BIOLOGY ZERO

week one

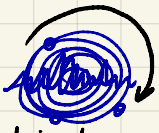
con-silience : jumping together two different practices design & science

from theory to practice in biology and science → next week agronomy and conservation

Nuria Conde - biology & computer science, multidisciplinary biologist.

complex systems → synthetic biology.

"Starting from zero" forget everything about Biology



big bang → quantum mechanics → chemistry → biochemistry → molecular biology → microbiology → cellular biology → physiology → cultural evolution

MAJOR TRANSITION

ACTION!

WHAT IS ALIVE? a piece of information that is able to perpetuate itself

what about conscience? Dan Dennett

Crispr technology - Cntrl + C Cntrl + V of genetics

↳ Genetic therapy without high probability of cancer

↓

Question becomes: WHAT SHOULD WE MODIFY?

- size?
- life span?
- replacements?
- new skills?

CANNOT PATENT GENES → open source

Alexandra Elbakyan: sci-hub, open source (illegal) platform for scientific papers.

PLANETARY WELLBEING

population growth = exponential

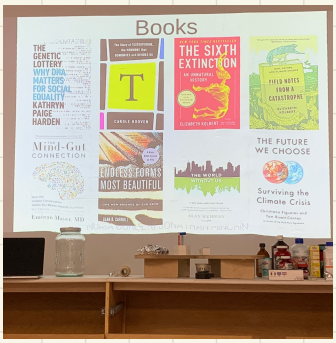
Element exhaustion: lithium, phosphorus ...
Contamination: microplastics, hormones ...

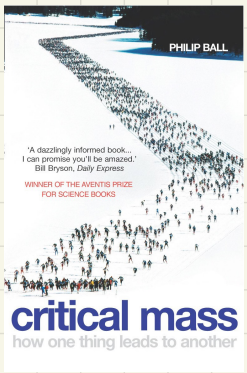
Global → Local: nuts, avocados, mosquitos ...
think globally, talk locally

Climate refugees: people relocation due to climate change.
Hidden CO_2 impact: hard to understand impact

→ Hidden Impact - good book to read

What we don't see - planned obsolecence
how many times do we have to reuse something to compensate CO_2
servers CO_2 emissions → streaming, 1MB = 7,072gr of CO_2





Replication of information
- Genes -
- Memes -
- Temes - technical replication of information

Evolution

Nature's optimised design ← evolution ← selective pressure

=there are always constraints.
→ this means that evolution will always take place in similar ways.

come from different ancestors - BUT look / function the same.
- GENETICALLY DIFFERENT
- VISIBLY (PHENOTYPE) SIMILAR

symmetry is present everywhere - due to division of cells

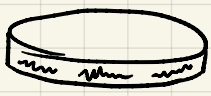
Biomimicry - copying techniques used by nature.

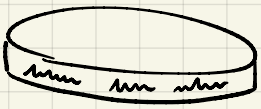
Biomimicry - copying techniques used by nature.

Mimicry / memistisme - nature copying itself.

Accelerated directed Evolution
↳ compressing the amount of time for processes to take place
= SYNTHETIC BIOLOGY

CREATING ENVIRONMENTS FOR BACTERIA/FUNGHI TO GROW





Mix together different ingredients to enhance growth of certain cultures.

MEDIUMS 1) Lactobacillus 2) Lactobacillus DIY 3) Yeast 4) Yeast DIY 5) All purpose
↓
- salt
- Bovrine
- Agar powder

→ collecting samples for each medium
make sure the object (hand / spoon) is not going to contaminate or sterilize the sample.
↳ dirty not sterile ↳ soap / alcohol residue

SAMPLES

ALL PURPOSE MEDIUM

1) IAAC PUDDLE

method: after sanitising my hands (and letting them dry), I collected some mud from the puddle at the back of IAAC.

expectation: large growth of bacteria and/or funghi due to lack of water circulation
→ like swamp.

2) TATIANA'S SCALP

method: hand sanitised & dry, I scratched and rubbed my scalp then deposited residue on dish.

expectation: growth of bacteria typically present on human skin & membranes
→ maybe perfume / hair products affect?

LACTOBACILLUS

3) TATIANA'S EYE

method: hand sanitised & dry, I rubbed my inner eye and collected residue from eyelashes.

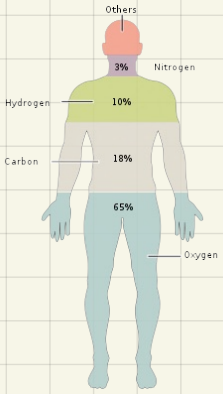
expectation: similar growth to scalp with variation of bacteria typically present in eyes.
→ maybe makeup / products residue?

BIO CHEMISTRY

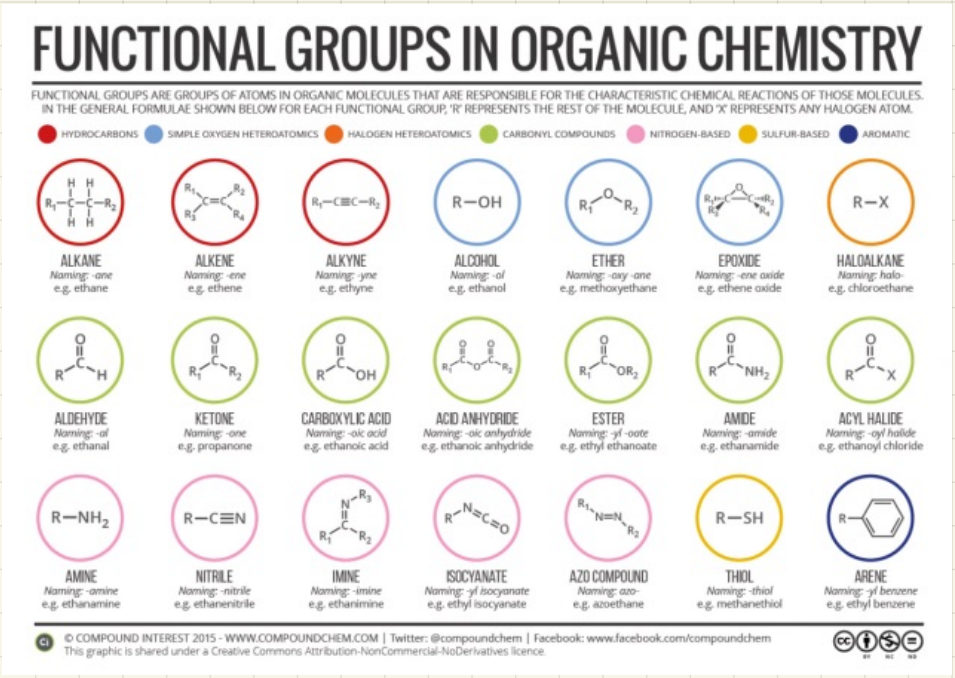
All living things on earth require

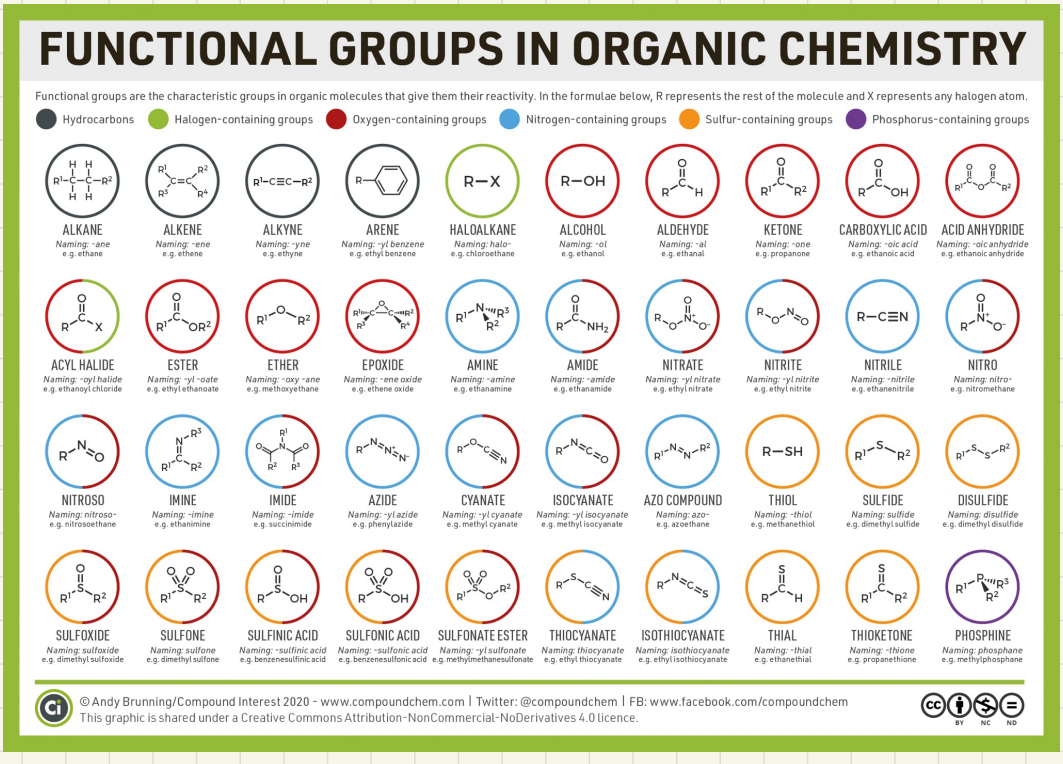
- Hydrogen
- Oxygen
- Carbon
- Nitrogen

} 4 organic basic elements.

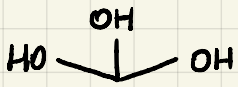


Functional groups are created by these 4 elements.

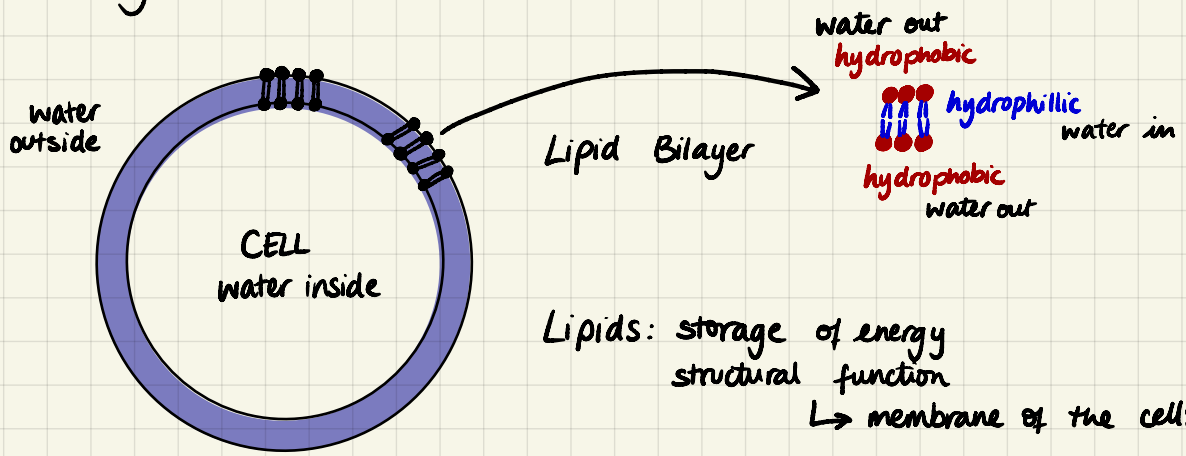




Glycerol

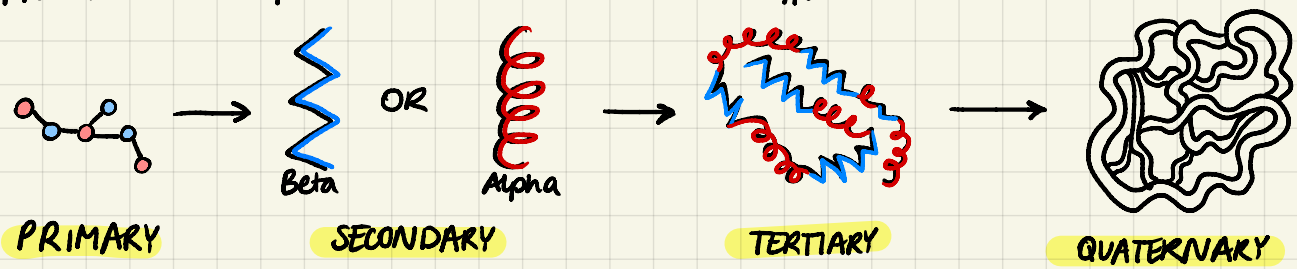


Fatty acids

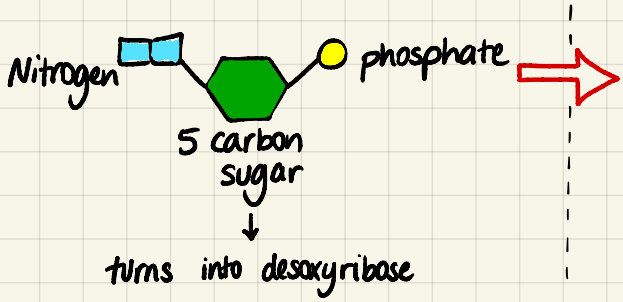


Lipids: storage of energy
structural function
↳ membrane of the cells

Protein - chains of amino acids which take on different structures:



Nucleotides



U	C	A	G	T
Uracil	Cytosine	Adenine	Guamine	Thymine

↓

replaces thiamine in mRNA

ATP : Adenosine Triphosphate
the energy-carrying molecule used in cells because it releases energy quickly

Enzymes: responsible for chemical reactions in body
= proteins ending in -ase

Metabolism: all the chemical reactions that take place in the cell.

↳ **Anabolism**: Building & bond making process that forms larger macromolecules
= requires energy

↳ **Catabolism**: Breaking down of molecules to make smaller ones
= releases energy

CATABOLISM : Aerobic respiration

Glucose in + Oxygen + Water → CO_2 out

glucose —(glycolisis)→ pyruvate + fatty acids } other processes inside mithochondria
= use processing in cells

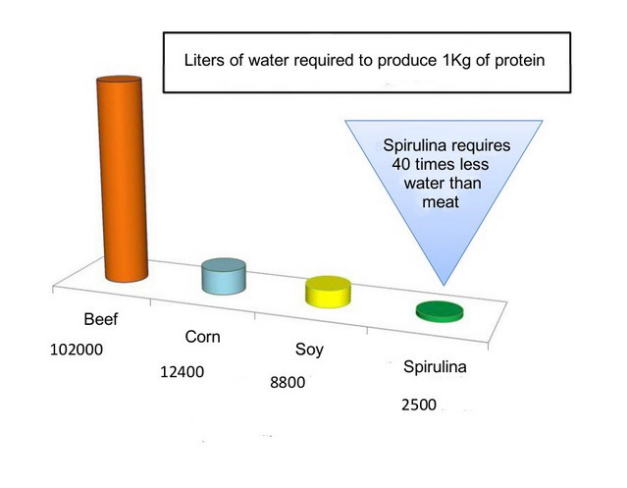
we need 9 enzymes for this transformation

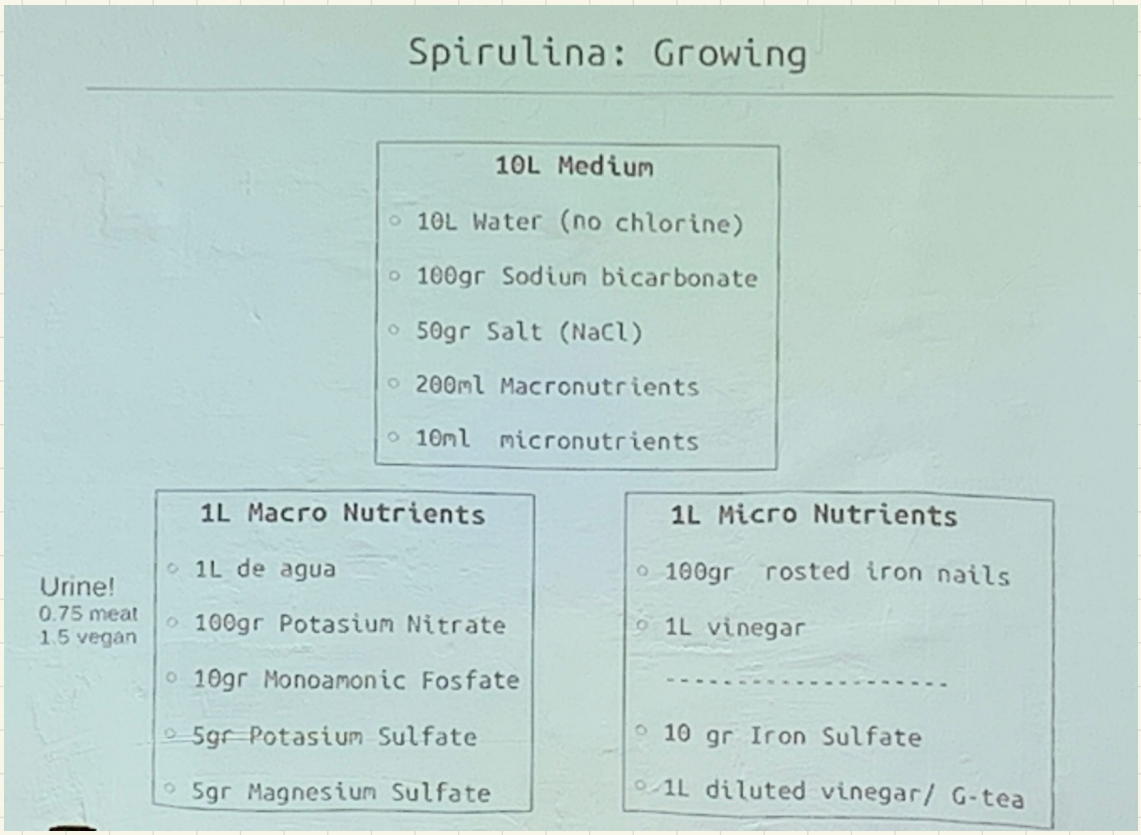
SPIRULINA will solve all your problems

→ low energy production

→ high protein + nutrition value / gram

→ can be made from pee





MICROBIOLOGY

the study of microscopic organisms (microbes)
↳ single cell (unicellular) or cell clusters.
includes fungi, protists & monera.

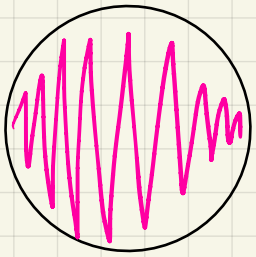
CLASSIFICATION - By nutrition

- Autotrophes - respiration, photosynthesis
  = able to feed themselves
- Heterotrophes - require food to live

- By information

- Eukaryote - "after the membrane"
- Prokaryote - "before the membrane"

IDENTIFYING MICROORGANISMS



→ colony shape will vary

FORM


circular

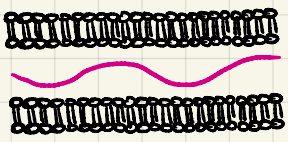

irregular


filament

etc.

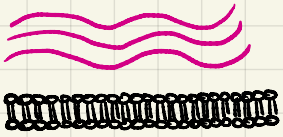
1) look for the colony shape
2) Microscopic observation

GRAM NEGATIVE



SANDWICH

GRAM POSITIVE

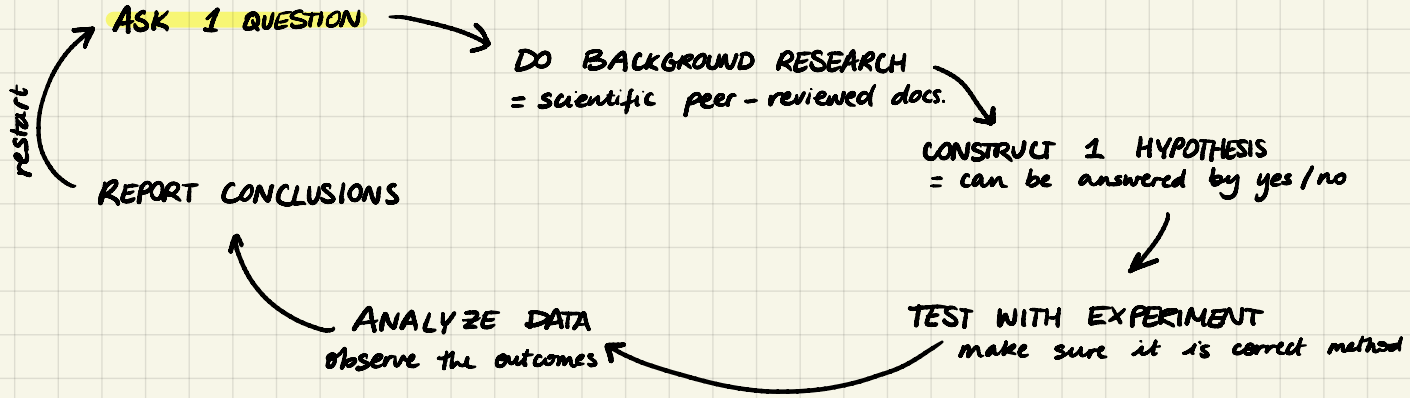


TOAST

the gut microbiome influences brain processes

our microbiome is an indication of our self.

The scientific method



Negative & positive controls
= have reference points

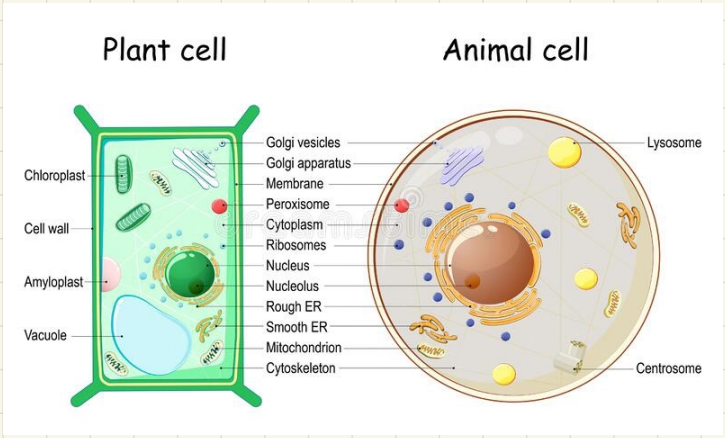
Negative yields 0 results, Positive yields desired result.

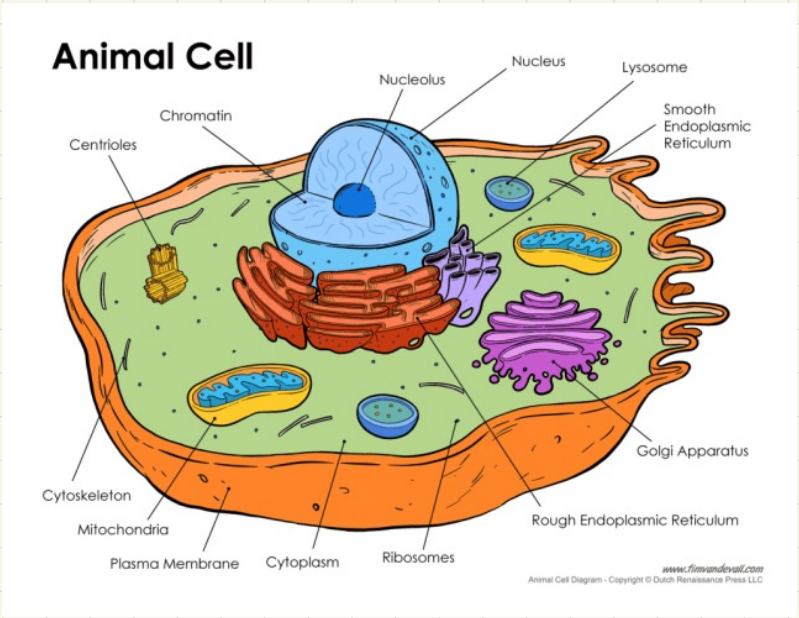
Assignment: Read a scientific paper + write summary of it & why it's important for future

What is an organell? → organs of the cell that keep us alive.

ANIMAL CELL:

main components of the cell:
1) Plasma membrane - Lipid bilayer
   - membrane protein
2) Cytoplasm - mostly water, soup of our cell
3) Nuclei - contains DNA
   - ribosomes





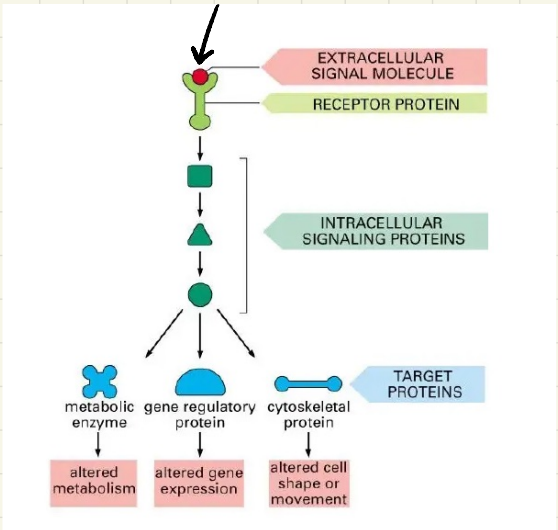
PLANT CELL: same components as animal cell but with extra:

- cytoplasm
- cell wall
- vacuole

Cybernetics: the science that studies the **homeostasis** of life
↓
maintaining balance & fluctuation

in order to maintain this balance, first we need to sense the environment

1) Change metabolism
2) Change cytoskeleton
3) altered gene expression



Information processing

iGEM - International Genetically Engineered Machine

1) Present the problem

2) Present possible solutions → make diagrams

In 2020, a major advance saw scientists identifying another enzyme that could degrade PET in just 10 hours[10]. The research screened a large variety of bacteria and enzymes for potential candidates, including the leaf-branch compost cutinase, LCC, that was first discovered in 2012. Hundreds of mutant PET hydrolase enzymes were then produced by varying amino acids at the binding site and improving thermal stability. Bacterial mutants were then screened to identify efficient PET decomposers. After running this process for multiple rounds, a mutant enzyme was isolated that is 10,000 times more efficient in degrading PET than the native LCC. It is also stable at 72°C, close to the melting temperature of PET. This finding contributes significantly towards attaining the infinite recycling of PET and is already at a pilot industrial stage[10].

CHEWING GUM

made out of plastic
→ polyethylene gum base

how to do «depolymerisation»

PET biodegradation has been extensively studied because esterase enzymes (enzymes that split esters into an acid and an alcohol) are abundant in nature[2]. Reports on the biological degradation of PET or its utilization to support microbial growth are, however, infrequent. Some organisms from the filamentous fungi group, *Fusarium oxysporum* and *Fusarium solani*, have been grown on a mineral medium containing PET yarns[3].

In 2016, Yoshida et al[4] reported the discovery and characterization of the soil bacterium strain, *Ideonella sakaiensis* 201-F6, found growing in PET-contaminated sediment near a plastic recycling facility in Japan. This gram-negative, aerobic, rod-shaped bacterium has the remarkable ability to use PET as its major carbon and energy source for growth.

I.sakaiensis employs a two-enzyme system to depolymerize PET to its building blocks, TPA and EG, which are further catabolized to a carbon and energy source. One of the two enzymes, ISF6_4831 protein, hydrolyzes and breaks ester linkages. With a preference for aromatic rather than aliphatic esters, and a specific inclination towards PET, it is designated as a **PET hydrolase (PETase)**. The PETase enzyme in *I. sakaiensis* is a cutinase-like serine hydrolase that attacks the PET polymer, releasing **bis(2-hydroxyethyl) terephthalate (BHET)**, **mono(2-hydroxyethyl) terephthalate (MHET)** and TPA. PETase further cleaves BHET to MHET and EG. The second enzyme, ISF6_0224 protein, MHET hydrolase (MHETase), further hydrolyzes the soluble MHET to produce TPA and EG (Fig. 2). Both enzymes are required, likely synergistically, to enzymatically convert PET into its two environmentally benign monomers, TPA and EG4, making it possible to fully recycle PET.

interesting enzyme: LLC

problem = unstable at high temp.

To achieve depolymerization, scientists have looked to nature, searching for microbial enzymes that can break down plastics. In 2012, researchers at Osaka University discovered an enzyme in a compost heap that can break down one of the world's most used plastics: **polyethylene terephthalate (PET,** CAS Registry Number 25038-59-9, formula $(C_{10}H_8O_4)_n$).

The enzyme, known as **leaf-branch compost cutinase (LLC)**, breaks the bonds between PET monomers, but it is intolerant to the 65°C softening temperature of PET, denaturing after a few days of working at this temperature and limiting its industrial practicability. Since depolymerization can only take place in molten plastic, enzymes must be stable at increased temperatures

source = CAS
American Chemical Society

AGRI ZERO

from forage to farm & back

worlds - 1, 2, 3, 4

first world: "developed" capitalist economies - USA, Western Europe

second world: socialist economies - USSR back in Cold War

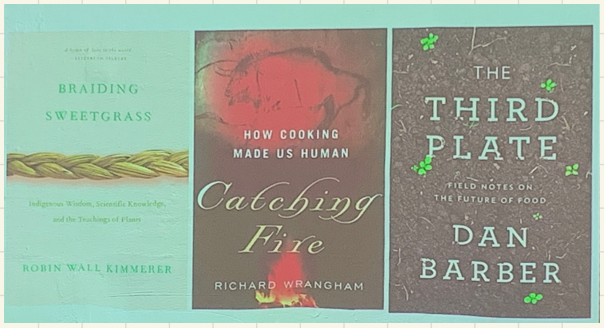
third world: "the global south"
resource procuring nations

fourth world: migratory & transitory countries

"Hunter - Gatherer" - the term hunting refers to Nomadic herding

ITK - Indigenous Technical Knowledge

Tacit knowledge - tactile, hand knowledge



Books on agricultural knowledge which led to the development of humans

Becoming sedentary - deciding to stay in fertile areas, 12,000 years ago ↓ beginning of history } MESOPOTAMIA

Due to floods from end of ice age ↓

new species of wheat - Emmer wheat
↳ easy to peel, easy to grow in fertile area.

= beginning of urbanism to protect wheat & preserve this from of wealth

Domestication: who domesticated who?

WW2 - synthesize nitrate & nitrite → make bombs
BUT ALSO fertiliser

The Importance of context

Permaculture
+ Agroecology

→ the edge: holds the most interesting species because they have to interact with one another

Self-sufficiency in Valldaura -

technology choice / Small is beautiful

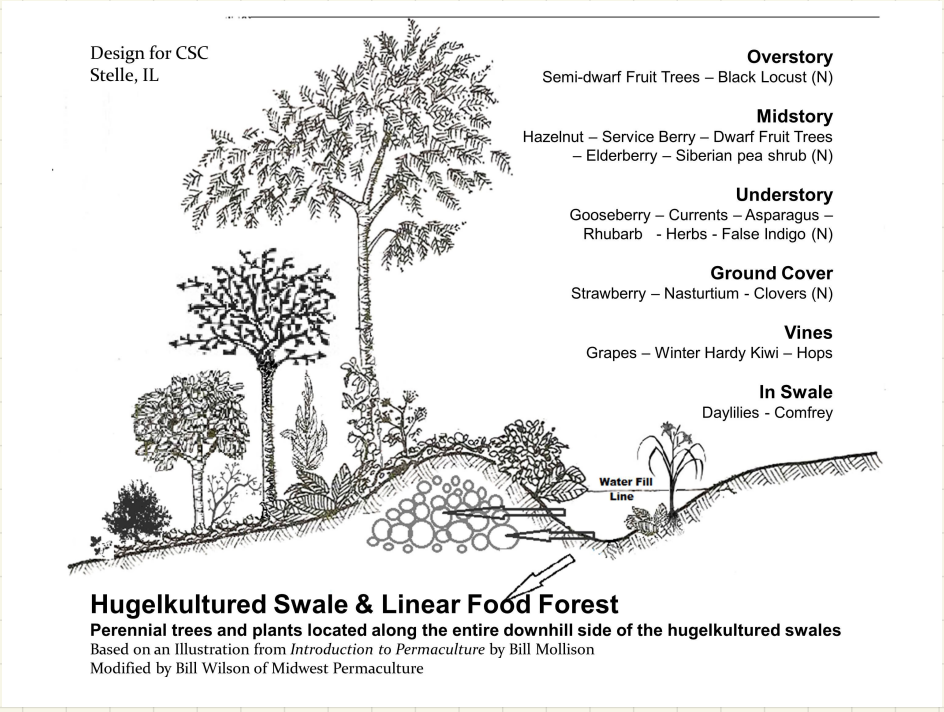
Data as a lens

Project: Romi – EU funded

Robotics for Microfarming

Polycultures: Many different crops - biodivesity

open soil = waste of light ⟶ healthy farms = can't see soil



synergy between agriculture & computing: do things will least amount of effort

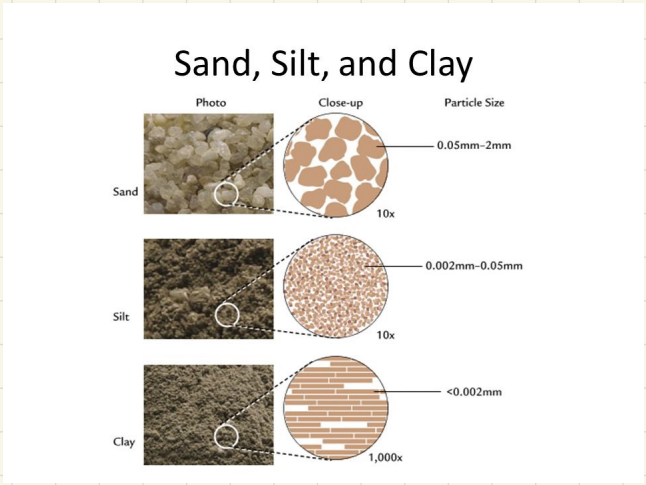
Computational Agro-ecology will be a tool to engage young generations in agriculture → these generations are no longer interested

SOIL - a living biome because it

cycles of composition & decomposition

Geophysical loam mineral

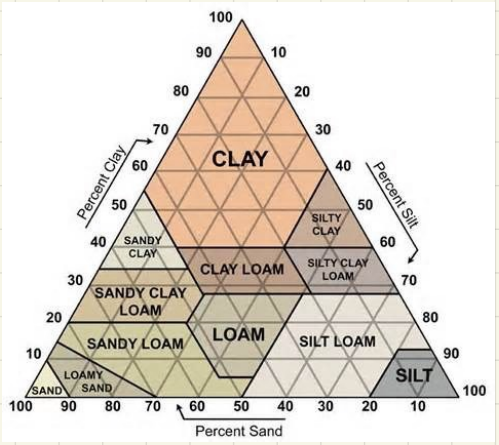
Meta genomic analysis - reading DNA code, sequence & compare results
↓ = looks at everything at the same time
meta because large scale, not single organism / being

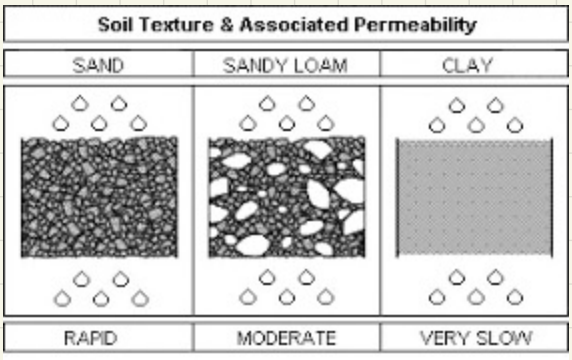


different types of particle sizes

bigger particles = absorb more water

smaller particles = easier to break down

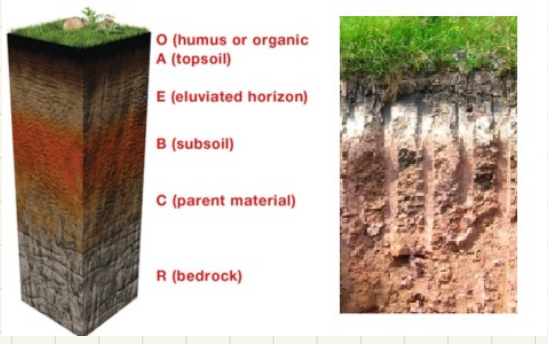




fluffy soil to grow plants

LOAM = organic part of soil
↳ compost ?

humus = ready-made top soil → the best to put on top & grow plants



different horizons
→ we are interested in A horizon (top layer)

Open source problems - how to brand & earn money

Monsanto herbicides

Nio Nicotine

5 TENETS OF AGRICULTURE
↳ 5 pillars

optimise the waste & production in Agriculture to make it regenerative & sustainable

CONVENTIONAL AGRICULTURE → how to transition?
what technologies / practices?

Ploidy

HAPLOID → 1 set of eggs / sperm
DIPLOID → 2 sets = human

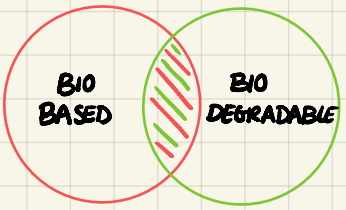
Chromosomes - some organisms have more than we do
= evolutionary complexity
↓
grass & plants have more ecological adaptation than we do → adaptable

BIO MATERIALS

plastic = malléable, moldable

precious plastics - remolding petrol-based plastics
↳ lose quality & malleability every time they're re-used

bioplastics = could be biodegradable or not
→ bio-based just means part of it contains bio-material



Benefits: reduced carbon footprint

What about ocean-degradable plastic?
↳ dissolve in saline solution

What about farm waste-based materials?
↳ from pruning, weeding, cutting

STOICHIOMETRY

ACID + HYDROGEN + POTATO STARCH

ACID → lemon juice, vinegar, tomato...
ACID + HYDROGEN: loosen hydrogen
HYDROGEN → glycerol
HYDROGEN + POTATO STARCH: mono-saccharide + water
POTATO STARCH → anything starch-based: cellulose, rice...

MILK + ACID = casein-based bioplastic
calcium
"Milk leather"

milk curdling - k casein is "neutralised"