Splash! Lesson Plan:

Prerequisites: none!

Introduction (2 minutes) : Hello everyone! We are so glad to be talking with you today. We are from iGEM, a science team that works in something called synthetic biology. And if you're wondering what that is, then you're in the right place! Our goal today is to introduce the idea of synthetic biology along with some of the fantastic women who have made their mark on the world of science. So let's get started!

Synbio station (3 minutes): Synthetic biology is the field of study that tries to redesign organisms in order to modify them for useful purposes. Scientists start with the power cells and molecules already have naturally and then harness them to express useful traits. The applications of synthetic biology range from medical devices to cleaning bacteria in lakes. With modern technology, it is possible to synthesize entire enzymes! This field often encourages much ethical debate because of its ability to modify the existing ways of nature (we will be discussing some sometime soon who work on boards discussing the ethicality of synthetic bio!)

- At this station, we will hand out pamphlets that better explain how synthetic bio works and what the different current and past applications have been

Emmanuelle Charpentier and Jennifer Doudna (9 minutes): Dr. Charpentier and Dr. Dounda are the scientists who won the Nobel Peace Prize in chemistry in 2020 for the creation of CRISPR, a unique technology that allows scientists to change DNA in order to create an editable genome (which is essentially a users manual for building the organisms that run around our bodies and the world). After completing work at the Pierre and Marie Curie University, Dr. Charpentier received her Ph.D. in microbiology at Pasteur University. As a researcher, she has worked on looking at the smallest inner workings of our body, including identifying small novel RNAs in the S. pyogenes genome and investigating how bacteria's CRISPR system can be used to defend itself against viruses. As for Dr. Dounda, she attended Harvard Medical school and received her Ph.D. in biological chemistry and molecular pharmacology. In her early career, she researched ribozyme structure and x-ray diffraction-based structure of the active site of a ribozyme. In addition to working in the lab, Dr. Dounda is a thought leader on the ethics of changing genes using CRISPR

- Our activity for these incredible scientists' work is to create a paper model of how CRISPR works. This model will also demonstrate how CRISPR can be used to to edit gene sequences in a specific manner and inactivate ("knock out") genes.
    - The model will have the following components:
        - Cas9: an enzyme that cuts DNA
        - Guide RNA: an RNA molecule that binds to Cas9; helps find the target gene
        - Target DNA: a DNA molecule that contains a "target gene" for CRISPR-Cas9 to cut
        - Random nucleotides: nucleotides that can be inserted where the target gene is cut

        - Donor DNA: DNA that can be used to edit the target gene in a specific manner
    - Follow steps from this manual: https://docs.google.com/document/d/1fsBaJQ-UB1icOD1n9Izu51GhxZlF1P_1jmR5NXb-Daw/edit

MATERIALS: copies of the paper model sheets (https://www.biointeractive.org/sites/default/files/media/image/2020-02/RNADNA_Model.jpg & https://www.biointeractive.org/sites/default/files/media/image/2020-02/Cas9_Model.jpg), scissors, clear tape

Elizabeth Blackburn (9 minutes): Dr. Blackburn was awarded the 2009 Nobel Prize in Physiology or Medicine, making her the first Australian woman to become a Nobel laureate. After achieving her Ph.D. at Cambridge, Dr. Blackburn has gone on to work on a variety of pivotal projects: she has worked to develop methods to sequence DNA using RNA, studied telomere (a structure at the end of chromosomes that protect the chromosome), and she currently works to find how stresses on telomerase impact one's ability to meditate. In addition to technical work, Dr. Blackburn has worked with medical ethics, even participating in the President's Council on Bioethics.

- We will hand out pamphlets at Dr. Blacukburn's station discussing chromosomes and genes. These will be dynamic and engaging infographic-style handouts that explain the concepts in a lower-level language.

Barbara McClintock (9 minutes): Barbara McClintock was a groundbreaking scientist who studied chromosomal and genetic expression, and was awarded the 1983 Nobel prize in physiology or medicine. Her work primarily consisted of studying genetic transposition and controlling elements in the genetic expression of maize, which is somewhat like studying how little molecules move around our body like cars moving in traffic. As a woman, she faced multiple barriers in the STEM field, especially because her theories (which were backed up by evidence) contradicted many of the prevailing genetic theories. She was labeled as being "crazy," and stopped publishing due to the backlash. However, she stayed steadfast in her beliefs and continued her research. After years, as other scientists started to come to similar conclusions, she was finally given credit for her revolutionary theories. As one of the foremost female scientists in a field that discounted her time and again, we can learn from her quote,"If you know you are on the right track if you have this inner knowledge, then nobody can turn you off... no matter what they say."

- Our activity for Dr. McClintok is to look at how the body can differentiate and organize those tiny pieces that move around our body like cars!
- Have a color by numbers of wild corn with multiple different colored kernels- can be used to explain genetic differences

Erin Stache (9 minutes): Professor Erin Stache is a synthetic chemist at Cornell University, and she has studied chemistry at the University of Wisconsin and Colorado State University. Her research aims to combine techniques from polymer chemistry and materials engineering to create new ways of making polymers. She is comparable to Bob the Builder of chemistry, working to combine materials that already exist to make new, very useful pieces. She is also a primary contributor to the field of synthetic biology because her lab has recently been studying how to make polymers in bacteria by engineering the synthesis pathway using compounds found commonly in biomolecules to make it much more efficient and sustainable for the environment.

- Our activity for Dr. Stache is to make slime
- Slime is actually a polymer, and a lot of the components of slime are synonymous with Dr. Stache's research. To begin, polymers are substances whose molecular structure is a chain of repeating units of molecules. These units are called monomers, and when many monomers are linked together with chemical bonds, they are called polymers or polymer chains. One way to think about polymers and monomers is to use a beaded necklace: Each bead represents a monomer, and when many of the beads are linked together, they form a polymer or a necklace. The "string" in biology and chemistry are actually chemical bonds called covalent bonds. And while we might call this process "making a necklace" or "stringing together some beads," scientists like Dr. Stache calls the process of connecting monomers together to make polymers "cross-linking," and this makes sure that the necklace (or the polymer) all stays together and doesn't move around.
- Dr. Stache's research tries to make sure that bacteria or other bio-organisms collect all the beads, put them together in the right order, and do this process as fast as possible. Some examples of polymers are PVC pipes, biological polymers like DNA, and many more.
- Specifically, examples of synthetic biology polymers like biofilms and hydrogels (think contact lenses!), which are super similar to the slime we just made. Our team, Cornell iGEM, uses a lot of hydrogels and biofilms in many of our engineering projects since they provide structure, a place for bacteria to live and grow, help with wound healing, and much more. Thanks to the work of women like Professor Stache and other women studying polymerization using synthetic biology, we can use biology to solve a variety of problems.

Rosalind Franklin (9 minutes): Rosalind Franklin was a British scientist born in 1920 who contributed to discovering the molecular structure of DNA, the molecule for life that holds all the instructions for telling our body how to grow and develop. She studied physical chemistry at the University of Cambridge and during World War II briefly worked for the British Coal Utilization Research Association where she helped research coal and carbon to contribute to the war effort. She studied called x-ray diffraction research methods, which uses very pointed light to see how structures and molecules move light. She applied this knowledge to DNA, which at the time had an unknown structure. Using x-ray diffraction techniques she discovered the density of

DNA and confirmed it had a helical structure. Her work helped later scientists better understand DNA and lead to the discovery of DNA's double-helix structure.

- Our activity for Rosalind Franklin is to model DNA
- Because Rosalind Franklin was instrumental in the discovery of DNA's molecular structure and the double helix the lesson would include creating a model of a DNA double helix structure
- Students would learn about the base pairs A-T and G-C and what DNA looks like by building the structure on their own
    - Can also go into hydrogen bonding and how the two separate strands anneal together into one
- The synthetic biology aspect → demonstrates what CRISPR/Cas9 does with the model of DNA (show how it cuts DNA on the model at a specific base sequence)