CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Catherine Aitken

Project Number

S1501

Project Title

Effects of Glycerol Solution on Freeze Tolerance and Photosynthetic Efficiency of Cyanobacteria for Use in Terraforming

Abstract

Objectives

The objective of this research is to further investigation of the possibilities of sustainable life on Mars. This research investigates the efficacy of glycerol as a cryoprotective agent (CPA) in cyanobacteria for use in terraforming the sub-zero degree Martian atmosphere.

Methods

The research was divided into two sections. The first section consisted of culturing the cyanobacteria 'Cylindrospermum' in an ideal environment, while also culturing the bacteria in varying concentrations of glycerol in a growth medium, to test the effect glycerol has on cell growth. The second section consisted of 2 phases: a flash freeze and a prolonged freeze, both of which tested for glycerol's preservation of cell health and function in temperatures comparable to Mars. The flash freeze consisted of placing samples of the bacteria in varying concentrations of glycerol and submerging in dry ice to test for survival. The prolonged freeze used similar samples in varying concentrations of glycerol, placed in closed frozen bio-chambers with oxygen sensors to record change in oxygen levels over time, as an indication of photosynthetic efficiency.

Results

The results of the first section exhibited a negative effect of glycerol on the growth of cells. The results of the second section exhibited positive growth in cell health and function, but plateaued after a period of time. The results of both sections supported the original hypothesis that glycerol would not aid growth, but that it's cryoprotective properties can preserve cell function even in a Mars type environment.

Conclusions

This research shows that, in sub zero temperatures such as Mars, the cryoprotective nature of glycerol will better preserve the health and function of cells with glycerol than those cells without glycerol. Therefore cynobacteria that is protected by a CPA may be effective in terraforming atmospheres of low oxygen and sub-zero degree temperatures. This research helps in advancing knowledge about the possibilities of sustaining life in the harsh atmospheres beyond earth.

Summary Statement

Given the recorded freeze tolerance and photosynthetic ability of cyanobacteria in the presence of glycerol, the project shows that glycerol can be used as an effective cryoprotective agent in terraforming purposes.

Help Received

I created the experiment procedures and carried them out on my own with some explanation of technical procedures (ex. using a vortex mixer) from my biology teacher.

Name(s)

Christopher Anderson; Katelyn Lozier; Celeste Robinson

Project Number

S1502

Project Title

What the Fungus Is Killing the Sea Stars?

Abstract

Objectives

Our goal is to determine if there is a fungi exacerbating the effects of the densovirus driven disease, Sea Star Wasting Syndrome, attacking Ochre Sea Stars, Pisaster ochraceus, and other species of sea stars.Sea Star Wasting Syndrome ravaged populations of sea stars along the Western Coast from Alaska to Baja California beginning in 2013 and the overall causes of that disease are largely unknown, postulated that it may be a combination of many pathogens and environmental factors. We hypothesized that if we saw a recurring fungus in the fungi culture from wasting sea stars, that there may be a correlation between that fungi and Sea Star Wasting Syndrome.

Methods

We collect data twice a month at low tide, counting and measuring the radius of all sea stars in our plot along with swabbing all wasting sea stars both on any apparent lesions and on the healthy flesh of the wasting sea star along with swabbing three healthy sea stars. We then take those swabs back to the lab and cultivate the fungi from them and determine different species of fungi based on how they look through the microscope.

Results

Our plates grew two different fungi, which were present in both healthy and wasting sea star swabs. Each fungus was shown in an equal percentage of the overall healthy and overall wasting sea stars, the white fungus showing up in 40% of each, and the black fungus showing up in 60% of each.

Conclusions

Our results demonstrated that there is not one fungi which is solely present in wasting sea stars, although there may be a different pathogen attacking the sea stars. Through this, we concluded that there is not a fungi which is correlated with the wasting disease.

Summary Statement

We cultivated fungi in order to see if there is a fungi related to the cause of Sea Star Wasting Syndrome.

Help Received

We would like to thank John Pearse (Professor Emeritus UCSC), Emily Gottlieb (LiMPETS), and Ian Hewson (Cornell University) for their assistance.

Name(s)

June Bernstein; Samarth Kadaba; Vincent Leong

Project Number

S1503

Project Title

The Effects of a Neurotoxin on the Gut Microbiome of Eisenia feita

Abstract

Objectives

D-limonene, a known neurotoxin to the worm Eisenia fetida, can be used to model neurodegenerative diseases in annelids. When exposed to acute d-limonene, the worms exhibit physical symptoms such as intense writhing and mucus secretion. These underlying side effects hint that the neurological toll d-limonene has on Eisenia fetida and may be indicative of alterations in their gut microbiome. This report presents an approach to monitor the change in the bacterial population of a worm s gut microbiome when the organism is exposed to a neurological stress. The gut microbiome was measured using the worm fecal matter. The feces of intoxicated worms and stock worms were collected and compared. Fecal solutions were grown in order to observe 1) the amount of relative CFU (colony-forming units), 2) the number of different colony morphologies, and 3) the differences in visible concentrations of gram positive and gram negative bacteria in each fecal sample. The goal in analyzing quantitative and compositional changes in the gut microbiome is to draw conclusions about changes in the human microbiome in response to the onset of neurodegenerative diseases such as Parkinson's or Alzheimer's disease. This novel research in the gut-brain axis holds implications for the future where treatments for these human conditions may use the gut microbiome to diagnose or treat symptoms.

Methods

Preparation of the Worms

Eisenia fetida worms were obtained from Island Seed and Feed, Santa Barbara. The worms were split into two groups of 10 worms (Groups A and B). Each sample group was isolated from nutrients and starved for 24 hours before being exposed to their respective conditions. Following the starvation period, we weighed and fed 6.000g of soul to Group A and B (Mettler Toledo New Classic MF MS303S). Introduction of the Neurotoxin

Group A was withheld from nutrients for 0.5 hours (control group). Group B absorbed d-limonene vapor for 0.5 hours in a 50 mL container. We added 2.5Lof d-limonene to the filter paper, resulting in a roughly 42.1 ppm concentration in the container. Then, both groups were sterilized using Kimwipes and DI water.

Collection of the Feces

The worms were allowed to excrete for 24 hours and then removed from the container. The feces that remained were collected using an inoculating loop. Approximately 0.001g of feces (Mettler Toledo New Classic MF MS303S) from each group were placed in 7.0mL of LB medium (1 g:700mL). Each sample was duplicated, producing four stock solutions (A1, A2, and B1, B2).

Summary Statement

This project models human nuerodegenerative diseases through observation and analsysis of the fecal bacteria in earthworms to establish the prescnece of compositional and quantitative changes in gut microbiome of a stressed organism.

Help Received

I would like to thank Baoqing Zhou and Mary McElroy for the assistance in the laboratory. I would also like to thank UC Santa Barbara, Dr. Lina Kim, Ms. Lisa Stamper, Mr. Ben Lopez, Ms. Jen Smith, Summer Discovery, and the Science & Engineering Research Academy for funding our project and providing a

Name(s)

Curtis Chen

Project Number

S1504

Project Title

Exploring Plant Natural Products for Novel Antimicrobial Activities

Abstract

Objectives

Antibiotics are essential to human health and wellbeing, providing cures to bacterial infections. However, due to a lack of new antibiotics being introduced and the growing threat of bacterial resistance to the currently available antibiotics, the human race is quickly running out of viable options. Therefore it is important to identify new resources for novel antimicrobial activities. The goal of my project is to explore natural plant products for candidates that can be used as antibiotics. In particular, I am interested in the enzyme Plastid Lipase 1 (PLIP1), which is a phospholipase that potentially targets the cell membrane, thereby pointing towards possible antibiotic properties.

Methods

I cloned the gene from the plant Arabidopsis thaliana using Polymerase Chain Reaction (PCR) into a plasmid that replicates in yeast. A secretion signal peptide (Pre-pro-alpha or pre-OST) was fused to the N-terminus of PLIP1 so that the proteins can be secreted out of the yeast cells. Yeast cells expressing and secreting PLIP1 were then examined for inhibitory effect on E. coli growth using two assays. First, yeast cells were spotted on LB plate covered an E. coli "lawn" and the formation of an inhibition zone indicates growth inhibition. Second, supernatant of yeast liquid cell culture were added in LB broth and E. coli cell density was monitored.

Results

I successfully cloned the PLIP1 gene, with two different secretion signal peptides, in yeast. Using the two assays, I was able to show that the yeast cells or supernatants inhibited the growth of E. coli. On the contrary, yeast cells carrying the empty plasmid vector, producing another enzyme, or producing PLIP1 without the secretion signal peptide did not have this antibacterial activity.

Conclusions

My results demonstrate that the natural plant enzyme PLIP1 possesses antibacterial activities, possibly by damaging the cell membrane. The significance of my project lies in that PLIP1 could be used as a novel antibacterial agent with specificity. It also highlights plant natural products as a highly diverse supply for novel antibiotic substances.

Summary Statement

I identified a plant enzyme that has highly specific antibacterial activity, highlighting the potential of novel plant products as antimicrobial substances.

Help Received

I designed and conducted all the experiments myself. Dr. Yanran Li and Ms. Shanhui Xu, University of California Riverside, provided the equipment/reagents and bacterial/yeast strains and plasmids. They also helped with the project through guidance and discussions during the experimental procedure.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Phoebe Durant

Project Number

S1505

Project Title

Sensitivity of Gram (+) and Gram (-) Bacteria to Essential Oils Based on the Sensitivity Disc Diffusion Method

Abstract

Objectives

Based on the Kirby-Bauer method of sensitivity disc diffusion, 7 100% pure essential oils were tested on Gram (+) and Gram (-) bacteria cultured from the Arcata Marsh to determine bacterial sensitivity.

Methods

A sterile pipette and inoculating loop were used to place 1 mL of Arcata marsh water on Tryptic Soy Agar (TSA) and nutrient agar plates. The culture plates were stored for 24 hours at 37 degrees Celsius to allow bacterial growth. The cultures were then streaked on CNA/MacConkey bi-plates to identify Gram (+) and Gram (-) bacteria which was then streaked on TSA and nutrient agar plates depending on their original growth media. Sterile sensitivity discs were soaked in 100% pure essential oil for 24 hours. The infused discs were placed on each bacteria-streaked agar plate according to the Kirby-Bauer method configuration. The cultures were stored at 37 degrees Celsius for 24 hours, and the sensitivity results were read using a ruler with mm markings to measure clear spaces around the discs where no bacterial growth occurred.

Results

Gram (-) and Gram (+) bacteria were most resistant to oregano, tea tree, and clove oils. Gram (-) and Gram (+) had less sensitivity to lavender, rosemary, eucalyptus, and a 4-oil blend on both growth media types. On nutrient agar, oregano prevented growth to 19mm with Gram (-) and to 55mm with Gram (+). On TSA, oregano prevented growth to 32mm with Gram (-) and to 66mm with Gram (+) bacteria. In all tests, Gram (+) bacteria was measurably more sensitive to essential oils than the Gram (-) bacteria.

Conclusions

While lavender, rosemary, eucalyptus and an antimicrobial oil blend may be effective at high concentrations against bacteria, the results of this project support the efficacy of low concentrations of oregano, tea tree, and clove oils to prevent or treat bacterial infections. Current societal trends encourage using antibacterial products, such as hand sanitizer, antibacterial face washes, laundry detergents, and fabrics infused with antibacterial agents, which has led to medically resistant bacterial strains. MRSA is Gram (+) bacteria and this project supports that a possible alternative to treatment with antibiotics for resistant bacteria may be essential oils. The use of essential oils may prove to be a non-toxic, effective alternative to treat or prevent bacterial infections that antibiotics may no longer treat.

Summary Statement

The sensitivity disc diffusion method to test Gram (-) and Gram (+) sensitivities to essential oils supports that essential oil may be a valid alternative to antibiotics for treating/preventing bacterial infections.

Help Received

Greta Turney provided supervision and instruction to follow appropriate sterility procedures throughout the project, aided in purchasing the materials and acquiring the Arcata Marsh water sample.

Name(s)

Daniel Feng

Project Number

S1506

Project Title

Discovering Antibacterial Molecules in a Previously Uninvestigated Native American Medicinal Herb

Abstract

Objectives

Antibiotic-resistant bacteria have rendered many modern antibiotics ineffective. Plants, however, have traditionally provided a rich source of medicines. In a previous project, I discovered that the Native American herb Ishwish (Ceanothus leucodermis) showed antibacterial properties. This year, my goals were to (1) purify the antimicrobial molecules in Ishwish from the thousands of other compounds present, (2) determine their identities, and (3) quantify their antibacterial strength.

Methods

To determine the optimal method to extract compounds from plant mass, I obtained several liquid extracts by changing the plant part, solvent, and heat applied. Antibacterial strength was tested using disk diffusion assays. I purified the optimal crude extract with C8 and silica gel chromatography columns. I then evaluated the effectiveness of my purification by using a low-resource method that I developed. This method can find the antibacterial strength (Minimum Inhibitory Concentration, MIC) of a sample by combining data from disk diffusion assays together with a diffusion simulation that I wrote in Python. After purification, I applied my most antibacterial fractions to LC-MS (Liquid Chromatography-Mass Spectrometry) analysis to identify the antimicrobial compounds. I compared my LC-MS data to molecular data found in the database METLIN.

Results

The extract from Ishwish stems in ethanol yielded the most antibacterial activity. I found that a C8 chromatography column, followed by a silica gel chromatography column, significantly purified my crude extract. By simulating disk diffusion assays in my Python program, I determined MICs using very small amounts of my active fractions and found that this purification was successful. Using LC-MS analysis, I determined that the active compounds were polymers of the molecule catechin. This antimicrobial class of compounds is also found in green tea.

Conclusions

I successfully isolated and identified the antibiotic molecules present in C. leucodermis as catechin and its polymers, and I demonstrated a real-life application of my computer simulation to determine antibacterial strength. This project provides a scientific basis for the Native Americans' use of Ishwish as an anti-infective. The strategies developed here can be applied to identify active compounds in other Native American herbs while using limited amounts of plant material.

Summary Statement

I purified the antibiotic molecules in C. leucodermis, identified them to be members of the catechin family, and characterized the effectiveness of my purification procedure by applying my simulation-aided method to determine MICs.

Help Received

Prof. N. Da Silva hosted me in her lab at UC Irvine, T. Kim helped with bacterial work, Drs. F. Grun & B. Katz (UCI Mass Spectrometry Facility) gave advice on chromatography and taught me about LC-MS, and R. Crowe (UCI Arboretum) allowed me to gather C. leucodermis.

Name(s)

Chen Filler

Project Number

S1507

Project Title

The Role of Tetraspanins in the Uptake of Candida albicans by Host Cells: Year 2

Abstract

Objectives

The fungus, Candida albicans grows on the skin and in the GI tract of healthy people as part of the normal microbiota. However, in hospitalized patients, the fungus can enter the bloodstream, where it is carried throughout the body, causing a severe infection called disseminated candidiasis that kills 40% of those who develop this infection. For C. albicans to escape from the blood vessels and infect the deep tissues, it must invade the endothelial cells that line the inside of the blood vessels. Previous studies showed that C. albicans invades an endothelial cell by binding to a receptor, N-cadherin, which induces the cell to engulf the organism and pull it inside. Last year, I discovered that CD9 and CD63, which are endothelial cell membrane proteins called tetraspanins, are required for C. albicans to invade endothelial cells. My current hypothesis is that CD9 is required for N-cadherin to mediate the endocytosis of C. albicans by endothelial cells, and my goal was to use CD9 siRNA to test this hypothesis.

Methods

The HUVEC-TERT endothelial cell line was grown in tissue culture and transfected with either control or CD9 siRNA using Lipofectamine 2000. The effects of siRNA on CD9, CD63, and N-cadherin protein levels were determined by Western blotting. The capacity of the CD9 siRNA and anti-CD63 antibodies to inhibit the uptake of C. albicans by endothelial cells was determined using a differential fluorescence assay. The accumulation of N-cadherin and CD9 around C. albicans in the endothelial cells was detected by indirect immunofluorescence using specific primary antibodies. Each antibody was detected with fluorescent labeled secondary antibodies, and the cells were imaged by confocal microscopy.

Results

By Western blotting, it was found that the CD9 siRNA knocked down CD9 protein levels by 82%, relative to endothelial cells transfected with control siRNA. The CD9 siRNA also increased CD63 levels by 25%, and reduced N-cadherin levels by 23%. The overall effect of the CD9 siRNA was to reduce the endocytosis of C. albicans by 42% 17%. Combining the CD9 siRNA with a specific monoclonal antibody against CD63 did not further reduce endocytosis. By confocal microscopy, CD9 and N-cadherin were observed to accumulate around C. albicans hyphae in endothelial cells that were transfected with control siRNA. When the cells were transfected with CD9 siRNA, very little CD9 was detected and N-cadherin did not accumulate around the organisms.

Conclusions

These results indicate that the tetraspanin, CD9 is required for C. albicans to invade endothelial cells. The

Summary Statement

I discovered that the tetraspanin, CD9 is required for N-caderin to function as an endothelial cell receptor for Candida albicans.

Help Received

Dr. Hong Liu provided access to lab facilities and scientific guidance.

Name(s)

Shreya Garg

Project Number

S1508

Project Title

Determining the Roles of CuSB, Flagellin, and AcrAB-TolC in Bacterial Responses to Nonlethal Nanosilver Concentrations

Abstract

Objectives

Renowned as potent antimicrobials, silver nanoparticles (AgNPs) have recently been integrated into several industries for a vast array of purposes, from countering HIV strains to treating wastewater. However, prolonged exposure to AgNPs will inevitably induce resistance in bacteria, which possess defense systems such as the AcrAB-TolC pump, CuSB pump, and flagellin. As a solution, this project aims to determine whether bacteria are capable of developing resistance when exposed to nonlethal concentrations of AgNPs, identify the mechanisms involved in resistance, and propose a method of suppressing resistance (a substantial and necessary step in ameliorating the global antibiotics overuse crisis).

Methods

Citrate-coated AgNPs were synthesized using AgNO(3) and trisodium citrate. Resistance to AgNPs was induced in E. Coli by exposing the bacteria to progressively increasing sub-inhibitory concentrations of the nanoparticles in agar media until the bacteria could consistently tolerate >50 mg/L AgNPs. Using an original assay design, UV/Vis spectroscopic characterization was used to determine the effects of inhibiting flagellin production with pomegranate rind extract (PGRE), the AcrAB-TolC pump with 2-chloroquinoline, and the CuSB pump with copper on AgNP stability in resistant bacteria. AgNPs would destabilize when in contact with resistant bacteria unless the defense mechanism involved in resistance was inhibited.

Results

Bacteria tolerated up to 90 mg/L AgNP after 6 sets of AgNP concentration increases (with an original tolerance threshold of 2 mg/L). When solutions of 50 mg/L AgNPs, resistant bacteria, and each inhibitor were characterized, only the solution where flagellin production was inhibited possessed silver that was still in nano-form. Max wavelength values indicating nanoparticle stability lie within 380-430 nm, and the vial with inhibited flagellin expressed a max wavelength of 413 nm an hour after the inhibitor was added.

Conclusions

Results indicated that flagellin production is involved in bacterial resistance to AgNP toxicity. PGRE shows promise as a novel approach to combating the global antibiotics resistance crisis by prolonging or even preventing bacterial resistance to AgNPs. Further research should test for potential carriers that can direct PGRE to harmful bacteria, preventing the inhibition of beneficial bacteria.

Summary Statement

UV/Vis spectroscopy demonstrated that bacteria strengthen flagellin production when developing resistance to silver nanoparticles and that this resistance can be combated by coupling the nanoparticles with pomegranate rind extract.

Help Received

I devised my experimental methodology myself and conducted the project independently. My AP Biology teacher Ms. Chelsey Beck and Biotechnology teacher Dr. Christine Koltermann provided me with materials and space to perform experimentation.

Name(s)

Saira Gupta

Project Number

S1509

Project Title

A Preliminary Assessment of Surgical Site Infection Prophylaxis with Topical Micronutrients

Abstract

Objectives

Surgical site infection (SSI) is the most common and costly healthcare-associated infection. Strategies to reduce SSI have been focused on antibiotics and intraoperative changes. Topical prophylactic measures have not been extensively studied. Currently, topical antimicrobials are applied to surgical sites as a standard of care. Anecdotal evidence suggests antimicrobial properties of micronutrients such as vitamin A, vitamin D, zinc oxide, and silver. This study examined antimicrobial properties of micronutrients using commercially available topical products on colonized simulated surgical incisions.

Methods

Agar well diffusion assays and surface assays were used. Bacitracin was used as the control as the current standard of care. Calcipotriene, Desitin, Acticoat, silver sulfadiazine (SSD), Tretinoin were used as proxies for vitamin D, zinc oxide, silver, and vitamin A. In the well diffusion trial, each product was dispensed into a 6mm well created on an agar plate inoculated with Staphylococcus epidermidis (S epi) For the surface assay, a one-inch slit was made in the agar inoculated with S epi in order to simulate a surgical incision site. Topical product was applied over the slit. The plates were stored at 37?C and the bacteria were measured at 24h and 72h.

Results

Well diffusion trial results showed that SSD had the largest zone of inhibition and zone of suppression. T-test data between experimental groups indicated that SSD had a significantly larger zone of inhibition than Desitin on day 1 and day 3. SSD also showed a significantly larger zone of suppression than calcipotriene in day 3. Surface trial results indicated that silver containing agents, Acticoat and SSD, showed significantly larger zones of inhibition than those of Bacitracin, Calcipotriene, Desitin, and Tretinoin on day 1 and day 3.

Conclusions

Antimicrobial properties of topical products with micronutrients appear to be equal to that of the standard of care in the well trial. Acticoat and SSD, silver containing products, showed promising results when applied on the surface as superior to the standard of care. Further testing with larger sample sizes needs to be done along with assessing the duration of effect of each agent before consideration of clinical use.

Summary Statement

This study examined antimicrobial properties of micronutrients using commercially available topical products on colonized simulated surgical incisions.

Help Received

I used lab equipment at Loma Linda University under the supervision of Dr Y Cho. Statistical analysis was done with my mathematics teacher.

Name(s)

Kelly Harvell

Project Number

S1510

Project Title

Effects of Ocean Acidification on Chaetoceros gracilis in the Monterey Bay

Abstract

Objectives

Ocean water pH levels have been continuously rising since the Industrial Revolution due to the increased carbon dioxide gas in the atmosphere. The dangerous levels of carbonic acid in the ocean ecosystem may have an effect on the health of marine algae, such as diatoms. Marine diatoms account for the production of 25-40% of all air in the atmosphere and are essential to the marine food chain. My project sought to determine if a decrease in the pH of a medium containing the marine diatom Chaetoceros gracilis has an effect on the photosynthetic ability of the diatom.

Methods

Using commercial buffers, I adjusted the pH of test tubes filled with distilled water, seawater medium, and the marine diatom C. gracilis. I then tested the photosynthetic ability of the diatoms over the course of four days by measuring the absorbance of each sample group with a spectrophotometer.

Results

According to the data collected, a decrease in the pH improved the photosynthetic ability of C. gracilis, but only within a specific range. The diatoms in medium of 7.5 pH, sample group B, had the highest average absorbance value, which was 35.13% greater than sample group C's average absorbance and 42.36% greater than sample group A's. Sample groups A and C, with pH 8.2 and pH 7.0 respectively, had very similar average absorbance values for all days. Sample groups A and B had identical growth rates according to their exponential regression equations, whereas sample group C had the lowest growth rate of any sample group. Overall, C. gracilis appeared to perform photosynthesis well at a range from pH 8.2 to pH 7.5, with its greatest efficiency at 7.5 pH. As the pH decreases past 7.5, the photosynthetic ability of the diatoms greatly decreases.

Conclusions

These findings indicate that, as the pH of the ocean continues to drop, C. gracilis may become more abundant in the Monterey Bay, potentially contributing to harmful algal blooms. Unanticipated algal blooms could wreak havoc on the Monterey Bay National Marine Sanctuary if measures are not taken to decrease the effect of ocean acidification on algae growth rates.

Summary Statement

I tested the marine diatom Chaetoceros gracilis, which is local to Monterey Bay, in mediums of different pH levels to discern what effect the decreased pH would have on the photosynthetic ability of the diatoms.

Help Received

Mr. Jason Nicholson, my high school science teacher, provided me with lab space at my high school and equipment to perform my experiment. He also supervised my experiment while it was in progress.

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2019 PROJECT SUMMARY

Name(s)

Dolores Hernandez; Natalie Montes

Project Number

S1511

Project Title

The Highlight of UV and Makeup

Abstract

Objectives

My partner and I know how many people all over the world wear makeup and that their applicators contain bacteria that they don't know they put on their face daily. In this experiment me and my partner hope to kill bacteria found in makeup applicators with a UV light more than soap and water can. Our hypothesis if UV light is known to kill bacteria, the makeup applicators placed under UV will have more decrease in bacteria than the applicators washed with soap and water.

Methods

We used powdered agar (23 grams) and mixed it with water, creating a solution and putting into an autoclave at 121 degrees Celsius and 15 psi in order to limit he most possible contamination. When we took out the solution, we poured it equally into 25 petri dishes and let them harden overnight.We swabbed the different types of applicators with sanitized cotton swabs and swabbed them into the dishes with the hardened agar. These dishes were then placed in an incubator at 37 degrees Celsius for 48 hours. During those hours, we placed the 1 blush and contour brush and a beauty blender under UV light for 8 hours and 1 blush and contour brush and beauty blender washed with soap and water. Once done, we swabbed these applicators again and repeated the same process with the cotton swabs.

Results

After doing both UV light and soap and water treatments, we found that the UV light treatment was most effective in killing bacteria than the soap and water treatment. The soap and water treatment did kill a significant amount of bacteria but not as much as the UV light treatment did. In the average,there was a 28 centimeters squared decrease in bacteria with the UV light treatment in beauty blenders. In the average with soap and water, there was a 20 centimeters squared of bacteria decrease also in beauty blenders. These results showed that UV light showed a greater decrease in bacteria.We made sure that everything on the petri dish was bacteria because we had a control group that showed no sign of contamination so that meant that everything on the petri dishes was bacteria.

Conclusions

The UV light treatment was more effective in killing bacteria than the soap and water treatment. This means that the UV light treatment is a more easy and effective way to kill bacteria off of makeup applicators than soap and water because unlike soap and water, you don't have to wait a long time for your applicators to dry. This expiration will save makeup users time and money by not having to wait days for makeup applicators to fully dry and saving money y not buying many anti-bacterial soap.

Summary Statement

We experimented an easier way to remove bacteria from makeup applicators.

Help Received

Our advanced placement Biology teacher and her experienced friends helped up with materials and with the process of autoclave.

Name(s)

Jibiana Jakpor

Project Number

S1512

Project Title

Comparison of Gene Expression in Pancreatic Cancer with and without Perineural Invasion

Abstract

Objectives

Pancreatic cancer is the third leading cause of cancer death. Perineural invasion (PNI) which is cancer cells invading the surrounding nerves, is associated with a poor prognosis. Understanding the gene expression of perineural invasion in pancreatic cancer will help in the development of precision medicine to treat this deadly disease. I hypothesized that gene expression would be different in the patients with PNI than in the patients without PNI.

Methods

The dataset (GSE102238) is a deidentified public dataset from the NIH s Gene Expression Omnibus (GEO). I performed statistical analysis with GEO2R on the gene expression of two groups: all of the samples without PNI, and all of the samples with PNI. I downloaded the output of GEO2R as a spreadsheet and used R to convert the microarray probe IDs to HGNC Gene IDs. From the top 2000 genes with the most statistically significant gene expression differences (those with the smallest p-values), I used R to select the genes with log2-fold change values greater than 0. This means that the genes were downregulated in the samples with PNI. I studied the functional enrichments of those genes using STRING, a protein interaction database. I studied some of the specific genes in the enriched function using GeneCards.

Results

In the patients with perineural invasion, more than 232 genes were downregulated. Among the 20 Gene Ontology (GO) biological processes with the lowest false discovery rates enriched in these downregulated genes, 7 processes were directly related to immune function. The GO biological process with the lowest false discovery rate (1.00E-5) was "positive regulation of immune system process." There are 34 downregulated genes from this process.

Conclusions

There are differences in gene expression between pancreatic cancer patients with PNI and without. It is known that PNI in cancer is associated with a poor prognosis. With PNI, I found downregulation in 34 genes associated with "positive regulation of immune system process." Perhaps perineural invasion is associated with a weakened immune system. Understanding gene expression is essential to applying precision medicine to treat pancreatic cancer.

Summary Statement

This study compared the gene expression in pancreatic cancer patients with and without perineural invasion and found downregulation in more than 34 genes associated with immune function.

Help Received

I asked questions of Dr. Inhan Lee of MiRcore, UCSD undergrad student Aaron Ta, and UCSD graduate student Alex Sharp, who taught me these transcriptome research techniques last summer at the MiRcore computational biology camp in San Diego.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Vivek Kamarshi

Project Number

S1513

Project Title

Cellular Pathways for Increasing Fusion and Decreasing Replication of Varicella Zoster Virus

Abstract

Objectives

Varicella Zoster Virus (VZV) causes chicken pox and shingles. Cells infected with VZV undergo cell-to-cell membrane fusion mediated by viral fusion proteins; fusion is important to VZV pathology.
In a cell-based screening assay, the drug tacrolimus increased fusion by 300%--previously identified as being dependent on the drug complexing with a cellular protein. This drug-protein complex has documented effect of inhibiting the calcium-activated phosphatase calcineurin (CaN). My aims: 1) understand CaN s role in virus-modelling cell-cell fusion; 2) extend knowledge to live viral infections.

Methods

To quantify fusion, a cell-based model assay was used. To measure viral replication, skin-cell monolayers were inoculated with live virus, then evaluated for infection size/shape. CaN activity's relationship to fusion was investigated using drugs. Cyclosporin inhibits CaN similarly to tacrolimus; drugs affecting CaN's upstream activation were also used, including Ionomycin (increase intracellular calcium concentration and thus hyper-activates CaN) and Nicardipine (decreases calcium, resulting in hypo-activation).

Results

When cyclosporin was added to assay experiments it increased cell-cell fusion. Nicardipine was found to increase fusion, whereas ionomycin decreased fusion. This is consistent with the theory that level of Calcineurin activity is negatively correlated with cell-cell fusion in the assay.
To describe the effects of calcineurin activity, cells were stained for NFAT, a CaN substrate protein. When ionomycin was added to cells, NFAT translocated from the cytoplasm to the nucleus (indicating dephosphorylation); addition of a CaN-inhibitor blocked this effect. This confirms CaN's phosphatase role.
In vitro live-viral infections in the presence of CaN-inhibitors showed proportionally large amounts of infected-cell detachment and plaques with smaller overall size, as compared to controls. Thus, drugs which inhibit Calcineurin activity change live virus-induced cell fusion and reduce viral spread in cell monolayers.
Finally, an alternate fusion protein, when used in the fusion assay, saw inconsistent effects on fusion upon CaN inhibition. This suggests calcineurin inhibitors hyper-fusogenic effects are VZV-specific.

Conclusions

This is the first ever approach for reducing a live virus' spread by changing cell fusion. My findings that fusion is virus-specific and that CaN behaves as expected confirm that this approach to therapies is medically relevant. CaN-inhibitors make poor antivirals because they have immunosuppressive properties in vivo; however, a downstream step of this pathway might create a new target for an anti-VZV drug.

Summary Statement

I created a potential new approach to treating Varicella Zoster Virus, identifying a cellular protein that interfaces with the virus' "cell-cell fusion" effect and demonstrating that drugs which inhibit that protein can slow viral spread.

Help Received

I would like to thank Drs. Stefan Oliver, Marvin Sommer, and Momei Zhou (Stanford Peds Infectious Diseases, Arvin Lab), who allowed me to use lab facilities and lent mentorship on experimental design and data analysis. Thanks also to Ms. Renee Fallon and Mr. Pooya Hajjarian for presentation advice.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Emily Kang

Project Number

S1514

Project Title

Turning Over a New Phage: A Novel Approach to Phage Therapy

Abstract

Objectives

The increasing incidence of antibiotic resistance in bacteria necessitates the development of a new approach to target such infections without the constant overuse of antibiotics. This project tests the viability of alternatives to phage cocktails, the current standard for bacteriophage therapy, in order to develop a more sustainable treatment option.

Methods

To test a sequential approach to phage therapy, E. coli was initially cultured with T1 phage, with a single addition of T4 phage after varying periods of time. As a model of a phage cocktail under similar conditions, both T1 and T4 phage were cultured with E. coli; kinetic growth curves were created using absorbance for both methods. Based on the results from the sequential method, a computational model was created using Matlab to map growth dynamics for phage and bacteria based on the acquisition of resistance.

Results

Both the phage cocktail and the sequential approach were effective in eradicating the bacterial population without the emergence of resistance. The phage cocktail was initially faster in killing bacteria than the sequential method, but both methods displayed a similar end result. In contrast, bacteria grown with only one phage (T1 or T4) eventually gained resistance and was capable of logistic growth in the present of the single phage.

Conclusions

Based on growth curve data, sequential phage treatment was demonstrated to be capable of successfully eliminating a population of bacteria, whereas bacteria grown with only one phage quickly developed resistance and were able to proliferate and multiply instead of being killed. Although the method of applying phage in a sequential manner may require more than two different phage in most cases, it still ensures that only the phage necessary to control an infection are used, minimizing the types of phage that the bacteria is exposed to. In contrast, the current use of phage cocktails runs the risk of exposing bacteria to all of the phage in stock, which poses a possibility for the emergence of multiphage-resistant bacteria. Future studies could build on the computational model and focus on the development of a simulation that determines the optimal interval between phage additions in order to completely eradicate a population of bacteria, based on the infection mechanisms of the phage and the specific growth rates of the bacteria and phage in question.

Summary Statement

My project addresses the problem of antibiotic resistance in bacterial infections using a novel approach that uses bacteriophage to sustainably treat bacterial populations while minimizing the long-term risk of resistance to phage.

Help Received

Primarily used the lab space and equipment at my high school. Used a plate reader and qPCR machine from Dr. Isaac Mehl for final assays and received S. platensis and S. platensis phage from Roland Liu from the Pogliano Lab in the early stages of the project.

Name(s)

Raymond Kuan; Derek Tan

Project Number

S1515

Project Title

Effectiveness of Phycocyanin, Isolated from Spirulina platensis, on the Inhibition of Neoblast Tumor Growth

Abstract

Objectives

Spirulina platensis is a type of cyanobacteria also known as the blue-green algae. It contains a pigment called phycocyanin, which is made up of protein molecules, and is shown to be a highly effective antioxidant and anti-inflammatory substance. Most importantly, it has also shown the potential to bind to carcinogens and neutralize their effects. Using planarian neoblasts as a model for human stem cells, we visualized the impacts of phycocyanin on tumor development. The objective of this experiment is to investigate the possible anti-cancer and antiproliferative effects of phycocyanin isolated from Spirulina platensis with the hopes of identifying a future inhibitor to neoplasia.

Methods

We hypothesized that planaria exposed to both phycocyanin and a carcinogen will develop fewer tumors than planaria exposed solely to a carcinogen. There have been no similar experiments prior to ours; as a result, we needed to come up with a guideline and protocol to effectively test our hypothesis. We refer to this process as Stage 1, which identifies the correct dosage and lethal dosage of phycocyanin and glyphosate on neoblast cells. By using a titration test, we were able to determine the LD(50) of phycocyanin and glyphosate were 1 ml and 0.2 ml (5% and 1% m/v dilutions) in 20 ml spring water respectfully. By applying a safety factor of 45%, we calculated 0.5 ml and 80 ul (2.5% and 0.4% m/v dilutions) as the values for Stage 2. Then, in Stage 2, we divided planaria into 4 groups: Group 1 exposed only to phycocyanin, Group 2 exposed to both phycocyanin and a carcinogen (glyphosate), Group 3 exposed only to the carcinogen, and Group 4 living in spring water as a control. After 7 days, we analyzed the planaria under a light microscope to check for neoplasia.

Results

Group 3 was the group with planaria that developed the most tumors (31.25%). Group 2 also developed tumors (9.09%), and the rest of the groups appeared normal without any significant physical or developmental changes.

Conclusions

By running a 2 Proportion Z-Test and Chi-Square analysis, we were able to conclude a statistically significant ($p < 0.05$) correlation between phycocyanin and tumor prevention in planarian neoblasts, supporting our initial hypothesis. Our experiment demonstrates that phycocyanin does exhibit anti-proliferation characteristics and is a potential agent in preventing and mitigating neoplasia.

Summary Statement

This project aims at validating phycocyanin as a potential agent that inhibits neoplasia.

Help Received

We had access to our school's biology classroom and borrowed basic laboratory equipment.

Name(s)

Jillian Labador

Project Number

S1516

Project Title

Engineering Pseudomonas putida KT2440 for Biodegradation of Ethylene Glycol

Abstract

Objectives

Maximize consumption of ethylene glycol by engineering a bacteria Pseudomonas putida (P. putida) KT2440.

Methods

Designed a plasmid with the genes involved in converting ethylene glycol into biomass and transformed P. putida. Measured the optical density (OD) of the engineered bacteria in various concentrations of ethylene glycol, and will measure the concentration of ethylene glycol before and after its presence with the engineered bacteria using high-performance liquid chromatography (HPLC).

Results

There was significantly more growth of the wildtype P. putida in ethylene glycol than of the engineered P. putida, and there was insignificantly more growth of the P. putida with the control plasmid (backbone with no genomic insert) than with the expression plasmid. An effective HPLC protocol for ethylene glycol is being devised.

Conclusions

The toxicity assays of ethylene glycol on P. putida with the expression plasmid and with the control plasmid demonstrated no statistical difference in the optical density of the bacteria. The genes that were inserted into the backbone plasmid might not be effective in facilitating the growth of P. putida in ethylene glycol, which is a significant factor in maximizing the consumption of ethylene glycol.

Summary Statement

I designed a plasmid to maximize the consumption of ethylene glycol in the bacteria Pseudomonas putida KT2440.

Help Received

I did my research, developed my research question and hypothesis, and organized the data independently at home. I conducted the experiments at the University of California Riverside in Dr. Wheeldon's lab in the Department of Chemical Engineering under the supervision and guidance of a graduate student who

Name(s)

Lana Lim; Wenxuan Tang

Project Number

S1517

Project Title

Methylglyoxal, Antibacterial Agent in Manuka Honey, and Its Efficacy in Treating S. aureus Related Nosocomial Infections

Abstract

Objectives

Measurement of efficacy of 40% concentrated methylglyoxal fabric treatment on the elimination of Staph. aureus-related nosocomial bacteria on healthcare personnel's apparels which is a pathway of transmission for hospital-acquired infections in a healthcare setting.

Methods

Obtained 40% concentrated methylglyoxal solution with H2O from Sigma-Aldrich (chemical institution). Apply solution evenly on 10 of 5cm X 5cm fabric pieces of scrub and leave in a hospital setting for 96 hours to be contaminated with nosocomial bacteria. Swab the bacteria from each piece of fabric into petri dishes and compare with bacteria counts from scrub pieces not treated with methylglyoxal solution. Go on to test different variations of concentration and antimicrobial fabrics.

Results

Average percentage of bacteria eliminated on scrub treated with methylglyoxal in trail one was 21.08% and 21.26% in Trial two. The results reflect that methylglyoxal isolated as the active ingredient in Manuka honey, achieves a consistent amount of reduction of Staph. aureus-related nosocomial bacteria on fabric by eliminating an estimate of ? of the bacteria swabbed from hospital scrubs. New results on different variations of concentration and antimicrobial fabrics are still being updated.

Conclusions

A fabric treatment made up of methylglyoxal, the active ingredient in Manuka Honey, was isolated to study its traits in suppressing the expression of bacterial surface proteins binding to apparels. It would limit biofilm production and prevent Staph.-related nosocomial infections from occurring at all. Methylglyoxal avoids the problem of dealing with antibiotic resistance by utilizing a natural remedy normally used to cure skin deformities and pave a step closer in limiting the spread of nosocomial diseases if the vessel containing the bacteria, contaminated clothing, would be abolished or reduced. Creating a methylglyoxal spray or hygienic room (further research) provide a more efficient and faster solution to counter the increasing risk of HAI transmission and infection around the world.

Summary Statement

Creating hygienic fabric treatments with methylglyoxal solution to eliminate transmission of Staph. aureus-related nosocomial infections through ways of physcial communication and air ventilation in hospital settings.

Help Received

Help recieved from Dr. Rachell Auld in facilitated labs and borrowed equipments of Eleanor Roosevelt High School

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Abbie Maemoto

Project Number

S1518

Project Title

Nutrient Removal Efficiency of Nitrates and Phosphates by N. oculata through Increased Infusion of Carbon Dioxide

Abstract

Objectives

With a significant increase in global agricultural runoff in the past decade, microalgae have emerged as an important catalyst for effluent treatment and a potential alternative clean energy source. Nannochloropsis oculata is a species of green microalgae that has been utilized in the industry for both its rapid growth rates and its ability to absorb both nitrates and phosphates, the two main compounds found in farm runoff. An increase in algal growth may lead to greater lipid extraction yields for the synthesis of biofuels. As carbon dioxide is a key reactant in photosynthesis, and thus essential for algal growth, this experiment was designed to see if there is a correlation between carbon dioxide levels and nutrient absorption, maximizing both algal growth and effluent purification.

Methods

This experiment took place at the Cabrillo Marine Aquarium laboratory during the month of November. Algal cultures were initially infused with varying levels of carbon dioxide in sealed flasks and then placed on stir plates at a low speed for six days. Each day, cultures were filtered to measure nitrate and phosphate levels using the HACH 900; in addition, cell counts were taken using the hemocytometer and pH levels were monitored.

Results

The results indicate that there is a direct positive correlation between carbon dioxide concentration and cell density, thus increasing nutrient absorption rates. The study shows that there may be a critical carbon dioxide level that maximizes algal cell growth, which would improve algae s potential as a biofuel and source of effluent treatment. However, pH may also play an important role in affecting these variables, warranting further research in this area.

Conclusions

This study proposes a real-life solution that is beneficial to both the ecosystem and the fuel industry; as it was found that higher carbon dioxide levels were optimal for both maximum nutrient absorption and colony growth, flue gas can be utilized in wastewater treatment facilities to both remediate the effluent and maximize algal growth for maximum lipid extraction. Thus the promise of this experiment is multifaceted and is critical for researchers in the industry.

Summary Statement

In this project, I focused on the effect of increased carbon dioxide on nutrient absorption and algal growth, determining an optimal pH growth condition for N. oculata.

Help Received

Cabrillo Marine Aquarium

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Eric Markarian

Project Number

S1519

Project Title

Targeting Enterococcus faecalis with Phage Therapy

Abstract

Objectives

The objective is to introduce bacteriophages to Enterococcus faecalis cultures and to evaluate its efficacy against it in hindering growth compared to antibiotics used by many dentists. My hypothesis was that if I expose E. Faecalis to bacteriophages then it will be more effective than antibiotics in inhibiting bacterial growth.

Methods

My first step was to make my own Q69 phage. I did this by homogenizing unpasteurized goat cheese in 2% sodium citrate in a Lab-Blender. Melted BHI agar was added to this solution and supplemented with cycloheximide to inhibit yeast and mold growth. This solution was incubated for 24 hours. Next, I rehydrated the bacteria and it was incubated again. The next day, I soaked sterile disks with Penicillin, Augmentin, and Sulfamethoxazole-Trimethoprim and also with the Q69 phage. After, Brain Heart Infusion Agar plates were inoculated with the bacteria and the disks were placed into 4 separate plates and left to incubate for 24 hours at 37 degrees. On the final day, I measured the zones of inhibitions of each plate and compared the diameters to determine the most effective treatment method. This was repeated in 2 trials.

Results

After the procedure, it was found that E. Facelis was susceptible to the Q69 bacteriophage and Sulfamethoxazole-trimethoprim, resistant to Augmentin, and in the intermediate range for Penicillin. The first trial showed the zone of inhibition of the culture, when exposed to the Q69 phage, was 41mm making it susceptible to the phage. The zone of inhibition of the culture, when exposed to sulfamethoxazole-trimethoprim, was 39mm. Additionally, the zone of inhibition of the culture, when exposed to Penicillin, was 22mm placing it in the intermediate range. Finally, when exposed to Augmentin, the zone of inhibition was 0mm, meaning the culture was completely resistant to Augmentin. The above was true for the 2nd trial with slight discrepancies in inhibition values.

Conclusions

In conclusion, I believe that phages can have a huge impact in medicine, as they are able to exponentially grow in host cells which can significantly lower the cost for treatment compared to expensive antibiotics which are becoming increasingly inefficient today. The results I found indicate how bacteriophages are a much more viable and cost-effective option when fighting bacterial infections.

Summary Statement

I determined that bacteriophages are more effective in inhibiting bacterial growth (in E. Faecalis) compared to traditional antibiotics, and are a solution to antibiotic resistance.

Help Received

I received help from Mr. Stepan and Dr. Jordan who permitted me to use their clinical laboratory to conduct my project. Dr. Jordan did provide a suggestion when the mixture was not successfully combined in the centrifuge; otherwise, the main procedure was done by myself.

Name(s)

Helen Nguyen; Ezequiel Ponce; Sophia Tran

Project Number

S1520

Project Title

Targeting Susceptibility to Mutations in the Cell Cycle: Disruption of the Ade2 Gene in Yeast Using CRISPR/CAS9

Abstract

Objectives

If we arrest the cell cycle in S phase and M phase using inhibitors, we will see significant differences in DNA damage. In S-phase, we find DNA synthesizing, whereas in M-phase, DNA has condensed into their chromosomal structures. By doing so, we will be able to conclude in which stage of the cell cycle is the cell most vulnerable to mutations and translate it into CRISPR editing to see if the same results are shown.

Methods

The procedure involves dividing the yeast cells in two groups for each trial and, within those groups, three experimental procedures in which the cells will be treated with cell cycle inhibitors [DMSO (negative control), hydroxyurea (arrests the S-phase), and nocodazole (arrests the M-phase)]. One half will be the used to measure the DNA damage susceptibility of the yeast cells at a cell cycle phase by exposure to UV irradiation via comet assay. The other half will be used to measure the CRISPR editing efficiency by culturing the cells in galactose-containing media to induce expression of the Cas9 protein, affecting the edited ade2 gene to completely knock out both ADE2 genes, allowing for the growth of red yeast colonies.

Data will be collected by measuring the comet assay via application ImageJ and counting the number of red colonies from the plated yeast. ImageJ will allow us to precisely measure the density and lengths of each gel streak which should correlate with the DNA damage and translate into the yeast red colony count. For precise analyzation, we ran a total of 5 trials to find averages and standard deviation of our data.

Results

Cells targeted at the S-phase experienced an 11% higher mutation rate whereas cells in the M-phase saw a -1% rate less compared to our DMSO control, which is directly translated into our CRISPR efficiency with plated yeast whose cells showed proportional numbers to the comet assay cells treated under the same conditions.

Conclusions

We see that the cell is most susceptible to DNA alterations in the S-phase, while in the M-phase the cell experiences less. The trials treated with Hyd. showed longer and denser streaks, which means damage and mutations are occurring, and that directly translated into gene editing using CRISPR since they also produced a higher yield of red colonies compared to the rest of the trials with different treatments. The trials treated with Noc. experienced less genomic changes than our control (DMSO), which could indicate that the M-stage is less likely to experience DNA alterations.

Summary Statement

As more genetic mutations occurred in S-phase than in M-phase in yeast cells, it can be correlated that S-phase has higher susceptibility to mutations and CRISPR editing.

Help Received

Our advisor supervised us while we were doing our experimental trials. Certain materials were also donated by graduate students from Stanford, and our yeast strain donated by the Tech Museum.

Name(s)

Elaine Noh; Amy Shimizu

Project Number

S1521

Project Title

The Effect of Public Restroom Stall Location on the Bacterial Growth on Toilet Seats in Each Stall

Abstract

Objectives

Observe how the location of a stall relative to the entrance affects its bacterial contamination. Higher bacterial contamination indicated a higher number of uses in each stall.

Methods

Nutrient agar, Petri dishes, sterile swabs, incubator. Measured the amount of bacterial growth by counting the colonies visible to the naked eye.

Results

The bacterial contamination of each toilet seat was graphed for each restroom, and the trends between the stalls were compared in addition to the ones between the restrooms. The second stall was found to have the highest amount of bacterial contamination in each restroom.

Conclusions

In general, the middle stalls were found to have the highest amounts of bacterial contamination, indicating that the centrality preference influenced the stalls into which the users would enter. Since the psychology and situation of the users at each location differed, however, the remaining bathrooms stalls did not have clear trends among them when compared to other restroom locations.

Summary Statement

We found how the location of a stall relative to the entrance affects it bacterial contamination.

Help Received

A researcher affiliated with the University of California, Irvine, advised us on how to collect bacterial samples. We collected the bacterial samples ourselves.

Name(s)

Jayna Patel

Project Number

S1522

Project Title

The Effect of Using Alcohol-Based Hand Sanitizer vs. Alcohol Hand Wipes on the Percent of Bacterial Reduction from Hands

Abstract

Objectives

The purpose of this experiment was to determine how alcohol-based hand sanitizer and alcohol hand wipes compared in reducing bacteria from hands.

Methods

There were ten subjects. The subjects' dominant hands were swabbed onto a petri dish with nutrient agar for the control amount of bacteria. The following day, the subjects' hands were swabbed after they rubbed "Purell Original Hand Sanitizer" on their hands to clean them. The day after that, the subjects' hands were swabbed after they cleaned their hands with a "CVS Instant Hand Sanitizer Wipe". The bacteria grew for 10 days, and then the percent of bacterial reduction between the control and experimental groups was calculated.

Results

The average percent of bacterial reduction from hand sanitizer was 90.30%, and the average percent of bacterial reduction from hand wipes was 95.32%. The hand wipes were slightly more effective at removing bacteria from hands than the hand sanitizer.

Conclusions

The difference between the two percent reductions was very minimal. The subjects who had extra grease from food on their hands before being tested on produced results where the hand wipes were more effective than the hand sanitizer. The subjects who were not eating before being tested on had results where both items produced relatively equal results. That suggested that both items produced similar results when used on visible clean hands, but that hand wipes work better than hand sanitizer when cleaning visibly dirty hands. This information can help people who are traveling decide which hand washing alternative would be best for them. It is also applicable to countries that do not have access to clean water.

Summary Statement

This experiment compared the effects of using alcohol-based hand sanitizer and alcohol based hand wipes on their ability to remove bacteria from hands.

Help Received

None, I designed and performed the experiment myself.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Sasha Ronaghi

Project Number

S1523

Project Title

Using Machine Learning and Surface Enhanced Raman Spectroscopy to Analyze the Effects of Antibiotics on P. aeruginosa

Abstract

Objectives

Every year, there are 6,700 multidrug resistant Pseudomonas aeruginosa infections and 440 deaths. Yet, medical professionals have no immediate way of determining the best antibiotic treatment for patients with P. aeruginosa because pathogen identification and antibiotic susceptibility tests take 3-5 days. Physicians must either prescribe broad spectrum antibiotics with harmful side effects or a combination of antibiotics that may increase antibiotic resistance. This problem inspired the design goals of this method: determine the identity of the pathogen, differentiate susceptibility and resistance to antibiotics, and determine minimum inhibitory concentration of an antibiotic in a time and cost efficient way.

Methods

After P. aeruginosa is exposed to the antibiotic, cell lysis is performed to obtain the metabolites inside of the cell. Thereafter, Surface Enhanced Raman Spectroscopy (SERS) is used to provide a chemical fingerprint of the sample. While most SERS studies analyze a single metabolite, this method examines the entire profile of metabolites at 1011 wavenumbers. The large extent of this data is simplified using the machine learning algorithm t- distributed stochastic neighbor embedding (t-SNE). t-SNE is an unbiased machine learning algorithm that reduces the 1011 dimensions of SERS spectra to 2 dimensions for simplification and evaluation. In a susceptibility differentiation test, P. aeruginosa is exposed to Rifampicin (resistant) and Carbenicillin (susceptible) for 30 minutes. In a minimum inhibitory concentration test, P. aeruginosa is exposed to varying concentrations of Gentamicin (susceptible) for 30 minutes. In a time optimization test, P. aeruginosa is exposed to the same concentration of Gentamicin (susceptible) for varying time periods.

Results

A support vector machine learning algorithm confirms that t-SNE can differentiate susceptibility versus resistance with 99% accuracy and differentiate concentration and time exposed with 90% accuracy. The time optimization test shows that changes in metabolites after just 5 minutes of exposure can be detected. Results showed similar trends found in colony forming unit analysis, the gold standard.

Conclusions

Instead of waiting 3-5 days for identification and antibiotic sensitivity results, doctors can see results after 1-2 hours of suspecting infection, which is the total time necessary to inoculate, perform cell lysis, analyze using Surface Enhanced Raman Spectroscopy, and run through the t-distributed stochastic neighbor embedding. Additionally, this method provides a new analysis method the scientific community can use to analyze the effect of antibiotics on bacteria while taking account of the full profile of metabolites.

Summary Statement

Instead of taking 3-5 days to learn which antibiotic treatment is best, I created a method to determine susceptibility and identity of pathogen after 2 hours.

Help Received

I worked on this project at Dr. Allon Hochabum's lab. The only aspect of this project that I didn't do was taking the Surface Enhance Raman Spectroscopy pictures. However, I shadowed the entire process.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Phoenix Rumbaugh

Project Number

S1524

Project Title

Mitigating Effect of Yucca Root Powder on Microcystis aeruginosa

Abstract

Objectives

Objective: To determine if Yucca Root powder can mitigate the growth of Microcystis Aeruginosa..

Methods

Five tubes of non-toxic Strain of Microcystis Aeruginosa, one bag of Yucca root powder, ,35 test tubes, test tube stand , four boxes of microscope slides, three boxes of microscope slide covers, digital microscope with camera built in, Apron, protective glasses, Nitrile gloves, Mask, Antibacterial wipes, plastic sheets for Small pieces of glass slide covers bacterial soap bucket bottle of bleach heater for test tubes, digital thermometer, digital metric scale, small funnel, small glass metric graduated cylinder, printer.

I filled 25 5ml bottles with 3ml of non-toxic Microcystis Aeruginosa, I made 5 groups of 5 test tubes. In each group, there were 2 control test tubes, 1 test tube with 0.06 mg Yucca root powder added, 1 test tube of 0.12 mg of Yucca root powder added, and one test tube of 0.24 mg of Yucca root powder added. Over the next 5 days, I would make a slide of each test tube once a day and take a photo of the slide. The test tubes were exposed to light and kept at a constant 20 -22 degrees Celsius. Then I would count the Microcystis. On the fifth day, I wrote my data and results.

Results

The Microcystins diminished about 30% in the solutions with 0.06 mg of Yucca root powder, about 40% in the solution of 0.12 mg of yucca root powder and about 65% in the solution of 0.24 yucca root powder.

Conclusions

Based on the quantitative analysis of this project, the Yucca root successfully diminished the amount of Microcystis Aeruginosa. This could mean that the Yucca root may be a viable deterrent for Microcystis Aeruginosa. I do believe that this project should be tested further with more testing. Before the Science and Engineering Fair, I would like to test further, including using meters for ammonia and possibly dissolved oxygen and temperature.

Summary Statement

This project is about using Yucca root powder to stop or slow down a toxic Microcystis Aeruginosa, one of the most common cyanobacterias.

Help Received

I received help from my Chemistry teacher at Santa Cruz Learning Center, AFE counselor Joanne Brown, Anne Rumbaugh

Name(s)

Ashley Schletewitz

Project Number

S1525

Project Title

Evaluation of Equisetum hyemale Extract as an Alternative Chemical for the Control of Penicillium italicum on Citrus

Abstract

Objectives

The objective of this study is to evaluate if Equisetum hyemale can inhibit the growth rate of Penicillium italicum on citrus fruit.

Methods

Bleach all oranges and containers in 10% bleach solution. Place 4 oranges in each of the 12 containers, splitting them up by Equisetum hyemale concentration. Puncture each orange in the center, spray concentrations of Equisetum hyemale and inoculate with Penicillium italicum. Observe and record growth of Penicillium italicum every 2 days. Continue over the course of 16 days. Record results in data book
*Cultured fruit was disposed of by professor

Results

The oranges containing 130.4 mg/ml of Equisetum hyemale extract was the most effective at inhibiting the growth of penicillium italicum.

Conclusions

Equisetum hyemale does decrease the growth rate of Penicillium italicum, because the results showed that the 130.4mg/ml of Equisetum hyemale decreased the growth the most, but the 195.6 mg/ml seemed to increase the growth. This shows that there may be a point when the fungus becomes immune to the Equisetum hyemale, and starts to feed off the Equisetum hyemale causing it to grow more rapidly.

Summary Statement

I discovered a natural organic solution to a destructive citrus fungus that could potentially save the agriculture industry millions yearly.

Help Received

Dr. Themis J. Michailides supervised me during project testing.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Elizabeth Zhang

Project Number

S1526

Project Title

The Effect of Metal Ions on Lactobacillus acidophilus Growth and Beta-galactosidase Activity

Abstract

Objectives

This project aims to assess Lactobacillus acidophilus growth and beta-galactosidase activity in response to the following divalent metal ions: magnesium, manganese, and iron.

Methods

To test bacteria growth, reactivated L. acidophilus (Carolina Biological) was inoculated into 4 groups of culture medium, with 3 groups containing additional Mg, Mn, and Fe ions, respectively. After incubation, the relative growth intensities were obtained through spectrophotometric measurements of turbidity at 610 nm.

To test beta-gal activity, bacterial cell pellet samples were treated with an O-Nitrophenyl-beta-galactopyranoside assay (Hardy Diagnostics). Spectrophotometric analysis at 440 nm measured the development of yellow color, which represented relative beta-gal activity.

Results

The positive control, Mg, Mn, and Fe growth samples (N=9) displayed bacteria growth intensities of 0.194, 1.335, 0.182, and 0.268, respectively. The positive control, Mg, Mn, and Fe samples (N=5, 4, 5, and 5, respectively) had beta-gal activities of 0.280, 0.593, 0.205, and 0.305, respectively.

The addition of Mg exhibited statistically significant increases of 598% and 112% in bacteria growth and beta-gal activity, respectively, in comparison with the control group. The effects of the Fe and Mn samples on bacteria and beta-gal activity were statistically insignificant.

Conclusions

L. acidophilus is a strain of gram-positive bacteria used commonly in commercial probiotics; this bacterium is often ingested for lactose fermentation, which is facilitated by the enzyme beta-gal. Mg appeared to significantly promote bacteria growth and enzyme activity, which are quantifiable indicators of metabolic activity. The data suggests that, of the three ions, the adjunct consumption of Mg with L. acidophilus probiotics may significantly improve conferred benefits.

Summary Statement

This project suggests that magnesium ions lead to the most significant increase in Lactobacillus acidophilus growth and beta-galactosidase activity.

Help Received

I designed and completed the experiment by myself. I received guidance from my school s science research advisor, Ms. Melissa Klose, through our designated research program.