

INTRODUCTION TO SYNTHETIC BIOLOGY

Includes Glossary,
Informative Comic series
and fun activities

"EDUCATION IS NOT THE LEARNING OF FACTS,
BUT THE TRAINING OF THE MIND TO THINK"
- ALBERT EINSTEIN

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Dear friends!

We at iGEM IISER TVM are coming up with this exciting Synbio book as a part of our outreach activity.

This small effort is to introduce the basics of synthetic biology to students at the level of high school and enthusiasts. It unravels the world of cells, bacteria, viruses, DNA, and RNA and how they play vital roles in today's synbio era.

Advancements in modern biology and technology made us understand more profound the working of biosystems. The field of synthetic biology focuses on experimenting with and manipulating life forms, genes, and other biological components to benefit society.

I hope you all will enjoy :)

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Glossary

ANTIBODY

An antibody is a blood protein produced in response to and counteracting a specific antigen by combining chemically with substances the body recognizes as alien, such as bacteria, viruses, and foreign substances in the blood.

ANTIGEN

Antigen is a toxin or other foreign substance which induces an immune response in the body, especially the production of antibodies.

DNA

DNA is the material that carries all the information about how a living thing will look and function.

ENZYME

Enzymes are important substances made by the cells of plants and animals. They are catalysts, or substances that control how quickly chemical reactions occur.

GENE

Genes carry the information that determines your traits which are features or characteristics that are passed on to you - or inherited - from your parents.

GMOs

GMO stands for 'genetically modified organism.' Organisms are plants, animals, bacteria, or viruses, and genetically modified organisms are organisms that have had their DNA changed using science.

HEREDITY

Heredity, the sum of all biological processes by which particular characteristics are transmitted from parents to their offspring.

IMMUNITY

The immune system's way of protecting the body against an infectious disease.

mRNA

mRNA is a single-stranded molecule of RNA that corresponds to the genetic sequence of a gene, and is read by a ribosome in the process of synthesizing a protein.

MUTATION

A mutation is a mistake or a change in a living thing's DNA.

PLASMID

A plasmid is a genetic structure in a cell that can replicate independently of the chromosomes, typically a small circular DNA strand in the cytoplasm of a bacterium.

PROTEIN

Proteins are made up of molecules called amino acids. Amino acids consist of atoms of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur.

RECOMBINANT DNA TECHNOLOGY

The joining of DNA molecules from different organisms and inserting them into a host organism produces new genetic combinations that are of value to science, medicine, agriculture and industry."

REPLICATION

The action or process of reproducing or duplicating of DNA or RNA.

RNA

RNA stands for ribonucleic acid, which is a long, single-stranded chain of cells that processes protein.

SPIKE PROTEIN

Spike protein is a protein that forms a large structure known as a spike projecting from the surface of an enveloped virus.

VACCINATION

Vaccination is the injection of a dead or weakened organism that forms immunity against that organism in the body.

VECTOR

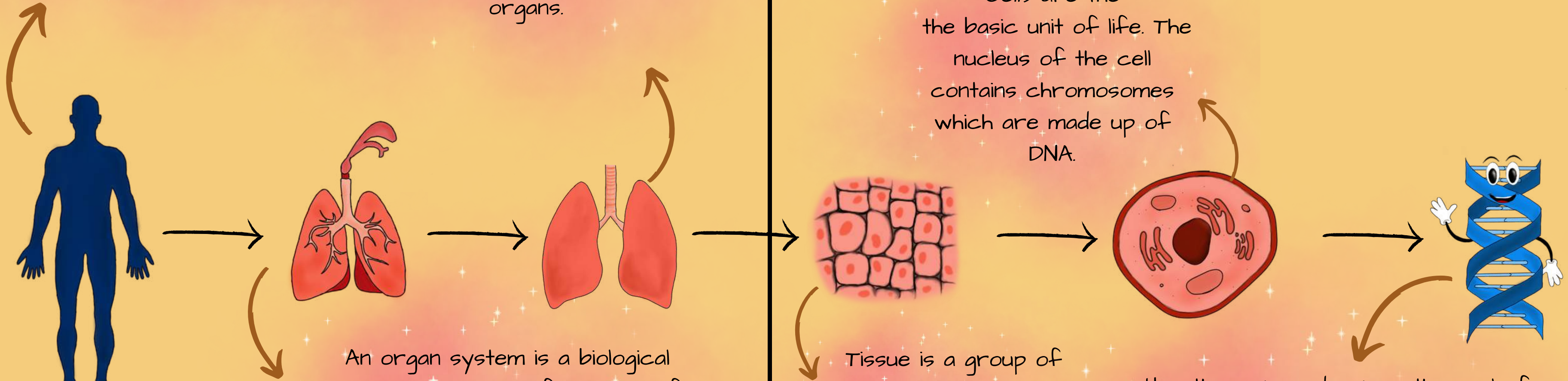
A vector is a DNA molecule (typically a plasmid or virus) that is used as a vehicle to deliver a specific DNA segment into a host cell.

Let's explore the fascinating human body. No wonder our body is one of the finest organisations of living matter.

An organ is a collection of tissues that structurally form a functional unit specialized in performing a particular function. Your heart, kidneys and lungs are examples of organs.

- 1 gram of DNA holds the equivalent of 700 terabytes of information.
- There are 24,000 genes inside human DNA.

Cells are the basic unit of life. The nucleus of the cell contains chromosomes which are made up of DNA.



An organ system is a biological system consisting of a group of organs that work together to perform one or more functions. Each organ has a specialized role in a plant or animal body and comprises distinct tissues.

Tissue is a group of cells with a similar structure and functioning together as a unit.

Hey there, I am dna. I am the soul of every organism. I am the one who makes you look similar to your parents. I store a lot of info. I am extremely important because I have control of your behaviour, actions, and identity. These days i am being modified by the human for useful purposes.

What is synthetic biology?

It is a field of science that involves redesigning organisms for useful purposes by engineering their genetic code to have new abilities.

My room



Hey friends,
I'm Rinku
I'm gonna share my story
with you all.
Before that, I'll introduce
other characters of my
story.



My mom



Nurse



Doctor

Let's hear my story



Oh dear , you are
having symptoms of
a viral infection. We
should visit the
doctor soon.



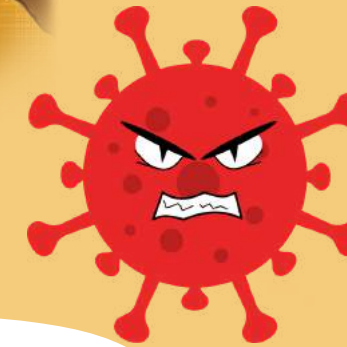
viral infection?
What is that?

First, I will tell you what a
virus is. When it enters your
body. Specifically, in your
cells, the virus gets the
power to increase in number
by killing the host cell.



let's go to
the doctor

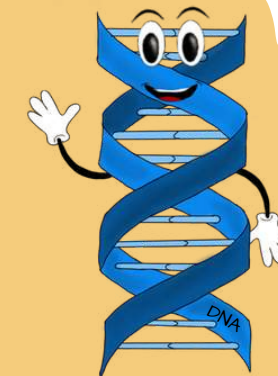
Oh how cool!.. I never
expected that such a tiny
creature which is not even
capable of survival outside
our body..when entering the
cell can cause such a
pandemic.



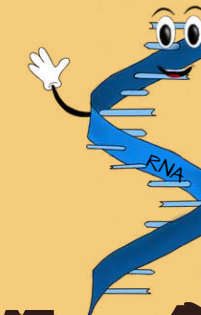
and u know I am the one
totally responsible for this.
I am enclosed within the
virus covered by protein
(spike).



don't flatter yourself.
Everyone knows how
important I am in conserving
and passing on hereditary
information from parents
to their children.



of course! I am more
active than my younger
brother DNA. I can
modify and change
myself from time to time
(mutation).



Hospital

Dear, you have got common viral infection. Don't worry I will give you medicine. Since it is the Pandemic time it would be better if you get vaccinated.

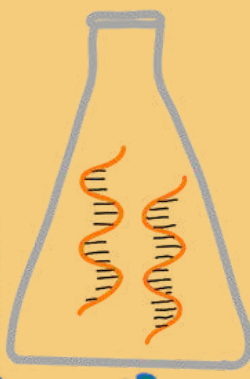
come here dear, I will explain u

what is vaccination?

To produce vaccines, we make use of the components of the virus



mRNA of the spike protein is developed in the lab which under translation machinery can code for spike proteins



These mRNA are made into vaccines for virus

As one get vaccinated, the introduced mRNA enters the host cell



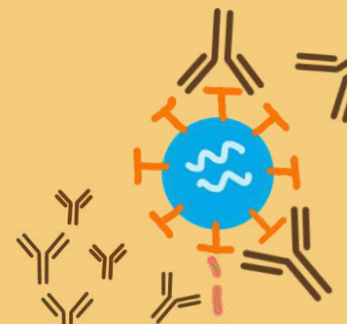
Once the mRNA enters, the host translation machinery forms the spike protein which is expressed on the cell membrane



Once our immune cells recognize these expressed spike protein, they produce specific antibodies against the virus which can neutralize it.



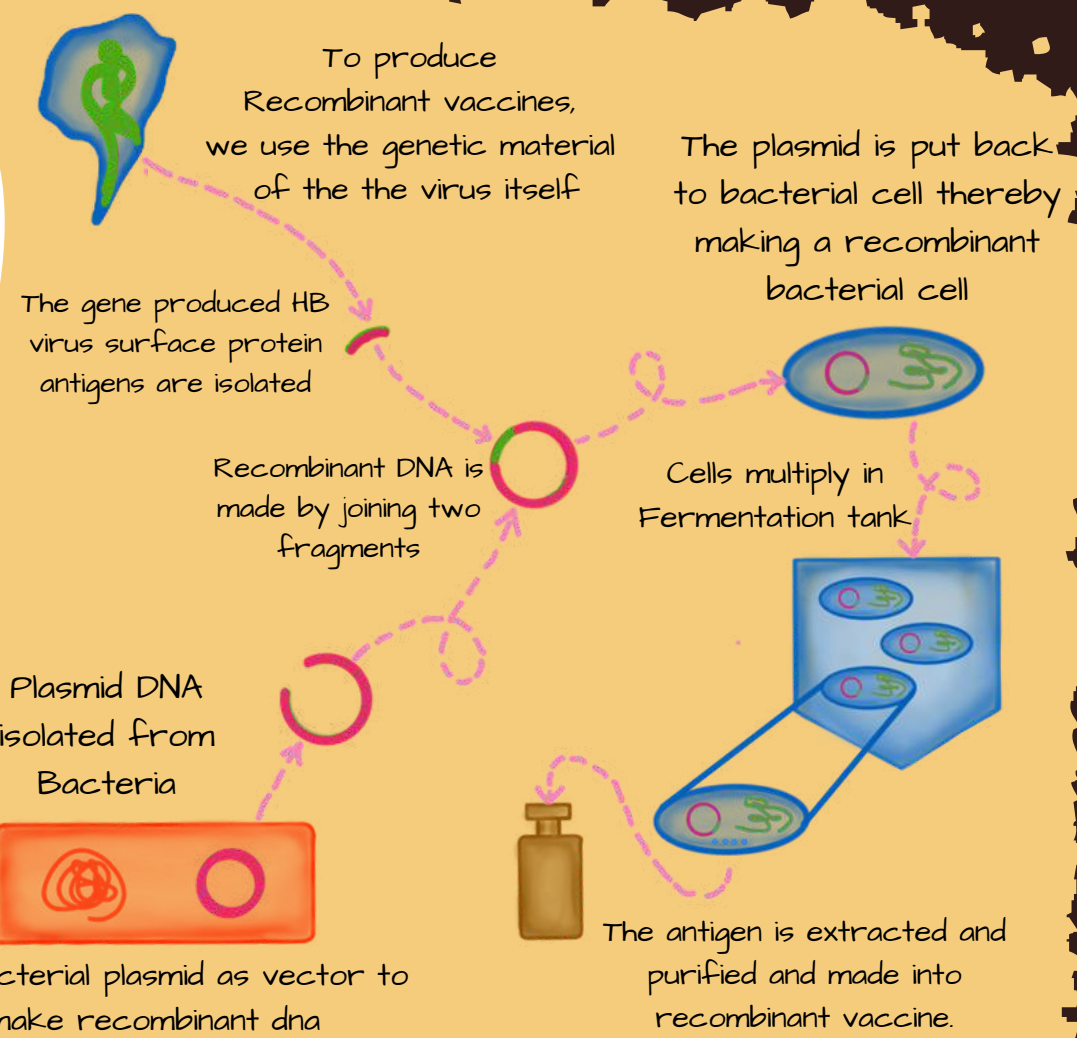
When Virus infects, its spike protein will be identified by immune cells and produce antibodies that bind to virus and stop their replication.



These days with the help of genetic engineering we are able to make very effective vaccines. Have a look here: Recombinant vaccines



wow so we can cut and modify any part of DNA to cure many diseases right "



Plasmid DNA isolated from Bacteria



Use bacterial plasmid as vector to make recombinant dna

yes dear. Not only for covid vaccine but there are many other applications of synthetic biology in medical field :



After few days....

Mom, where are the seeds in the grapes? They are missing.

oh these are GMOs

GMOs are genetically modified organisms. They are modified at a genetic level to bridge a few changes in their physical and chemical properties. The development of seedless grapes may actually date back to Roman times, but in modern times the first seedless table grape we can track was developed by William Thompson during the period from 1875 to 1900.

GMOs? What do you mean?

So can we make seedless oranges also?

oh yes we can... such ones are available in the market too.

This reminds me we need to go to the shop to get a few things.

Feeding the growing human population while preserving the environment is a major problem facing societies across the globe. today various enzymes are used to improve the efficiency of existing processes of food production, increase the quality and nutritional value of produced food, and generate novel food products.

Mom I just saw a section of food stuff that says "synthetically modified foods". What does that mean?

They also engineer traditional producers of food, i.e. agricultural plants and farm animals, to improve disease resistance, environmental tolerance, and food quality and yield.

wow that sounds interesting



Beta, you know these days plastic waste disposal is becoming a serious problem. But with the help of Synthetic biology we are able to come up with plastic eating bacteria like *Ideonella sakaiensis*. Such bacteria produce PETase enzyme which degrade plastic. Further genetically engineered ones produce these enzymes more efficiently

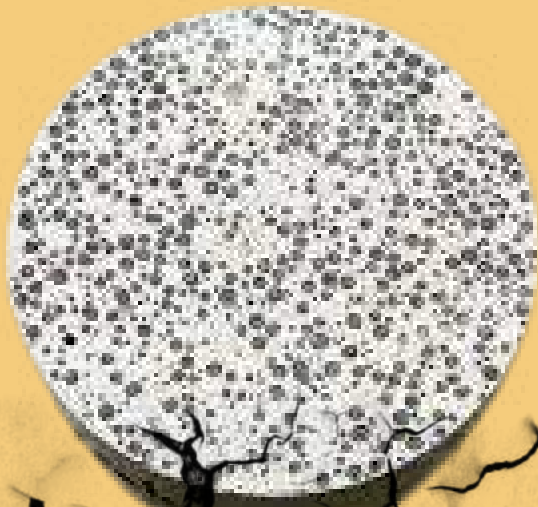


APPLICATION OF SYNTHETIC BIOLOGY

Synthetic biology will transform how we grow food, what we eat, and where we source materials and medicines.

BIOCONCRETE

Bio concrete is a type of concrete in which the addition of water awakens dormant bacteria, which secrete the components required to mend cracks. This "microbial self-healing approach" has the potential for "long-lasting crack repair that is rapid and active, and it is also friendly to the environment"



HUUE'S INDIGO DYE

Now that your favourite pair of jeans is eco-friendly, thanks to Huue's efforts, you can feel good about wearing them. Further, bioengineering techniques are used to develop microbes that, like in nature, thrive on sugar and produce dye through an enzymatic process.

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VEGAN MEAT BURGER

To create a truly authentic burger experience, Impossible Foods realised that blood, specifically the iron-containing heme, is necessary. After being severed, the roots of some plants bleed. Soy leghemoglobin is a protein that can be engineered into the yeast *Pichia pastoris* in order to give vegetarian burgers a more authentic meaty flavour and aroma.



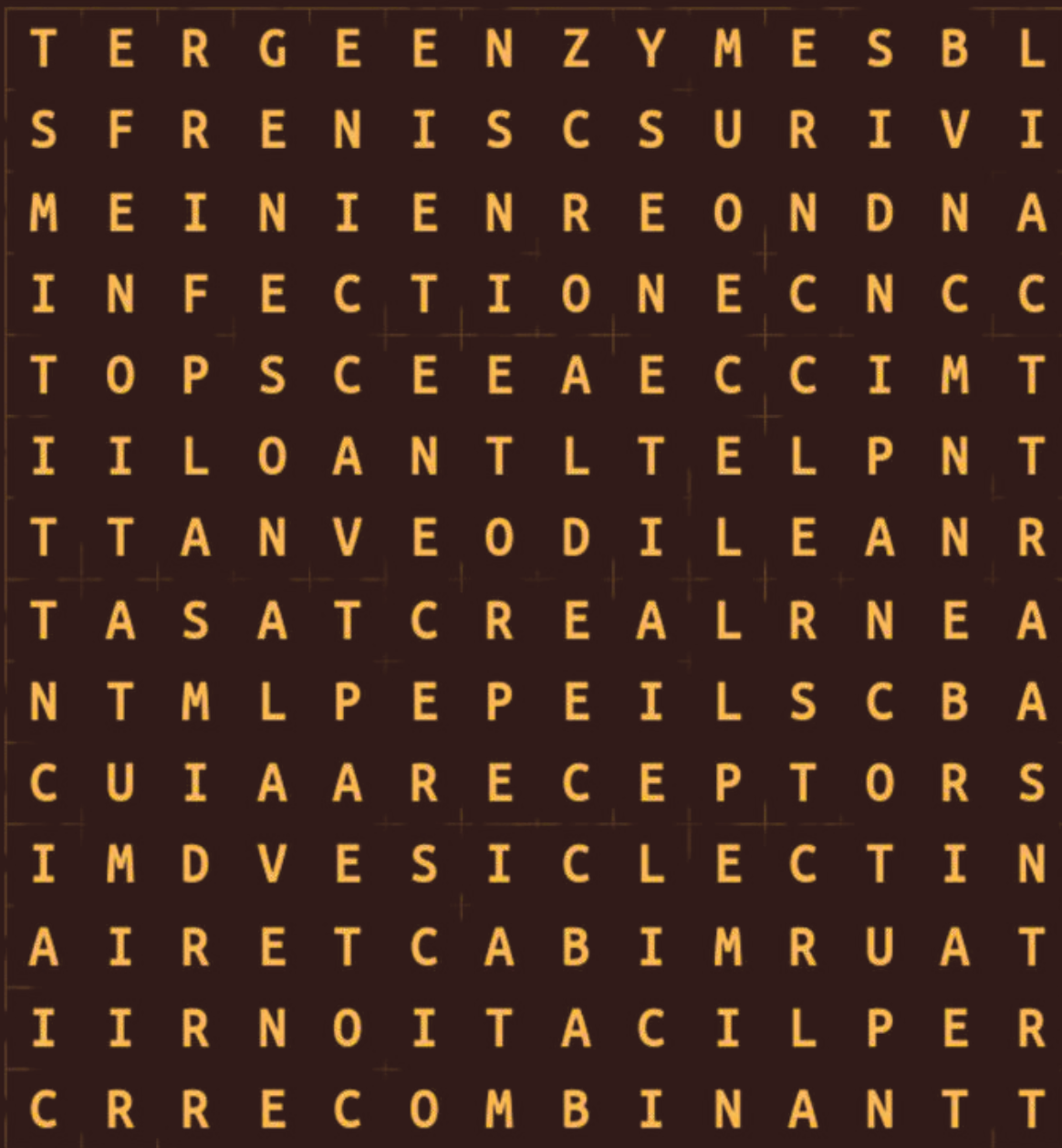
PLASTIC-EATING BACTERIA

Polyethylene terephthalate (PET) seems to be a favourite food of *Ideonella sakaiensis*. The bacteria were found to secrete two digestive enzymes, which upon interaction with PET plastic, degrade the plastic by cleaving the long molecular chains into shorter ones. Efforts in this area of study have included transforming enzyme-producing bacteria, like *E. coli*, into PETase factories through genetic engineering.



Activity corner

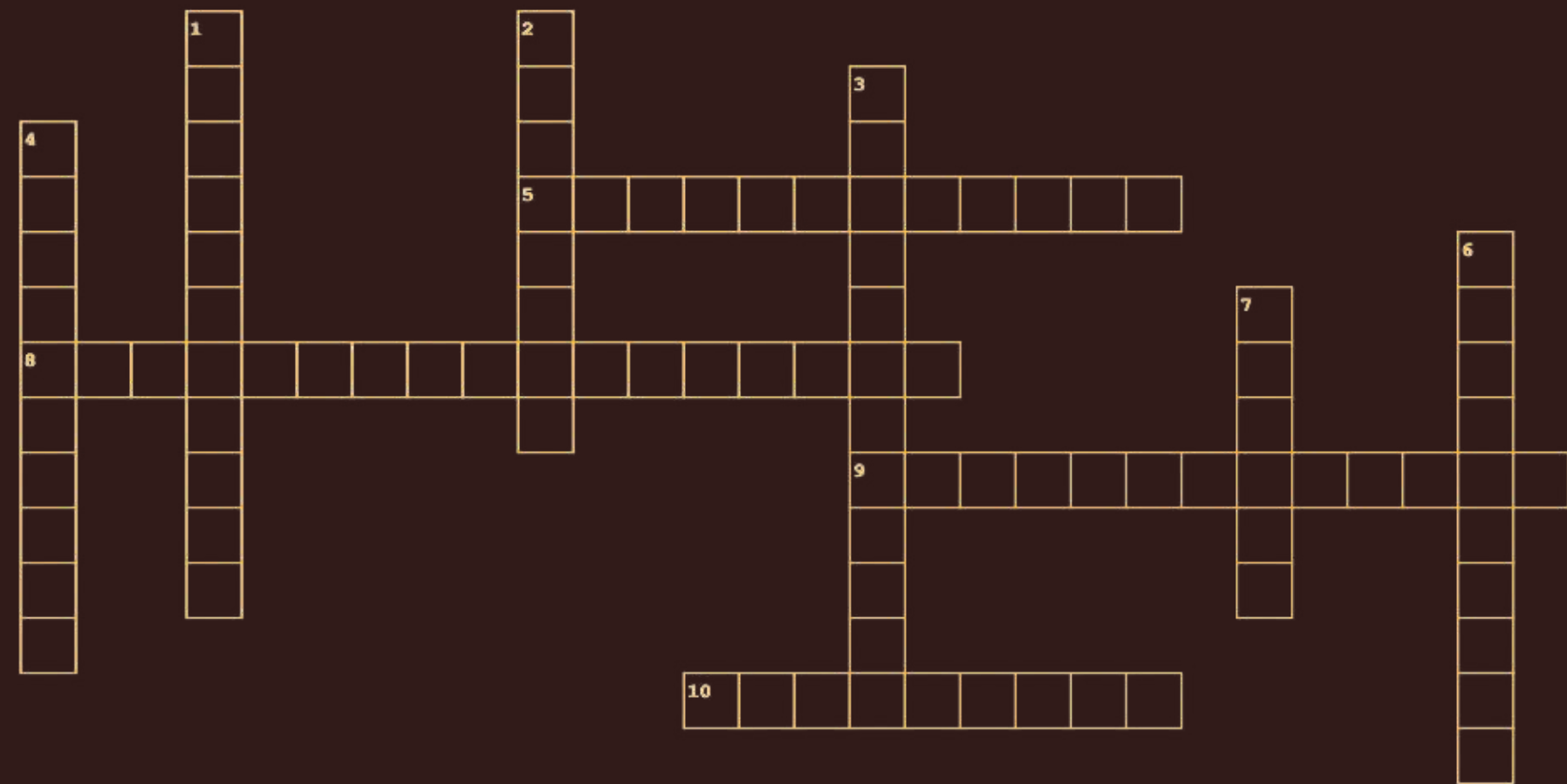
Synbio word search



- RECEPTOR
- BACTERIA
- RNA
- INFECTION
- CELL
- PROTIENS
- RECOMBINANT
- DNA
- VIRUS
- VESICLE
- REPLICATION
- ENZYMES
- VACCINE
- MUTATION
- PLASMID



Famous scientists in biology



ACROSS

- 5. Created a plot to understand protein.
- 8. Dark Lady of DNA
- 9. Father of evolution
- 10. Father of synthetic biology

DOWN

- 1. Double helix of dna
- 2. Complementary base pairing in dna double helix of dna
- 3. First observed dead cell under microscope first
- 4. Discovered jumping genes
- 6. Father of genetics

Pioneers in Synbio



George McDonald Church

Professor of Genetics
Harvard Medical School
He directs the evolution of molecules, polymers, and whole genomes to create new tools for regenerative medicine and chemical bioproduction.



Drew Endy

Assistant Professor of Bioengineering, Stanford University
His research teams were the first to use genetic logic amplification, rewritable DNA data storage, standard biological parts that can be used over and over again, and genome refactoring.



Ron Weiss

Director of Synthetic Biology Center MIT
His lab is working on putting together genetic circuits to learn more about how cells work and how they talk to each other, and making in vivo biosensors.



Randy Rettberg

Principal Research Engineer, Biological Engineering Division MIT; President iGEM
An engineer who has worked for technology companies including Apple, Sun and BBN, is the founder and director of the iGEM competition.



Tom Knight

(father of synthetic biology) got the bug for bioscience since he was a computer engineer at MIT. He founded the synthetic biology field and help set up bioengineering company Ginkgo BioWorks.

Bio Calender

IMPORTANT DATES

- 27 February Biotechnology day
- 28 February National science day
- 21 March World forestry day
- 7 April World health day
- April 24 Laboratory animal day
- April 25 DNA Day
- 3 May International energy day
- 22 May International day for biological diversity
- 1 August World Breast Feeding Day
- 10 August Biofuel day
- 16 September The industry day
- 17 September International Microorganism Day
- 1 October World donation day
- 3 October World Animal welfare Day
- 1 December AIDS day
- 3 December World conservation day
- 29 December International day for biological diversity