DID YOU SAY CULTIVATED MEAT ?

Presented as the future animal protein, cultivated meat seems to be answer for most of animal agriculture's challenges.
But how do we cultivate meat ? And are these products really flawless?

STEM CELLS

Are taken by biopsy from the animal whose meat is to be cultivated. They can also be recovered from...

... STEM CELLS BANK

These cells are able to grow into tissues such as muscle fibres if placed in the right environment.

THESE CELLS ARE CULTIVATED IN

BIOREACTORS

STERILE TANKS PROVIDING A SUITABLE ENVIRONMENT FOR INTENSIVE STEM CELL PROLIFERATION

which will form muscle tissues and thus... MEAT

NUTRITIVE FLUID
+
GROWTH FACTORS

(Fetal medium or synthetic medium)

THIS TYPE OF PRODUCTION EMERGED IN THE 90S

FIRST BURGER WITH SYNTHETIC MEAT IN 2013

ISSUES RELATED WITH LIVESTOCK

POOR COW CONVERSION

100 g of plant protein

15 g of animal protein

LIVESTOCK FARMING IS RESPONSIBLE FOR

18 % of greenhouse gas emissions

30 % of land use

8 % of water

... and energy consumption

THE GROWING POPULATION AND THE TREND TOWARDS INCREASED MEAT CONSUMPTION ARE CAUSING SUSTAINABILITY ISSUES

WE SHOULD SEE MEAT CONSUMPTION DOUBLE BY 2050

AS MEAT PRODUCTION IS ALREADY REACHING ITS MAXIMUM...

CULTIVATED MEAT SEEMS TO BE THE BEST OPTION TO FACE THESE CHALLENGES

YES, BUT ...

The cultured meat industry is young. In 2019, producing 140 g was still costing 500 euros.
The production processes need to be improved.

The environmental impact of this industry is seen to be increasing due to the energy costs of the facilities, their operation and the synthesis of culture media among others.

The use of growth promoters, particularly hormones, raises questions about the food safety of consuming these products.

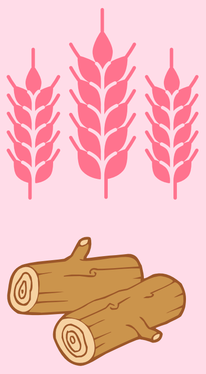
Today, hundreds of millions of people live directly or indirectly from livestock production. The social impact of a transition to synthetic meat should not be overlooked.

IS SYNTHETIC MEAT THE FOOD OF THE FUTURE OR IS IT AN ENTREPRENEURIAL FANTASY?

BIOFUELS

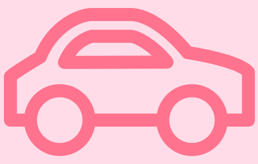
Biofuels are fuels produced from **biomass**, i.e. all organic matter of animal or plant origin. Biofuels are used in 2 sectors: **transportation** and **heating**.

TYPES OF BIOFUELS ?



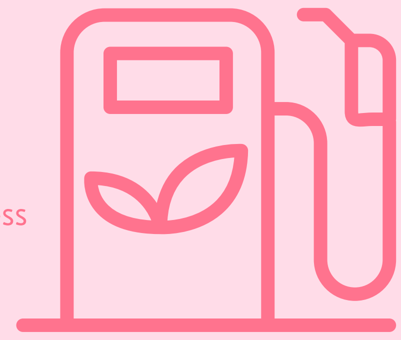
First generation biofuels are obtained by processing agricultural products for food. The **second generation** biofuels are obtained by the transformation of non-food raw materials (wood, straw, animal fats).

TYPES OF CHANNELS ?



For **gasoline-powered vehicles**, biofuels are essentially made up of ethanol, obtained from the fermentation of sugars present in cereals, beets and wine residues. For **diesel-powered vehicles**, biofuels are produced from oleaginous materials.

WHY DEVELOP BIOFUELS?



Biofuels are blended with traditional fuels to address the following issues:

- reduce greenhouse gas emissions
- improve air quality
- promote energy independence
- anticipate the depletion of oil reserves
- recovering industrial waste
- provide an agricultural outlet
- create jobs

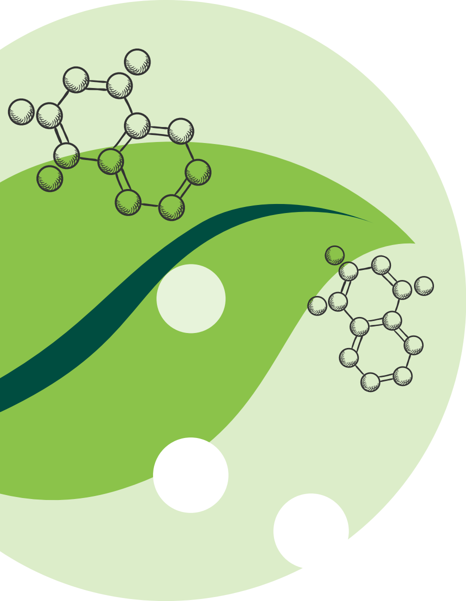
Synthetic biology tools can be used in the field of renewable energy:

Bacteria are **easy to cultivate**, some are even anaerobic. By transforming bacteria, it is possible to make them express enzymes that will convert cellulose from plant waste into biodiesel.

It is also possible to stimulate the **metabolic activity** of bacteria to produce **isoethanol** or **butanol**, which are types of biofuels.

However, the techniques to harness the metabolism of bacteria are expensive and time consuming to implement. In addition, the yield is low and these bacteria would have to be mass-produced to produce a sufficient amount of biofuel.

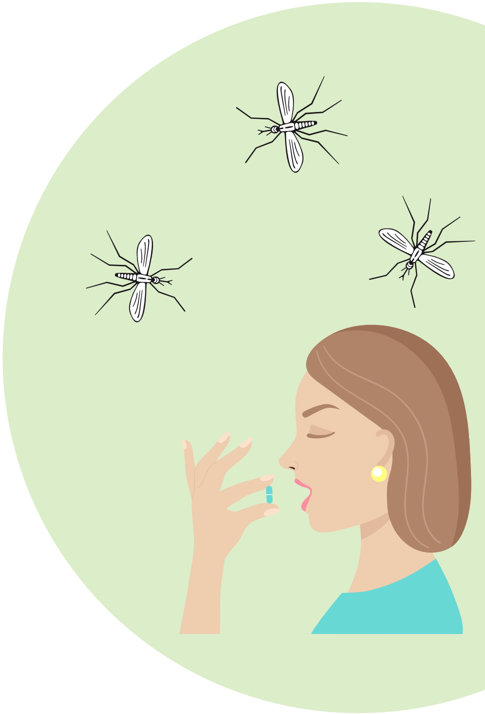
PRODUCING A DRUG IN A YEAST



ARTEMISININ

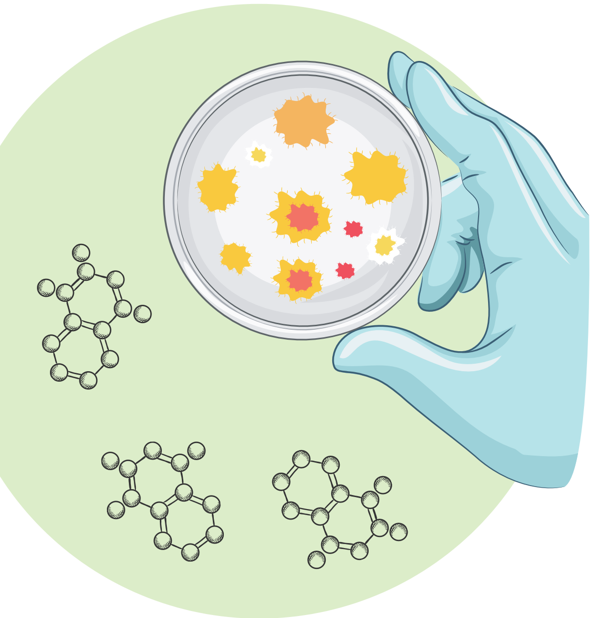
Artemisinin is a molecule historically extracted from a plant: ***Artemisia annua***. The medicinal virtues of this molecule have been known in China for a long time. Traces of its use can be found dating back more than 2000 years. Artemisinin is contained in the leaves of Artemisia annua, which must be dried and then crushed to obtain the precious **medicine**. The time it takes to grow the plant and the **low yield** of artemisinin make it an expensive compound.

NUMBER 1 ANTIMALARIAL DRUG



In 2004, the World Health Organization declared artemisinin to be the **drug of choice** to treat **malaria**, which was killing more than one million people in Africa. This has resulted in a **strong demand** from the regions in which malaria is ravaging. Thus, there is a strong increase in the price of artemisinin, which can then exceed the cost of **one thousand euros per kilo**.

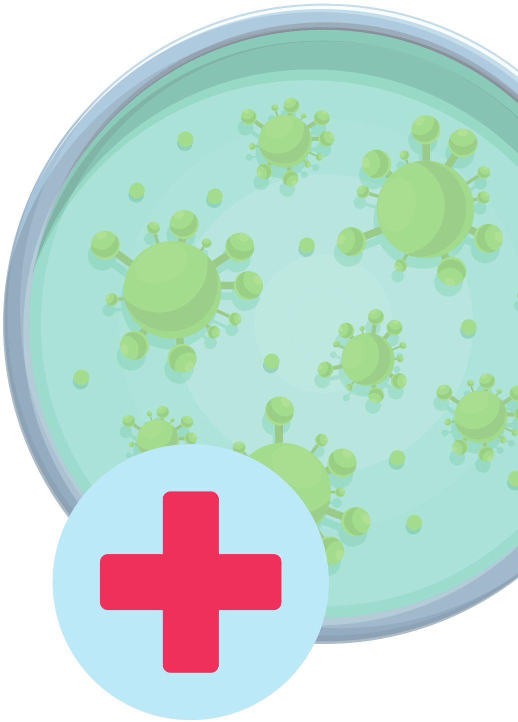
BIO-PRODUCTION OF ARTEMISININ



Faced with the challenges of artemisinin production, innovations have emerged: varieties of Artemisia annua richer in artemisinin, chemical **synthesis** methods and in particular a biological synthesis method in yeast. A team from the University of California Berkeley developed this technique in 2006. Yeast were **genetically modified** in order to carry out the synthesis of artemisinin autonomously in the cell. This strategy is now the method of choice for producing the drug. It allows a **more important and continuous supply**, not depending on agriculture. Moreover, this significant contribution has led to a drastic reduction in the price of the drug.

SYNTHETIC AND HEALTH

This example illustrates an application of synthetic biology in the **health** field. Indeed, the **design of living systems** with an engineering approach allows the production of new organisms and biological compounds. These prove to be valuable tools to address the challenges facing humanity. Health is a major issue today. Cancer, cardiovascular diseases and AIDS are public health **challenges**. Will the solution to these problems come from **synthetic biology**?



PLASTIC EATING BACTERIA?

Some bacteria are able to break down plastic naturally. **How can we modify these bacteria so that they can break down plastic waste much faster?**

POPULATION GROWTH
+
USE OF SINGLE-USE PLASTICS (FOOD PACKAGING, MASKS)

→ **THE EARTH SHOULD CONTAIN AS MUCH PLASTIC AS FISH IN 2050**

2016

Discovery of the *Ideonella sakaiensis* bacterium, capable of degrading in 6 weeks the most common plastic : **PET**. Later, researchers show that the fungus of the genus Fusarium is also able to degrade PET, and other strains of bacteria can degrade polyurethane plastic.

The bacterium produces a first enzyme (**PETase**) that degrades the PET polymer into a monomer called MHET. A second enzyme (**MHETase**) degrades the monomer into ethylene glycol and terephthalic acid, which the bacterium is able to digest.

PET plastic
↓ PETase
MHET
↓ MHETase
Ethylene glycol + terephtalic acid
⇣
Bacterial growth

By modifying the bacteria to produce a super-enzyme, a combination of the two plastic-eating enzymes, the bacteria can degrade the plastic within days.

Overcoming the evolutionary barrier: Microorganisms have had millions of years to learn to break down organic matter. Plastic only appeared at the beginning of the 20th century, so organisms have to adapt to be able to break down plastic waste.

Bacteria are not able to degrade plastic into carbon and oxygen. The resulting monomers are often intended to be **reused to make new plastics**, which does not solve the problem.

To deal with the increasing amount of plastic waste, bacteria producing the super enzyme would have to be **mass-produced**. This would risk releasing **chemical additives** normally stored in the undegraded plastic.

CONCLUSION

The use of plastic-eating bacteria is a good way to limit waste but it is not enough. Synthetic biology should be used to produce bacteria capable of degrading all plastic. To fight against the accumulation of plastic waste, this technique should be combined with the use of biodegradable materials and find environmentally friendly alternatives.