Terminology

Term	Explanation
(product) Titer	The final or broth outflow product concentration achieved in the fermentation, generally expressed in moles or mass of product per unit of volume or mass
(product) Yield	The amount of product that is produced per amount of converted substrate (mol product/mol substrate or kg product/kg substrate)
5-carbon sugar	A sugar with 5 carbon atoms
6-carbon sugar	A sugar with 6 carbon atoms (e.g. Glucose)
Aerobic	A process that requires oxygen
Affinity parameter	Is the concentration of converted compound which permits the enzyme or transporter to achieve half V_{max}
Agave	Plant native to the Southern United States of America and tropical America
Airlift loop reactor	A type of reactor that is mixed by gas sparging and by internal gas circulation
Anabolism	The synthesis of molecules from small units at the expense of energy
Anaerobic	A process that does not require oxygen
Anammox	Anoxic Ammonia Oxidation. A process carried out by microorganisms that is a.o. used to remove ammonium from wastewater. The following reaction is catalysed: NH4+ + NO2- => N2 + 2H20
Anion	An ion with a negative charge
Aquaculture	The farming of aquatic animals and/or plants for food and other products
Arable	(Land) suited for growing crops
Aspect ratio	Liquid height divided by the fermenter diameter
ATP	The universal energy carrier in organisms
Bacteria	Large group of unicellular microorganisms that have cell walls but lack organelles and an organized nucleus
Balance i	An equation (mol i/h) which exists for each compound i. Balances consists of: Conversion rate (mol i/h), the sum of transport rates (convective or transfer, in mol i/h) and the accumulation rate (in mol i/h). The balance is a differential equation and is essential to calculate rates of conversion
Batch operation	A mode in which fermentation processes can be operated. The liquid based reactants and the microorganism are added simultaneously in the beginning of the process, and the process ends when all the added substrate is converted.

Biobased products	Products which are composed for the major part of elements (carbon, oxygen, hydrogen) that stem from biomass
Biochemical composition	Main molecules comprising a certain compound
Biodegradable	A compound that can be broken down by microorganisms
Biodiversity	The variety of life in the world or in a particular habitat or ecosystem
Bioeconomy	A biobased economy instead of an economy based on fossil fuels (see biobased)
Biomass	In week 1 it refers to biomass used as feedstock. From week 2 refers to the microorganisms that do grow and make product in the fermenter
Bioplastic	Plastic made from biologically produced compounds (rather than from petroleum)
Biotechnology	The use of biological systems to develop or make a valuable product
Black box kinetic model	A mathematical model which links the cellular biomass specific uptake and secretion rates to each other and to the cellular environment
Broth	The mixture in which industrial fermentation are carried out
Broth	Mixture in the fermenter containing microorganisms, residual substrate, remaining nutrients, (by) products and water
Bubble column	A type of reactor that is mixed by gas sparging at the bottom
CAPEX	Capital Expenditures (see Capital Investment)
Capital investment	Money used to acquire fixed assets
Carbon	A chemical element that a.o. forms the physical basis of all life
Carbon cycle	Biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth
Catabolism	Break down of molecules into smaller units to release energy
Catalyst	A substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change
Cations	An ion with a positive charge
Cell duplication	Cell division
Cell membrane	A biological lipid based membrane that separates the interior of a cell from the outside environment
Chemostat	Continuous operation of a fermentation. Can also refer to the type of reactor used for continuous fermentation.
Circulation rate	Internal flow of broth
Circulation time	Time to travel from top to bottom and back
Circulation velocity	Circulation rate divided by 1/2 cross sectional area
Classical biotechnology	Processes that are based on the inherent capability of microorganisms to make a product (e.g. brewing, cheese)

Competition/ selection	Contest for resources (competition) such as substrate that may result in an increase (selection) in the frequency of a variant (mutant) of the species better suited (due to the mutation) for survival and reproduction in the same environment as the parent
Contamination	The growth of unwanted microorganisms in the fermenter
Continuous fermentation	A mode in which fermentation processes can be operated. In general the continuous process is operated in a steady state in which there is no accumulation of the different components in the fermentation. This is achieved by continuous inflow with nutrients and continuous outflow of broth
Cradle-to-Gate	Boundary of a system that describes a process from resources to product manufacturing (factory gate)
Cradle-to-Grave	Boundary of a system that describes the whole process from resource to product consumption and waste handling.
Crude oil refinery	Industrial installation where crude oil is broken down into intermediate chemicals
C-source	The chemical compound that provides carbon atoms and energy needed for growth and product formation
Differential equation	A mathematical equation that relates some function that contains a derivative. Each balance is a differential equation
Dilution rate	The liquid outflow rate (m3/h) divided by the liquid volume of the reactor (m3) or the mass outflow rate (kg/h) divided by broth mass in the reactor (kg)
Distillation	The action of purifying a liquid by a process of heating and cooling
DNA	The biochemical macromolecule (1 copy in each cell) that carries genetic information
Dry biomass	The mass of the cells after water removal (e.g. by drying)
Due diligence	Investigating a business(idea) prior to investing or realizing it
EC	European Commission
Electron acceptor	A oxidized compound that can be reduced using electrons from the donor
Electron donor	A reduced chemical compound can be oxidized to release electrons
Element conservation	The principle that an element cannot be destroyed or made in (bio) chemical systems
Element cycles	Biogeochemical cycles by which elements (C,N,P,Fe,..) present in different compounds are exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth
Elephant grass	A tall tropical African grass (also called Napier grass)
Environmental footprint	The impact of a process on the environment (e.g. In terms of water use, greenhouse gas emission, social effects etc.)

Enzyme	A protein that acts as a catalyst for a specific (bio)chemical reaction
Enzyme	A protein that efficiently catalyses a specific biochemical reaction
Eukaryote	A unicellular or multicellular organism whose DNA is stored in the form of chromosomes contained within a distinct nucleus
Evolution	Evolution is the mutation/selection process which results in change in the inherited characteristics of microbial populations over successive generations
FAO	Food and Agriculture Organization of the United Nations
Fed-batch operation	A mode in which fermentation processes can be operated. This process starts with a batch phase. As soon as all substrate is converted, substrate is fed to the reactor at a feed rate resulting in optimal production conditions. There is no broth outflow
Feedstock	Raw material to supply or fuel an industrial process
Fermentation	The bulk growth of microorganisms on a growth medium. Fermentation is also used more specifically to refer to the catabolism of an organic compound by microorganisms where the compound serves as both the electron donor and the electron acceptor, and in which ATP is usually produced by substrate-level phosphorylation
Fermenter	A sterilisable reactor used for biotechnological processes (also called bioreactor)
First generation biomass	Biomass from the nutritional parts of plants
Fossil fuel	A natural fuel derived from biological material (organic molecules) that accumulated in the subsurface in the very distant past, and under high pressure has been converted to solid, liquid or gaseous substances with a high energy density
Fungi	Large group of spore producing organisms feeding on organic matter
Gasification	Conversion of a solid or liquid into gas
Genetically modified organism (GMO)	An organism whose genome has been artificially altered using in vitro genetic engineering techniques
GHG emissions	abbreviation for greenhouse gas emissions (CO2, CH4, N2O)
Glucose	A sugar with 6 carbon atoms. It is an important energy source for many living organisms
GM	Genetic modification
Greenhouse gas	A gas that traps heat between the atmosphere and the earth surface, thereby contributing to the greenhouse effect (e.g. CO2)

Hemicellulose	Any of a class of substances that occur as constituents of the cell walls of plants and are polysaccharides of simpler structure than cellulose
Hydrolysis	The chemical cleavage of a compound in reaction with water
Hydroxyl group	The -OH group linked to the carbon backbone of an organic molecule
Ideal broth mixing	Means that the broth is homogeneously mixed throughout the fermenter. There are no spatial differences in concentration
Impact Assessment	Part of the LCA where ecological and human health effects and resource depletion are assessed.
Impeller (also called turbine)	A rotating device in the fermenter used to increase the flow of the contents of the reactor to achieve mixing and gas dispersion
Inoculum	The cells added to the fermenter to initiate the biological reaction
Insulin	A hormone produced in the pancreas that regulated the amount of glucose in the blood
Internal rate of return	The interest rate at which the net present value of costs of the investment equals the net present value of the benefits of the investment
Internal Rate of Return (IRR)	The interest rate that makes NPV = 0
Intracellular	Inside the cell
IPCC	International Panel on Climate Change
Jatropha	A genus of plants, one species of which (Jatropha curcas) produces seeds that are used in the production of biodiesel
Life cycle assessment	A technique to assess the environmental aspects and potential impacts associated with a product, process or service
Life Cycle Assessment (LCA)	A method/tool to assess environmental impacts of a process
Lignin	A complex organic polymer in the cell walls of many plants, making them rigid and woody
Lignocellulose	A complex of lignin, cellulose and hemicellulose present in the cell walls of woody plants
Margin	Net profit (profit after taxes) in this course
Marginal soil	Soil that has little potential for profitable agricultural use
Medium	An aqueous solution or gel designed to support the growth of microorganisms
Metabolic engineering	Optimizing genetic and regulatory processes within cells to increase the cells' production of a certain substance.
Metabolism	Anabolism and catabolism combined
Metabolite	A compound present in the metabolism of a particular organism or to a particular metabolic process
Microbiology	The branch of science that researches microorganisms
Microorganism	A microscopic (unicellular or multicellular) organism

Mol fraction	The amount of a compound (expressed in moles), divided by the total amount (in moles) of all compounds in a mixture
Mutation	A change in the genetic sequence
Net Cash Flow	Change in cash balance over a certain period (Net profit - other payments)
Net present value	The value in the present of a sum of money, in contrast to some future value it will have when it has been invested at compound interest
Net Present Value (NPV)	Time series of cash flow which takes into account the time value of money. It is one of the most commonly used criteria for making investment decisions
NGO	Non-governmental organization
NREU	Non-renewable energy use
Nutrients	Compounds needed for the cell to grow and make product
OPEX	Operational Expenditures
Organic molecule	A molecule containing carbon
Overview effect	Term coined by Frank White for the psychological impact that seeing the earth from outer space had (and has) on astronauts and society at large
Oxfam	An international confederation of 17 organizations acting to lift people out of poverty
Payback time	The amount of time required to earn back your initial investment
Pay-back time	Time required for earning back the initial investment required
PDO	1,3-Propanediol
PET	Polyethylene terephthalate
Photosynthesis	A process used by plants and some microorganisms to convert light energy H2O and CO_2 into chemical energy and O_2
Phyllotaxis	The arrangement of leaves on an axis or stem
Platform chemical	Molecule that can serve as the basis for a multitude of different industrial products
Polycondensation	Reaction of multiple molecules that link to each other, releasing H_2O molecules, and forming a polymer
Pre-treatment	The treatment of biomass in order to make fermentable sugars accessible to microorganisms
Productivity	The amount of product that is be produced per unit of time and per unit of fermenter volume
Prokaryote	Single-celled organism that has neither a distinct nucleus with a membrane nor other specialized organelles (e.g. Bacteria, Archaea)
Propylene	A gaseous alkene hydrocarbon, produced by cracking alkanes

Protein	A macromolecule consisting of one or more long chains of amino acid residues
Pseudo steady state	The rates of processes (production of a component and its subsequent consumption) are always very closely balanced
PTT	Polytrimethylene terephthalate. A synthetic polyester.
Pyrolysis	Decomposition due to high temperatures
q-rate	The biomass specific rate of a compound; < 0 when consumed, > 0 when produced
Rate i (R_i)	The produced or consumed amount of a certain compound i per unit of time (e.g. mol i/h) in the fermenter
Renewable feedstock	Raw material from biological origin
Return on Investment (ROI)	Annual benefits to an investor expressed in percentages of the total investment.
Second generation biomass	Biomass from the woody parts of plants
Socio-economic analysis	An analysis that weights the pros and cons for society when introducing a new process or product
Solvent	Able to dissolve other substances
Sparger	Device at the bottom of the reactor that is used to introduce gas (air) in the reactor in the form of bubbles.
Steady state	A state that can be achieved in continuous processes, in which volume, in and outflow rates and all concentrations (in the fermenter, and in- and outflow) remain constant in time (no accumulation)
Stirred tank reactor	A type of reactor that is mixed using a stirring device
Stoichiometry	The relative consumptions and productions of components in a reaction
Strain	A genetic variant of a micro-organism
Substrate	Compounds needed for the cell to grow and make product, but in the course context often referred to as sugar or carbon source
Substrate-level phosphorylation	The synthesis of energy-rich phosphate bonds through the enzymatic reaction of inorganic phosphate with an activated organic compound
Superficial gas velocity	The volumetric gas flow rate (m3/s) divided by the cross sectional surface area of the fermenter (m2)
Sustainable	The degree in which needs of economy, society and environment are met, both on the short and the long term
Sustainable development	Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs
Switchgrass	A tall North American grass that forms large clumps

Syn-gas	Synthesis gas. A mixture of Carbon monoxide, Hydrogen, and Carbon Dioxide
Techno-economic analysis	An analysis that takes into account both the technical and economic viability when introducing a new product or process
Thermodynamics	Quantifies the amount of Gibbs energy and/or heat produced in (bio)chemical reactions in this context
Third generation biomass	Third generation biobased products are based on improvements in the production of biomass. It takes advantage of dedicated streams such as aquatic biomass.
Toxicity	Degree of poisonous effect
Trace metals	Metals that are required in extremely small quantities for microbial growth
Transporter	A protein embedded in a membrane that serves the function of the transportation of molecules over a membrane
Turn around time (t.a.t.)	The time that a reactor cannot be used for production due to maintenance and cleaning
UN WCSD	United Nations World Commission on Sustainable Development
US EIA	United States Energy Information Administration
Vitamin	A vitamin is an organic compound and a vital nutrient that an organism requires for growth in limited amounts
Vortex	A region in the fermenter in which the liquid flows in a circular motion
Wet biomass	The mass of the cells with intracellular water still present
Wild-type	An organism isolated from nature where no genetic modification has been performed