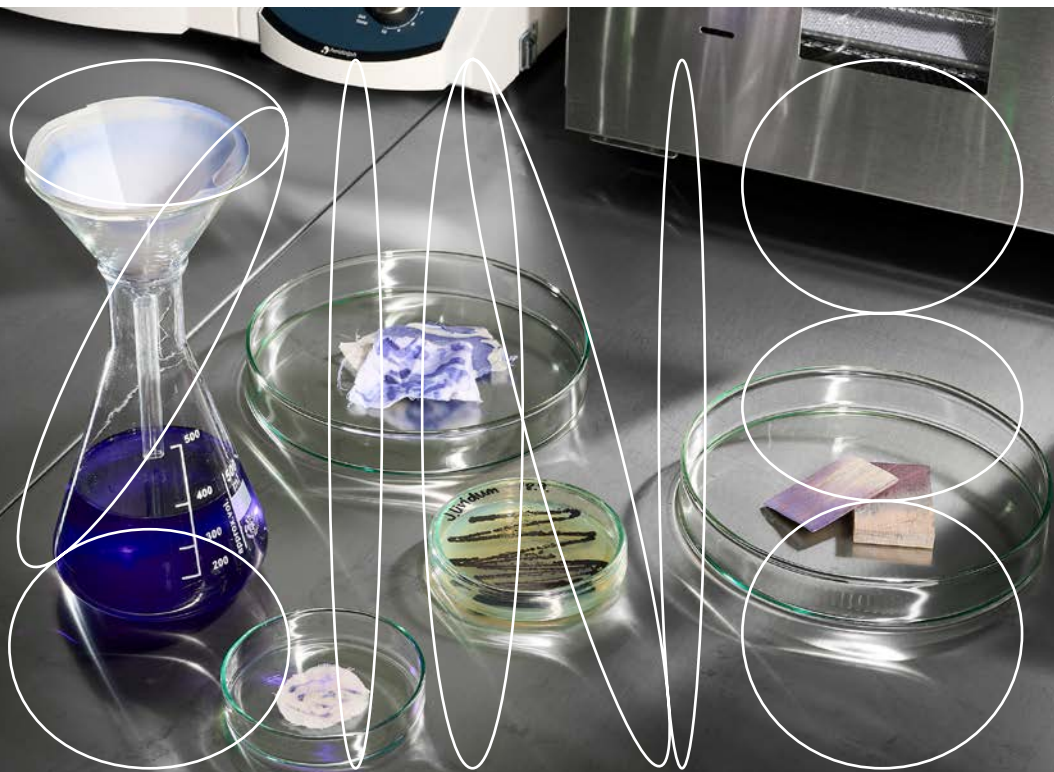


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SPACE FOR BIOMATERIALS
How to Biolab [EN]

#08
09/2026

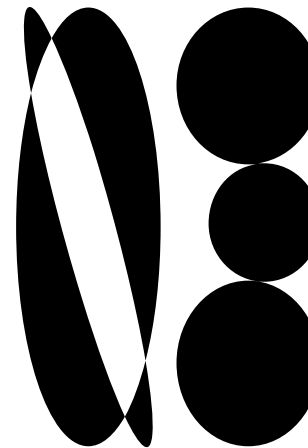




SBYD AND
THE SPACE FOR
BIOMATERIALS



BIOLABS AS
INTERDISCIPLINARY
SPACES



TOOLS AND EQUIPMENT

BOTTLING, MEASURING, WEIGHING

CUTTING AND GRINDING

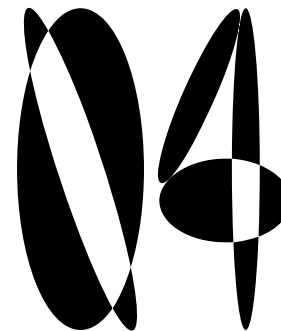
SEPARATION

HEATING UP

CULTIVATION

OPTICAL ANALYSIS

STORAGE



REGULATIONS AND SAFETY

PERSONAL PROTECTIVE EQUIPMENT

HAZARDOUS SUBSTANCES

LABORATORY RULES

SKIN PROTECTION

SAFETY EQUIPMENT



GLOSSARY

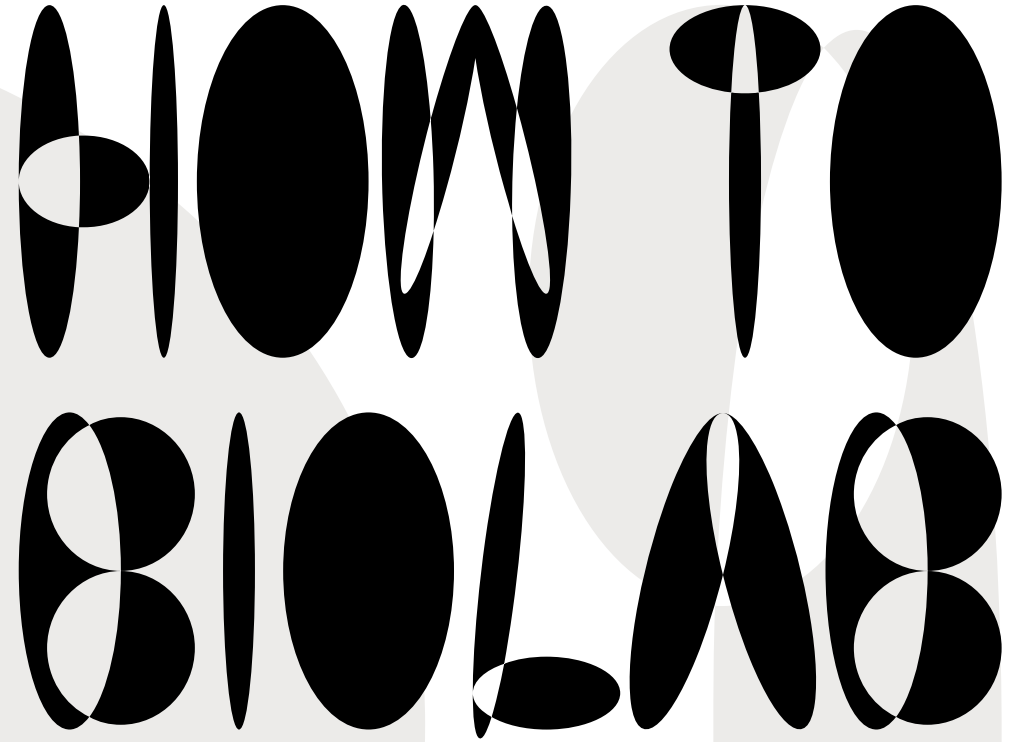


SBYD.SPACE explores new climate-neutral and resource-light ways of living and production. It transfers knowledge from sustainability research into society and the economy through design. The capability of design in making theories and abstract concepts tangible – and transferring them into everyday life – is used to explore, discuss, and test these theories and ideas in practice.

SBYD.SPACE engages with diverse audiences and collaborators through a range of formats, including workshops, international symposia, exhibitions, an artist / designer in residence programme, and support for entrepreneurial endeavours. It is located at Folkwang University of the Arts' North Campus at the UNESCO World Heritage Site Zollverein, a former coal mine in Germany's Ruhr region – a location that could not be more symbolic of the transformation of industries, ways of life, and entire regions.



SBYD.SPACE creates SPACES of possibility for exploring sustainable alternatives. Each SPACE is composed of a different set of interdisciplinary team members – akin to a working group. In different and continuously evolving SPACES, such as the SPACE FOR REPAIR, the SPACE FOR TEXTILES, and the SPACE FOR BIOMATERIALS, room is created for projects that pursue a circular, resource-light, and regenerative design approach. The SPACES form a thematic and conceptual structure within SBYD, around which activities such as interdisciplinary workshops, design projects, and exhibitions are clustered. Each SPACE approaches sustainability with a slightly different perspective, definition, and way of working, creating a multiperspective approach within SBYD that makes different possibilities for sustainable living and production visible and tangible.



How to Biolab is a practice-oriented guide to working with biological processes, biomaterials, and food in an interdisciplinary biolab within a design context. This zine is intended for anyone interested in working in a biolab and seeking either an introduction to or a deeper engagement with the experimental development of projects at the intersection of design and biology.

The guide provides foundational knowledge, offers orientation for getting started, and demonstrates how equipment and tools can be used to develop your own projects. Design is understood not only as a form-giving practice, but also as an attitude and a methodological approach through which complex relationships and questions can be explored, made visible, and experienced through interdisciplinary exchange.

The zine aims to encourage readers to use the biolab as an open space in which knowledge is shared, processes are tested, and new design approaches can be developed.

BIOLABS AS INTERDISCIPLINARY SPACES

Biolabs are interdisciplinary spaces for work, teaching, and research where design methods meet biological materials and processes. They can be found at art and design universities, in makerspaces, or in fablabs, and their equipment can vary depending on their specific focus. Biolabs combine theoretical inquiry with practical experimentation: design is understood not only as a form-giving practice but also as a reflective process through which ecological, social, and technological questions can be explored and made tangible. Scientific and analytical methods are complemented by open-ended and experimental approaches.

This is evident, for example, in the exploration of and work with living or biological materials such as mycelium structures, plant pigments, and bio-based polymers. This involves not only investigating growth processes and material properties but also deliberately incorporating them into design decisions, particularly in relation to questions concerning regenerative materials and dyes. Food and related processes such as fermentation, cultivation, and preservation also play a role, for example in exploring more sustainable food systems, production methods, and supply chains. Because biological processes can only be controlled to a limited extent, work in a biolab is often process-oriented. Observing, documenting, reflecting, and adapting are just as important as maintaining hygiene and safety standards and handling biological waste responsibly. Unexpected results can lead to new insights and design approaches. Biolabs thrive on collaboration between different disciplines. Through exchange between design, the natural sciences, technology, and craft, different forms of knowledge can be brought together and new ways of working can be developed. In this context, sharing knowledge is just as important as recognising the limits of one's own expertise.

Today's biolabs have emerged from a range of developments in design, science, and society. Since the 1960s and 1970s, debates surrounding environmental pollution, resource consumption, and industrial modes of production have contributed to a stronger focus on ecological cycles and social responsibility in art and design. From the 1990s onwards, bioart, biotechnology, and DIY biology increasingly shaped engagement with living systems and bio-based materials. In the 2000s, these approaches became more firmly embedded within institutions, and the first biolabs with a focus on art and design were established at universities – for example, SymbioticA, founded at the University of Western Australia in Perth in 2000, and metaPhorest, established at Waseda University in Tokyo in 2007. In the 2010s, biodesign, biomaterial development, and food design gained importance in research and teaching. As a result, the biolab evolved from a specialised experimental space into an infrastructure that is now firmly established at a growing number of universities and open-access

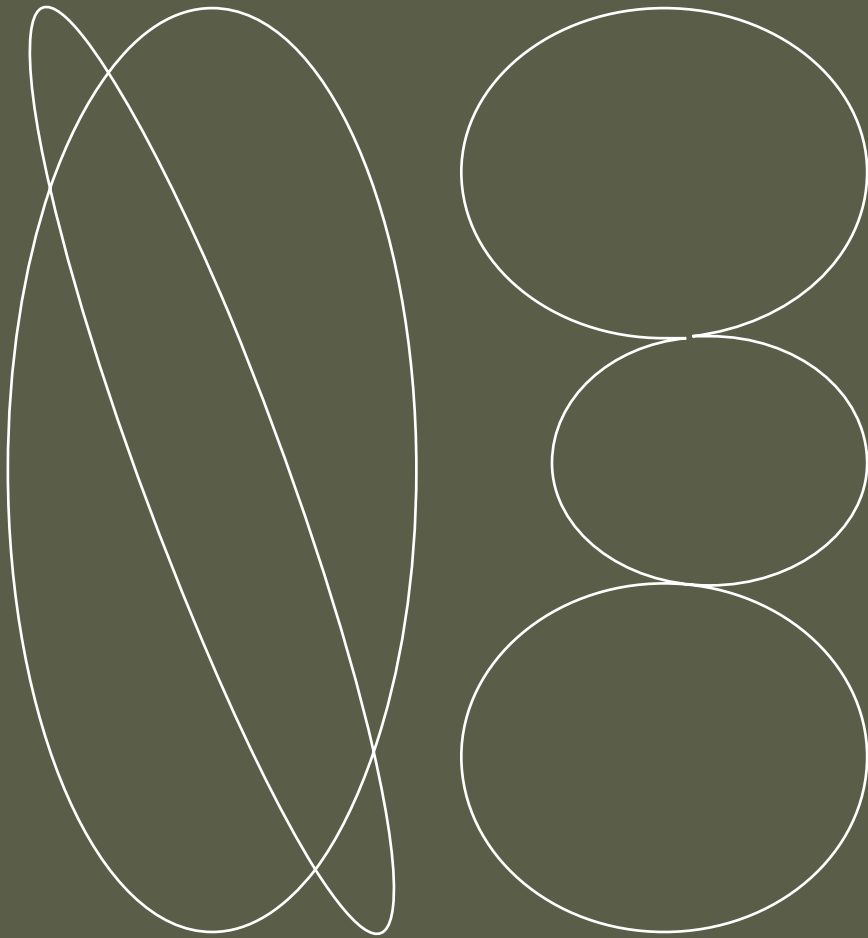
workshops. Alongside practical work, ethical and societal questions concerning biotechnology are also addressed in biolabs. When living organisms are cultivated, modified, or used in the production of materials and food, questions arise concerning responsibility, control, ownership, accessibility, and potential consequences for humans and the environment. Design can help make these often abstract issues visible and open to discussion through experiments, prototypes, and scenarios. Critical reflection on risks, the limits of knowledge, and the consequences of design decisions is therefore just as integral to working in a biolab as practical experimentation.

There is no standard model for a biolab. While some have a technical-analytical focus rooted in the natural sciences, others see themselves as accessible spaces for experimentation and learning, using basic technical equipment and DIY methods. Hybrid forms combine both approaches¹. What matters is less the classification as a particular type of laboratory than the question of which forms of working, learning, and collaboration are made possible.



¹ Ihls, J. and Pollini, B. (2025) 'From observation to operation: The role of lab spaces in biodesign practice', *Biotechnology Design*, 4, e2, pp. 1–12. Available at: <https://doi.org/10.1017/S2977905725100012>.

The transition towards resource conservation and climate neutrality is one of the central challenges of our time. Biolabs can contribute to the experimental development and investigation of alternative materials, foods, and modes of production. Their potential lies not only in developing possible new solutions but also in making relationships, dependencies, and questions visible and open to discussion.



TOOLS AND EQUIPMENT

BOTTLING MEASURING WEIGHING



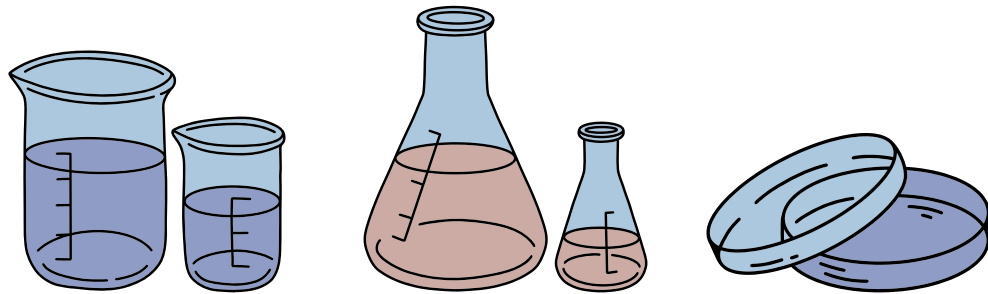
BOTTLING, MEASURING, WEIGHING

Accurate measurement plays a particularly important role in the development of new formulations and recipes.

It is also important that the results obtained are reproducible.

For this reason, the Biolab is equipped with a range of instruments for weighing, measuring, and pipetting.

LABORATORY GLASSWARE AND UTENSILS

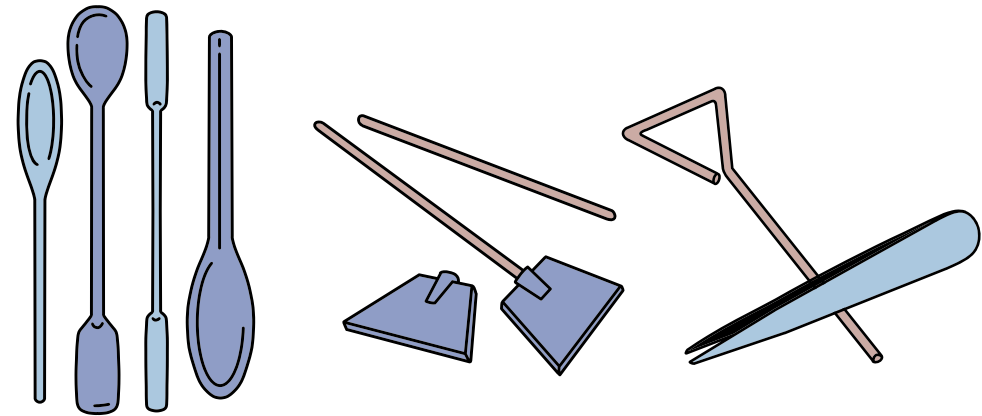


Laboratory glassware is part of the basic equipment in any laboratory. Most glass vessels are made from soda-lime or borosilicate glass, which is resistant to chemicals and high temperatures and well suited to measuring, mixing, and heating liquids.

A beaker is a cylindrical glass vessel with a spout. Beakers come in various volumes and are categorised as low form or tall form. Beakers are usually graduated, meaning they have an external scale. However, these scales are only a rough guide and are not suitable for precise volume measurements.

An Erlenmeyer flask is a conical glass vessel with a wide base and a narrow neck. In addition to variations in volume, a distinction is made between narrow-neck and wide-neck Erlenmeyer flasks with different diameters. Like beakers, Erlenmeyer flasks are typically graduated. Erlenmeyer flasks are particularly well suited to mixing or heating liquids, as their conical shape makes them particularly easy to swirl.

Petri dishes are round, flat dishes with a matching, overhanging lid. Their most common use is the cultivation of microorganisms such as bacteria on various culture media, for example agar gels. The use of transparent dishes is advantageous in that the growth of the cultures being observed can thus be clearly viewed from all sides.



Laboratory utensils such as spoons, tweezers, and spatulas are suitable for portioning solids. Spatulas are spoon-like, elongated tools that come in various shapes and can be made from different materials. Traditionally, most spoons and microspatulas are made of stainless steel.

Glass rods are ideal for stirring various solutions in the laboratory, particularly corrosive solutions, as they are generally more chemically resistant than metal spatulas and rods. When heating, the use of glass rods can prevent delayed boiling*, as the gas bubbles formed are directed along the rod and can thus escape. Attachable silicone wiper heads extend the range of functions of glass rods, enabling viscous liquids to be transferred with as little residue as possible. Specially shaped glass rods, such as Drigalski spatulas, are used for plating cell cultures onto agar plates. Thanks to their curved shape, these glide particularly well over soft agar plates.

* A BOILING DELAY REFERS TO THE PHENOMENON WHEREBY SOME LIQUIDS CAN BE HEATED BEYOND THEIR ACTUAL BOILING POINT. THIS IS PARTICULARLY OBSERVABLE IN VESSELS WITH SMOOTH INNER WALLS. INSTEAD OF A CONTINUOUS BOILING PROCESS, THE FORMATION OF GAS BUBBLES CEASES AND A LARGE GAS BUBBLE FORMS ABRUPTLY, WHICH ESCAPES SPONTANEOUSLY, CARRYING HOT LIQUID WITH IT.



GRADUATED CYLINDERS & PIPETTES

Liquids can be measured accurately using pipettes or measuring vessels fitted with a suitable scale. Measuring cylinders are narrow, cylindrical glass vessels with a detailed scale for measuring volume. In contrast to the relatively coarse graduations on beakers and Erlenmeyer flasks, volumes can be measured with an accuracy of ± 0.5 per cent to ± 1 per cent of the nominal volume, depending on the model. It is crucial to follow the rules for taking readings. As a general rule, human error should be kept to a minimum by ensuring that the same person uses the same viewing angle for all measurements within a single experiment. The correct volume is read at the so-called meniscus, the curve formed by the liquid. For concave liquids such as water, the volume is read at the lowest point of this curve, at eye level and parallel to it.

Pipettes are generally used for dispensing smaller quantities of liquids. These are available in various technical designs, each intended for specific volumes. What they have in common is that liquid is drawn in a controlled manner into a reservoir, usually tubular in shape, by means of a vacuum created by negative pressure. The quantity of liquid drawn up can thus be determined precisely.

Traditional glass pipettes are glass tubes that taper at the end and can draw up liquids with the aid of pipetting aids such as suction balls or so-called Peleus balls.

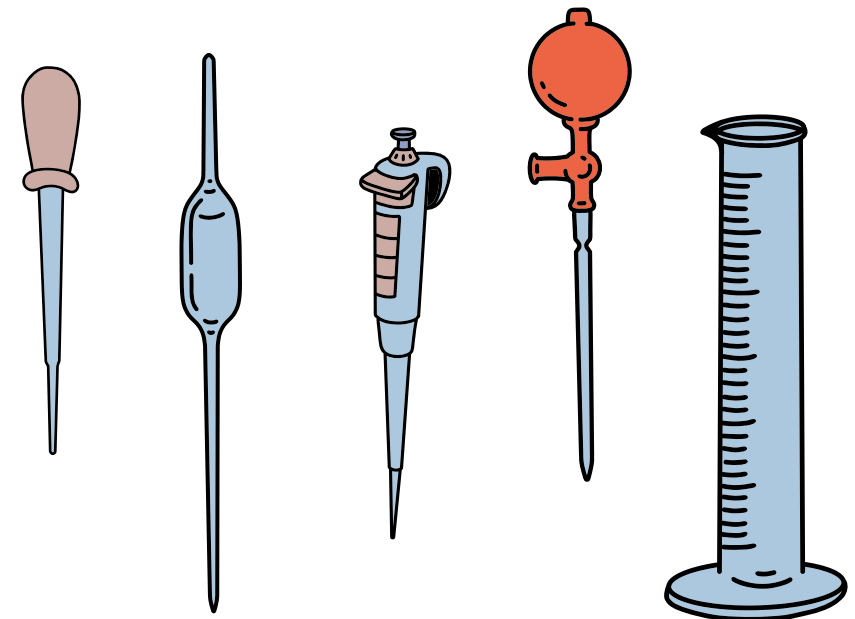
In addition to the widely used disposable plastic pipettes, there are small glass pipettes made of soda-lime glass, known as Pasteur pipettes. These have an approximate pipetting volume of 2 mL and are well suited to drop-by-drop dispensing that does not require particular accuracy. Glass pipettes with a printed scale are known as measuring pipettes. They are usually used when variable but precise volumes in the millilitre range are required, for example when preparing solutions or dilutions. If a calibration mark is marked on the pipette, it is a volumetric pipette. These are precisely calibrated to the specified volume and are suitable for work where a precisely defined volume is required. Graduated measuring pipettes are less accurate than volumetric pipettes.

Pipetting aids* can be used to create a vacuum, thereby drawing the solution to be pipetted into the pipette and subsequently dispensing it by applying pressure to the pipetting aid. The desired volume is read at eye level from the lower meniscus of the scale.

Micropipettes, such as those frequently used in molecular biology, are technically more complex. Micro-pipettes operate on the principle of displacement and are designed for very small volumes in the microlitre range. Depending on the model, the liquid is drawn up and dispensed via a pressure point at the upper end of the micropipette. The pipette tip is ejected either via a second pressure point or a separate ejection button. Whether using pipetting aids such as a Peleus ball or micropipettes, care must be taken to ensure that no drawn-up liquid is drawn into the pipetting aid.

In addition to single-channel micropipettes, multi-channel pipettes and multi-dispensers are also used in micro- and molecular biology laboratories. The use of special disposable tips enables particularly clean and, where required, sterile working conditions.

* A PIPETTING AID IS A DEVICE THAT ENABLES THE CONTROLLED ASPIRATION AND DISPENSING OF LIQUIDS USING A PIPETTE. ITS PRIMARY PURPOSE IS TO ENSURE SAFE HANDLING AND TO PREVENT LIQUIDS FROM BEING DRAWN UP DIRECTLY INTO THE MOUTH. WHILST THIS WAS HISTORICALLY COMMON PRACTICE, IT IS NO LONGER PERMITTED TODAY. AN EXAMPLE OF A PIPETTING AID FREQUENTLY USED IN THE LABORATORY IS A PIPETTING BALL.

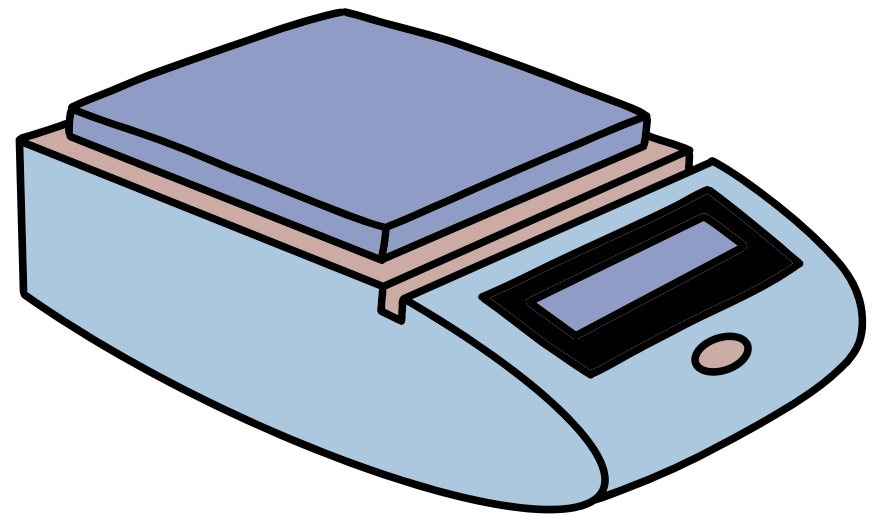


LABORATORY SCALES

The best way to measure solids is using a scale. A scale determines the mass of an object by measuring the force of gravity acting on it. This can be used to determine the weight of a substance and to measure the desired quantity.

Scales come in various designs. A distinction is made between mechanical and digital scales. Mechanical scales include spring scales and beam scales, which determine weight by measuring the deformation of a spring or by comparing masses. Nowadays, many scales operate electronically, utilising the principle of electromagnetic force compensation or the measurement of deformation. To avoid errors, it is necessary to be aware of and take into account the specific characteristics of each model.

When using a scale, it is important to ensure that it is correctly calibrated and levelled. Calibration involves checking and, if necessary, adjusting the scale to ensure that its measurements are accurate. Many laboratory scales are fitted with a bull's-eye spirit level, which indicates whether the scale is level. As with a conventional spirit level, the small air bubble should be centred by adjusting the height of the scale's levelling feet. Subsequently, the scale's correct functioning must be checked using test weights. This process must be carried out whenever there is a change in environmental conditions, which is why a scale should not be moved after it has been levelled. The rule is: the smaller the weight, the greater the impact of errors! Special precision scales are therefore often placed on dedicated weighing tables, which shield the scale from floor vibrations caused by footsteps or other movements in the room. Furthermore, the model-specific maximum load specified should not be exceeded to protect the scale.



THERMOMETER



A thermometer is used to measure temperature. This is a physical quantity that indicates how warm or cold an object or the surrounding air is. Temperature plays a crucial role in the laboratory. A low temperature can influence growth processes during cooling, whilst heating can trigger reactions. Many processes and reactions have an ideal temperature range, which can, for example, suppress unwanted competing reactions.

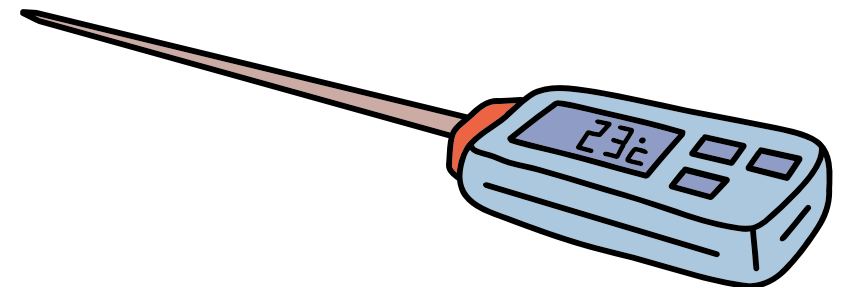
Temperature describes the current thermal state of a system. The faster the particles move, the higher the temperature. Heat is a form of energy that can be present in varying amounts in any body. When two bodies come into contact, a flow of heat occurs if there is a temperature difference. The direction of this heat flow is determined by the temperature, as heat always flows towards the colder body. The SI units of temperature are degrees Celsius ($^{\circ}\text{C}$) and Kelvin (K). Kelvin is based on absolute zero, at which point there is no longer any particle motion. This absolute zero is 0 K, which corresponds to -273.15°C . At this point, there is no longer any molecular motion and the energy of a system assumes the smallest possible value. The Celsius scale is based on the phase transition of water such as the change from one state of matter (solid) to another (liquid). The zero point of the Celsius scale, at 0°C , corresponds to the melting point of water at standard atmospheric pressure.

In the laboratory, temperature can be measured in various ways. Room thermometers indicate the ambient conditions, as even when storing microorganisms at room temperature, for example, there can be a significant difference depending on whether the temperature is 20°C or 25°C .

Glass thermometers are classic expansion thermometers and are suitable for monitoring solutions. They are immersed in the solution and, when heated, the liquid contained in the thermometer expands accordingly, allowing the temperature to be read off the scale.

A pyrometer enables non-contact temperature measurement by detecting electromagnetic thermal radiation, which is usually in the infrared range.

More specialised thermometers include, for example, penetration thermometers, which are made of heat-resistant materials and enable the core temperature inside a furnace to be monitored.





JAPANESE KNOTWEED LEAF COMPOSITE JACQUELINE LOBODDA

INGREDIENTS

7.5 g leaves – coarsely chopped
7.5 g leaves – chopped into medium pieces
6 g agar agar
120 ml water
2 ml glycerin

TOOLS

pot
stove
thermometer
mixing spoon
mould
oven or dehydrator

INSTRUCTIONS:

1. Stir agar agar and glycerin into a pot with water and heat until it begins to bubble gently. Measure the temperature while stirring continuously. Agar gels at about 90 °C.
 2. Remove the pot from the stove and stir in the solid material. Mix quickly so the solid material is well coated with the agar gel. If the mixture cools too quickly, reheat it on the stove.
 3. Press the mixture into a mould and leave it under pressure for at least one hour. Then let it continue to dry in the mould until the surface feels dry.
 4. Remove from the mould and dehydrate in the oven or dehydrator at 30–50 °C. It dries very slowly in the air.
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MEASURING THE PH VALUE

The pH value describes the nature of a solution, specifically how acidic or basic it is. This plays an important role in many reactions and experiments. In chemical terms, the pH value is the negative decimal logarithm of the activity of the hydrogen ions contained in a solution. Activity is a thermodynamic quantity which, for example in physical chemistry, is used in place of molar concentration to describe the properties of solutions more precisely.

Derived from the autoprotolysis of water, the ionic product can be determined, which serves as the basis for the pH scale. The pH scale ranges from 0 to 14 and classifies dilute, aqueous solutions as acidic ($\text{pH} < 7$), basic ($\text{pH} > 7$), and neutral ($\text{pH} = 7$). For example, fermented foods have an acetic acid environment with a pH of around 4, whilst many grease-dissolving detergents have a basic pH.

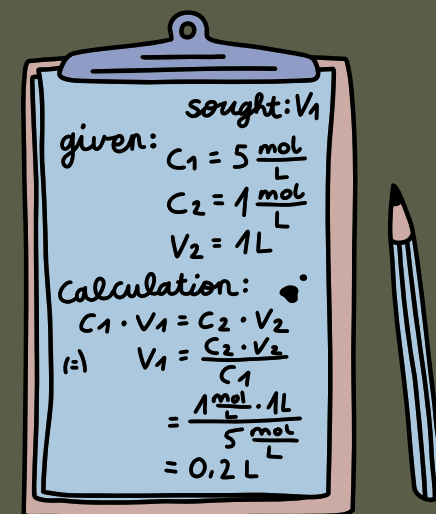
The pH value can be measured, for example, using an indicator strip. To do this, a drop of the solution to be tested is placed on the indicator strip and the result is read using the colour scale provided. Another option is to use pH indicators, whereby the pH value can be determined from the colour of the solution by adding a few drops of a pH-sensitive dye. When choosing an indicator, it is important to consider which pH range is to be examined. Universal indicators such as bromothymol blue are particularly popular for general observation of pH values. Bromothymol blue appears yellow in acidic solutions and blue in alkaline ones. The end point can be identified by a green colour change and occurs at a pH of 7. Due to the cyanidin it contains, red cabbage juice can function as an indicator. The colour, which is rather reddish in acidic conditions and bluish in alkaline conditions, is also reflected in the local names 'red cabbage' and 'blue cabbage', which stem from the different soil conditions and methods of preparation.



A pH meter enables a precise measurement of the pH value. A pH meter, also known as a pH single-electrode probe, consists of a measuring electrode and an associated readout unit. The measuring electrode reacts to the concentration of hydrogen ions in the solution and transmits an electrical signal, which is converted into the corresponding pH value and displayed. As the pH value is temperature-dependent, this is usually specified as well.

The electrode must be cleaned with distilled water after use. The electrode is stored in a 3 M potassium chloride solution to prevent it from drying out and to avoid ageing.

LABORATORY CALCULATIONS



When developing new formulations, the ratios of the various components play a central role. In the Biolab, many culture media or solutions – such as those used to prepare agar plates – are prepared in liquid form. For this reason the concentration of a solute is particularly crucial. This describes the amount of a solute per specified volume of the solution. Care must be taken to note the relevant unit.

In addition to percentages, molar concentration is usually used in the laboratory. This describes the amount of solute per unit volume of the solution and is typically expressed in mol/L. A mole is the corresponding SI unit and is defined as the amount of substance consisting of the same number of particles as are contained in 12 g of the carbon isotope ^{12}C . This reference value was determined experimentally and is described by Avogadro's constant N_A . A mole is therefore the amount of substance consisting of $N_A = 6.02214076 \times 10^{23}$ particles.

The required sample weights can be calculated using the following equation:

The molar mass M of a substance is determined from its stoichiometric* molecular formula. Molecules and compounds are fundamentally described by their chemical formula. A molecular formula specifies how many atoms of each element are present in the molecule. To calculate this, the relative atomic masses A_r – which are listed in tables – are added together.

* STOICHIOMETRY IS A MATHEMATICAL TOOL USED IN CHEMISTRY. IT IS USED TO CALCULATE THE RATIOS OF REACTANTS AND PRODUCTS IN CHEMICAL REACTIONS. THE STOICHIOMETRIC MOLECULAR FORMULA DESCRIBES THE EXACT NUMBER AND RATIO OF ATOMS OF DIFFERENT ELEMENTS THAT MAKE UP A MOLECULE.

For water (H_2O), for example, this gives:

$$M(\text{H}_2\text{O}) = 2 \cdot A_r(\text{H}) + 1 \cdot A_r(\text{O}) = 2 \cdot 1.008 \text{ g/mol} + 1 \cdot 15.999 \text{ g/mol} = 18.015 \text{ g/mol}$$

The mass m of the respective substance required for weighing is given in grams and can be calculated by rearranging the equation:

$$\text{Amount of substance (n)} = \text{mass (m)} / \text{molar mass (M)}$$

For solutions, the molar concentration c is given by:

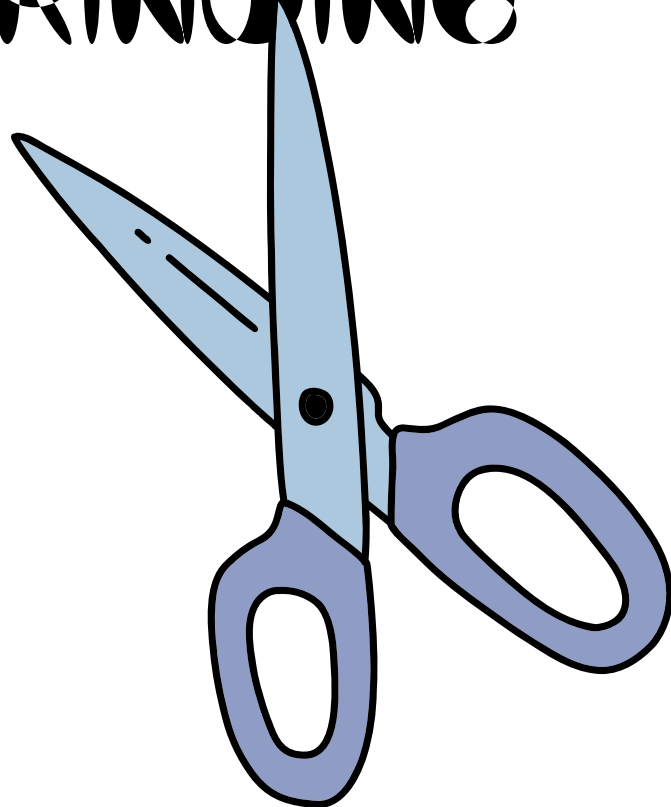
$$\text{Molecular concentration (c)} = \text{amount of substance (n)} / \text{volume (V)}$$

When a solution is diluted, only the corresponding volume changes while the amount of substance n remains the same. The concentration of such a dilution can therefore be determined using the following equation:

$$n_1 = n_2 \Leftrightarrow c_1 \cdot V_1 = c_2 \cdot V_2 \Leftrightarrow c_2 = (c_1 \cdot V_1) / V_2$$

Virtually all reactions are determined by limiting reactants and the stoichiometry of the reaction. Particularly in larger projects, and also for safety reasons, it is advisable to pay close attention to the details here, as this can, for example, help to avoid using excess reagents for the actual reaction or formulation.

CUTTING AND GRINDING



CUTTING AND GRINDING

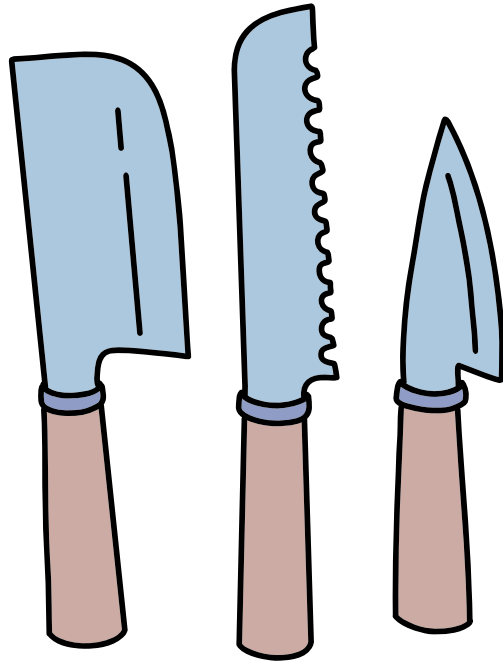
In material and formulation development, but also in the general processing of coarser raw materials, it is often necessary to grind them down at the outset.

This allows mixtures and materials to be produced with the most homogeneous particle size distribution possible.

Grinding also creates a larger surface area, which can be beneficial for certain chemical reactions and physical processes.

The following section presents a number of tools and devices for comminution.

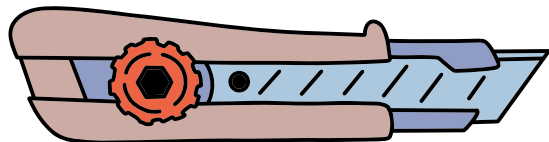
KNIVES & BLADES



Knives and blade-like tools are suitable for the manual comminution of materials. When handling cutting tools, correct usage is essential to avoid cuts and damage to the material. Knives and blades generally encompass a wide range of cutting tools, from kitchen knives, scissors, and utility cutters right through to laboratory scalpels. The choice of the appropriate tool depends on the nature, hardness, and size of the source material, as well as the desired precision of the cut.

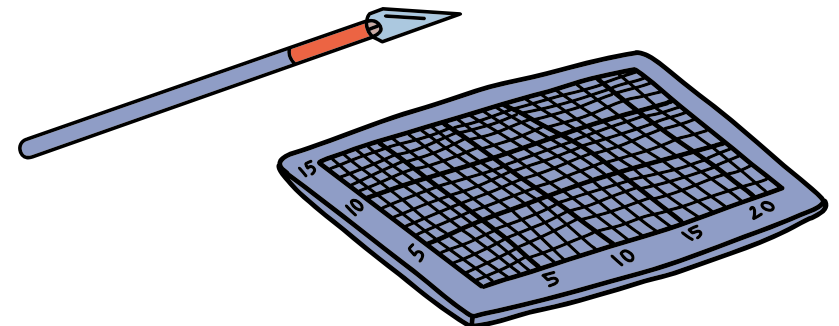
Scalpels are small, exceptionally sharp blades which are suitable, for example, for the precise separation of plant materials. Their exceptionally delicate cuts allow for the preparation of microscope slides or the performance of precise extraction work.

Utility cutters are sturdy, elongated blade tools with a retractable blade. They are suitable for all manner of rough cuts, such as opening packaging or shredding solid materials.

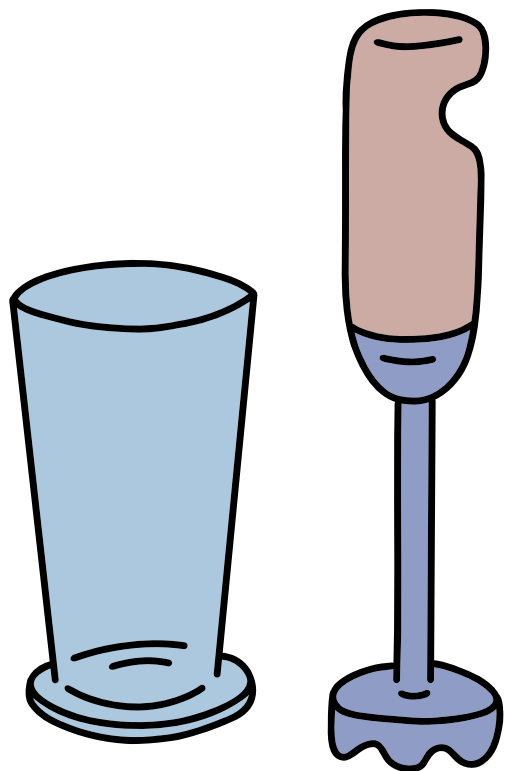


As a general rule: Blades should always be directed away from the body to minimise the risk of injury. Where necessary, cut-resistant gloves should be worn and cut- and slip-resistant work surfaces used. Suitable work surfaces include, for example, cutting mats or plastic and wooden boards.

Sharp tools should be cleaned and dried immediately after use to prevent corrosion. Dull blades should be resharpened or replaced as appropriate. They must be stored in secure containers to prevent cuts when handling them. When disposing of them, blades and sharp cutting tools should also be collected separately to prevent cuts.

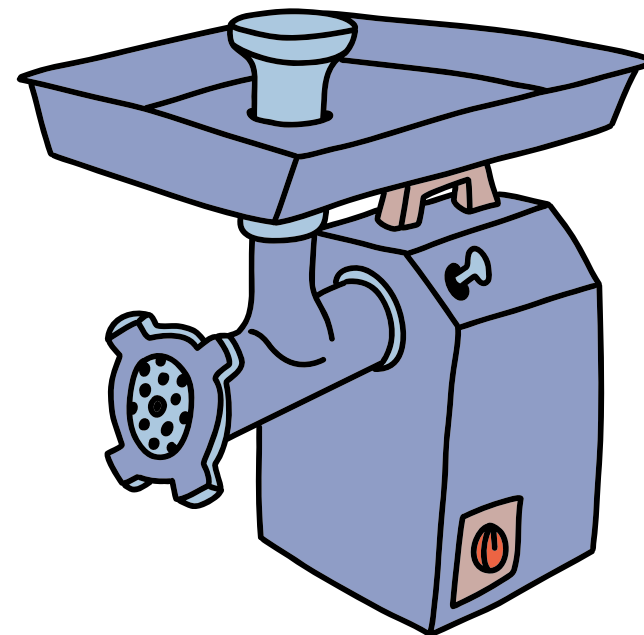


BLENDER



Mechanical grinding and mixing of materials can be achieved efficiently using a blender or a hand blender. The desired consistency of the material or the fineness of the particle size can be adjusted by varying the duration and rotational speed. Care must be taken not to place too much material into the appliance at once, as overloading can lead to the motor and the materials overheating. Delicate materials should therefore only be processed in batches and, where necessary, with cooling intervals. If too little material is used, there is a risk that the sample will be ground and mixed unevenly or inadequately. For this reason, the minimum fill level should not be undercut.

GRINDER



A rotary grinder enables soft ingredients or materials, such as soft-cooked vegetables or plant parts, to be chopped and simultaneously mixed into a firm paste. To do this, the prepared, coarsely chopped ingredients are fed into the appliance via the feed hopper. A screw conveyor, operating on the principle of Archimedes' screw, feeds the bulk material towards a rotating blade disc. In combination with various attachments and accessories, such as special piping or filling nozzles, the resulting mixture can be shaped directly.



BANANAPEEL PAULINA HEIDLBERGER

INGREDIENTS

80 ml cold water
80 g fresh banana peels
1 g acetic acid (vinegar essence)
2.5 g glycerol
1.5 g cornstarch

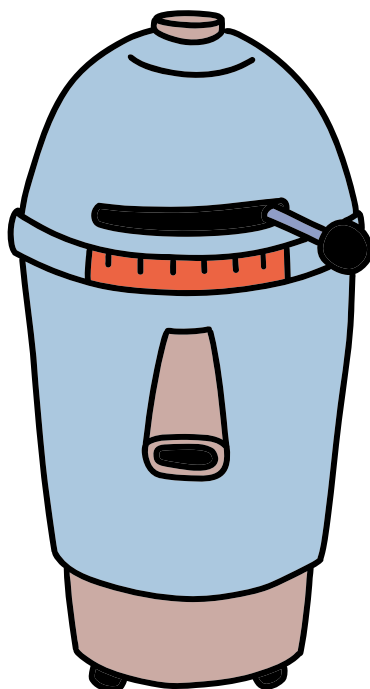
TOOLS

knife and cutting board
scale
bowl
measuring cup
blender
microwave
spoon
old cloth
baking paper
rolling pin

INSTRUCTIONS

1. Cut fresh banana peels into small pieces and weigh them.
 2. Put the cut banana peels and cold water into the blender, and puree thoroughly until a smooth mixture forms.
 3. Weigh the acetic acid, glycerin, and cornstarch using the scale and mix them in a bowl. (Adding more glycerin will make the final product softer; less glycerin will make it harder but also more brittle.)
 4. Add the mixed ingredients to the pureed banana peel mixture and blend thoroughly again.
 5. Place the bowl with the mixture in the microwave and heat at 700 watts for about 2–3 minutes, stirring occasionally to ensure even heating.
 6. Remove the heated mixture from the microwave and let it cool slightly.
 7. Put the slightly cooled mixture onto an old cloth and squeeze out the excess water.
 8. Place the mixture between two pieces of baking paper and roll it out evenly with a rolling pin to the desired thickness.
 9. Carefully peel off the top layer of baking paper after half an hour.
 10. Let it dry openly for several days (approximately 1 week). Alternatively, the bioplastic can be dried in the oven at 60 °C for about 5 hours.
 11. Once the banana peel bioplastic is fully dried, it can be cut as desired.
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GRAIN MILL



In addition to tearing or cutting materials or using a mortar, you can use more complex appliances, such as an electric grain mill, to break down solid materials. This can be used not only to grind grains into flour, but also to grind many free-flowing raw materials such as dried leaves or herbs. The grinding process can turn coarse-grained raw materials into fine powders. This significantly increases the surface area of the material, which may alter its physicochemical properties. An electric grain mill enables convenient and controlled grinding, whereby rotating grinding tools reduce solid materials such as grains or other dry materials into granules or even fine powder. Depending on the settings and the chosen raw material, the grinding intensity and particle size can vary.

It may be advisable to dry the material beforehand, as high residual moisture can cause clumping and thus place an unnecessary strain on the mill. Care should also be taken to ensure a steady, slow feed of the material in order to achieve as uniform a grinding process as possible and to prevent overheating. Substrates with a high fat content, such as oilseeds, should be mixed with other grains beforehand to prevent the grinding mechanism from becoming clogged. The mill must be thoroughly cleaned after each use to prevent cross-contamination.

When working with rotating parts, the safety instructions provided by the equipment manufacturer must be followed. For this reason, the mill's safety devices should always be in the correct position to prevent interference with the grinding process.

The grinding process produces fine particles and dust which should not be inhaled. Depending on the raw material and the amount of dust produced, appropriate workplace and respiratory protection measures should be taken, such as suitable extraction or wearing a particulate respirator.



SEAWEED JULIUS SCHNETTGER

INGREDIENTS

125 ml water
25 g cornstarch
5 g seaweed powder

TOOLS

tea bag
blender
smooth surface, e.g., glass
stove
syringe
baking paper

INSTRUCTIONS

1. The production of algae-based bioplastic requires only cornstarch, water, and brown algae of your choice. In this example, the native German bladderwrack is used.
2. To produce a clear material, grind the seaweed into a powder using a blender. A mortar and pestle can be used to produce an even finer powder.
3. The prepared seaweed powder can now be boiled in a tea bag with 75 ml of water. Once the water takes on a brown-green hue, the tea bag can be removed.
4. Meanwhile, mix the remaining 50 ml of water with the cornstarch. Then, carefully pour the starch water into the hot seaweed water while stirring continuously. It is important that the water does not boil vigorously, as the mixture will become lumpy.
5. Heat and stir continuously until a thick, sticky mass forms. This can be extruded in a warm state using a simple tool such as a syringe or spread out between sheets of baking paper or on a smooth surface such as glass, to form a flat material.

This recipe can be modified to produce a material which includes visible pieces of algae. To do so, don't grind the seaweed into a powder, but grind it into small pieces with a size of 1–2 mm each. Then boil these algae granules with 75 ml of water, without using a tea bag, and leave the granules in the mixture. Then, continue with step 4.

SEPARATION

It is often necessary to separate mixtures from one another or to separate raw materials according to their particle size.

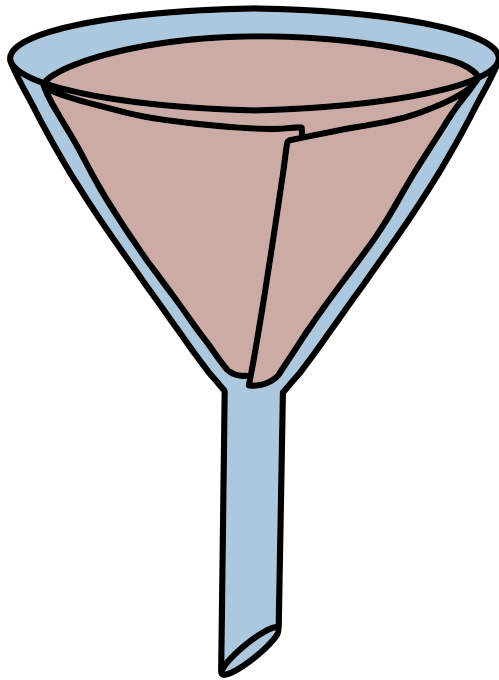
Pure substances are defined as elements or molecular compounds. Mixtures, on the other hand, consist of at least two different pure substances.

A general distinction is made between heterogeneous and homogeneous mixtures. Homogeneous mixtures, also known as solutions, are mixed at a molecular level, so that the individual components are no longer distinguishable from the outside. In this context, liquid, gaseous, and solid substances can all be dissolved in a solvent.

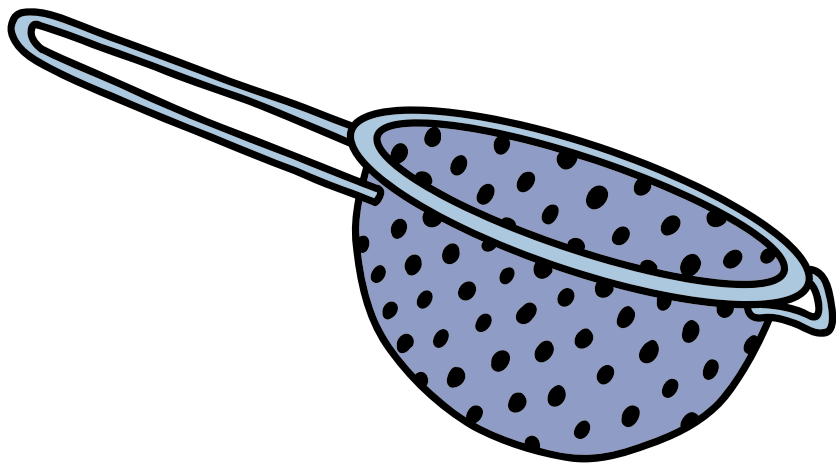
Heterogeneous mixtures, on the other hand, still contain components that can be separated from one another.

They are broadly categorised into aerosols, dispersions, and mixtures of solids. Aerosols describe mixtures of liquid or solid substances in a gaseous dispersion medium. Dispersed liquids, also known as dispersions, can be subdivided into emulsions, foams, and suspensions, depending on the physical state of the dispersed substance.

SEPARATION



FILTERS & SIEVES



Mixtures of substances can be separated in various ways. This process, also known as separation, makes use of the different physical properties of the substances in the respective mixtures. In mechanical separation processes such as sieving and filtering, the material is sorted according to particle size.

Sieving enables the separation of solid materials, known as bulk materials, according to their size. It is also possible to isolate individual grain sizes from a single raw material in this way. Particles whose grain size is larger than the mesh openings are retained in the sieve.

This mechanism can also be utilised when separating solid components from viscous liquids. These can be passed through muslin or straining cloths, thereby filtering out the solid components. With the aid of particularly fine straining sieves, a very fine consistency can be achieved. Hand-operated straining mills, in which the required pressure is applied via a crank, significantly reduce the mechanical force required.

In filtration, the aim is generally to remove as many particles as possible from a solution. The quality of filtration is determined by the pore size of the filter used. Furthermore, filters are also suitable for separating particles from the gaseous phase, for example for purifying air.





APPLE YIFEI SHI

INGREDIENTS

250 ml water
5 g citric acid
10 g tapioca starch
4 apple pieces

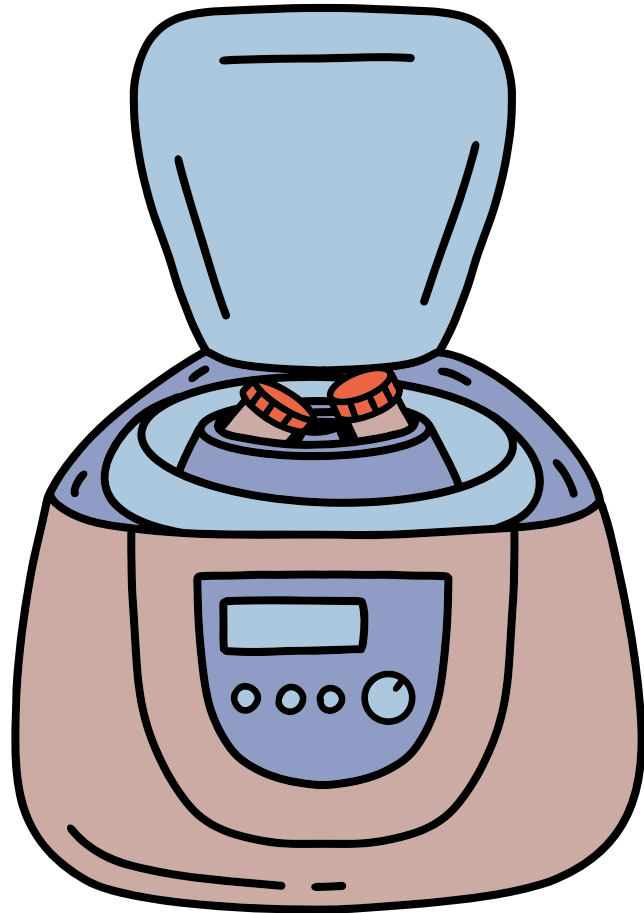
TOOLS

pot
measuring cup
scale
spoon for stirring
sieve
mould

INSTRUCTIONS

1. Put the apple slices in a pot with 250 ml of water and bring to a boil.
 2. Add citric acid and stir constantly.
 3. Once the apples have completely broken down, add the tapioca starch solution and continue stirring until the mixture is uniform.
 4. Then, strain through a sieve to obtain a clear liquid.
 5. Finally, pour a thin layer into a mould and wait for the material to dry at room temperature.
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CENTRIFUGE



Among other things, a centrifuge can be used to separate suspensions into their constituent parts, namely to separate solid particles or cells from liquids.

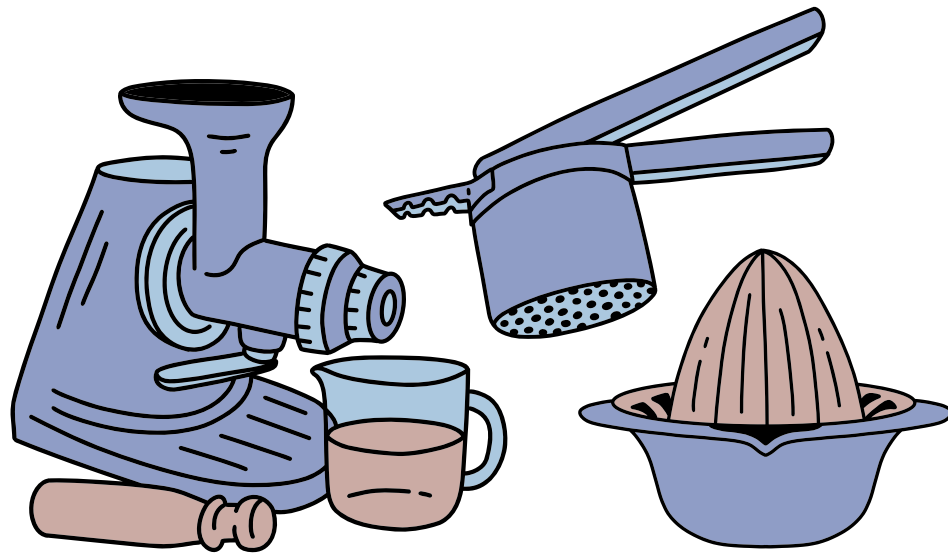
Centrifuges come in various sizes and designs, ranging from hand-operated centrifuges to ultracentrifuges, which can achieve rotational speeds of up to 150,000 revolutions per minute (rpm). Centrifuges essentially consist of a stationary part containing a motor and a moving part that can be set in rotation by the motor. A control unit allows the rotational speed and duration to be adjusted.

Sample tubes are placed in this moving rotor and spun at high speed around the rotor's central axis. When loading the centrifuge, the samples must be distributed evenly to prevent imbalance and the resulting damage to the equipment. In the case of particularly sensitive equipment, the samples must be weighed in advance and balanced* accordingly. The heavier components of the solutions are pushed outwards and thus towards the bottom of the tube by the centrifugal force acting upon them. The more precisely the rotor speed, loading, time, and temperature are controlled, the more efficiently and reproducibly substances can be separated from one another in the centrifuge.

* IN CENTRIFUGATION, BALANCING REFERS TO ENSURING THAT THE MASSES OF OPPOSING CENTRIFUGE TUBES ARE EQUAL. THIS ENSURES THAT THE CENTRIFUGE RUNS SMOOTHLY DURING OPERATION AND THAT NO IMBALANCE OCCURS.

The centrifugation time required for the desired size separation can be estimated using the Svedberg equation and the Stokes–Einstein relation. The relative centrifugal force is an important parameter for centrifuges, as are the rotor radius and the rotational speed in revolutions per minute (rpm).

JUICER



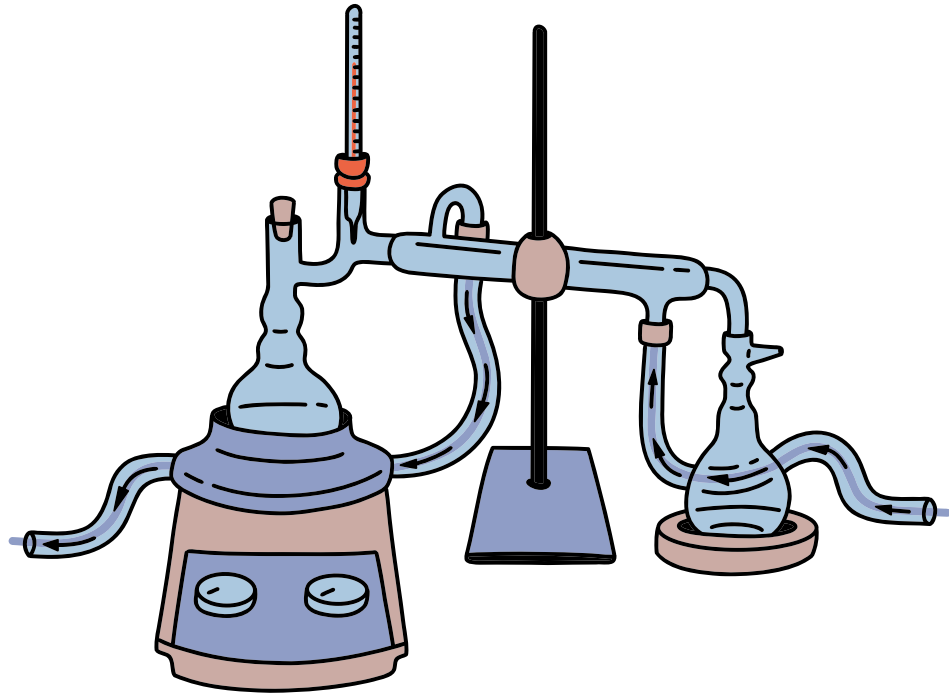
Juicers offer another method of separating solid and liquid components, such as plant matter. By pressing vegetables, leaves, or grasses, the contained liquids can be extracted and the remaining pulp reused. A basic distinction is made between different types of juicers. Traditional juicers, such as the manual citrus press, separate the juice from the plant material using mechanical pressure. A more efficient method of juicing involves technically sophisticated mechanical presses, in which counter-rotating screw or roller mechanisms squeeze the plant material. More specialised juicers, such as centrifugal juicers, grind the plant material using so-called friction discs and utilise the centrifugal force of the rotational movement to extract the juice. Steam-powered juicing is also possible.

OIL PRESS



The extraction of oils, for example from nuts or seeds, is a specialised application of pressing technology which, due to the hardness of the material being pressed, often requires greater mechanical force. Common oil presses are usually so-called screw presses, in which the material is forced through a cylindrical chamber by screw conveyors, allowing oil to flow out continuously. This oil can flow out through small holes in the cylinder and is then collected.

DISTILLATION



From a chemical point of view, pure water consists exclusively of water molecules. A water molecule consists of one oxygen atom and two hydrogen atoms bonded to it. Pure water is virtually non-existent in nature as ordinary tap water often contains many other constituents, such as dissolved salts. These have a decisive influence on the electrochemical properties of the water and, consequently, on the reproducibility of experiments, the corrosion resistance of equipment, and the quality of the solutions produced. For this reason, different grades of treated water are used, which must be selected specifically according to the intended application.

The composition of standard tap water and the resulting water hardness are subject to regional variations. Tap water contains dissolved minerals such as calcium and magnesium ions, as well as small amounts of organic compounds. Tap water is sufficient for many laboratory tasks, such as cleaning laboratory glassware or operating less sensitive equipment. However, it is unsuitable for analytical work or the preparation of specialised media such as buffer solutions* with defined, precise volumes, as the ions and impurities it contains could interfere with the experiments.

* A BUFFER SOLUTION IS A BIOCHEMICAL SYSTEM THAT LARGELY MAINTAINS THE PH OF A SOLUTION AS A MEASURE OF HOW ACIDIC OR BASIC IT IS, EVEN WHEN SMALL AMOUNTS OF ACID OR BASE ARE ADDED.

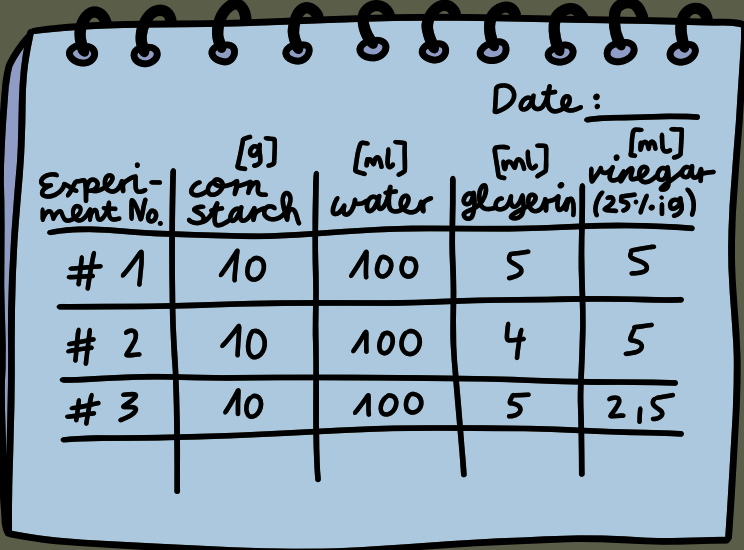
Tap water can be treated accordingly by means of distillation. In this process, the tap water is heated and the resulting water vapour is then condensed again. Dissolved substances such as salts or organic impurities remain in the original evaporation vessel, and the condensed distillate subsequently exhibits significantly lower conductivity and a lower particle content.

Fully demineralised water can be produced using ion exchange processes, in which dissolved ions are removed from the water. Unlike distillation, this process does not require high temperatures. Demineralised water has only very low conductivity and is largely free of dissolved salts. However, it may still contain organic substances or microorganisms. Further purification stages can be achieved using specialised membrane filters or sterilisation.

PLANNING AN EXPERIMENT

When testing new materials and formulations, a good and traceable documentation system is crucial, alongside an experimental approach. Particularly for projects spanning a longer period, all relevant information should be carefully recorded. A laboratory logbook is suitable for this purpose. This journal records experimental protocols, noting the date, a description of the experiment, all relevant weighings, and observations. As a rule of thumb, documentation should be carried out in such a way that the experiments can be repeated several months later based on the notes.

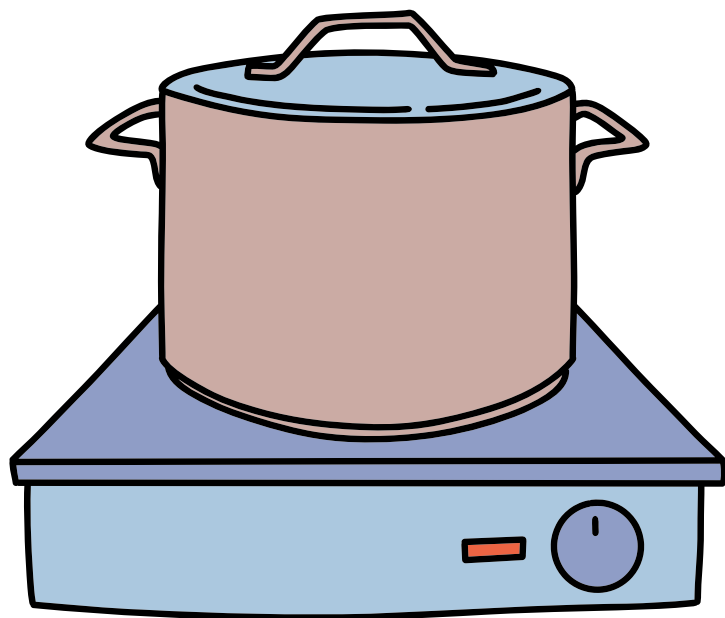
When testing new formulations, it can be helpful to use an experimental design matrix. To do this, the various variables are set out in a table and modified in separate experiments, so that only one variable is changed at a time. This structured approach enables better reproducibility.



Date: _____

Experiment No.	[g] corn starch	[ml] water	[ml] glycerin	[ml] vinegar (25% i.g)
# 1	10	100	5	5
# 2	10	100	4	5
# 3	10	100	5	2,5

HEATING UP



HEATING UP

When developing new materials and formulations, as well as during the general processing of raw materials, it is often necessary to adjust the temperature precisely.

Controlled temperature regulation can also influence chemical reactions and physical processes.

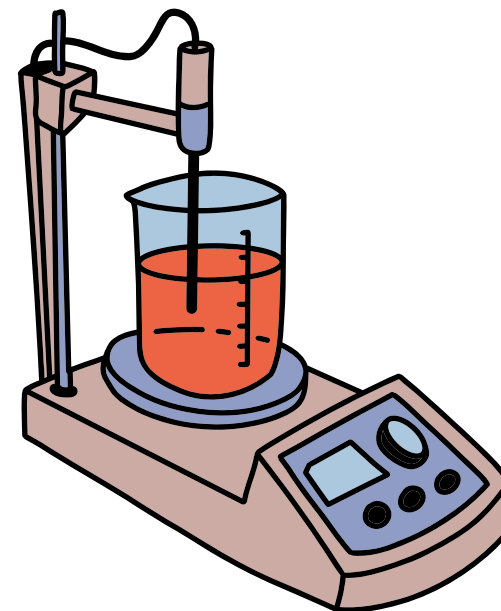
The following section outlines a number of methods for heating and temperature control.

HEATING & STIRRING EQUIPMENT



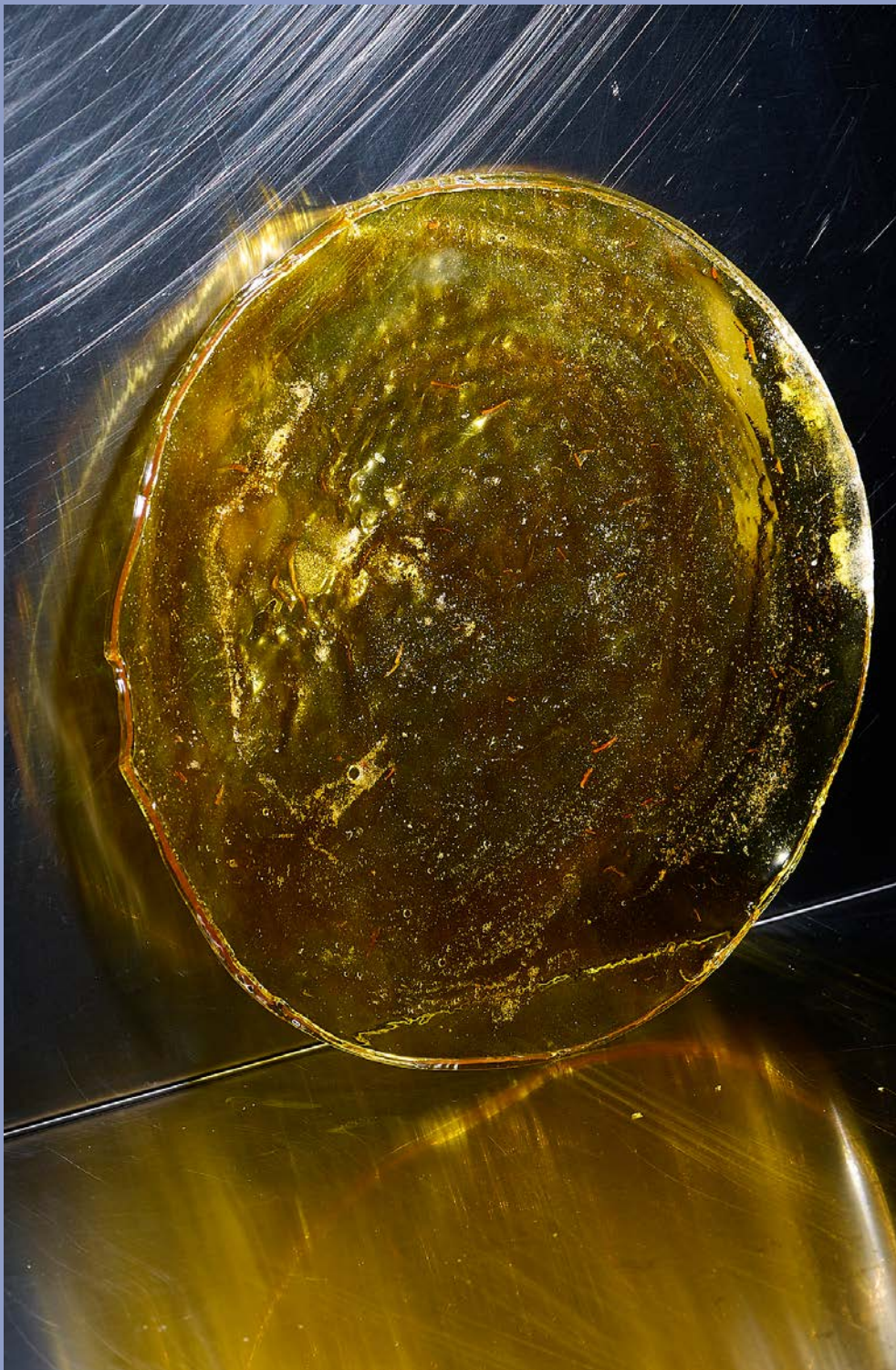
Many recipes and procedures require the application of heat, for example, briefly bringing a mixture to the boil to activate starch. In the laboratory, heat can be applied for instance by heating over a Bunsen burner. However, it is safer to use a hob with a glass vessel or saucepan. For larger quantities, combination appliances such as automatic preserving cookers are also suitable. These are essentially saucepans with an integrated heating function.

The controlled mixing and heating of liquids and solutions is an important step, as thorough mixing prevents local variations in concentration and dead zones. This is necessary for producing homogeneous solutions and for preventing delays in boiling or reactions. Dead zones refer to those areas within a reaction vessel that do not participate, or participate only minimally, in the mass flow. This might be the case when solids settle on the vessel wall and cannot be reached by a stirring rod. This can lead to uneven mixing and fluctuating residence times, which may affect mixing ratios, efficiency, and reaction safety.



A magnetic stirrer with temperature control enables this step to be carried out conveniently under defined and reproducible conditions. A stir bar located in the reaction vessel is driven by a rotating magnetic field. In combination with the integrated heating function and the temperature sensor, the reaction mixture can be heated to the desired temperature.

The selection of a suitable stir bar should be based on the size and viscosity of the reaction solution. The correct positioning of the reaction vessel is also crucial. Ideally, once the desired rotation speed has been set, the stir bar will move in a smooth, whirring motion within the centred and securely positioned vessel.



GELATINE

MARZIEH MOKHTARI BAGHKOMEH

INGREDIENTS

96 g gelatine powder
16 g glycerin
380 ml water
a large round coffee filter for absorbing foam
colour (optional)

TOOLS

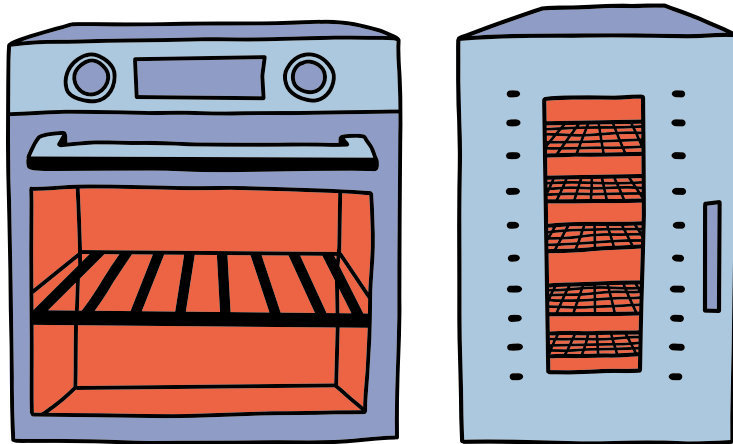
cooker, stove, or hot plate
measuring cup
cooking pot
scale
stirring spoon
mould
dehydrator or oven

INSTRUCTIONS

1. Weigh your ingredients.
2. Bring the water to a boil.
3. Add natural dye if you want to use colour.
4. Add the glycerin, then the gelatine.
5. Keep the temperature below 80 °C and stir very slowly and carefully to avoid bubble formation.
6. Let the mixture simmer for between twenty minutes and one hour at 60–80 °C, stirring slowly. Reduce the temperature if bubbles form. The liquid should remain still; it should not boil. A longer cooking time allows more water to evaporate and can drastically reduce the shrinkage of the cast object. You will get a thicker liquid. To cast larger volumes and solids with this recipe, evaporate a lot of water until the liquid is very thick.
7. If foam forms on the liquid and does not disappear, you can use a coffee filter to absorb it by covering the surface with it and then removing it.
8. Pour into the desired mould from the centre and keep the mould still to allow the liquid to spread by itself.
9. Dry in a dehydrator at 30 °C for eight hours. To achieve a flat surface, place a counterweight on it as the edges tend to curl during drying.

This material was developed to be visually similar to pine resin materials (colophonium), but without the allergenic potential and brittleness.

OVEN & DEHYDRATOR



In certain cases, it is useful to dry solid materials to remove any adhering or contained liquid. By removing the moisture, materials can be preserved for longer, making them easier to store and protecting them from corrosion and mould.

It is well known that liquids transition to a gaseous state above their boiling point. For example, water boils at 100 °C at standard atmospheric pressure. However, particularly in the case of water, this process also occurs at lower temperatures, such as room temperature. This process happens much more slowly and is called evaporation. Individual water molecules become gaseous at the interface with the surrounding air and pass into the air. The warmer the air and the larger the surface area, the faster evaporation takes place. A vigorous exchange of air, for example through ventilation with fresh air, removes moisture-laden air and further accelerates evaporation. The evaporation process can be accelerated even further by applying heat, for example in an oven. An oven usually has a thermally insulated interior, which can be heated by heating coils or combustible material.

A gentler method of drying food and other materials can be achieved using a food dehydrator. Similar to an oven, air is heated to a specific temperature. Continuous air circulation allows the water contained in the material to evaporate efficiently. Due to the low temperatures involved, this method is generally gentler than drying in an oven, as heat-sensitive ingredients are largely preserved. A food dehydrator is suitable, for example, for producing dried plant parts as well as for drying other delicate materials.

Compared with open drying methods, such as those using ambient air and room temperature, a food dehydrator allows for much more precise temperature control, which is usually within a range of 30 °C to 70 °C. Biologically active substances in particular, such as enzymes and many colouring or flavouring agents, are unstable above these temperature ranges, which is why they are not suitable for drying in an oven at higher temperatures.

The even air circulation also ensures that the material to be dried loses moisture as uniformly as possible, so that no localised pockets of moisture develop, which could encourage mould growth, particularly during protracted drying processes.

When using a dehydrator to dry materials, several factors must be taken into account. The initial size, layer thickness, and original moisture content of the material directly influence the required drying time. There must be sufficient space inside the dehydrator to allow for adequate air circulation. Regular monitoring of the drying progress is essential, as an excessively high residual moisture content can impair the material's shelf life. However, removing moisture beyond a certain level can also lead to a loss of structural integrity in the material being dried, causing it, for example, to warp or become brittle.



ALGAE ZEYNEP DELIOMEROGLU

INGREDIENTS

350 ml water
4 ml glycerol
16 g carrageenan kappa
0.5–2 g spirulina

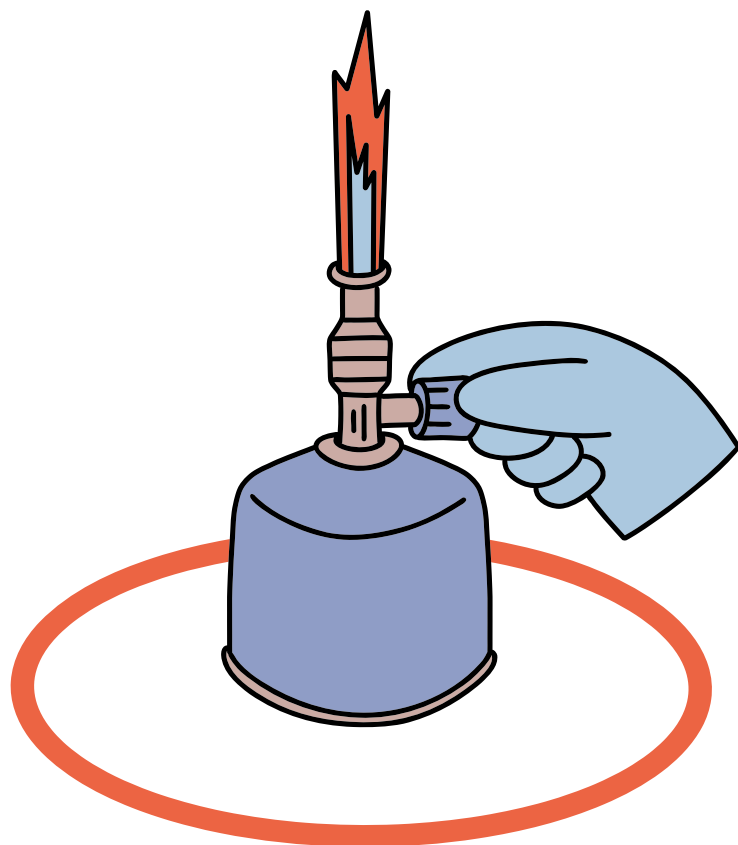
TOOLS

scale
syringe
measuring cup
cooking pot
whisk
stove
silicone mould
spatula
dehydrator or oven

INSTRUCTIONS

1. Measure the carrageenan and spirulina using a scale.
 2. Measure the glycerin with a syringe and the water with a measuring cup.
 3. Mix the water, carrageenan, and spirulina in a pot using a whisk.
The amount of spirulina can vary between 0.5 and 2 g, depending on the intended colour of the material.
 4. Bring to a boil over high heat, and after 1.5 minutes, add the glycerin.
 5. Boil for 2 minutes until the mixture is homogeneous.
 6. Pour the mixture into the silicone mould using a spatula and spread it evenly.
 7. Place the silicone mould containing the mixture in a dehydrator or oven (70 °C – about 5 hours – until dry).
 8. Moisten the dried material with water and smooth it out again.
The dried material can now be sewn and folded.
-

OPEN-FLAME OPERATIONS



A Bunsen burner is regarded as the standard tool for producing a stable, adjustable flame. It consists of a gas connection and a tube from which the flame emerges. A control valve allows the flame to be regulated by adjusting the ratio of gas to air supply. A high oxygen content produces a hot, blue flame, whilst a lower oxygen supply results in a cooler, yellow flame.

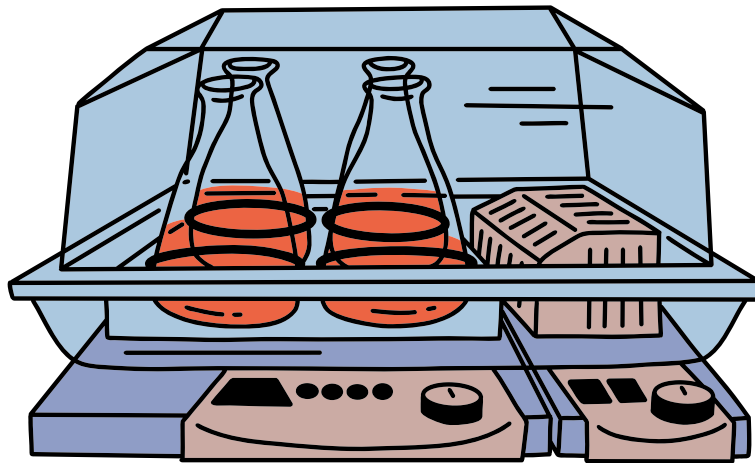
Before starting work, the Bunsen burner must be placed on a stable surface, the immediate vicinity cleared of flammable materials, and the location checked to ensure that suitable fire-fighting equipment is available. When working with an open flame, personal protective equipment must be worn. As a general rule, a flame-retardant cotton lab coat and safety goggles provide protection against splashes and flying sparks. Nitrile or latex gloves should not be worn in the vicinity of an open flame. When heating, open reaction vessels must be heated carefully whilst being gently swirled and must always be kept away from the body so that, in the event of delayed boiling, no hot liquid can splash onto people. After using the Bunsen burner, the gas supply must be shut off immediately. Once the work area has cooled down, it can be cleaned.

As well as providing a means of heating, working with a Bunsen burner also allows you to work in as sterile an environment as possible. The immediate area around the Bunsen burner is considered to be a largely sterile environment. This means that microbiological cultures can be streaked with minimal risk of contamination*, even without the use of large-scale equipment such as a microbiological safety cabinet.

* CONTAMINATION IS THE INTRODUCTION OF UNWANTED SUBSTANCES OR MICROORGANISMS INTO A SAMPLE, MATERIAL OR CULTURE, WHICH CAN NEGATIVELY AFFECT ITS PURITY OR QUALITY.

Caution: Hot glass looks just like cold glass!

CULTIVATION



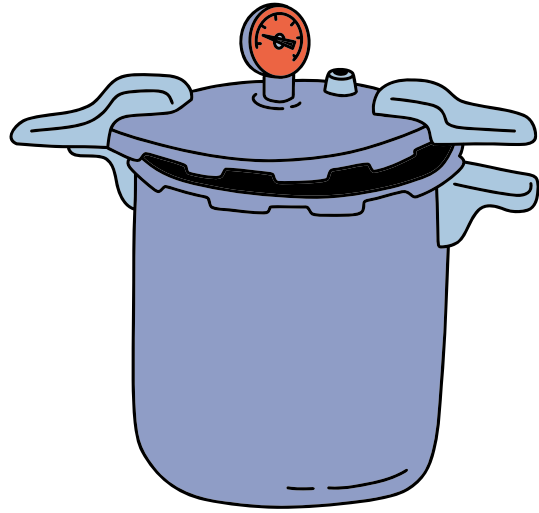
CULTIVATION

Cultivation describes the initiation, propagation, and controlled growth of biological organisms under defined conditions.

Targeted control of environmental conditions such as temperature, humidity, and nutrient supply can influence key parameters of growth and metabolism. The cultivation of organisms thus forms a methodological basis for the development and testing of bio-based materials, as well as for the analysis of their properties.

Systematic documentation of the respective cultivation conditions enables better comparability and reproducibility of experimental results.

AUTOCLAVE & PRESSURE COOKER



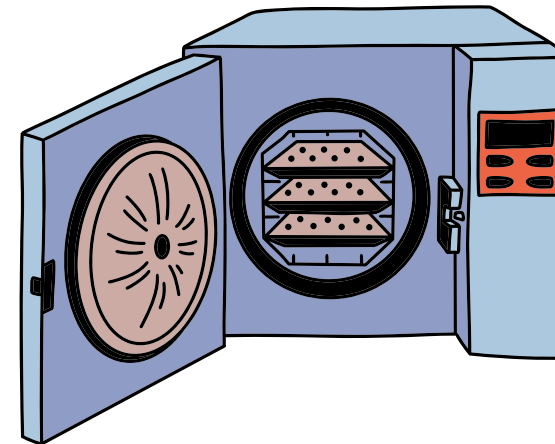
The controlled application of heat and pressure is used in many laboratory situations, particularly for the sterilisation of instruments, culture media, and raw materials. Sterilisation serves to kill microorganisms and inactivate spores and enzymes.

Modern autoclaves are usually employed for sterilisation. Their operation is based on the principle of heating water beyond its normal boiling point of 100 °C. An autoclave uses saturated steam under elevated water pressure to kill microorganisms such as bacteria. Increasing the pressure shifts the boiling point of water, so that steam sterilisation generally involves temperatures of 121 °C or 134 °C at an overpressure of 1–2 bar. These temperatures are necessary to effectively inactivate even heat-resistant spores. This process is also referred to as autoclaving.

A pressure cooker is the low-tech version, but is based on the same principle. Here too, heating water in a sealed vessel creates excess pressure, which enables rapid cooking at temperatures above the boiling point of water (100 °C). Compared to an autoclave, a pressure cooker offers fewer control options. Furthermore, the minimum temperatures required for the safe destruction of spores cannot be reliably guaranteed in a pressure cooker due to the lack of control, meaning a higher error rate must be assumed.

It is essential to observe basic safety principles when working with any type of pressure vessel, such as autoclaves or steam pressure cookers. Before each use, it should be checked that all seals, valves, and closures are intact. Similarly, the interior must not be overloaded, as a restricted circulation volume for the steam can impair the effectiveness of the sterilisation. Furthermore, a sufficient cooling-off period must be observed to allow the necessary pressure equalisation to take place before the appliance is opened. Only suitable heat- and pressure-resistant glass or plastic containers must be used. Otherwise, the materials could be damaged during the process. Containers must not be sealed airtight in order to allow for the necessary gas exchange. Liquid containers should be filled to no more than two-thirds of their volume to prevent delayed boiling during pressure release.

To prevent confusion between sterile and non-sterile materials, labelling – for example, using special autoclave tape – is important. At the same time, this also provides a process control mechanism as the colour strips on the autoclave tape change colour in a characteristic manner once a critical steam temperature is reached.





VEGAN CAMEMBERT

JONAS GOEBEL

INGREDIENTS

300 g cashew nuts
220 ml sterile water
1 tsp salt
20 ml neutral coconut oil
0.5 g mesophilic cultures
0.5 g *Penicillium candidum*
optional fillings

TOOLS

scale
hand blender
cheesecloth
small mould
sieve
electric kettle
measuring cup
spoon
steel bowl

INSTRUCTIONS

1. Soak the cashew nuts for several hours or overnight.
 2. Pour boiling water over the cashew nuts to sterilise them, then drain the water.
 3. Puree very finely with boiled water.
 4. Mix in the coconut oil.
 5. Add both mushroom cultures and stir them in.
 6. Let it rest, covered, at room temperature for about 10 hours.
 7. Divide the raw mixture into moulds lined with cheesecloth.
Fold the cloth over the top and let it ripen in the refrigerator at 8 °C.
 8. Remove the cheese wheels from the moulds and cheesecloth and sprinkle with salt on both sides.
 9. From then on, turn them daily and remove the liquid from the ripening container.
 10. When a continuous layer of white mould has formed and the wheel has reached the appropriate firmness, it is ready.
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MICROBIOLOGICAL SAFETY CABINET

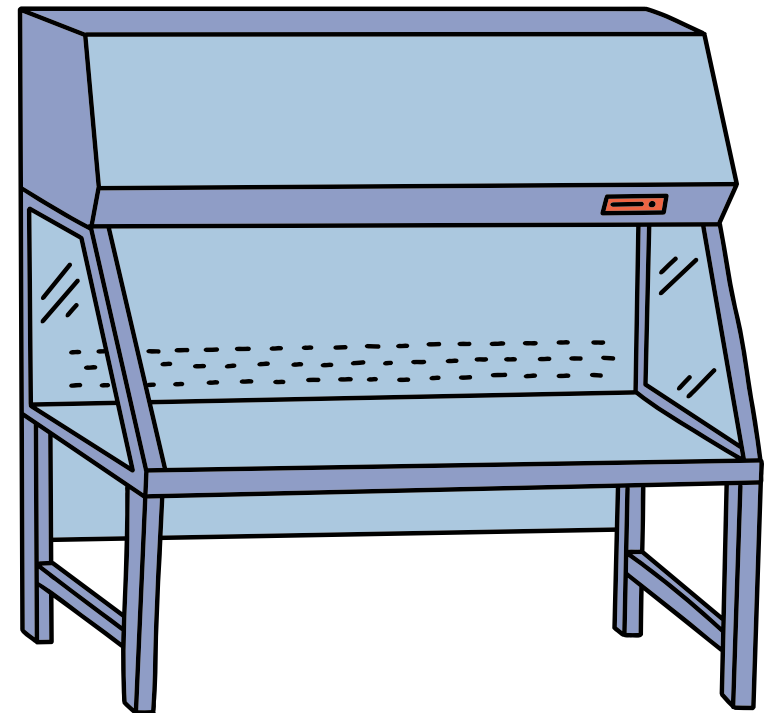
A microbiological safety cabinet enables sterile working, for example with sensitive microorganisms, by continuously extracting and purifying the air inside a defined working area.

Sterile working refers to all measures taken to prevent contamination caused by the introduction of microorganisms or foreign particles into a sample. A typical example from the laboratory is the unwanted contamination of a bacterial culture by mould spores from the ambient air. This begins with preparing the workstation by thoroughly cleaning and disinfecting the work surface before each use, and ensuring that all tools and materials are sterilised accordingly. Optimal sample organisation significantly reduces the risk of sample contamination. When using the microbiological safety cabinet, care must be taken to ensure that sample containers are only opened inside the cabinet. Tools and materials should be positioned in advance so that they can be reached with as few movements as possible. Reaching across open culture media or other open vessels should also be avoided wherever feasible. Inside the microbiological safety cabinet, the airflow is directed so that, as far as possible, all incoming air is passed through the filter and continuously purified. For this reason, it is important that this delicate airflow is not restricted by rapid movements, loose-fitting clothing on the arms, or materials left lying about.

Microbiological safety cabinets are divided into different classes. Class I safety cabinets offer protection solely for the workers. Class II safety cabinets also protect the cultures and samples being handled. When working with particularly sensitive organisms or materials that pose a health risk, Class III microbiological safety cabinets offer increased protection against exposure thanks to their design, which includes an integrated airlock and access ports (known as a glove box). In modern systems, air filtration is usually carried out using special particulate filters, known as HEPA filters (high-efficiency particulate air filters).

If the safety cabinet is used incorrectly, there is a risk that biological hazards may escape. To protect both yourself and the surrounding environment, the above guidelines on working safely in a microbiological safety cabinet must be followed. Contaminated waste, such as solutions or contaminated pipette tips, must be collected and disposed of appropriately, for example by autoclaving.

It should also be noted here that, unlike a chemical laboratory fume cupboard, a microbiological safety cabinet does not provide adequate protection against gases and vapours that are hazardous to health.



WORKING UNDER STERILE CONDITIONS

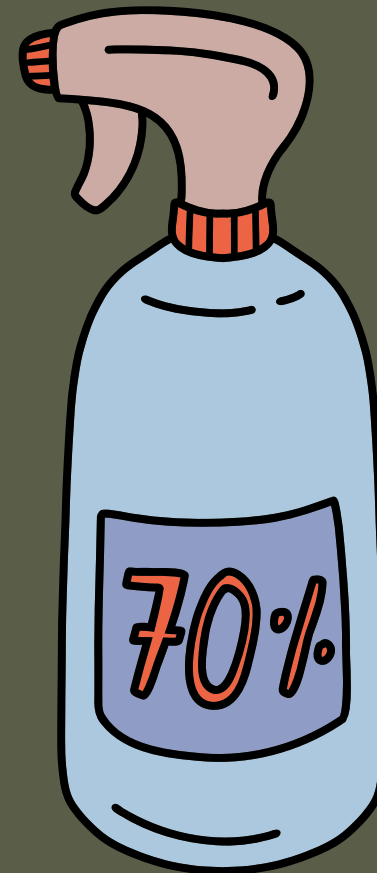
In addition to thoroughly cleaning and disinfecting your hands and all equipment and surfaces, there are a number of other basic rules for sterile working that must be observed.

As a general rule, contact should be kept to a minimum to prevent contamination. This includes, for example, ensuring that surfaces or tools which are touched without gloves are not touched whilst wearing gloves. Contact with one's own skin and hair, such as brushing hair back, should also be strictly avoided.

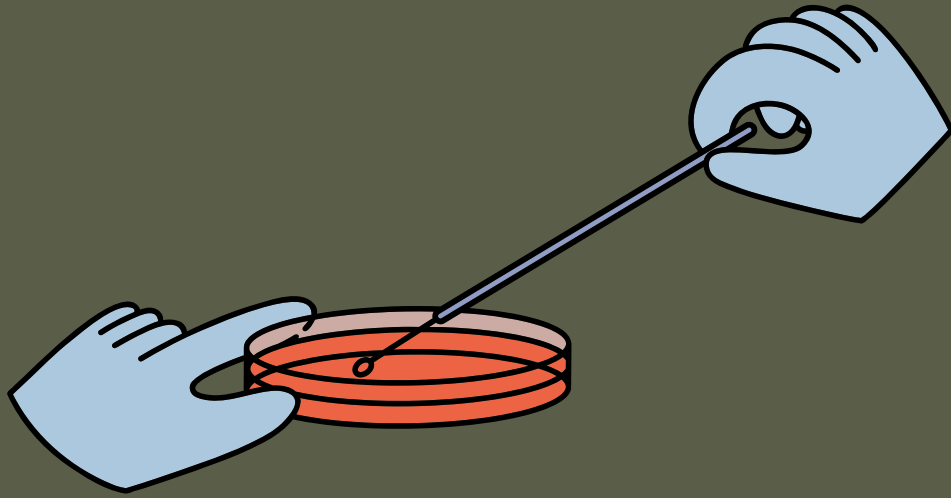
Before and after inoculating cultures or streaking agar plates, all surfaces should be cleaned and disinfected appropriately. To do this, suitable surface disinfectants, such as a 70% solution of ethanol or isopropanol, are applied to the surfaces to be disinfected either by wiping or using a spray device. For specific purposes, the use of separate fungicides or bleach may also be necessary to prevent contamination. When carrying out work at the microbiological safety cabinet, all items must be disinfected before being brought inside. As few items as possible should be brought in to ensure an even airflow and to prevent the ventilation slots from becoming blocked.

At the start of the work, it may be advisable to slightly loosen the lids of any required containers in advance, so that they can be opened easily whilst inside the safety cabinet. Avoid passing hands, tools, or materials over open containers. Sterile materials intended for later use must not be touched with any part of an instrument that has come into contact with samples or cultures.

In addition to a microbiological safety cabinet, a Bunsen burner is a suitable option for sterile work. This creates a radially sterile working area in the immediate vicinity due to the heat, within which working materials and containers can be opened, removed, and handled.



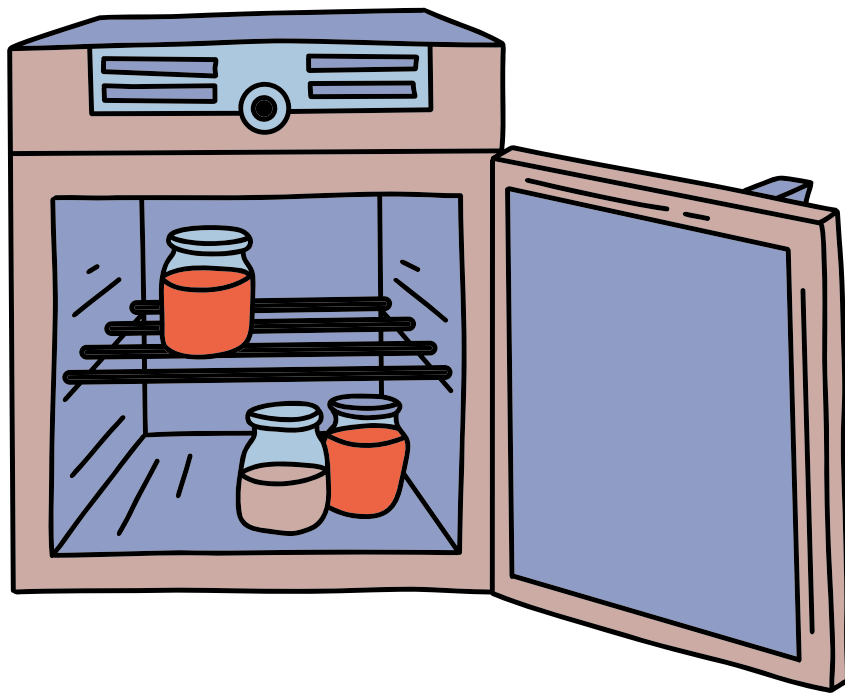
STREAK PLATE METHOD



In order to carry out specific microbiological or biochemical experiments in the laboratory, it is often necessary to isolate the desired bacterial strain. Such isolation of a pure culture is usually carried out on solid culture media such as agar plates. To do this, cells are separated from a cell population or spread out in such a way that so-called single colonies form. Depending on the organisms to be examined and the composition of the sample, more specialised selection media may also be used. These promote the growth of certain organisms whilst simultaneously inhibiting the growth of unwanted organisms. This work is carried out in a sterile environment. Due to the necessary sterilisation steps, Bunsen burners are a suitable tool if disposable materials are not to be used. Reusable inoculation loops are sterilised by heating them in the flame before and after each inoculation or streaking procedure. They are allowed to cool down next to the flame within the sterile working area of the Bunsen burner.

The agar plates must be prepared in advance. Once poured, these must be allowed to cool sufficiently so that the agar gels and no film of liquid forms on the surface due to condensation, which could interfere with the desired isolation. Using the sterilised inoculation loop, individual colonies can now be taken from reference plates and streaked onto the fresh agar plates. The inoculation loop is placed gently onto the agar surface without applying any pressure, so as not to damage the delicate agar layer. The inoculated agar plates should then be carefully labelled on the underside of the Petri dish with the date, name, microorganism, and medium used. For incubation, the agar plates are placed upside down in the incubator so that any condensation that forms cannot drip onto the agar plates.

INCUBATOR



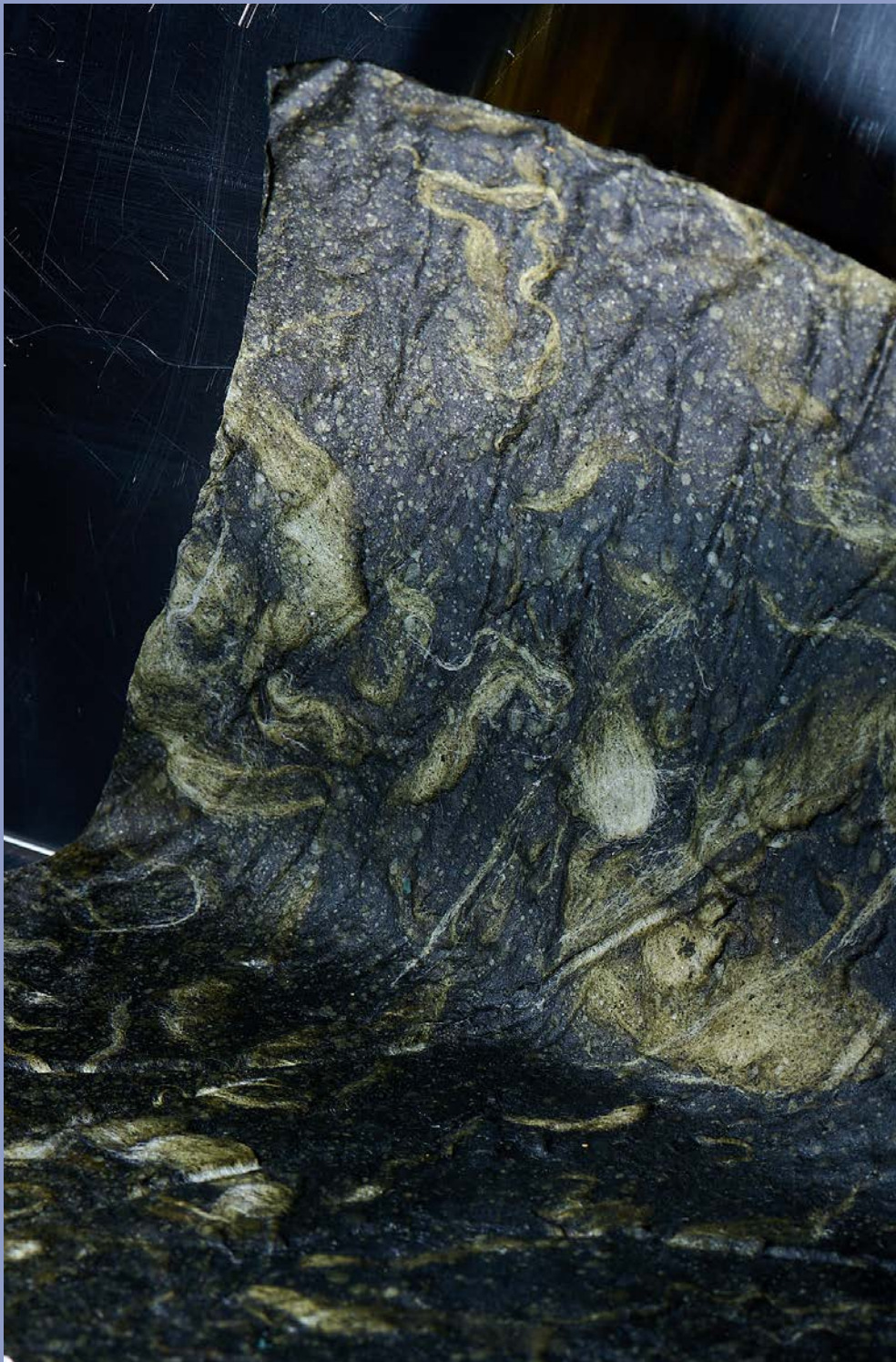
Constant temperatures allow biological processes, such as the growth of microorganisms, to be precisely controlled. An incubator enables heat to be supplied under defined and reproducible conditions. To this end, the incubator is equipped with specialised heating and ventilation systems, so that, in more technically advanced models, the atmospheric composition can be maintained at a constant level.

Typically, the temperature in incubators ranges between 20 °C and 60 °C, depending on the application and the material being cultured. Temperature-controlled cabinets for cooler temperatures are used, for example, in the controlled ripening of food. Temperature gradients are prevented by a circulation system and correct loading.

In the laboratory, microorganisms such as bacteria or fungi can be cultured in incubators. In the kitchen, microorganisms can be used to produce sourdough and yoghurt.

Controlled environmental conditions for development and growth processes can be achieved not only in conventional temperature-controlled cabinets but also in shaking incubators. These are used in particular when continuous nutrient distribution is important, for example during cultivation in liquid media.

The base plate of the shaking incubator is movable, which prevents the formation of a so-called scum layer, a microbiological biofilm, during the cultivation of microorganisms. This is necessary as this biofilm could interfere with the optimal gas exchange required. For aerobic microorganisms, which depend on oxygen, adequate mixing is important to ensure the supply of oxygen from the air space above. To achieve even better mixing, it may also be advisable to use special baffled flasks in the shaking incubator. Compared to standard Erlenmeyer flasks, these have additional protrusions inside the flask (baffles) which, in addition to the rotational movement of the shaking incubator, ensure further mixing.



KOMBUCHA GUNILLA PILTZ

INGREDIENTS

10 g wool fibres (long)
1000 ml water
50 g spirulina
180 g kombucha scoby
12 g sodium alginate
42 g glycerin
5 g coconut oil
2–3 sprays of calcium chloride

TOOLS

immersion blender
pot
spoon
(cake) scraper
baking paper
baking tray
wooden board
spray bottle

INSTRUCTIONS

1. Neutralise the odour of the kombucha scoby. Boil it with detergent for about an hour over low heat, then rinse with cold water.
 2. Combine the kombucha scoby, sodium alginate, coconut oil, spirulina, glycerin, and water in a pot and blend until a smooth mixture forms.
 3. Let the mixture cool overnight at room temperature or in the refrigerator.
 4. Add the wool fibres individually and mix well.
 5. Spread the mixture evenly on a baking sheet.
The layer should be 1–2 cm thick.
 6. Dehydrate in the oven at 60 °C (convection) for 12–24 hours.
Turn the material after eight hours.
 7. (Spray the semi-dry material lightly with calcium chloride and finish drying over a heater.)
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OPTICAL ANALYSIS



OPTICAL ANALYSIS

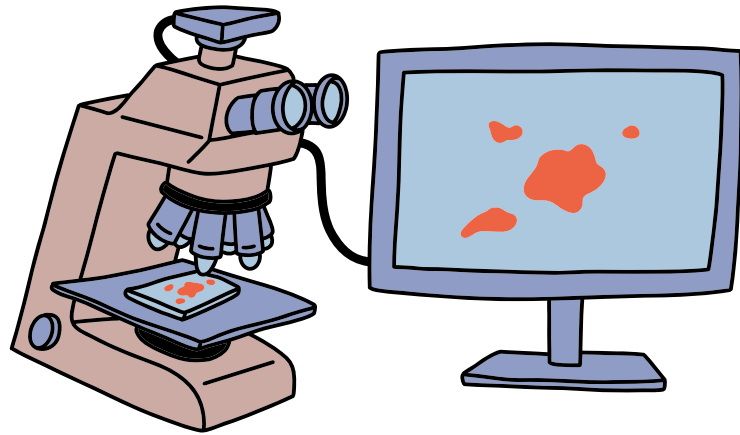
Optical methods can be used to examine in greater detail the properties of samples and materials that are not visible to the human eye, or are only visible to a limited extent.

For example, they can be used to visualise structures or detect changes in composition.

Depending on the specific research question, different techniques are employed to enable both qualitative observation and quantitative analysis.

Some methods and instruments for optical examination and analysis are described in more detail below.

MICROSCOPE & MICROSCOPE CAMERA



A light microscope focuses incoming light rays and produces a magnified image of samples at a microscopic level, revealing structures such as cell components or microorganisms that would otherwise remain hidden from human vision. A choice of different objectives is available. Typically, a light microscope can achieve magnifications ranging from 4x to 100x, although the latter requires the use of immersion oils*.

* IMMERSION OIL IS A SPECIAL TYPE OF OIL USED BETWEEN THE MICROSCOPE LENS AND THE SPECIMEN TO IMPROVE IMAGE SHARP-NESS AND RESOLUTION BY REDUCING THE REFRACTION OF LIGHT.

Another crucial factor, alongside the magnification level, is resolution. This describes the ability of the light microscope and its components to clearly distinguish between two structures that are close together. This resolution limit – the minimum distance at which two objects can still be distinguished – is known as the Abbe limit. A transmitted-light microscope typically comprises the following components: objective lens, eyepiece, tube, stage, condenser, and a light source.

When observing objects under a microscope, the observer looks through the eyepiece, which is situated at the top of the microscope. The eyepiece is connected via the body tube to the revolving nosepiece, which holds the objective lenses. Below the objective lens is the stage with the slide, on which the specimens to be examined are placed. Depending on the magnification level, the objective lens produces a larger intermediate image of the specimen, which is then magnified once more by the eyepiece. In a transmitted-light microscope, the light source is located in the base. The light shines from below onto the

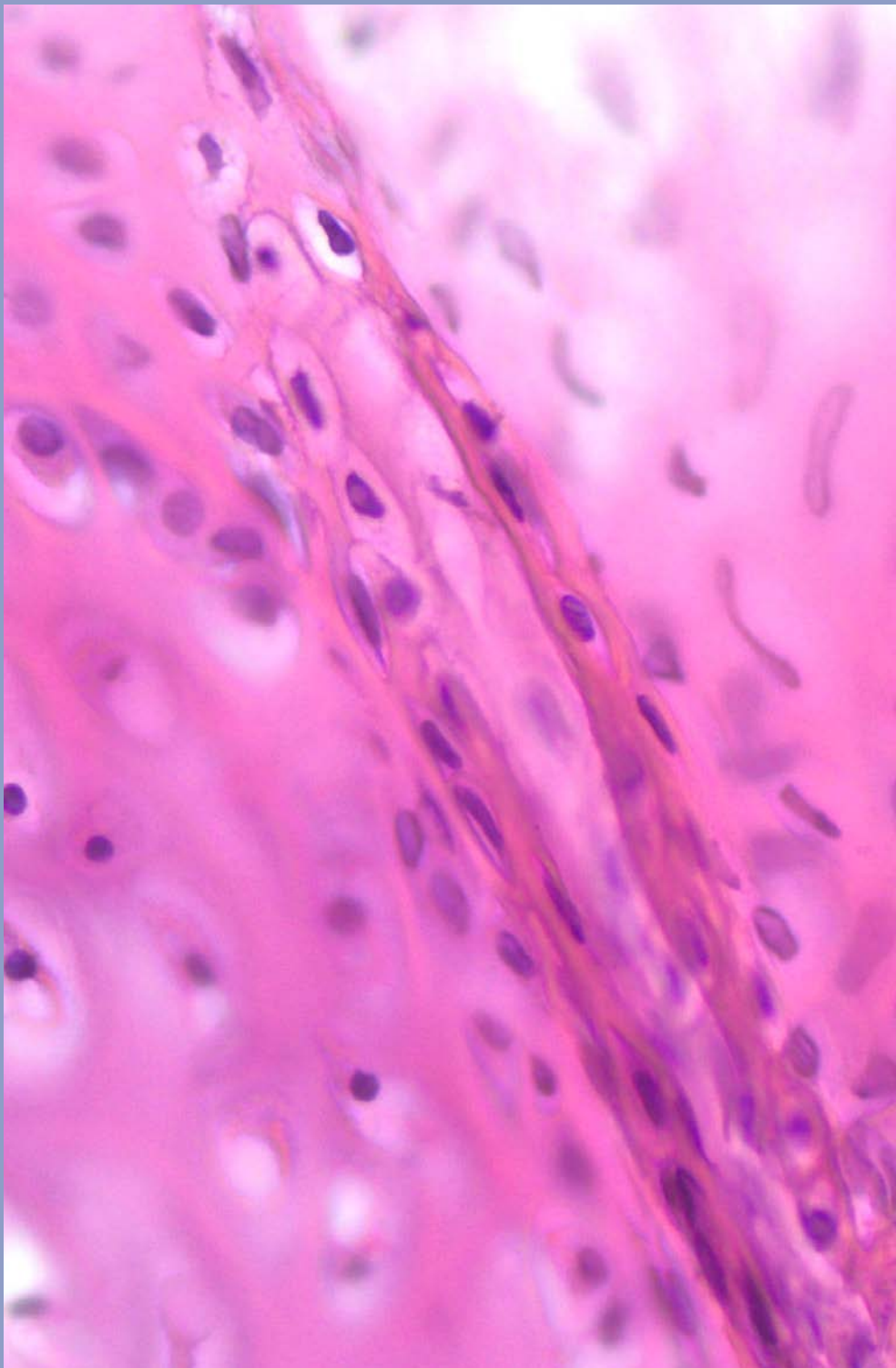
specimen placed on the stage above. A condenser attached to the stage ensures optimal illumination of the specimen.

The so-called Köhler illumination serves to ensure uniform illumination of the field of view. To this end, modern microscopes are equipped with a field diaphragm, so that by adjusting the illumination, a sharp, high-contrast image can be produced without distracting stray light.

It is important to handle the optical components with care, as even small dust particles can damage the sensitive objectives. When moving specimens onto and around the stage, and when switching between different magnification levels, care should therefore be taken to ensure there is sufficient clearance between the objective and the stage.

An integrated camera complements the microscope's standard eyepiece and enables digital capture and documentation. In addition to viewing through the binoculars, the images can thus be displayed at a higher magnification on a screen next to the microscope for joint viewing and discussion. Furthermore, images and video footage can be recorded and saved to a storage medium. These recordings can then be used for comprehensive documentation, presentations, or further analysis and post-processing. Many modern cameras and their operating software now also allow for the digital measurement of specimens and further digital post-processing.

IN THE CONFIDENCE OF FEAR – ANNA KEBE
MICROSCOPY OF TISSUE SAMPLES, 40X MAGNIFICATION

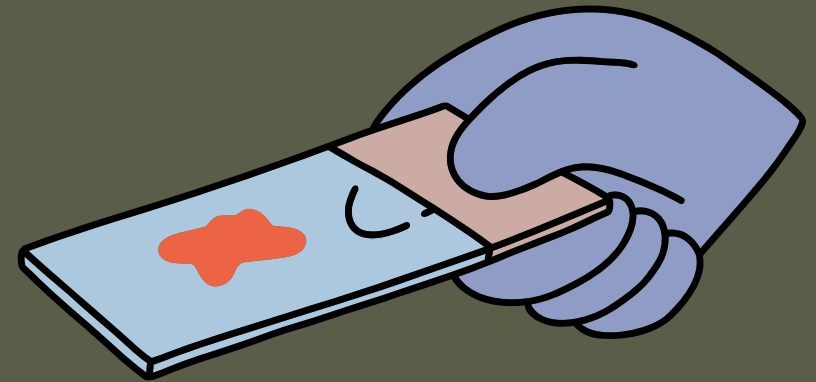


SPACE FOR FAILURE – ANTHONJA HEROLD
MICROSCOPY OF PHOTOGRAPHIC CRYSTALS, 5X MAGNIFICATION



MICROSCOPY

Microscopy allows samples to be optically magnified so that details invisible to the naked eye can be observed. Transmitted light microscopy is suitable for light-transmitting samples. This means that the specimens to be examined must be sufficiently thin and transparent for the structures to be visible under the microscope. To prepare a specimen, you will need the object to be examined, a microscope slide with a cover slip, and a mounting medium. The specimens to be examined are placed in the centre of the slide. They must be positioned as flat as possible on the slide. For fresh specimens that do not require special storage, water combined with a cover slip can be used as a mounting medium. Specimens intended for long-term preservation can be sealed using mounting media such as resins. When working with microorganisms, heat fixation, achieved by briefly heating the slide over an open flame, is a common method. Microscopic observation can be documented both in analogue and digital form. In addition to the sketch itself, microscopic drawings should include details of the date, magnification, mounting medium, and any staining, as well as a description of the object under observation. Digital documentation can be carried out using a camera connected to the microscope. Initial experiments can be carried out using plant cells. Onion layers can be easily removed with tweezers. Samples from leaves or fruits can also be scraped off thinly with a scalpel and examined under the microscope. In tomatoes, for example, the chromoplasts can be identified even without further staining, due to the characteristic pigments they contain, which colour the plant parts yellow to red depending on their degree of ripeness.



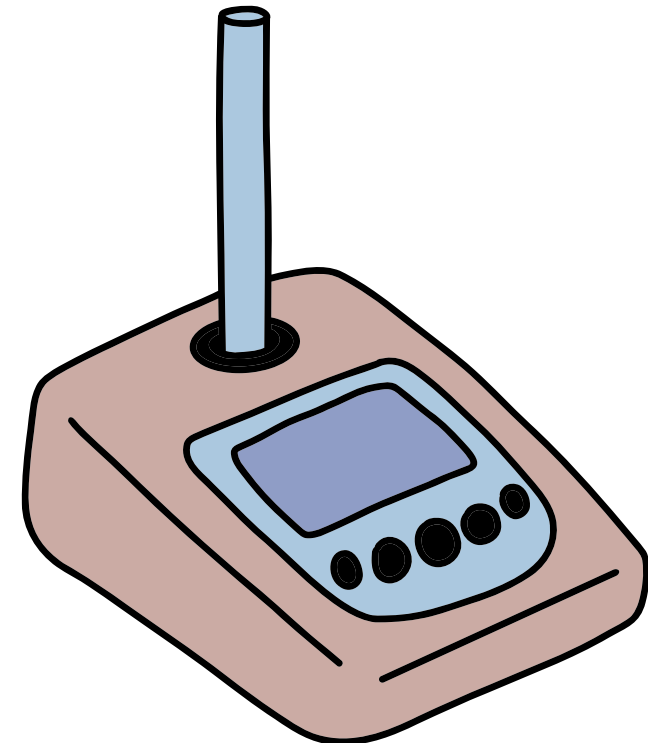
PHOTOMETER

The light absorption of a sample can provide information about its concentration, composition, or turbidity. This is used, for example, in quality assurance or medical diagnostics. Light absorption can be measured using a photometer.

A photometer is typically constructed as follows: a light source generates the light required for the measurement. This light is passed through a prism, which splits the light beam into monochromatic light. Light of the required wavelength is then passed through a slit and directed onto the sample contained in a cuvette. On the other side of the cuvette is a detector, which measures the intensity of the incoming radiation.

One specific application is the measurement of optical density at 600 nm, also known as OD_{600} . This wavelength of incident light is frequently used to monitor the growth of microbial cultures in liquid media and to plot growth curves. In biotechnology, this enables growth phases to be determined and the optimal time for harvesting to be estimated. The optical density at 600 nm serves as an indirect indicator of cell density. The higher the turbidity of the liquid culture, the higher the measurable absorption. This enables a rapid, non-invasive assessment of cell growth.

In general, it is important to ensure that the measuring cuvette is clean and the solution is free from air bubbles or particles during measurement, in order to avoid false readings. Ideally, the measuring cuvette should only be handled by its upper rim or on the sides that are not in the path of the light beam. At high cell densities, the OD_{600} measurement may fall outside the linear range. In this case, a series of dilutions is required. In OD_{600} measurements, the difference between the incident light intensity and the measurable residual light intensity is often based less on actual absorption than on light scattering caused by particles and suspended matter. Different cell types may therefore exhibit different OD_{600} values even at the same cell density.



BACTERIAL GROWTH

When bacteria are cultured in a liquid nutrient medium, their numbers usually continue to increase until this growth is restricted by a limiting factor and eventually comes to a halt.

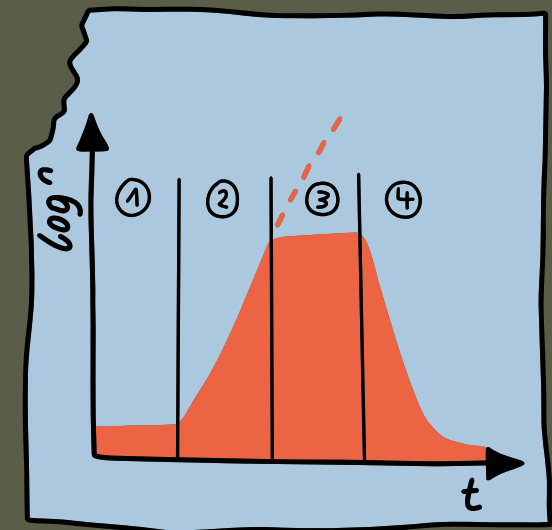
Microorganisms such as bacteria do not grow at a constant rate at all times. Rather, their growth is exponential due to cell division. In a closed system such as a discontinuous batch culture in a bioreactor, also known as a static culture, growth occurs in distinct phases due to limiting factors such as nutrient consumption. A logarithmic plot of the bacterial count in the culture against time shows a characteristic growth curve, which can be roughly divided into four phases: the lag phase (1), the exponential phase (2), the stationary phase (3), and the death phase (4).

At the start of the culture, the microorganisms adapt to the available medium. Potential nutrients are analysed with the help of receptors in the cell membrane. The presence of specific substances activates the gene expression of relevant enzymes required for the digestion of the available nutrients. The duration of the various growth phases depends on the quality of the initial culture and the appropriate composition of the chosen nutrient medium. At the start, during the start-up phase, no growth has yet occurred. This first phase is called the lag phase.

Following this preparatory phase, the transition to the exponential phase takes place. Through repeated cell division, the number of microorganisms doubles exponentially until the stationary phase is reached. The generation time reaches a minimum value here, as cell division occurs at a constant rate and the time between cell divisions is reduced to a minimum. In theory, growth could continue indefinitely. In practice, however, it comes to a halt after a certain time. This stationary phase results from growth being restricted by limiting factors such as reactor volume and available nutrients. At this point, a balance is established between cells dying and new cells being produced. As no new nutrients are added to a static culture, the death phase begins once the existing nutrients are exhausted.

During this phase, the death rate exceeds the cell division rate. This death phase can be further accelerated by the release of secondary metabolites by the dying microorganisms. The culture dies off until cell division ceases.

Various measurement methods can be used to assess the growth of a liquid culture. A rapid, indirect method is to measure the optical density (OD) of the culture. Using a photometer, the turbidity caused by the cells present in the suspension can be measured. This method is more suitable for the continuous monitoring of growth rates and provides little information about the actual number of cells and their viability, as dead cells also contribute to measurable turbidity. To determine the viability of a culture, an aliquot is taken from the culture and plated onto a solid nutrient medium, such as an agar plate. After a specified incubation period, the number of colony-forming units per unit volume plated can be determined.



STORAGE



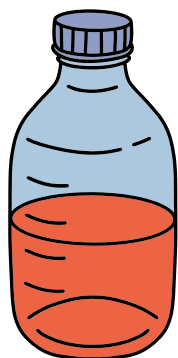
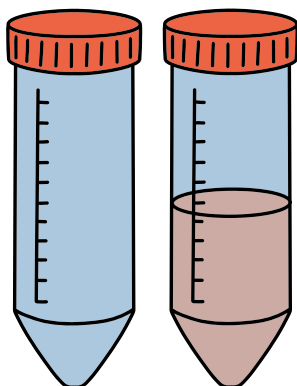
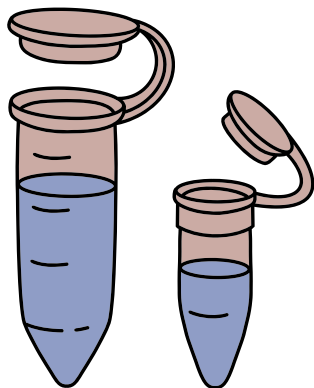
STORAGE

Proper storage is of particular importance when working with microorganisms and hazardous substances.

Suitable containers and storage conditions help to protect substances and cultures from external influences and ensure safe handling.

Depending on their properties and the intended use, different requirements may apply to the containers and storage locations.

SUITABLE CONTAINERS



The appropriate storage of hazardous substances, ongoing experiments, and final materials can be technically challenging when working with living organisms and biodegradable products.

One of the basic rules for storage in a laboratory environment is the use of suitable containers. These include plastic and glass containers in various sizes and shapes, ranging from micro-reaction vessels to canisters. From a technical perspective, materials must be selected that are resistant to the substances they contain. Furthermore, certain hazardous substances must not be stored together and must be kept away from electrical ignition sources in order, for example, to minimise the risk of fire-promoting properties as far as possible.

To avoid mix-ups, food packaging in particular must not be reused. This means that no drinking bottles or packaging may be stored in the laboratory or used for purposes other than those for which they were intended. In general, food intended for consumption should not be stored or processed in work areas where potentially hazardous substances are handled. A strict separation of work areas and storage areas must be maintained.

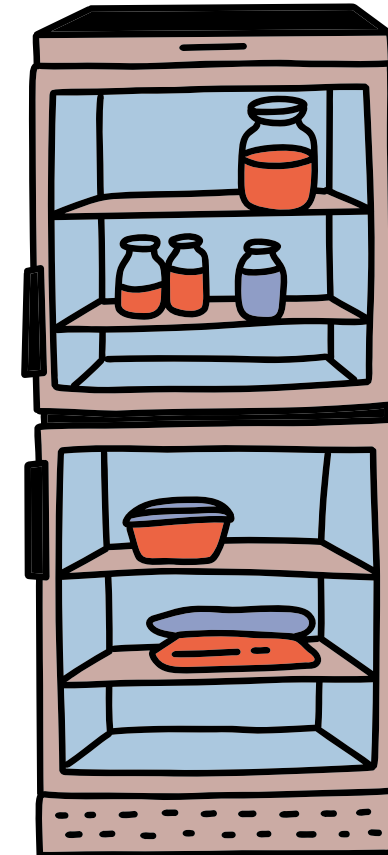
When working with microorganisms, regular checks and appropriate safety measures should be carried out to ensure that there is no uncontrolled proliferation of undesirable organisms, such as through contamination.

REFRIGERATOR & FREEZER

Refrigeration slows down metabolic processes, enzyme activity, and microbial growth, which collectively results in longer shelf life for many foods and bio-based materials.

Similar to standard domestic fridges, laboratories also have fridges designed for storing reagents at temperatures between 2 °C and 8 °C. Freezers allow storage below the freezing point and are usually used for long-term storage. Freezers in the conventional sense usually operate within a temperature range of -18 °C to -20 °C. Specialised laboratories have both colder freezers (-80 °C) and separate liquid nitrogen tanks (-196 °C) for storing particularly sensitive substances such as cell cultures or complementary DNA. The low temperatures almost completely halt microbial growth, and chemical reactions that could lead to a loss of quality are slowed to a minimum.

Traceable labelling is crucial, particularly for long-term storage, to ensure that samples cannot be mixed up. Another important consideration is the planning of freeze–thaw cycles, as repeated freezing can significantly impair the quality of the samples. For this reason, sensitive starting materials should, where possible, be divided into smaller, ready-to-use quantities (aliquots) and only the required amounts should be withdrawn at any one time.





PLANTPOP
NORA JO CZARDYBON

INGREDIENTS

VARIATION 1: DANDELION AND ROSE

300 g oat yoghurt
2 tsp sugar
1/2 handful of dandelion leaves
2 rose petals (edible, untreated)

VARIATION 2: SORREL, GROUND ELDER, AND WOODRUFF

300 g oat yoghurt
2 tsp sugar
1/2 handful woodruff
1/4 handful ground elder
1/4 handful sorrel

TOOLS

freezer
mixing bowl
spoon or whisk
teaspoon
kitchen scale
cutting board
sharp knife
colander or sieve
clean kitchen towel or paper towel
ice pop moulds or silicone moulds

METHOD

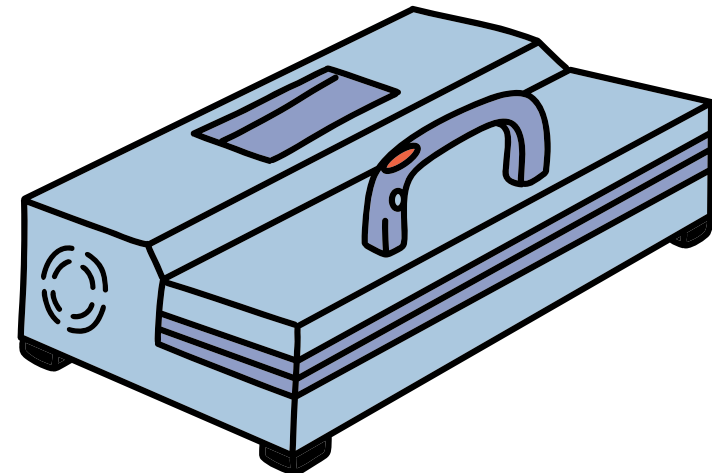
1. Mix the oat yoghurt thoroughly with the sugar.
 2. Wash the wild herbs and petals, shake them dry, and chop them coarsely.
 3. First, place a small amount of the wild plants into the mould. Then alternate layers of yoghurt and plants until everything is used up.
 4. Place the moulds in the freezer overnight.
 5. The next day, remove the frozen mixture from the mould, allow it to thaw briefly, and decorate it with fresh wild plants to add extra colour and flavour.
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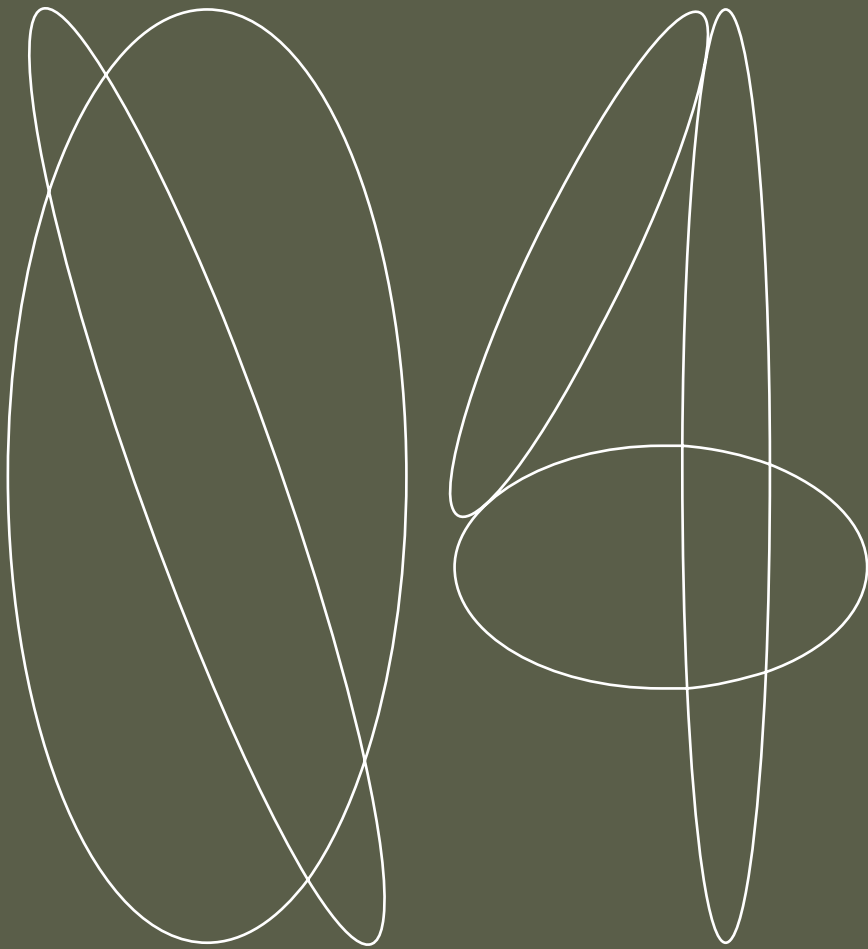
VACUUM SEALER

Film sealing and vacuum sealers are used both for food preservation and for sealing mushroom cultivation bags. By removing the ambient air and creating a vacuum, processes and reactions can be significantly slowed down. A vacuum describes the state in which the gas pressure is significantly below the standard atmospheric pressure of 1013 mbar.

A general distinction is made between external vacuum sealers and chamber vacuum sealers. With the latter, the entire vacuum bag is placed inside a chamber, whilst with external vacuum sealers, only the opening to be sealed is clamped in place. By removing the ambient air and thus largely suppressing microbial growth or oxidative reactions, the materials can be protected from contamination such as mould, and the shelf life of food can be extended.

To vacuum-seal the material, place it in a suitable bag and position the bag in the vacuum sealer according to the manufacturer's instructions. The machine then removes the air and seals the bag. If the vacuum-sealed bags are to be heated afterwards, care must be taken to select the appropriate material. Food-safe vacuum bags are required for the particularly gentle vacuum cooking (sous-vide) of food. In mushroom cultivation, autoclavable materials are generally required, as the prepared growing medium must be sterilised before inoculation.





REGULATIONS AND SAFETY

REGULATIONS AND SAFETY

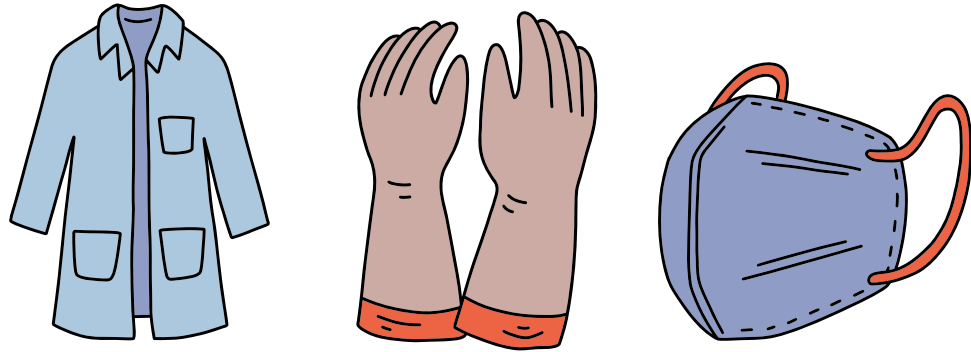
Experimental work in a Biolab requires adherence to fundamental safety standards. For this reason, the responsible handling of materials and equipment, as well as consistent compliance with applicable safety and conduct rules, form an important basis for working safely in the lab. A safety briefing is required before work commences, and a refresher course must be undertaken at least once a year. Specific workstations and equipment also require separate training. Furthermore, the relevant operating instructions and safety data sheets must be taken into account. These include, on the one hand, legal requirements for handling hazardous substances such as chemicals or biological agents, and, on the other hand, requirements relating to health and safety at work, the handling of electrical equipment, and storage and disposal. When handling biological agents, known as 'biosubstances', specific safety regulations and rules of conduct must be observed. Relevant legislation in Germany includes, amongst others, the Biological Agents Ordinance (BioStoffV), the Technical Rules for Biological Agents (TRBA), the Infection Protection Act, the Occupational Safety and Health Act, and the Maternity Protection Act. In general, occupational health and safety requirements, as well as measures to protect the environment and the public, apply. The Ordinance on Safety and Health Protection in Activities Involving Biological Agents regulates safety and health protection. It provides the framework for a risk assessment and the evaluation of relevant safety risks.

When working in the laboratory, visual checks must be carried out on the tools and equipment to be used before work begins. Faulty equipment must be reported to the laboratory management immediately and taken out of service. Particular caution is required when working with open flames, sharp and pointed objects, hazardous biological and chemical substances, and live electrical equipment. When disposing of reagents, the relevant regulations on proper disposal must be observed.

A biolab can be divided into different areas or zones depending on the specific work processes involved. This division may be based on different hazard levels or to ensure the physical separation of areas designated for food production from those containing other materials. When working with food, specific hygiene regulations also apply, such as the Food Hygiene Regulation and the HACCP scheme. The latter serves as a quality management tool, describing »hazard analyses and critical control points« (HACCP) in the handling of food. In addition to key elements such as maintaining the cold chain and preventing cross-contamination, preventive measures must be taken when working with food, such as the strict physical separation of work areas. Depending on the project and work process, this results in varying safety requirements and protective measures that must be assessed on a case-by-case basis.



PERSONAL PROTECTIVE EQUIPMENT

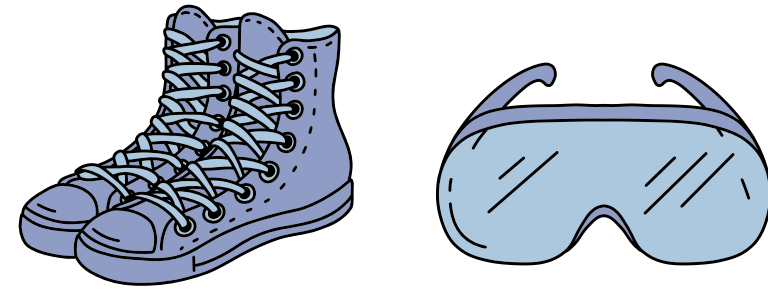


Wearing suitable personal protective equipment (PPE) is one of the fundamental prerequisites and safety requirements when handling biological and chemical hazards.

Personal protective equipment must only be worn in the laboratory. It must be removed before any breaks, visits to the toilet, or similar activities, and hands must be washed thoroughly.

A laboratory coat made of flame-retardant cotton fabric, reaching down to the wrists and thighs, protects the skin and clothing from any spilled reagents. Safety goggles protect the sensitive eyes, particularly from splashes. In the laboratory, care should be taken to ensure that no hand movements are made towards the face. For those who wear glasses, it is advisable to wear so-called safety goggles, which can be worn over regular glasses. Wearing contact lenses should be avoided in the laboratory, as chemicals may become trapped behind the lenses in the event of eye exposure, making it more difficult to rinse the eyes thoroughly and promptly.

Depending on their specifications, protective and work gloves shield the hands from mechanical, thermal, or chemical hazards. When working with sharp knives, for example, cut-resistant gloves must be worn. Disposable gloves protect the hands from external exposure to reagents for a short period of time. Disposable gloves are used in particular in food production and when working with microorganisms to protect materials from microorganisms on human skin and thus prevent contamination. When working with hazardous substances, it should be noted that gloves provide only limited protection against them. The relevant material and selection tables must be consulted.



Wearing face masks covering the mouth and nose may be necessary for various activities. When working with microorganisms, it is advisable to wear a face mask to minimise contamination of the cultures. Specific work involving hazardous substances such as dust may require higher protection classes for personal safety.

Closed and sturdy footwear must be worn in the laboratory. This provides protection against slipping and skin damage in the event of an accident.

Long hair should be tied back in a plait whilst in the laboratory. When working with rotating tools, hair should be tied back in a bun. Dangling jewellery, such as long necklaces or earrings, should also be removed so that it cannot become caught in rotating tools.

When working with food intended for consumption, specific hygiene regulations must be observed. To prevent hair from entering the food preparation, hair and beards must be covered with appropriate caps or hairnets. Work clothes and personal clothing should be kept strictly separate to prevent the introduction of foreign substances.

HAZARDOUS SUBSTANCES



Hazardous substances include all substances and mixtures of substances that may pose a risk to human health and safety or to the environment due to their chemical, toxic, or physical properties. The authorisation, classification, and labelling of these hazardous substances are regulated at EU level by regulations such as REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals), CLP (Classification, Labelling and Packaging), and the Biocidal Products Regulation (BPR). Further regulations, such as the Hazardous Substances Ordinance and the Biological Agents Ordinance, govern this at federal level, based on the directives of the European Union.

These hazardous substances must be labelled in a specific manner. Under the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), the labelling must include not only the chemical name but also signal words (Warning, Danger) as well as hazard and safety statements. The latter comprise the so-called H- and P-phrases (from the English 'hazard statements' and 'precautionary statements'). Hazard pictograms are also used to identify potential hazards at a glance.

Many substances and mixtures are significantly less hazardous at low concentrations, which is why the labelling requirement does not apply below specified thresholds. However, in view of the potential accumulation of sensitising or toxic substances, they must always be handled with care. As a general rule, work may only commence after a competent risk assessment has been carried out. Furthermore, it must be checked whether any hazardous substances can be substituted with non-hazardous substances.

BIOMATERIAL LABORATORY RULES

1. Always wear the appropriate protective equipment and familiarise yourself with the relevant safety measures before starting work.
2. Read instructions, labels, and operating guidelines carefully and follow them.
3. Do not eat or drink in the laboratory.
4. Keep your work area clean and tidy.
5. Keep contaminated items and your personal protective equipment in the laboratory.
6. Dispose of your materials and reagents correctly.
7. Label all your materials carefully and clearly.
8. Treat materials and equipment with respect.
9. Take responsibility for your own safety and that of those around you.
10. If you are unsure about anything, ask the laboratory management.
11. Report any faulty equipment or injuries to the laboratory management.

KITCHEN LABORATORY RULES AND FOOD SAFETY

1. Wash your hands thoroughly before starting work, after breaks, and whenever there is a risk of contamination.
2. Only handle food if you feel well. If you have a contagious illness, a gastrointestinal infection or certain skin conditions, you must not handle food.
3. Clean work surfaces, equipment, and utensils regularly and remove any dirt immediately. After work, return all materials used to their designated places.
4. Separate raw food from cooked food to prevent cross-contamination. Handle raw food in such a way that no germs can be transferred to food that is ready to eat.
5. Handle food as little as possible and ensure that it is not contaminated by your hands, clothing, utensils, or other food.
6. When tasting food, use clean cutlery and crockery for each tasting. Never reuse tasting spoons.
7. Observe refrigeration temperatures, use-by dates, and storage guidelines. Food intended for consumption must be clearly labelled and protected.
8. Use materials and equipment for their intended purpose and ensure that knives, blades, and electrical equipment are used safely.
9. Take particular care when handling hot surfaces and containers, as well as hot liquids, fat, and steam.
10. Take responsibility for your own safety and that of those around you. If you are unsure about anything, ask the management, and report any faulty equipment or injuries to the management.



SKIN PROTECTION



To disinfect your hands, apply the hand sanitiser to dry hands and rub it in thoroughly, as you would when washing your hands.

Ensure the recommended contact time of approximately thirty seconds is observed!



When handling food intended for consumption, special hygiene regulations must be observed.

For catering activities, training in accordance with the Infection Protection Act is required!



When working with microorganisms, hands must be disinfected after completing the task **BEFORE** washing them, so that no microorganisms can be carried out of the laboratory in the wastewater.

The same applies to work surfaces and tools: they should be disinfected before being cleaned with water.

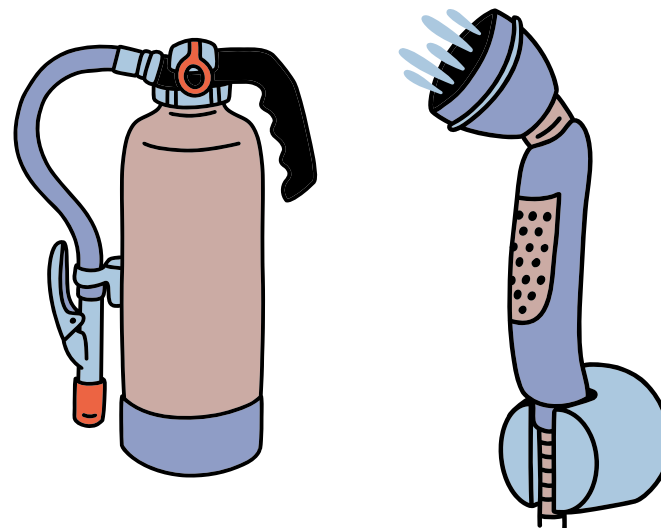
SAFETY EQUIPMENT



To ensure safe working practices in the Biolab, it is essential that all relevant safety equipment is within easy reach in the event of an emergency. Before starting any work, you must always familiarise yourself with the location of this safety equipment.

An eye wash is used if chemicals or foreign objects get into the eye. This may be permanently fitted to the sink or provided as a portable eye wash bottle in the first-aid kit. In case of emergency it is important to ensure that the affected eye is always rinsed outwards, so that the second eye is not contaminated during the rinsing process.

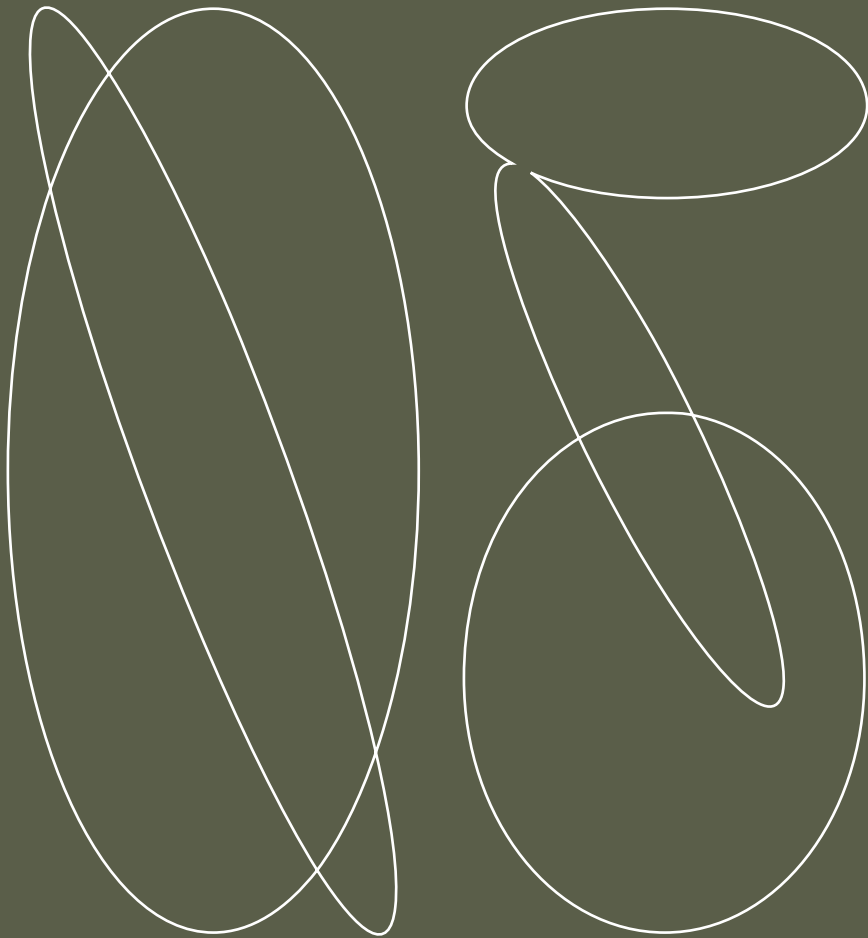
In the event of a small fire, fire extinguishers can be used. Fire extinguishers are categorised into different fire classes depending on the extinguishing agent they contain. This classification is indicated on each fire extinguisher as a pictogram. Fire class A covers fires involving solid materials, fire class B those involving liquid or molten materials, and fire class C those involving gases. Metal fires are classified as Class D, whilst oil and grease fires fall under Class F. Colloquially, based on these fire classes, ABC extinguishing foam is suitable for Class A, B, and C fires. Other common extinguishing agents include carbon dioxide, water, dry powder, or extinguishing sand to smother the fire.



If a person catches fire, for example due to clothing catching alight, a fire blanket can be used to smother the flames. It is crucial to act decisively in this situation. A person engulfed in flames may panic, which is why the affected person should be brought to the ground as quickly as possible and covered with the fire blanket.

Emergency showers are used in the event of an accident where chemicals have been spilled and a person has been doused over a large area. A first-aid kit or a permanently installed first-aid station is used to provide initial medical care in an emergency. In addition to sterile dressing materials such as gauze bandages, wound dressings, and plasters, it also contains disinfectants or more specialised items such as eye-washing solutions. First aid measures carried out and the removal of items from the first-aid kit must always be documented in writing.

Assembly points are marked areas outside a building and are used to ensure an orderly evacuation in the event of a fire or other hazards. People must proceed to these assembly points immediately so that arriving emergency services can be quickly informed of how many people may still be inside the building.



GLOSSARY

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ACCUMULATION:

The build-up of substances in tissues, cells or soil.

ACIDIC:

A property of a solution with a pH value below 7. Acidic, aqueous solutions contain an elevated concentration of oxonium ions (H_3O^+).

ALIQUOT:

A portion of a sample's total volume, for example to prevent contamination of the sample or to reduce freeze-thaw cycles.

AMOUNT OF SUBSTANCE:

A physical quantity that indicates how many particles of a substance are present in a sample.

AUTOPROTOLYSIS:

The self-dissociation of water, in which one water molecule transfers a proton to a second water molecule. This produces an oxonium ion (H_3O^+) and a hydroxide ion (OH^-).

AVOGADRO'S CONSTANT:

The number of particles contained in one mole. Its value is $6.02214076 \times 10^{23} \text{ mol}^{-1}$.

BASIC:

Solutions with a pH value greater than 7. Basic, aqueous solutions have an elevated concentration of hydroxide ions (OH^-).

BATCH CULTURE:

A static system for the cultivation of microorganisms. The culture medium and starter culture are added to the reactor at the outset. As no further nutrients are added, growth usually ceases after a few generations due

to a lack of nutrients and the accumulation of metabolites.

BIO-BASED:

Materials and substances consisting entirely or at least partly of renewable raw materials.

BOILING POINT:

The temperature at which the vapour pressure of a liquid equals the ambient pressure and the liquid begins to boil, transitioning from a liquid to a gaseous state.

BUFFER:

A biochemical system that largely maintains the pH of a solution as a measure of how acidic or basic it is, even when small amounts of acid or base are added.

CELL:

The smallest structural and functional unit of a living organism, capable of carrying out fundamental life processes (e.g. respiration, reproduction).

CENTRIFUGAL FORCE:

An apparent force acting outwards in a rotating reference frame.

CHROMOPLAST:

A plastid in plant cells that primarily contains pigments such as carotenoids, which colour plant parts yellow, orange or red, for example.

CIRCULAR DESIGN:

The aim of circular product design is to optimise a product's life cycle so that materials are kept within a closed loop as far as possible by being reused, repaired or recycled.

CONTAMINATION:

The contamination of a sample, material or culture through the introduction of undesirable substances or microorganisms.

CULTIVATION:

The targeted rearing and propagation of cells or microorganisms under specific, suitable conditions.

DEAD ZONE:

An area within a technical or biological system in which there is little to no mass transfer or flow.

DILUTION SERIES:

A series of samples in which an initial sample is diluted step by step at defined intervals. Used, for example, to plot calibration curves.

DISPERSION:

A heterogeneous mixture of at least two different substances, in which one substance (the dispersed phase) is distributed in a very fine form within a dispersion medium.

ENERGY:

An important physical quantity that can occur in various forms, such as electrical, chemical, kinetic or thermal energy. In a closed system, the total energy of the system is always conserved, but it can be converted into other forms of energy.

ENZYME:

Large biomolecules, often proteins, which catalyse biochemical reactions and play a key role in the metabolism of organisms, for example in the digestion of nutrients and the replication of genetic information.

FABLAB:

Colloquial abbreviation for 'fabrication laboratory', an open workshop aimed at making modern manufacturing processes accessible to a wider section of society.

FERMENTATION:

A biological process in which microorganisms convert organic substances such as sugar, under certain conditions, into other substances such as acids, gases or alcohol.

FOOD DESIGN:

The field encompasses all aspects of design relating to food, such as recipe development, as well as presentation and packaging design.

GENE EXPRESSION:

A molecular biological process in which the genetic information of a gene is used, for example, to synthesise RNA or a protein.

HETEROGENEOUS SYSTEM:

A mixture of substances in which the various substances or phases are not uniformly distributed and are macroscopically distinguishable.

HOMOGENEOUS SYSTEM:

A mixture of substances that has a uniform composition.

INOCULATION:

The introduction of microorganisms or cells into a culture medium for propagation or further investigation.

ISOTOPE:

Different atomic forms of a chemical element which differ in their neutron number.

LIGHT ABSORPTION:

The absorption of light by a substance, whereby the light energy can be converted, for example, into heat or other forms of energy.

MAKERSPACE:

An open workshop designed to provide a space that makes fabrication methods and processes more accessible to a wider audience.

METABOLITE:

An intermediate or end product of a metabolic process.

MICROORGANISMS:

Microscopically small organisms such as bacteria or fungi, which cannot be seen individually with the naked eye.

MOLARITY:

The molar concentration of a solution. This indicates how many moles of a substance are contained in one litre of solution.

MOLECULAR MOTION:

The constant movement of molecules due to their thermal energy. At absolute zero ($-273.15\text{ }^{\circ}\text{C}$), there is no longer any classical molecular motion; as the temperature rises, molecular motion increases.

MOLECULE:

A chemical particle consisting of at least two atoms bonded together.

MYCELIUM:

A thread-like network in fungi, consisting of interwoven hyphae.

NEUTRAL:

Solutions that are neither acidic nor basic / alkaline. At $25\text{ }^{\circ}\text{C}$, this corre-

sponds to a pH of 7.

OPTICAL DENSITY:

A measure of the extent to which the sample under investigation absorbs incident light. It is used in microbiology to estimate the cell density of a culture.

OXIDATION:

A chemical reaction in which electrons are released. It frequently occurs in combination with oxygen.

pH indicator: A chemical compound that indicates the pH range of a solution through a visible colour change.

PH VALUE:

A measure of how acidic or basic an aqueous solution is. A low pH value (<7) describes acidic solutions, whilst a high pH value (>7) indicates a basic solution.

PHASE TRANSITION:

The transition of a substance from one state of matter to another, for example during melting (solid to liquid).

PRE-CULTURE:

A preliminary stage of a cell or microorganism culture. This is usually used later on to inoculate the main culture.

REACTANT:

A starting material in a chemical reaction that is converted in the course of that reaction.

REACTION (CHEMICAL):

A process in which starting materials (reactants) are converted into new substances (products). In the process, new chemical bonds are formed.

RECEPTOR:

A molecule or cell component that

recognises and binds specific messenger substances or signals, thereby triggering a reaction or a cascade of reactions within the cell.

SECONDARY METABOLITE:

An intermediate or end product of metabolic reactions that is produced within a cell under the influence of enzymes, but is not immediately necessary for basic life processes.

SI UNIT:

A standardised, defined unit of the International System of Units (Système international d'unités), for example metre for length or kilogram for mass.

SOLUTION:

A homogeneous mixture of two or more substances, in which one substance is dissolved in a solvent.

SPORES:

Specialised, often particularly resilient forms of certain microorganisms and fungi that facilitate dispersal and survival.

STERILE:

Free from microorganisms capable of reproduction. Sterility can be achieved, for example, by autoclaving or other sterilisation methods.

STOICHIOMETRY:

The study of the quantitative relationships between substances in chemical reactions. It describes the ratio in which reactants are converted and products are formed.

STOKES-EINSTEIN RELATION:

A relationship in physics that describes how the diffusion coefficient of a small, spherical particle depends on tempe-

rate, the viscosity of the medium and the particle size.

SUSTAINABILITY:

A general principle of action whereby resources are used in such a way that present needs can be met whilst preserving the ability of resources to regenerate for future generations.

SVEDBERG EQUATION:

An equation describing the sedimentation behaviour of particles during centrifugation. In addition to the mass, particle density and shape of the particle, the properties of the medium are also taken into account.

THERMODYNAMICS:

A branch of physics and chemistry that deals with energy, heat, work and their transformations within systems.

WAVELENGTH:

The distance between two consecutive points of equal phase on a wave. In the case of light, the wavelength determines, among other things, the perceived colour; for example, red light has a wavelength of approximately 650 nm .

LIST OF ABBREVIATIONS:

A _r	relative atomic mass
BioStoffV	Biological Agents Ordinance
CLP	classification, labelling and packaging
DIY	do it yourself
DNA	deoxyribonucleic acid
GHS	Globally harmonized system of classification and labelling of chemicals
HEPA	high efficiency particulate air
M	molar mass / molar
mbar	millibar
mL	millilitre
L	litre
nm	nanometre
pH	potential of hydrogen
PPE	personal protective equipment
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
TRBA	Technical Rules for Biological Agents
UNESCO	United Nations Educational, Scientific and Cultural Organization
°C	degree Celsius
K	Kelvin
HACCP	Hazard Analysis and Critical Control Points

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