉMINAIRE DE SHERBROOKE
INSTITUTION D'ENSEIGNEMENT PRIVÉE
secondaire et collégial

RÉSULTATS (SUITE)

Western Blot pour le récepteur mGluR-5



Le récepteur mGluR-5 se trouve à 142kDa.
Nous pouvons observer un signal très clair autour de ce poids moléculaire.

DISCUSSION ET ANALYSE

Ces résultats démontrent l'expression des récepteurs mGluR-1 et mGluR-5 sur des mégacaryocytes et des plaquettes. Bien-sûr, d'autres expériences de confirmation et d'analyses en profondeur (test d'activation des récepteurs) sont prévues.

IMPACT DES RÉSULTATS

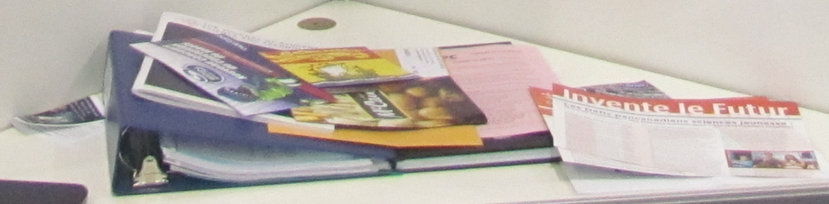
Ces résultats ont validé l'utilisation de mégacaryocytes et de plaquettes comme bon modèle d'étude pour le Syndrome de l'X fragile.

Du point de vue clinique, les expériences sur les plaquettes vont permettre l'élaboration d'un test plus performant pour diagnostiquer le Syndrome de l'X fragile axé sur la quantification de FMRP et peut-être des récepteurs mGluR-1 et mGluR-5.

CONCLUSION

Merci d'avoir pris le temps d'écouter ma présentation d'expo-sciences!

Marianne Drolet-Sénéchal
Secondaire 4 - Séminaire de Sherbrooke



CWSF ESPC
Canada-Wide Science Fair
Expo-sciences pancanadienne

040232 Louis-Antoine Ge

Le pouvoir de

LE POUVOIR DES [illegible]

Qu'est-ce qu'un glucide

CLASSIFICATION DES GLUCIDES

Glucose
Fructose
Holosides
Saccharose
Lactose

COMMENT LE CORPS FAIT-IL POUR PRODUIRE DE L'ÉNERGIE?

QU'EST-CE QUE L'ÉNERGIE POUR NOTRE CORPS?

QU'EST-CE QUE L'INDICE GLYCÉMIQUE?

Background

- Neurodegenerative disorders like Alzheimer's and Parkinson's diseases result in progressive loss of nerve function and lead to dementia
- Worldwide, approximately 1 billion people are affected by neurodegenerative disorders
- Acetylcholine (ACh), a neurotransmitter, is linked to many neurodegenerative disorders
- ACh is important in neurotransmission and transfers impulses between neurons
- Depletion of ACh is associated with Alzheimer's disease
- Imbalance between levels of dopamine and ACh causes decreased muscle control in Parkinson's disease
- After neurotransmission, acetylcholinesterase (AChE) is used to break down ACh
- Plant secondary metabolites like phenols can act as inhibitors of AChE
- My question is "Which foods are most beneficial for neurodegenerative management?"

Figure 1: Mechanism of Action for ACh Activity

Purposes

- Identify common plant-based food sources for the preventive management of neurodegenerative disorders through in vitro screening methods
- Determine relation between secondary metabolites such as phenolics and AChE inhibition potential
- In silico screening and validation of phytoconstituents present in selected materials for AChE inhibition using chemical docking

Hypothesis

- In vitro screening for AChE inhibition potential can be useful for selection of convenient plant-based foods for the preventive management of neurodegenerative disorders
- Plant-based foods enriched with defensive secondary metabolites like phenols may exhibit positive correlation with AChE inhibition

Materials

A: Zucchini B: Tomato C: Eggplant D: Lettuce E: Mint Leaves F: Mushroom G: Parsley H: Radish Leaves I: Seaweed J: Spinach
K: Sweet Potato L: Beet Root M: Beet Leaves N: Bok Choy O: Choy Sum P: Broccoli Q: Brussel Sprouts R: Cabbage S: Celery T: Cilantro

Figure 2: Common Plant-based Foods Selected for AChE Inhibition Potential

Methodology

Extract Preparation

Ellman's Test

Results

Conclusion

Future Applications

Acknowledgements

References

Purpose

Discover the molecule with the highest probability of acting as a receptor antagonist for the Niemann-Pick C1 receptor (NPC1), a protein crucial to the survival of the Ebola Virus.

Hypothesis

Given the relatively small number of molecules tested, it is anticipated that such molecules will be unlikely to inhibit the NPC1 protein.

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Disorders

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Melody Song

Background

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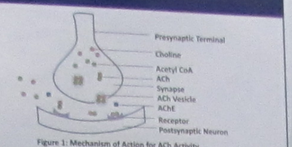

Figure 1: Mechanism of Action for ACh Activity

Ref: McGleenon et. al (1999), Dall'Acqua, S. (2013), Beri, V. and Gupta, R. (2007)

Purposes

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Figure 2: Common Plant-based Foods Selected for AChE Inhibition Potential

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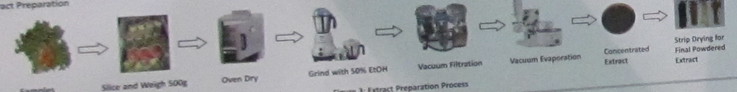

Figure 3: Extract Preparation Process

Ellman's Test

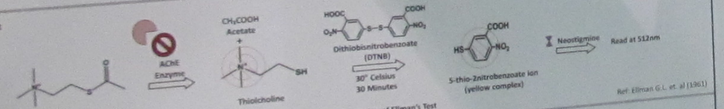

Figure 4: Reaction of Ellman's Test

Ref: Ellman G.L. et. al (1961)

Folin-Ciocalteu Assay

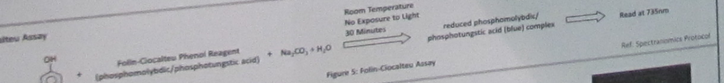

Figure 5: Folin-Ciocalteu Assay

Ref: Spectrasonics Protocol

Chemical Docking of Phytoconstituents and AChE Enzyme

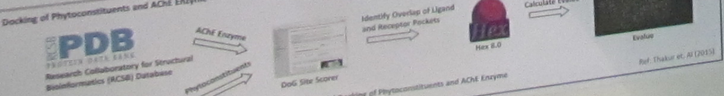

Figure 6: Chemical Docking of Phytoconstituents and AChE Enzyme

Ref: Thakur et. Al (2015)

Results

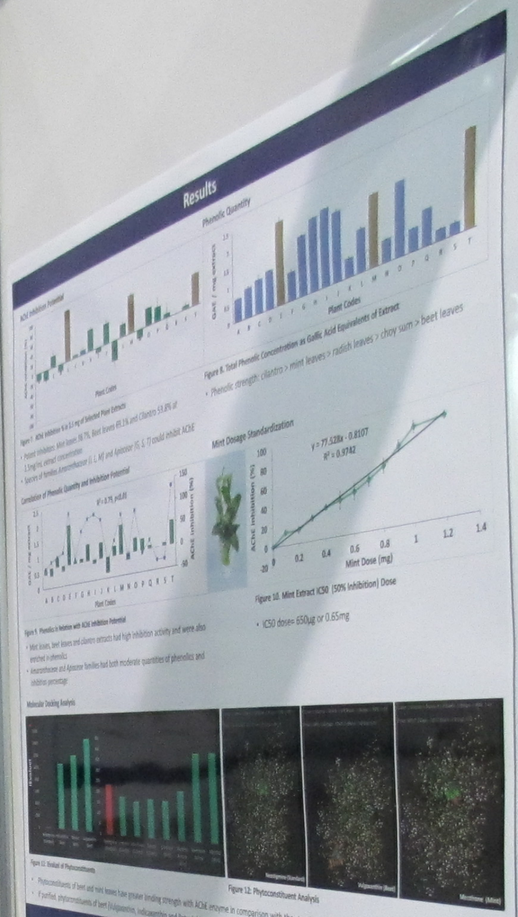

Figure 8: Total Phenolic Concentration as Gallic Acid Equivalents of Extract

- Phenolic strength: cilantro > mint leaves > radish leaves > choy sum > beet leaves

Figure 10: Mint Extract IC50 (50% Inhibition) Dose

- IC50 dose: 650µg or 0.65mg

Molecular Docking Analysis

Figure 12: Phytoconstituent Analysis

- Phytoconstituents of beet and mint leaves have greater binding strength with AChE enzyme in comparison with the standard, Neostigmine
- If purified, phytoconstituents of beet (Vulgaxanthin, Indicaxanthin and Betanin) have great potential as strong inhibitors of AChE enzyme

Conclusion

- Common plant-based foods (beet root, Broccoli, Brussel sprouts, Celery, Cilantro, Choy Sum, Eggplant, Mint leaves, Mushroom, Parsley, Radish leaves and Spinach) are effective as inhibitors (kA Chih, Cabbage, Lettuce, Seaweed, Sweet potato, Tomato and Zucchini)
- Plant-based food sources like mint leaves, beet leaves and cilantro have potential in drug development and could be used to manage neurodegenerative diseases
- Results support proposed hypothesis: positive correlation between phenolic quantity and AChE inhibition activity
- Mint is the strongest inhibitor and 50% inhibition occurs at 650µg or 0.65mg dose
- Beet has very strong phytoconstituents with potential as inhibitory drugs

Future Applications

- Further test collection for preventive management of neurodegenerative disorders
- Researching the effectiveness of mint leaves, beet leaves and cilantro as medications
- Further insight through fractionation and fingerprint profiling of chemical compounds responsible for AChE inhibition in the selected extracts
- Investigation of other species in Amaranthaceae and Apiaceae families
- Further research on the phytoconstituents of beet (Vulgaxanthin, Indicaxanthin and Betanin) and their ability for AChE inhibition

Acknowledgements

Dr. Natasha Gilabert and Dr. Sarita Bajaj of the Plant Sciences Department, University of Saskatchewan are greatly thanked for their mentorship, guidance and support. Research Proposal Grant funds have been possible without their generous time and resources.

References

1. Natasha Gilabert and Dr. Sarita Bajaj. Phytochemical Screening and Phytoprofiling of Selected Plants for Acetylcholinesterase Inhibition Potential. Unpublished research proposal. Plant Sciences Department, University of Saskatchewan, Saskatoon, SK, Canada. 2021. 4pp.
2. Ellman G.L., Courtney K.D., Andres V. Jr., Featherstone R.M. A new and rapid colorimetric determination of acetylcholinesterase activity. Biochemical Pharmacology 7.2 (1961): 88-95.
3. Dall'Acqua S. A Review on Biological, Nutritional and Chemical Aspects of Physalis Alkekengi L. Current Pharmaceutical Design 19.9 (2013): 1571-580.
4. Beri, V. and Gupta, R. Identification Of Peptides Derived Antigenic Regions Highly Conserved Pathogenic Strains Of Bacteria Like Vancomycin Resistant Enterococci

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Challenge Award
Prix du défi

Special Award
Prix spécial

Introduction

The Technology

Properties of Carriers

CEEP: The Solution

Experimental Method

Results

Future Considerations

Conclusio

Acknowledgement

030306 Laurie Anne Roy

Concentrations utilisées:

- 0,7 mg/L afin de se baser sur les normes de Santé Canada
- 9,5 mg/L afin de se baser sur la

ing A Natural Fertilizer

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Rachel Brouwer

Developing a

Background:

Social Application:

Purpose:

Hypothesis:

Experimental Design:

Acknowledgements:

Endangered

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Climate Change at Our Doorstep

Results – Warming and Melti

Global vs. Local – Eve

Causes & Consequen

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