## TBP01x - 1.2 - Industrial Biotechnology

The key technology needed to make biobased products is industrial biotechnology. I think it is good in this unit to carefully describe in a nutshell where it stands for, because Perceptions may vary.

How does it fit in the context of bioplastics, genetically modified organisms, applications in health, and to biological large scale processes.

First let us address biotechnology: We can define Biotechnology as the use of biological systems to make a valuable product.

Biotechnology is very old, it was used long before people knew about microorganisms. Beer, cheese and bread are all examples of classical biotechnology. But also fruits and vegetables that farmers have improved over the years by breeding can be considered biotechnology.

But how do we define

"a biological system"? The biological system is defined as microorganisms or their derivatives, such as enzymes.

So microorganisms form the heart of biotechnology.

In industrial biotechnology we make industrially relevant chemicals on a large scale with biological systems.

These could be products you would normally not associate with biotechnology, like plastics, paint, medicine or fuels.

In a nutshell, you have roughly two kinds of industrially useful microorganisms, bacteria and fungi. Bacteria are extremely useful and are widespread.

They can be found in your food, such as yoghurt, in your gut, where they are responsible for digestion of food, but also in waste water treatment.

Industrially, they are used to produce insulin. Fungi are the second class of microorganisms, they are the molds that appear on deteriorating bread. Industrially, they have been used, for example, to produce penicillin.

Enzymes are produced by micro-organisms and they themselves catalyze their own reaction inside or outside the cell. As such, they are also biological systems. Enzymes can be used to improve bread, make cheese, or remove stains more effectively when you wash your clothes.

They can also be applied as catalysts in organic synthesis.

If we take a closer look at bacteria, you can see they are actually relatively simple micro-organisms. They are prokaryotic, so there is a single cell with a cell membrane in which all processes happen.

Fungi are more complex micro-organisms, they are eukaryotes and processes happen in different compartments within the cell.

Fungi and Bacteria are living organisms because they can grow on feed, and multiply themselves. Microorganisms can grow on and in any biological ecosystem on earth.

They can also be trained to affect certain conversions, especially the ones that we find useful in an industrial setting.

In order to allow for growth, and to serve as source of carbons, sugars are a suitable form of biomass, that has been commonly applied in industrial biotechnology.

Thus for our applications, the organisms are given a form of biomass as feed. Then the microbial conversion of organic material into substances takes place in a process called fermentation.

The products that result are usually simple molecules such as ethanol, lactic acid, succinic acid or propanediol.

In a real-life industrial biotechnology process, many more intermediate steps are needed to link biomass to microorganisms and product.

Sugars from biomass need to be released prior to fermentation, and a number of downstream processing steps are needed to obtain purified product. The resulting compounds require additional modification by either chemical or biochemical steps to make the final product. So don't expect a plastic cup to come out immediately!

Several scientific breakthroughs led to the development of industrial biotechnology as we know it.

A number of them occurred right here in Delft – the place I come from -, and I would like to share some of this with you. Delft owes its rich history in microbiology to the microscope. We all find it very normal that we can visualize micro-organisms, but the microscope was actually invented here in Delft by Antonie van Leeuwenhoek.

He was the first one to observe microorganisms, which since then have been used by industrial partners in the Netherlands to make penicillin and spirits.

Following the footsteps of van Leeuwenhoek we have some famous professors in microbiology who have discovered a number of very important facts. Professor Beijerink was the first professor in Microbiology in the Netherlands and he discovered the Tobacco Mosaic Virus. Van Iterson was the pupil of Beijerink and he developed the mathematical approach

to plant growth, named phyllotaxis. Next in line is Kluyver, who discovered the unity in biochemistry.

This means that every mechanism on biochemical level is identical. Then professor Kuenen, who is still alive today, he discovered the Anammox bacterium, which had a great impact on nitrogen removal in wastewater treatment processes worldwide.

The foundation of many of the microorganisms that are used today was laid right here in Delft. And you can imagine that top performing microorganisms are of vital importance to develop a 'top" industrial bioprocess.

Join us next unit for more "Technology for biobased products".