Warwick IGEM Collective

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A collection of different IGEM 2021 Team projects collated together to show the diversity of the field of synthetic biology

The diverse world of Synthetic biology presented through IGEM competition

31 page booklet with project details from over 15 different teams across 3 different continents. Tasks for students included.

INTRODUCTION

iGEM is an international Synthetic Biology competition which was developed by MIT. Teams of students are chosen to represent the university in the competition and create a solution using synthetic biology to real life problems in a range of fields. Such as problems in the field of diagnostics, environment and agriculture

"Synthetic biology is a field of science that involves redesigning organisms for useful purposes by engineering them to have new abilities"(1).

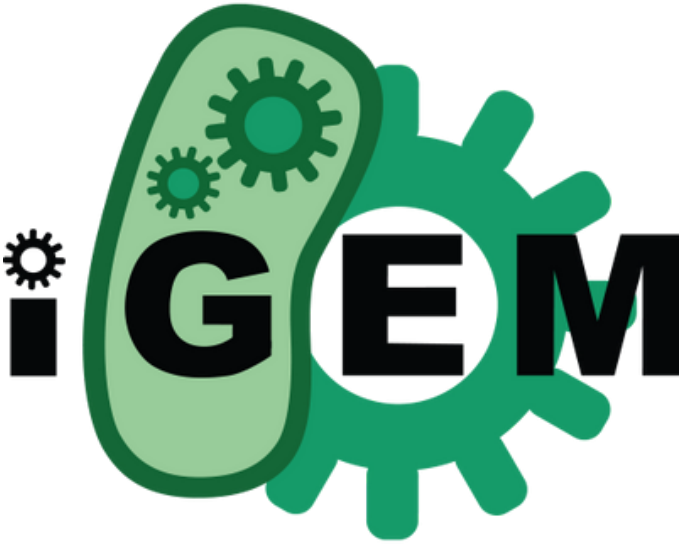
Being part of the iGEM Warwick allows you to be part of a multidisciplinary team working with students from a range of degree streams as well as work with PhD students and a range of professors. You have the opportunity to design and create your own experiments and work with a range of students on different iGEM teams across the globe such as Russia, USA and Taiwan. You will have the opportunity to not only develop your understanding of the field of synthetic biology but improve and gain key transferrable skills in communication and management.

This booklet created provides a taster in to the importance of synthetic biology in providing solutions to real life problems, with iGEM teams across the globe sharing their project and also tasks which can be completed if you would like to further develop your knowledge on the field of Synthetic biology. This Booklet is aimed for 16-18 years olds who are studying biology or would like to pursue a degree in life sciences.

Feel free to complete the tasks for your own personal knowledge development and to gain a deeper understanding of the vast application synthetic biology has.

To learn more about the overall competition head to igem.org. You can also check out our social media pages: igem_warwick (Instagram) , warwickigem (twitter, Facebook). Our Social media pages will keep you up to date with the development of our project and is also where you can send in your questions.

(1) - Synthetic Biology (genome.gov)



WARWICK IGEM COLLECTIVE

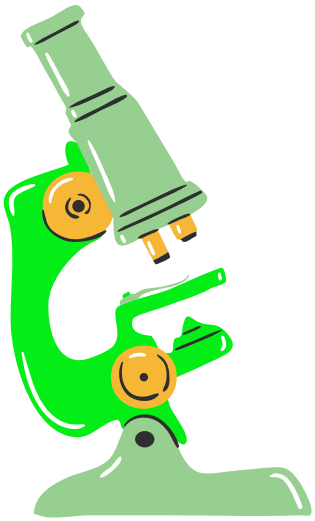
ISSUE 1

TEAM WARWICK

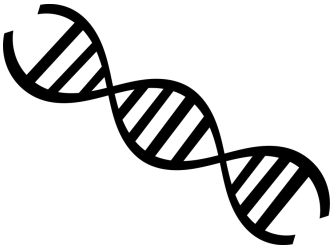
Biosensor based detection method for CRE which can pre-emptively catch outbreaks of **Carbapenem resistant Enterobacteriaceae** (CRE) as well as identify areas which need to be sanitised.

In recent years, some Enterobacteriaceae have developed resistance to carbapenems. Carbapenems were already considered a “last-resort” antibiotic, used to treat severe infections with multi-drug resistant bacteria. Infections with such bacteria are thus particularly difficult to treat and an outbreak could have disastrous consequences. Currently, the focus lies on containment – patients with CRE infections are isolated and staff have to use personal protective equipment when attending to them, putting strain on the hospital’s space and resources.

Application of disinfectant is often enough to kill any bacteria present; however, improper application can leave significant numbers of viable bacteria alive. To aid in containing the spread of CRE, we propose a detection method based upon a biosensor sensitive to the presence of a molecule indicative of live CRE. When the molecule is detected, a fluorescent protein is transcribed and translated to produce a visual identifier. Ideally, this system would be provided as a cell-free extract which would be applied to disinfectant solutions before use.



Research Task :
Create a poster presenting information on CRE , what it is , symptoms experienced by patients , type of bacteria and how it is currently managed in hospitals.
As a summary ,answer the following questions - Why do you think Synthetic Biology poses a possible solution to the lack of detection tools we currently have in hospitals for certain diseases/bacteria and do you believe that syn bio has an impact on the detection of disease/ bacteria in clinical environments ?

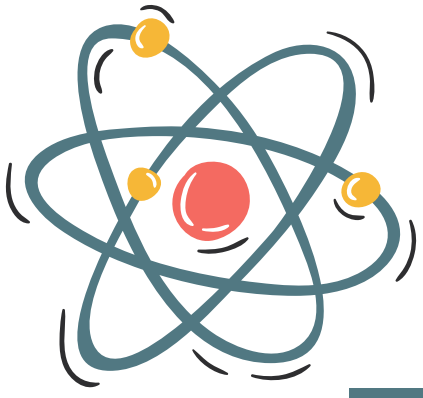


IGEM UPPSALA

Our project aim to improve the way beef is grown in the lab. This is done by controlled mutations of the gene that is responsible for the growth of the meat.

Importance of Synthetic Biology in their Project :

Synthetic biology is important to be able to gain the protein the makes the meat grow before and after we have changed it.



How important is your project in being a solution to a current problem in your local area or world wide ?

It is very important since we believe that lab grown meat is the future way of gaining meat.

Research Task :

Draw a mind map of pros and cons you can think of regarding lab grown meat vs traditional meat and compare to your friends.

IGEM LINKÖPING

Our Project :

Our project is about modifying a cyanobacteria to be able to take in the salt in salt water. A gene that codes for the ion channel Halorhodopsin will be inserted into the cyanobacteria. This channel will allow the bacteria to take in Cl-, which would then lead to Na+ flowing in as well because of the change in electrical charge. This change will lead to a higher negative charge on the inside of the cell which will cause the cell to compensate for it. To make this process easier, we will also insert a gene that codes for the Na+ channel Mscl. Because we do not know how this new and modified cyanobacterium will affect the environment, they need to be filtered out before the water can be used. We want to solve this by inserting a gene that codes for a so-called Cellulose Binding Domain, which would attach to the surface of the cyanobacteria. This domain can bind to a filter composed of cellulose and therefore be filtered out of the water. This water can then be used in agriculture and sewage.

What is the importance of Synthetic Biology in your Project ?

With the use of synthetic biology, we get to engineer our cyanobacteria to do what we want. The desalination will take place while only consuming sunlight, making it much more energy efficient and environmentally friendly than regular desalination methods.

How important is your project in being a solution to a current problem in your local area or world wide ?

We, in Sweden, are lucky when it comes to the availability of freshwater. It is only at a few places that water shortage is a major problem. In many other areas of the world, water shortage is always a major problem. The success our project will hopefully lead to future research regarding the usage of cyanobacterial desalination on an industrial scale.

Research task :

Make a poster about water shortage, the extent of it as well as brainstorm possible solutions to improve the situation.

IGEM EINDHOVEN

Our Project:

As the iGEM team Eindhoven, we will be working on a genetically modified organism (GMO) for non-invasive monitoring of inflammatory bowel disease (IBD). IBD, including Crohn's Disease, is a chronic inflammatory disorder of the intestine. Over 2 million Europeans and 1.5 million North Americans suffer from IBD. Currently, monitoring of IBD is mainly performed with a survey, a calprotectin test and endoscopy, of which the latter is invasive and therefore, unpleasant for the patient. Our goal is to make the current monitoring procedure more pleasant, by making it non-invasive. The non-invasive procedure will contain a sensing mechanism for chronic bowel inflammation by means of engineered *E.coli* bacteria and ultrasound technology. The *E.coli* bacteria can detect inflammatory markers in the intestinal wall. As a response to the presence of these markers, the bacteria will produce tiny gas vesicles and these gas vesicles can be observed via ultrasound and measured quantitatively.

How important is your project in being a solution to a current problem in your local area or world wide ?

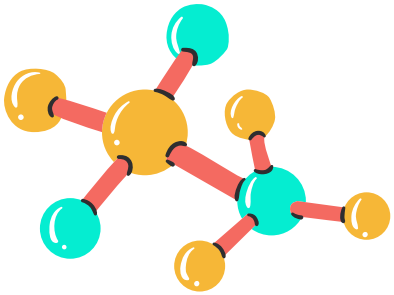
Inflammatory Bowel Disease (IBD) has an occurence of 2 million patients in Europe and 1.5 million patients in North America. IBD is also still rising in relative numbers, meaning that more and more people get this disease every year. It is not known what causes this disease and how it can be treated to be fully cured. For now, regular check-ups of the patients take place in the hospital by survey, a calprotectin test and, if necessary, an endoscopy, which can be up to every 4 months. An endoscopy is a very invasive and unpleasant procedure for the patient. Not only during the procedure, but also the preparation from the patient's point of view before the procedure (2 days of laxative medication take-in and hardly eating anything). With our project, we aim to make a non-invasive monitoring procedure for these check-ups, to make their life a bit easier.

What is the importance of Synthetic Biology in your Project ?

In our project, we aim to make two different components, divided over three different plasmids, working together in an *E.coli* bacteria. For simplicity, we will call them here plasmid 1, 2 and 3. Plasmid 1 is responsible for the production of the sensor component, plasmid 2 for the regulator component which is responsible for the activation of the cascade in plasmid 3 once the inflammatory marker is sensed, and plasmid 3 which produces the tiny gas vesicles. In order for our project to work, we are adjusting the promoter of plasmids 3 to make this possible. Resulting in the fact that once the molecule is sensed, via the cascades of the three plasmids, our gas vesicles are made.

Research Task :

For the IBDetection Project, the three plasmids need to be connected in a way that they are all active after one another, but only when the receptor made by plasmid 1 senses the specific molecule for your system. For this specific case that means that plasmid 2 needs to activate plasmid 3. Which promoter would you change, and with what promotor would you change it ? Or is there another way how you would achieve this, and please explain why you think so? ***Hint: You don't need to research the specific names for each promoter, just name them promoter 1, 2, and 3 for the plasmid you want to change or you want to use a duplicate promoter from.**



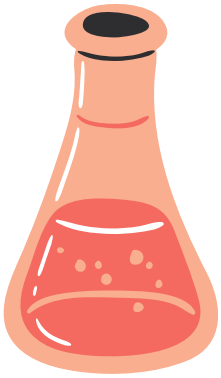
IGEM UCALGARY

How important is your project in being a solution to a current problem in your local area or world wide ?

Our project is integral in order to sustainably recycle e-waste in an efficient and cost-effective way. In the age of technological advancement, electronic waste is the fastest-growing solid waste stream. Just last year, almost fifty-four million tonnes of e-waste were dumped globally, with Canada being a large contributor to the problem. Among these high-value metals, rare earth elements (REEs), are some of the hardest to recover, with an increasingly growing global demand. They are used in catalytic converters, and a multitude of electronic devices such as phones, hard drives, and computers. Currently, the main source of REEs are found in metal ore mines in China, and the supply chain is highly monopolistic and unstable. Conventional REE extraction methods from e-waste include hydrometallurgy, which uses high volumes of strong acids, and pyrometallurgy, which uses high temperature to extract metals. However, these have detrimental environmental impacts, posing a major problem that needs to be addressed in our transition to a circular economy.

Our Project:

Our project, Neocycle, consists of three major components aimed to solve the existing problems in the extraction, separation, and measurement of REEs in e-waste recycling processes. First, bioleaching provides a cost-effective alternative to conventional industrial extraction methods. We plan to conduct a comparative study between two bioleaching species: Gluconobacter oxydans and Acidithiobacillus thiooxidans where the acids created by these microbes will be used to leach out the REEs from e-waste in a sustainable manner. Next, we plan to pack lanmodulin-functionalized cellulose beads in an adsorber column to selectively separate REEs from a mix of metal ions present in the digested electronic waste. This will enable undesired metals to pass through the absorber column, separating out the REEs. Lastly, we have developed three user-friendly and highly selective measurement systems using lanmodulin. These novel systems utilize an electrochemical or luminescent signal to determine the concentration of REEs in the sample.



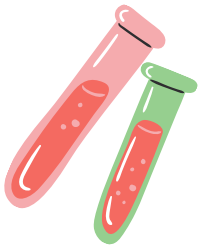
What is the importance of Synthetic Biology in your Project ?

The novel lanthanide-binding protein, lanmodulin, is found natively in Methylorubrum extorquens, a methylotroph. However, if we were to upscale lanthanide extraction via lanmodulin, using a more well-characterized bacterial chassis, such as *Escherichia coli*, would be more ideal. Hence, synthetic biology allows us to heterologously express lanmodulin in *E. coli* in an attempt to produce the protein in a much more industrially relevant scale.

Research Tasks :

Research what elements are in electronic waste and then research proteins that can bind to these specific elements! For example look at our project: Lanthanides are found in electronic waste and lanmodulin is a protein that can bind to lanthanides. How many different proteins can you find that bind to elements relevant to e-waste?

TEAM KOREA_HS



What is the importance of Synthetic Biology in your Project ?

Recall the description of our project: we have explained that we are putting three different biological "parts" - CPP, siRNA, and doxorubicin - to form a new product that combines the unique properties of each into one significant product. The concept and methods of synthetic biology allowed us to redesign different parts to come up with a novel cancer therapy that utilizes the strengths of each part to overcome different impediments of cancer treatment that previous methods were not able to resolve.

Research Task :

Design a new drug (containing CPP)! First, choose a disease that you want to tackle and learn more about it. What are the treatment options available for that disease, and what obstacles do physicians face during the treatment process? Second, research different types of CPP and learn more about them. What are their characteristics, and what CPP model do you believe best suits the treatment of your disease? Third, research different types of cargoes that you want to attach to your selected CPP model. What type of cargo should you deliver into the cell using CPP? Think of medications that can't go through the cell easily. Lastly, model it! You can either hand-draw this or complete a digital design.

Our Project :

Our team this year is attempting to design a novel therapy to both lung and breast cancers. Cell-penetrating peptide (CPP) is a protein that can penetrate a cell; it also can carry different types of cargoes (for example, medications) with it. CPP is modified so that it targets only cancerous cells without any side effects. siRNA is a molecule that, after a complex biological process, "silences" a gene encoding for specific characteristics of a cell. Doxorubicin, also know as the "red devil," is an anticancer drug that kills cancerous cells by destroying important proteins protecting a cell's DNA.

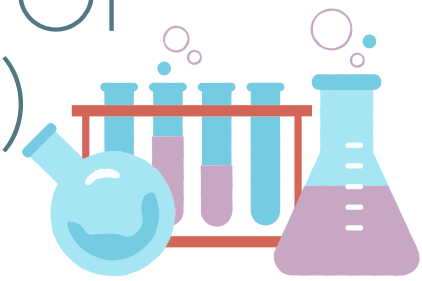
The problem physicians have with treating cancer is that the cancerous cells are resistant to anticancer drugs, meaning patients earn no benefits from taking anticancer drugs. To solve this issue, our project combines CPP, siRNA, and doxorubicin into a single product. What will this product have in effect? First, having CPP, it will locate and penetrate only the cancer cells without any side effect. Second, having siRNA, it will silence the gene that makes cancerous cells drug-resistant (that is, making cancerous cell unable to fight back to any drug). Third, having doxorubicin, it will kill the cancer cell!

How important is your project in being a solution to a current problem in your local area or world wide ?

Cancer is a global issue: approximately 20 million people have been diagnosed with cancer only in 2020, and in South Korea, for people 40 years old or older, cancer ranks the first among factors that cause death.

Our product overcomes these impediments in two ways. First, our CPP only targets cancer cells. Second, our siRNA "cancels" cancer cells ability to resist drugs as it silences the DNA that allows cancerous cells to do so. In conclusion, our product locates cancerous cells and nullifies their ability to fight back, which previous methods never were able to accomplish.

SDU (THE UNIVERSITY OF SOUTHERN DENMARK)



How important is your project in being a solution to a current problem in your local area or world wide ?

Depression can affect a persons well-being to the degree that they become unable to work and uphold their responsibilities. If too many people suffer we will be left with a smaller workforce. More than that, it is intrinsically bad to have a population who are not well. Our project contributes to dealing with this issue, by trying to produce a compound which researchers can determine to be a treatment option.

Our Project:

This past year with COVID-19 pandemic lockdown(s), the data has shown that more people are getting diagnosed with depression. Our iGEM project will focus on synthesizing the psychedelic substance, psilocybin, as a potential alternative treatment to the illness. There is a growing body of evidence suggesting that psilocybin can be used to treat mental illnesses such as depression, anxiety and PTSD.
This means that psychedelics might be used to treat depression, because it shows potential for prolonged improvement of depressed patients mental health after only a short treatment period. The research also tells us that there is only mild side-effects when treating mental illnesses with psychedelics.

Research Task :

1. Start by watching this video: https://www.youtube.com/watch?v=BLTT4QfD97M&ab_channel=TinyMedicine
2. Discuss what you think about treating mental illnesses with psilocybin.
3. Then go to find a graph showing the increasing number of patient with depression, by googling "increase, depression, corona, data".
4. Watch this video: https://www.youtube.com/watch?v=dfYu-FVgSYE&ab_channel=WorldScienceFestival
5. Discuss what synthetic biology is, and how you can use it

What is the importance of Synthetic Biology in your Project ?

Psilocybin is produced naturally in certain mushrooms, like the liberty cap. However, administrating the whole fungi as medication is risky and difficult to control, because the amount of psilocybin varies. It can be expensive and difficult to extract and purify from the mushrooms. In our project, we are planning to use biosynthetic production mechanisms, utilizing *E. Coli* as a chassis, to produce psilocybin. Our project will mainly focus on streamlining the production of psilocybin, thereby making it cheaper and more available.

OHIO STATE

Our Project :

We are proposing a genetically engineered phage therapy solution to combat sepsis. Sepsis is the overreaction to a bacterial infection which results in a cytokine storm. Phage therapy utilizes bacteriophages (phages for short) which are viruses that only infect bacteria. Phages can influence bacteria from the inside by inserting their DNA into the bacteria cell. Our solution uses phages to deliver modified DNA into the bacteria.

Sepsis results from bacterial infections, which occur when bacteria colonize in incorrect places in the human body. Bacteria have a component called lipid-A in their cell walls which is recognized by cytokines. These cytokines send a message to the immune system that there is an infection so that immune cells can respond to this.

Too many cytokines can lead to a cytokine storm, resulting in organ damage and eventually death due to low blood supply to organs. If lipid-A is modified so that it goes undetected from the immune system, then there won't be an overreaction leading to organ failure. This is why we are engineering a phage to have the bacteria produce a protein that will prevent the immune system from recognizing lipid-A.

What is the importance of Synthetic Biology in your Project ?

We leverage the natural ability of phage to infect a specific bacteria. We also utilize synthetic biology to have the phage carry the DNA we have modified and insert the DNA into the bacteria.

The engineered DNA sequence includes instructions to build a protein that binds to the existing lipid-A molecule. This will change the conformation of the molecule so that it is undetectable by the human immune system.

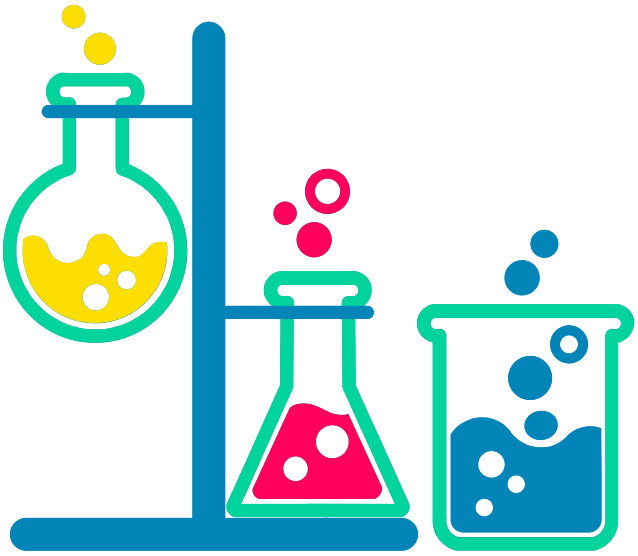
How important is your project in being a solution to a current problem in your local area or world wide ?

At least 1.7 million adults in America develop sepsis each year, and approximately 1 in 5 deaths worldwide are sepsis-related. Sepsis results from a bacterial infection and the rise of superbugs will increasingly make this a common condition that can affect everyone. However, the immunocompromised such as premature infants and the elderly are more susceptible. Sepsis is best when caught early, but there is not one solution that solves this problem. Our solution will serve as a targeted route to prevent cytokine storms.

Research Task :

Brainstorm other uses for having a phage deliver the desired DNA instructions so that a bacteria can have a certain ability or produce a desired protein.

DUKE UNIVERSITY



Our Project:

Our team is creating a drug screening platform for one of the most aggressive forms of brain cancer: glioblastoma. A drug screening platform is a system that allows you to test how good a certain drug is at doing its job. In order to build an efficient platform, we are utilizing brain organoids, which are miniature models of the brain that are grown up in the lab and mimic the structure and function of the organ! Additionally, we are using synthetic biology tools to build a reporter system, which is built from DNA and targets specific genes that will allow us to visualize the impact of a variety of drugs on these brain tumours. This technology has the potential to facilitate breakthroughs in the field and offer hope to patients in the battle against this disease.

How important is your project in being a solution to a current problem in your local area or world wide ?

Glioblastomas are one of the most difficult to treat cancers. There is an urgent need to determine the most effective and personalized drug treatment for patients because they have a median survival of only 11 months and can react very differently to various treatments. Using our drug screening platform, researchers and healthcare professionals can test drugs specific to certain cell lines or cancer mutations at a lower cost, lowering the barrier to drug development and improving personalized treatment for difficult-to-treat cancers. By testing how patient-derived cells react to different drugs, our glioblastoma-organoid technique can also better inform patient care at hospitals. Beyond clinical applications we aim to integrate synthetic biology in primary cells and multicellular

What is the importance of Synthetic Biology in your Project ?

We are using synthetic biology in our project to design a reporter system that can assess the efficacy of different cancer therapies on treating glioblastomas. We are designing this reporter system by piecing together specific sequences of DNA that encode for particular genes that will allow us to visualize how cells respond to these drugs using fluorescent proteins. Fluorescent proteins are a key player in synthetic biology, as they allow us to monitor the levels of important molecules within the cell, since we can see cells glow under the microscope depending on the level of expression (i.e. the amount of the important molecules in the cell). This reporter system will allow us to target a specific molecule that will tell us how effective the drug is, so we can quantify the efficiency and efficacy of a variety of cancer therapies. Without utilizing the tools of synthetic biology, we would not be able to create a versatile, efficient system to help us measure the success of new and old cancer drugs.

Research Task:

Research existing therapies for glioblastoma. How effective are they? What are some issues they have?

One important aspect of a drug screening platform with multiple cell types is that it must distinguish between different cells. In our project, we must tell cancer cells apart from normal brain cells.

One way is to utilize specific mutations that are common in cancer cells but not in normal cells. Find some common mutations in glioblastoma and brainstorm how they can distinguish between cell types. For example, do they cause the cell to produce different compounds than normal, affect the rate of cell growth, or affect neighboring cell activity?

Our reporter systems are delivered as plasmids, which are engineered circular pieces of DNA that the cell expresses. For these plasmids to work, they must contain several important pieces. What are they and what do each of them do?

For our system to work with drug screening, we need the circuit to respond to different levels of compounds relevant to glioblastoma cells and produce a visualizable output whose intensity depends on these compound levels.

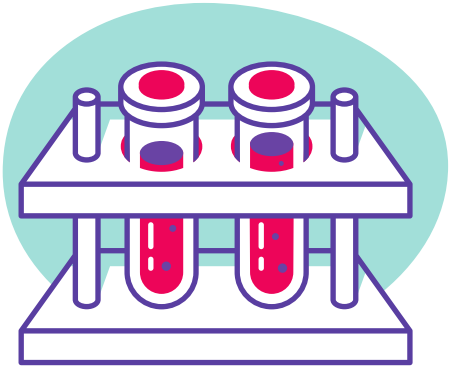
MINGDAO IGEM TEAM

Our Project :

We have decided to focus on food safety issues. In modern days, more dietary manufacturers have started to use inferior or sometimes harmful materials to produce our daily-life food to lower their budget. The same thing happens to egg manufacturers, leading to a common issue with eggs, the presence of salmonella. Salmonella often appears on raw eggs, causing consumers to experience severe stomach flu and typhoid fever after ingestion. The current approach to detect Salmonella is time-consuming, taking 2-7 days. Therefore, we have focused our product to genetically modify a bacteriophage carrying a reporter gene such as GFP or luc, which can specifically infect Salmonella on food samples. We have narrowed down our product to a spray that has the potential to detect salmonella on eggs. The way we envisioned this product is to have that synthetically-modified phage attack salmonella only. After their contact, we expect the salmonella to release acidic chemicals that can react with the acid-base indicator in the spray to create a color change. If there is a color change in the liquid, then it is an indication that the egg has salmonella.

What is the importance of Synthetic Biology in your Project ?

We are using synthetic biology to modify our phage so that it will specifically attack Salmonella only.



How important is your project in being a solution to a current problem in your local area or world wide ?

There are more than 450,000 people infected with Salmonella in Taiwan, which ranked fourth in food poisoning incidents. It was even ranked first in America! We are expecting a 70% decrease of salmonella infection cases in Taiwan after our product is officially published.

Research Task:

We would like you to further research on bacteriophage, the main key that leads to our success, especially focusing on its appearance and its applications. First of all, please kindly sketch a bacteriophage onto a blank sheet of paper. Secondly, either label all of its essential parts or simply write down all of its applications around the sketch you previously created.

OPEN SCIENCE GLOBAL

What is the importance of Synthetic Biology in your Project ?

It is crucial for designing appropriate plasmid vectors for production in GRAS (Generally Regarded As Safe) organisms such as *Bacillus subtilis* and *Pichia pastoris*, and incorporating modules such as M13 sequences, silica-binding domains, homology arms, secretion signals, and developing a more powerful MoClo (Modular Cloning) assembly standard. In addition, we will be developing an open plate reader and powerful automation software to optimize and expand the DBTL (Design Build Test Learn) cycle, in conjunction with other frugal biofoundry components, which feed back into what decisions we can make on the synthetic biology front.

Research Task:

Research the pBS72, pHT01, and pHT43 plasmids, find and characterize the sequence found in pHT43 but not pHT01, explain what that difference means for a cell that takes up and expresses the plasmid, and think about what that could mean for protein purification.

Our Project :

We plan on tackling this issue by developing and optimizing an IP-free DNA construct and designing a protocol to frugally produce and purify the best off-patent DNA Polymerase, which is a backbone for a majority of biotech work. We will be partnering with the FreeGenes initiative for the free distribution of our DNA constructs anywhere in the world. In addition, we plan on expanding our protocol to include other frugal biofoundry components - including but not limited to: open plate reader, open PCR, opentrons robotic liquid handlers, bioreactors/fermenters, nanopore sequencing, and chromatography. If funding goes well, we plan on expanding our focus to democratize other important enzymes including T4 ligase/kinase and restriction endonucleases. Overall, our vision is that frugal biofoundries with those cheap, accessible parts can be found all over the world, giving everyone access and opportunity for contribution to science, for the purposes of expanding and hastening development towards fixing the climate crisis, health, sustainability and more.

How important is your project in being a solution to a current problem in your local area or world wide ?

It is very important - especially for developing countries, and for bringing the world together on a mutual cause.

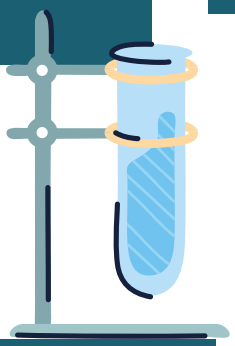
It aims to tackle all of the United Nation's sustainable development goals - but mainly focuses on: -Peace, Justice, and Strong Institutions! -No Poverty! -Decent Work and Economic Growth! - Industry, Innovation, and Infrastructure!

Our Project :

Our project centers around the theme of fungal infections. Fungi are present almost ubiquitously in our surroundings. However, our immune system is normally able to protect us from these foreign pathogens. In some cases when the immune system of patients is compromised, such as with AIDS patients and those receiving organ transplants, fungal pathogens have to opportunity to infect the individual. Alarmingly, there are very few effective antifungal drugs present in the market. Our project is an attempt to change this. We seek to develop a novel antifungal drug based on naturally present chitinase enzymes to save the lives of patients worldwide!

What is the importance of Synthetic Biology in your Project ?

Synthetic Biology is the centerpiece based on which our entire project is built. Our project seeks to combine chitinase enzymes in novel ways in order to evolve new enzyme activities. This requires directed and focused cloning experiments with diverse domains, directly drawing from the powers of SynBio! In addition, we are expressing our constructs in the *E. coli* chassis, which would not be possible without Synthetic Biology.



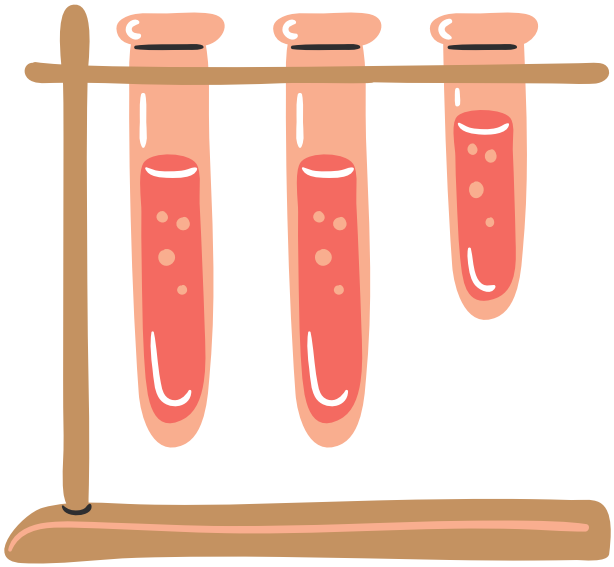
How important is your project in being a solution to a current problem in your local area or world wide ?

Our project is addressing a problem which is of utmost importance in our country (India) right now. With the current pandemic weakening the immune systems of several patients, opportunistic fungal infections have risen rapidly, taking with them many lives. The limited set of antifungals had made treating these infections a real challenge. It is precisely here that we believe our approach can make a difference; by designing an effective antifungal agent drug we can save numerous lives and reduce the burden of fungal infections in our country and the entire world.

Research task :

Read about how to prepare fungal samples and visualize them under a microscope. This can also be undertaken as a practical activity with a demonstration. They can also read out protein domains and how those are essential for defining the identity and function of diverse proteins. An interesting thinking point can be the potential effects of joining domains from different proteins into one.

STONYBROOK



What is the importance of Synthetic Biology in your Project ?

Current methods of MC-LR removal from water (such as Ozonation, Chlorination and Granular Activated Carbon) are either expensive or produce corrosive and toxic byproducts which are harmful to our environment. Synthetic biology is a promising solution as using a contained system of bacteria is much cheaper, self-sustaining and safer for the environment! By genetically engineering *E. coli* to break down MC-LR, we can effectively produce a safe and efficient bioremediation method of MC-LR degradation.

Our Project :

Toxins from cyanobacterial harmful algal blooms (cHABs) contaminate lakes and cause severe illness or even death in humans who consume contaminated water. These toxins are also a severe threat to wildlife! Microcystin-LR (MC-LR) in particular is one such toxin that is the most common in lakes but is challenging to remove with conventional water purification techniques. Our project is to develop a synthetic biology solution to water contamination that will be cheaper and safer than conventional water filtration methods. To do this, we have designed two novel strains of an easy to grow bacteria known as *E. coli* which can break down MC-LR by genetically modifying it with an enzyme called mlrA, found in other bacterias. One can over-express the MlrA enzyme onto the surface of the *E. coli* to degrade MC-LR. The other strain can freely secrete MlrA into the periplasm via a modified secretion system. A third strain was also designed to detect MC-LR in water. These modified bacteria can then be embedded into a bioreactor to act as a filtration device in bodies of water and drinking-water filtration plants.

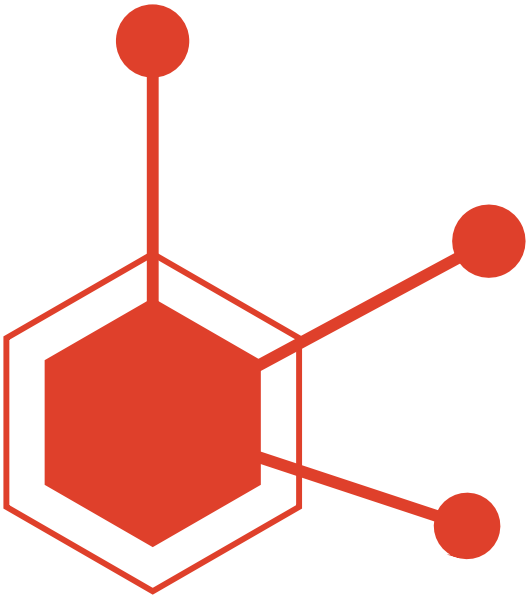
How important is your project in being a solution to a current problem in your local area or world wide ?

Harmful Algal Blooms are a huge problem in both our local area and world-wide. Every summer, these blooms create an environment that is unsafe for both the fish and birds living in these bodies of water and water reservoirs for drinking water. Some common local examples of these include our University's Roth Pond, Ronkonkoma Lake and Agawam Lake. This is also a major global crisis. In 1996, microcystin contamination of water at a dialysis clinic in Brazil caused 116 of 130 patients to develop acute liver failure which then led to the death of 26 patients. Due to climate change, these blooms are increasing in both frequency and intensity. Therefore, having a cheap and efficient method of MC-LR removal is very crucial.

Research Task:

What conditions cause cyanobacterial harmful algal blooms (cHABs)? Take a paper and design a bacteria which would be able to reduce these blooms. First, pick a bacteria you would like to modify, this is called a chassis. Then select 2 to 4 characteristics you would like this organism to do in order to reduce cHABs. Bonus challenge: can you find enzymes which may be able to perform the characteristics you chose for your bacteria?

Fun challenge: Hero Coli is a great game to learn about genetic modifications of bacteria in order to decrease toxins in water. How far can you get in this game? Play at http://herocoli.com/



IGEM MOSCOW CITY

OUR PROJECT :

Equine herpesviruses are the most dangerous viruses for horses, but there are problems with EHV diagnosis. Therefore we decided to create our test system for rapid diagnosis of EHV. The method is based on the property of beta-lactamase subunits to combine into a functional protein when the halves physically approach. Two fusion proteins consisting of a Cas13 and two beta-lactamase subunits with gRNA make the target nucleic acid detection possible.

What is the importance of Synthetic Biology in your Project ?

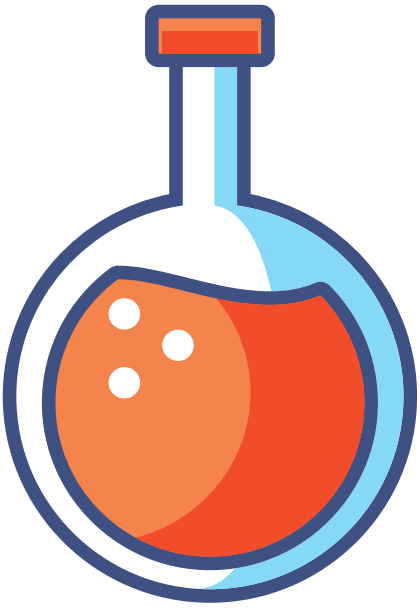
Our project is based on principles of synthetic biology and integrating biobrick into our test-system

How important is your project in being a solution to a current problem in your local area or world wide ?

Our test system is the fastest way to detect rhinopneumonia which is crucial for its cure and for stopping the disease from spreading

RESEARCH TASK :

Imagine how you can implement synthetic biology methods in equestrian sports and horse breeding.



NIT_WARANGAL

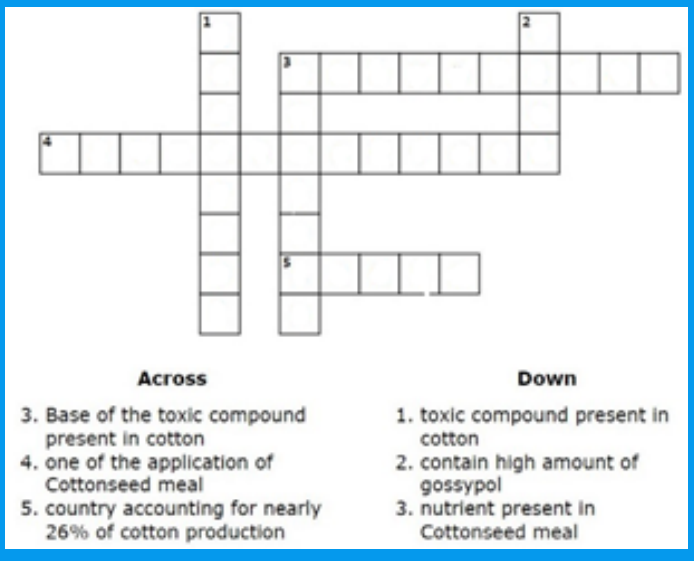
How important is your project in being a solution to a current problem in your local area or world wide ?

India is one of the largest producer of Cotton. Cottonseed meal is fed to Domestic animals on a daily basis in our country. But people here lack the knowledge of Gossypol, so the domestic animals would consume the Cottonseed meal which has high levels of Gossypol. High levels of Gossypol results in Gossypol Poisoning which leads to fatigue, infertility and even leads to death. Traces of Gossypol would also pass onto Humans resulting in Gossypol Poisoning in Humans as well.

OUR PROJECT :

De-Gossypolisation of Cotton-Seed Meal using Synthetic Biology India is one of the world's largest cotton producers, accounting for about 26% of the global cotton production. While the cotton bolls support India's giant cotton textile industry, the plant seed offers high value in livestock feed and oil production. Cottonseed meal has a high protein and vitamin E content. Gossypol is a toxic polyphenolic product derived from cotton plants. High concentrations of free gossypol are responsible for acute clinical signs of gossypol poisoning. The toxicity of gossypol has limited the utilization of cottonseed meal (CSM) in the feed industry. Our research aims to screen enzymes that can degrade gossypol by checking their interaction with gossypol using in-silico methods and mutations. With this enzyme known, we would sequence the gene from the enzyme producing microorganism and express it in a biotechnological chassis. Our work would also solve a significant industrial waste problem as we plan to use crude glycerol as a growth medium for the chassis.

RESEARCH TASK



Across

3. Base of the toxic compound present in cotton
4. one of the application of Cottonseed meal
5. country accounting for nearly 26% of cotton production

Down

1. toxic compound present in cotton
2. contain high amount of gossypol
3. nutrient present in Cottonseed meal

The answer will be on the tracker page

What is the importance of Synthetic Biology in your Project ?

We plan to engineer organisms which can reduce Gossypol present in Cottonseed in an effective and sustainable manner

NU_KAZAKHSTAN

Our Project :

In the project, we will modify standard *P. putida* a soil bacteria to increase lipid production. *P. putida* is a bacteria commonly encountered in soil, and has a well-established genetic system. The modified strain could find application in enhanced oil recovery from tailing wells, which increase the efficiency and decrease the environmental impact of the oil industry in Kazakhstan. Conclusively, in our project, we aim to increase the expression and yield of rhamnolipids by enhancing metabolic processes in the bacteria *P.putida* for application in soil and water purification from oil spills.

What is the importance of Synthetic Biology in your project ?

Synthetic Biology has a central role in our project. Our title reveals it itself: "Dual-expression system for nicotinamide adenine dinucleotide and rhamnolipids biosynthesis in Pseudomonas putida for electrofermentative remediation of crude oil".

The project's concept is to:

1) Detect and isolate respiratory and rhamnolipid genes from *P. aeruginosa*.

2) Insert into novel dual-inducible duet-expression system

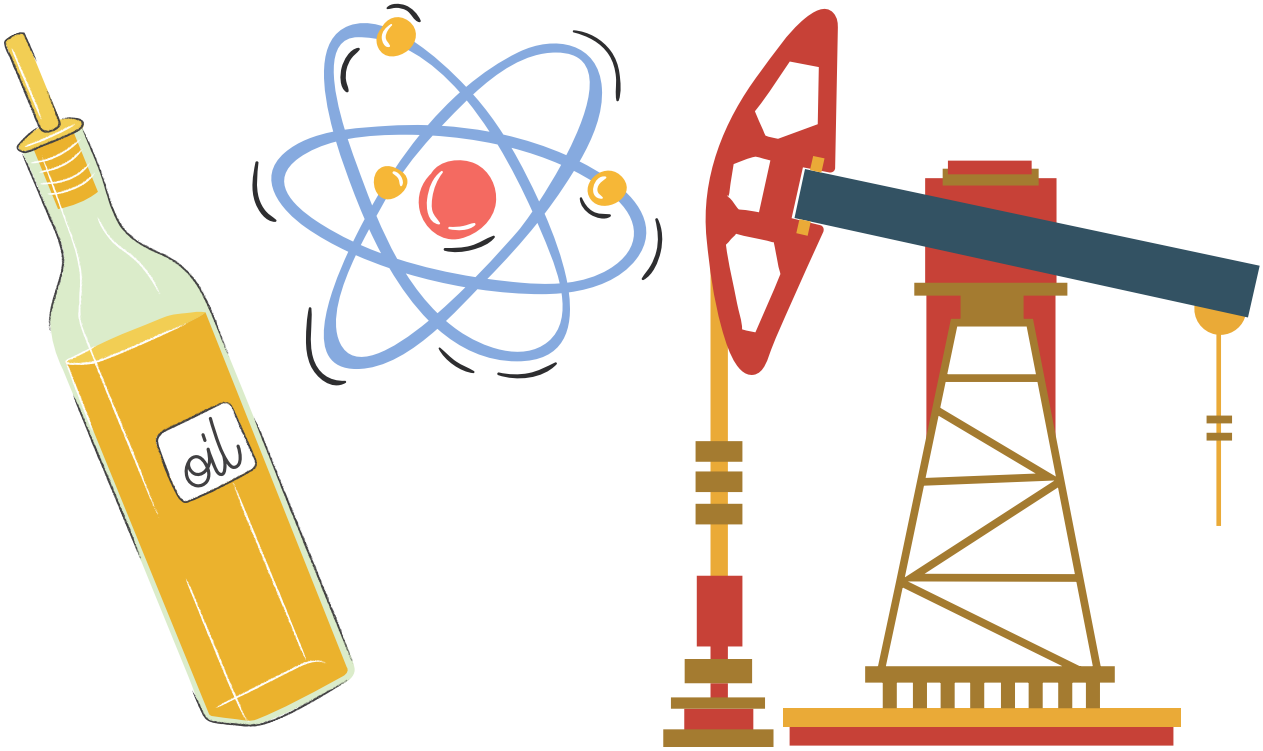
3)Transfer and express in non-pathogenic *P. putida*. Ex-situ bioremediation. We aim to achieve increased yields of rhamnolipids by a combination of electrofermentation and genetic engineering.

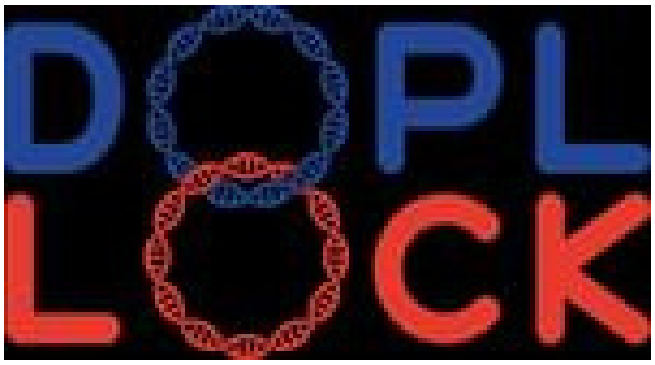
How important is your project in being a solution to a current problem in your local area or world wide ?

Oil spills are becoming one of the huge problems with all aspects of the petroleum supply chain that have detrimental effects for both environmental and public health. This problem is especially critical in Kazakhstan, where oil industry is one of the largest economic sectors of the country, which negatively affects both local aquatic environment and soil. One of the independent zoogeographical region regions, where oil extraction is leaving its harmful footprint in Kazakhstan is Caspian Sea, which is the largest inland water body with high endemism, where 85% of the world's sturgeon population lives. Among numerous problems, Caspian Sea is witnessing sea level fluctuations, contamination and habitat changes. It is of high importance to reduce the scope of this problem by solving one of the causes of this environmental disaster - oil spills. Therefore, our project aims to remediate crude oil under electrofermentative conditions using engineered *P. putida*.

Research Task

Research two bacteria: *Pseudomonas Putida* and *Pseudomonas Aeruginosa*. Why *P. Putida* was chosen in our project? Make a simple illustration of how the expression and yield of rhamnolipids is increased in *P.Putida*.





IGEM LEIDEN

Our Project:

We are making a system to contain bacteria that carry synthetic (man-made) genes. We are working on a system with 2 plasmids (circular pieces of DNA that can easily be transferred to cells), that depend on the presence of each other for the survival of the cell that carries them. Cells that carry only one of both should die. In this way, we hope to prevent the spread of these plasmids, since they need to spread simultaneously for the cell to survive, which reduces the odds of it happening.

How important is your project in being a solution to a current problem in your local area or world wide ?

The problem we hope to solve is the question of how we should best let GMO's out into the wild in a responsible way that causes the least risk to the environment. We hope that our system, perhaps in combination with other biocontainment strategies will reduce the risk to the environment to an acceptable level.

What is the importance of Synthetic Biology in your Project ?

The altering of these plasmids, which is synbio, is the very foundation of our project. Without synthetic biology, this could not be done.

Research Task :

Find out what a plasmid is, and how you could use this to alter the genes of a cell. Use the internet to search for this. Tips for words to look for: - plasmid - transformation - synthetic biology (- restriction enzymes) If you understand how it works, make a schematic drawing of what happens during a transformation.

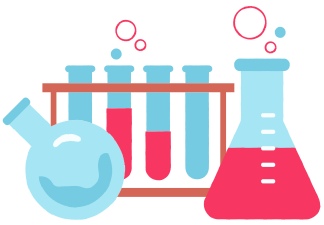
IGEM THESSALY

Our Project :

Our project takes two different directions: Our first goal is to design a capsule that "senses" those imbalances between the different microbial populations, by measuring the amount of certain microbial derived substances. This way, we can warn the patient about their microbiome's state. Our second goal is to develop a live, genetically engineered bacterium that replenishes the lack of those substances, aiding the microbiome to regain its balance. This balance is achieved by helping the beneficial bacteria of the gut, raise their numbers, and this way stop the overgrowth of harmful ones. In the same time, higher numbers of good bacteria, produce higher levels of products that benefit the human or animal host.

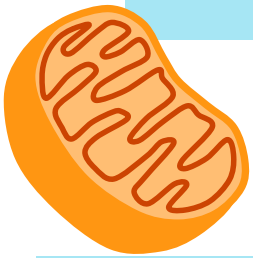
What is the importance of Synthetic Biology in your Project ?

Synthetic Biology is the tool with which we built the very core of our project: The evaluation of the state of the gut microbiome, is determined using a series of genetic modules that were assembled and then combined with each other, using the logic and techniques of Synthetic Biology. Our genetically modified probiotic bacterium was engineered by inserting genes that this strain did not naturally occur. This way, we were able to give it new properties, and also make its capacity of producing certain substances scalable. This characteristic, the ability to make a system dynamic and adoptable, is one of the core principles of Synthetic Biology.



How important is your project in being a solution to a current problem in your local area or world wide ?

Our project tackles a variety of problems such as the lack of tools evaluating the gut microbiome, existence of only invasive methods for determining the state of the gut's interior and unavailability of tests that take real time measurements of the substances of our interest, inside the gut. We also recognize the problem of non-personalized foods and the existence of wrongful general beliefs around food products, like “one size fits all”. The utilization of our capsule can warn the patients about disturbances in their gut in a non-invasive way and then maybe lead them to an early diagnosis of a serious gastrointestinal disorder. Furthermore, the collection of data is performed at the exact area of production of the substances of our interest, thus giving more reliable results. The probiotic bacteria that we are going to engineer, are going to fall into tree categories, depending on their ability of producing certain substances. In this way, the consumer is going to be able to chose which of the three products fits their needs better and, in this way, purchase a product with personalized characteristics.



Research Task :

The interior of the gut is an extremely complex environment, consisting of a huge variety of different microorganisms (bacteria, archaea and viruses). All those kinds of microorganisms interact with each other, either producing molecules useful for neighbouring bacteria (or for the host) or by "fighting" each other over nutrients and space.

Try to draw how such an environment could look like under a microscope. Would the bacteria form completely separate colonies or develop on the top of other? Do they have different colours or they are all transparent, adopting the colour of the host? You can then search for real pictures taken using the microscope, and discuss the differences between the real aspect of those microbes and the one you imagined.

Renervate Therapeutics

KCL IGEM

How important is your project in being a solution to a current problem in your local area or world wide ?

Every year, between 250,000 and 500,000 people suffer a spinal cord injury globally (WHO) and an estimated 2500 people per year in the UK (Aspire). Currently, the treatments available for spinal cord injury do not restore function but instead only focus on helping patients manage their injury. Our research into novel therapies for spinal cord injuries was developed to tackle the cause of paralysis and functional loss.

Our Project :

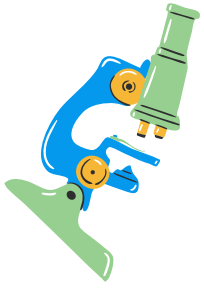
We are Renervate Therapeutics, a student-led research team at King's College London planning the development of a therapy for the treatment of spinal cord injuries. We have developed a spinal insert, which will be coated in a bioadhesive, to promote functional repair. Our bioadhesive coating is made out of a mussel foot protein, which is similar to a glue-like substance. It is naturally secreted by the mussel in order to allow for underwater adhesion and we are employing it in our project to ensure our insert remains in the spinal cord environment.

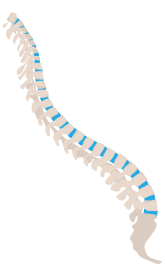
What is the importance of Synthetic Biology in your Project ?

As mussel foot proteins are originally found in nature, we have used synthetic biology to artificially produce our protein in the lab. This can be achieved by using DNA sequences and E.Coli.

Research task :

Head to page 26 (the next page) to see the details of KCL IGEM Task.





HOW TO

DEEP SEA SLIME

Mother Nature Collaboration

This guide was created in collaboration with Mother Nature Science- We believe that every child is special. We inspire and enrich your children through science so they can reach their full potential, not just in science but across all academic subjects.
https://www.mnature.co.uk/about-us/

Scientific Background

This activity serves to highlight how polymers are formed. Polymers are a large chain of molecules made up of smaller units that repeat themselves.

Since we use a PVA slime, which is a polymer and when we add the borax solution it alters the structure to become thicker chains.

Safety Guidelines

1. All participants should ensure they keep the slime away from their mouth, nose and eyes.
2. Participants should keep the slime away from animals and younger participants without adult supervision.
3. After the completion of this activity, please make sure to wash your hands.

STAY COVID SAFE

Whilst completing this activity, participants should ensure they are at least **2M or 1M apart.**

Please ensure to **maintain social distancing** guidelines in accordance wiith your school rules.

REQUIRED MATERIALS

1. Slime Pot
2. Chopstick
3. Seaside Beads (Blue)
4. Borax (40%) – 25ml (Add Blue Dye)*
5. 75ml PVA Glue (20%)**
6. Kitchen Towel
7. Spoon
8. Plastic Tray

*If you're performing this at home you can also use contact lenses fluid
** If you're performing this at home you can also use white PVA glue

AIX-MARSEILLE UNIVERSITY

What is the importance of Synthetic Biology in your Project ?

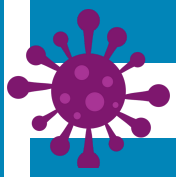
Our bacteria need to be genetically modify to develop the project. So, synthetic biology is central to our project.

How important is your project in being a solution to a current problem in your local area or world wide ?

This project aims to limit existing epidemics and prevent new ones where mosquitoes proliferate. In fact, if we prevent human-to-human transmission via mosquitoes, the epidemic will not spread and make more people sick. Of course, this method will not be 100% effective, so it will have to be coupled with other control methods.

Our Project:

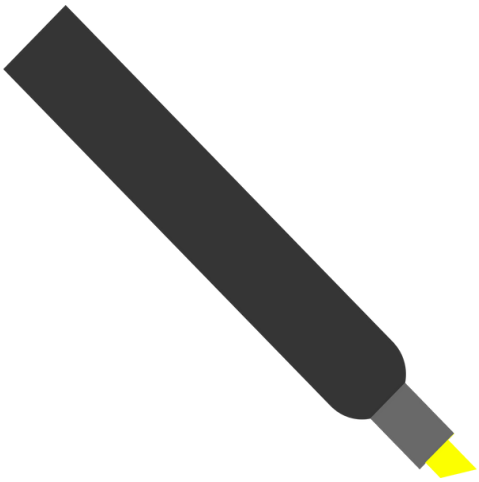
Our project consists of cutting the chain of transmission of diseases caused by arboviruses. In fact, these diseases like Zika, Dengue, Chikungunya... are at the origin of many epidemics in the world. To address this issue, we are developing a genetically modified bacterium that can recognize virus-carrying mosquitoes once it is in the mosquito's digestive system. If and only if the mosquito is infected with an arbovirus, the bacteria will produce and release a toxin capable of killing the mosquito. However, if the mosquito is not infected, the bacteria will not affect it.



Research task :

Look for information on the proliferation of the tiger mosquito around the world and the increase in the number of cases of arbovirus disease. If there is time, you can also look for information on what local authorities are doing to control mosquitoes and the diseases they transmit. Complete research on the impact of these methods on the environment.

Highlight the team names to keep track of the tasks you have completed !



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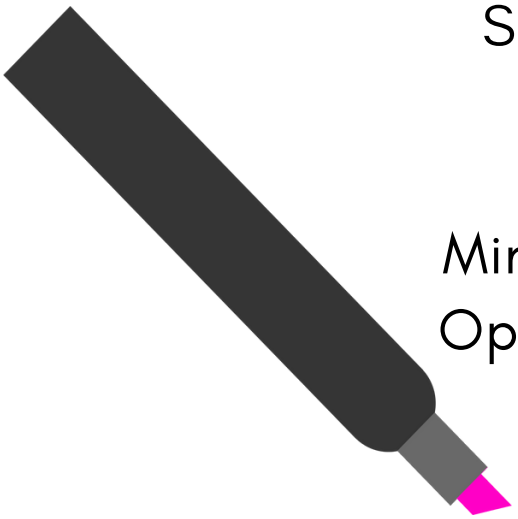

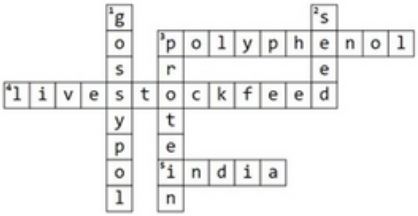

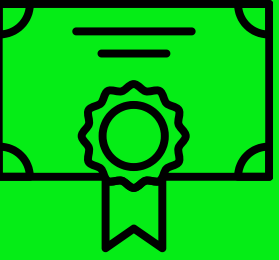

CERTIFICATE OF COMPLETION

This certificate is awarded to

For the completion of set tasks in the iGEM Collective Issue 1 booklet.

From iGEM Warwick 2021 Education Manager

This certificate is not a valid credential and is not affiliated with the University of Warwick. This Certificate is for your own recognition that you have completed set tasks.

Acknowledgments :

Thank you to :

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Ameera Ghani
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Sponsers :

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