From idea to solution with synthetic biology:

A guide for a two-hour workshop at high school level.

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iGEM CIDOSIS

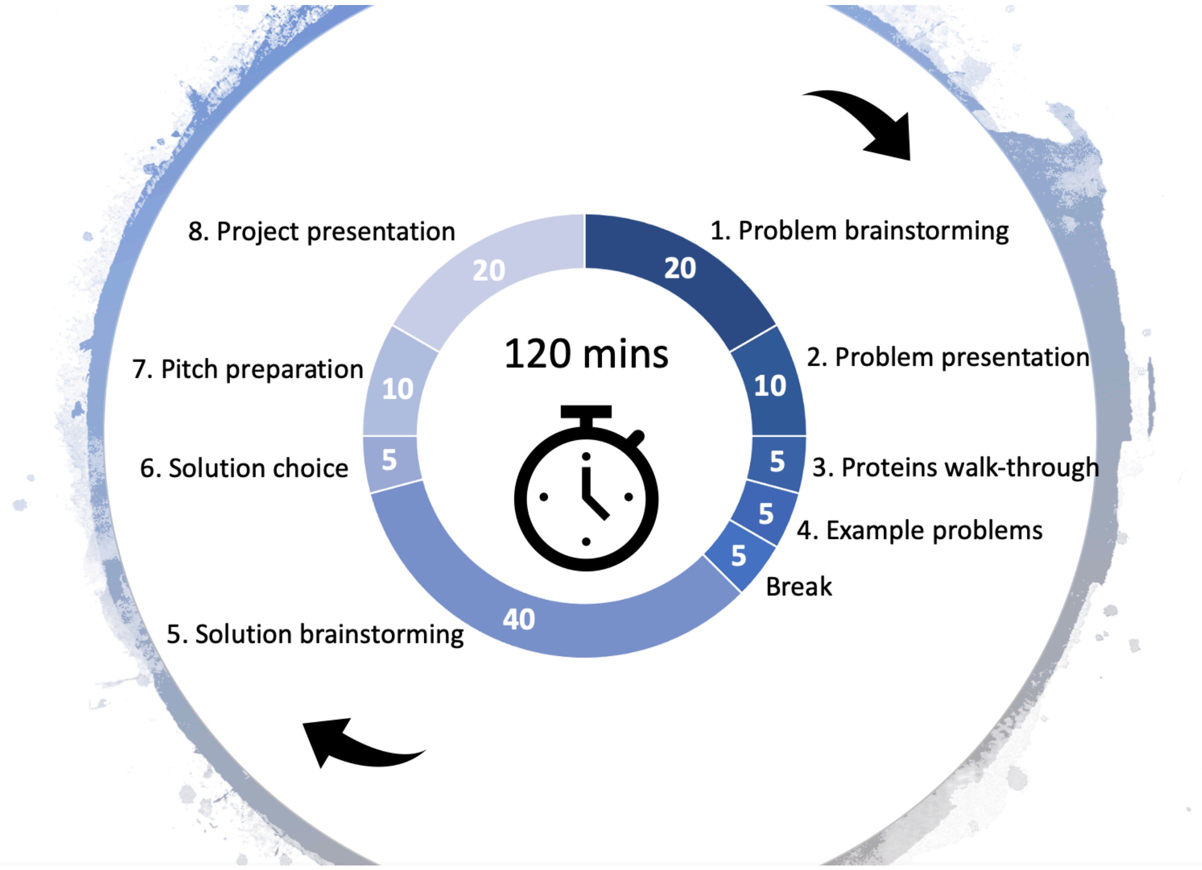
The objectives of the workshop:

This workshop is designed to engage student in the field of synthetic biology. It is meant to inspire SynBio ideas by making the concept of idea generation graspable and relatable. This workshop is constructed in a way such that the students do not need a background in biology to follow and understand the concepts presented. Background in biology can elevate the sophistication of project ideas generated, however it is not the goal of the exercise. The focus is on spreading the awareness of SynBio solutions, while learning how to go from problem to solution and be able to present the concept in a clear and convincing way.

The format of the workshop:

Start by dividing the students into groups of 3-5 (depending on the class size). Explain to them the objectives of the workshop, explaining to them that the goal is to come up with simple SynBio solutions to everyday problems.

The workshop is designed to last 2 hours, but can be modified easily depending on the needs.
The different parts are allocated time as follows:



1. Problem brainstorming
   Give the students 20 min to start brainstorming problems that affects either themselves or the world. They do not necessarily have to be obvious SynBio problems. To help them get started these for categories of problem areas can be suggested: Health, 3rd world, Environment/Climate and Space.

2. Problem presentation
   Allow 10 min for the groups to all present some of their favorite problem ideas to the rest of the students. They should explain what the problem is, why it is important to them, and what impact a solution can have.

3. Protein walk-through
   Now present the student with the protein list (Part A). This is a list of some possibly useful enzymes and proteins that can be used in synthetic biology. Here it is important to highlight the first protein the "wonder protein". This is a protein that can do whatever the students want it to do -as long as they can describe it. This highlights that in SynBio it can sometimes be possible to synthesized new proteins with very specific capabilities. In addition, make sure to explain the idea of fusion proteins to the students. That is where you can combine some parts (known as domains) of one protein with another protein to combine their functions.

4. Example problems
   Go over one or two of the example problems (Part B) with the students to inspire them to start solving their problems with the given protein tools.

--- 5 min BREAK ---

5. Solution brainstorming
   Allow the students 40 min now to brainstorm solutions to their problems. They can choose an example problem from the list given in Part B, or they can work on their own problems from part 2. The students should come up with AT LEAST two solutions to either different problems or the same problem. After 20 minutes we suggest that the students be encouraged to start working on their second solution, if they have not already.

6. Solution choice
   Make sure the students choose two of their solutions to present to the class.

7. **Pitch preparation**
   The students now have 10 minutes to prepare a pitch of their problems and solutions. The format of the pitch should be:
   1. Present the problem and why it is important
   2. Present the solution and explain any use of fusion proteins or wonder proteins.
   3. Round of with any expected challenges
   The pitch should be no longer than 2 minutes per idea. The students should be encouraged to split the presentation parts between themselves to allow everyone from the group to practice pitching.

8. **Project presentation**
   End the workshop with everyone presenting and allow for questions from the other students to the presenting group after the pitch.

Part A: Protein, Protein Parts, and Compounds

Name	Role
Wonder Protein!	This protein can do anything, as long as you can describe its function!
Amino acid transporters	Can move amino acids in and out of cells
Relaxin	Collagen rearranger that can promote skin repair
PETase	Part of this protein can bind to PET plastic, and another can cleave PET into MHET
SGLT	Transporters that move glucose into cells together with natrium
Aquaporins	Water channels
PBP	Penicillin-binding proteins
Structural fungal proteins	Makes an intricate mesh of protein around fungi
Chromoproteins	Proteins that color corals for example
KBD	A piece of protein that binds to keratin (found in hair, skin, feathers, nails etc)
CBM	A piece of protein that can bind to cotton (uld)
Spider Silk Protein	Makes up the fibers in spider web
mCherry	Red colour
HsbA	Hydrophobic protein that can bind to the waxy exterior of some insects
Methyl salicylat	Compound that stops the ripening of fruits
Ethylene	Compound that starts the ripening of fruits
UV-receptor	Reacts to UV light
Melatonin	Compound used to tune the circadian rhythm
Fotoreceptor	Reacts to light
Chitinase	Breaks down chitin on insects' bodies and opens into their innards
MHETase	Part of this protein can bind to MHET, and another part can cleave it into EG and TPA (non-toxic compounds)
MEFP-5	Mussle protein that glues mussles to stones and other surfaces

Part B: Problems!

Problem	Additional information
Limited ressources	For example, cocoa beans are becoming a scarcity
Remnants of antibiotics in water	
Scarring	Highly stigmatizing for people who have them
Vitamin D deficiency	
Insomnia	
Pain	
Allergens and carcinogens in cosmetics, dyes etc	
Erosion	
Coloring textiles	Present coloring methods are bad for the environment
Food waste	Fruits, thawed meat, vegetables …
Sorting plastic	Inefficient, at the moment
Using plastic	Slow degradation, environmental issue
Male Pattern Baldness	
Smelly garbage	
Insufficient access to clean water	
Pollution in the air	See 'Asian Dust' for example!
Melatonin	Compound used to tune the circadian rhythm
Permanence of tattoos	What if you want a tattoo that can be erased again?
Differential diagnoses	When making a diagnosis, lots of diseases look like each other and have the same symptoms – how do we discern between two diseases that look the same?
Prevalence of wildfires	
Dried-up soil	

Part C: Example solutions

Problem: The extensive use of plastic has caused an environmental problem. Especially in the ocean plastics are accumulating.

Solution: Make a buoy with an underwater compartment that houses modified E-coli bacteria. Use aquaporins in the bacteria cell to allow for a great influx of water (and microplastics) into the bacteria. Make the bacteria express PETase that can cleave PET (plastics) into MHET. Then express MHET in the bacteria so the generated MHET can be degraded to non-toxic compounds.

Alternative approach: We could detect plastics in the water instead of degrading it, to see where the biggest problems are. This could be done in a similar way, however modifying the bacteria with a fusion protein. Combining the PET recognizing domain in PETase with a red colored chromatin that is made to only express its color when the PET domain binds to PET. This way the bacteria will start turning red when they detect PET in the water.

Challenges: Getting enough PET inside the bacteria through the water channels.

Problem: Around the globe food waste is a big problem. A part of this waste comes from throwing away fruits that are getting bad. Especially the consumers through away lots of fruits at home, because they go bad fast.

Solution: Make a plastic container to sue at home in the fridge. This container will be coated inside with safe bacteria that have been modified to express excess amounts of the compound Methyl salicylat which stops the ripening process of fruits. In addition, when the food is starting to be over-ripen (ethylene signals) the bacteria will turn red to signal that the fruit must be eaten now. This will happen because of the fusion of mCherry with our wonder protein that can detect excess ethylene and switch on mCherry. This way we can help the consumers waste less fruits.

Challenges: Separating the bacteria from the fruit in the container, so you don't eat the bacteria as well.