IB01x - 2.1 - Intro to micro-organisms

Welcome to the first lecture unit in week 2! Isabel has explained that you can use microorganisms to produce chemicals instead of using a chemical catalyst.

I will now tell you more about these microorganisms and what their function is in nature.

Microorganisms have been around for billions of years and can be found in many places on earth in many different forms and at very different conditions.

For example, if you would look at your skin through a microscope, you would find all kinds of microorganisms. But also in places where you would think life is impossible, like at the bottom of the ocean, in so called black smokers or deep in the mines. Or under other extreme conditions, like in freezing water, acid or alkaline environments and soda lakes.

So what is the role of these microorganisms?

We know that the energy of the sun can be used to convert carbondioxide and water into reduced carbon compounds and oxygen.

If there would be no microorganism, we would sit in a big pile of organic material.

The main function of microorganisms in our biosphere is to create element cycles, they consume carbon compounds and oxygen and covert them back to carbondioxide, creating a carbon cycle And so they do for other molecules containing elements like sulphur, nitrogen and iron.

Creating S, N and Fe cycles.

Cause of their role in the global element cycles, microorganisms convert materials occurring in nature. Given the enormous diversity of microbial conversions under different conditions it is obvious that microorganisms are the masters of sustainable chemical technology.

Now let's have a closer look at these microorganisms.

They come in different shapes and sizes.

But as you can see, they are all small, in the order of micrometres.

They also share a distinctive property.

They divide to propagate themselves with doubling times in the order of 1 hour. When they divide, the DNA of the cell is copied and divided over two cells. The DNA essentially dictates the properties of the organisms. Copying the DNA molecule is not an easy task. With typically 107 base pairs per DNA molecule, mistakes are bound to happen.

A copying mistake is called a mutation. Mutations can also be induced by external sources like UV light or oxygen radicals. These mutations can have no visible effect, can kill the organism or, fortunately, can improve the properties of an organism, leading to evolution.

For example, assume that a mutated substrate transporter-protein allows for faster transport.

Then the mutated organism will outgrow its competition giving it a selective advantage. Which allows this mutation to be carried on to the next generation in contrast to negative mutations.

The unique microbial mechanisms of division, mutation, competition and selection cause that favourable properties are preserved and will be improved in future generations.

Selection and evolution from natures microbial treasure trove provide us with unique possibilities. We can select suitable microorganisms from nature or use evolution experiments in the lab to develop them ourselves. I'll show some examples.

Selection is a very powerful method to obtain suitable microorganisms.

It is used in Delft, by Mark van Loosdrecht and myself, with powerful results. For example it is used to select for biofilm forming organisms on sand particles by applying a high wash-out rate, which removes non-attaching microorganisms, making all food available to attaching organisms This was the basis of a new biofilm reactor technology in Delft. This principle has led to many new microbial processes in the past 20 years.

An example of evolution comes from our department by the group of Jack Pronk. A yeast was modified, by adding two enzymes, which allowed the cell to transform a second-generation feedstock, xylose, into ethanol. However this organism produced ethanol at a very unsatisfying rate. Knowing the underlying mechanisms of evolution, he put the organism under a selective pressure for faster xylose consumption. In four months the organism showed significant improvement. And improvements are still possible for this organism using this technique.

Besides increased growth rate, evolution also allows to improve other properties such as product tolerance. An example from Delft, also by Jack Pronk, is the improved butanol or acetic acid tolerance of saccharomyces cerevisiae.

So to wrap it all up, we have limitless possibilities if we go to nature to find our organisms. We can improve these organisms and turn them in to feasible production units by converting sustainable feedstocks present in nature into commercial products.