YEAST-O-GRAMS

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Yeastogram CoCoon

The art of making living picture out of yeast.

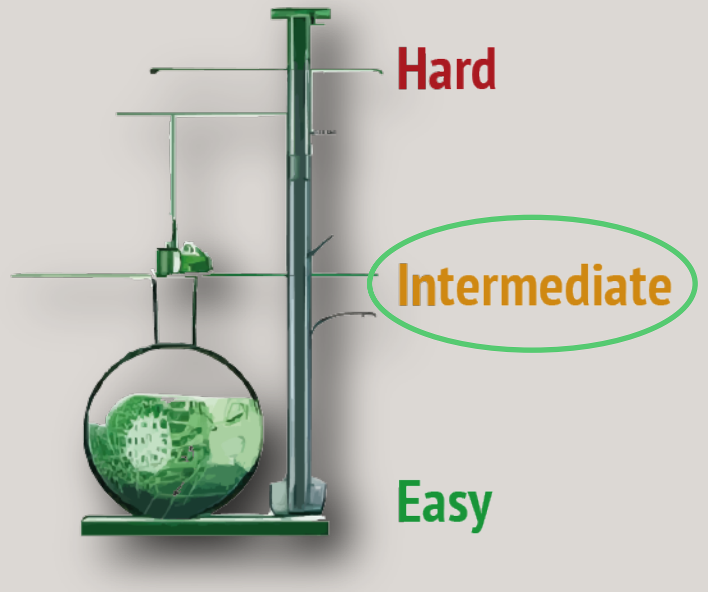
Timeline

Days

Day 1:
- Prep growth medium
- Prepare stencil

Day 2:
- Prep yeast solution
- Combine growth medium and yeast
- Place under UV light for 24 hours

Day 3:
- Collect yeastogram



1|ABOUT

A Yeastogram is a picture made from yeast. It is similar to the process of printing black-and-white photographs. In black-and-white photography printing, you start with the film or a small version of the picture that you have taken with the film camera. Then the film is printed onto a piece of paper. The creators of the yeastogram process described it as "a method to cultivate baker's yeast and to shape the cultivation according to aesthetic and artistic decisions" pavillon_35 (Seyfried & Czjzek, 2013).

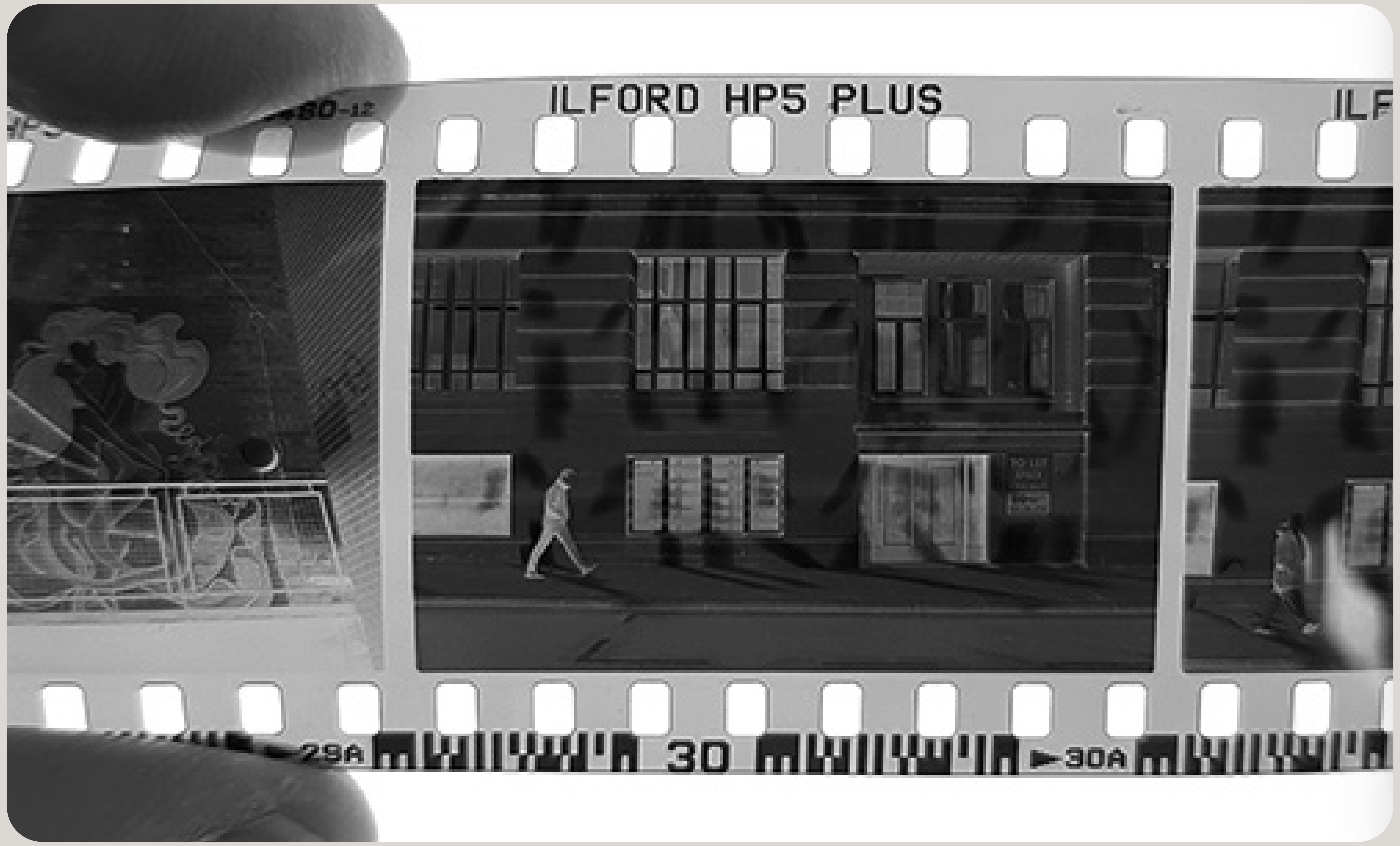


Photo of black and white film (Meehan, 2020)

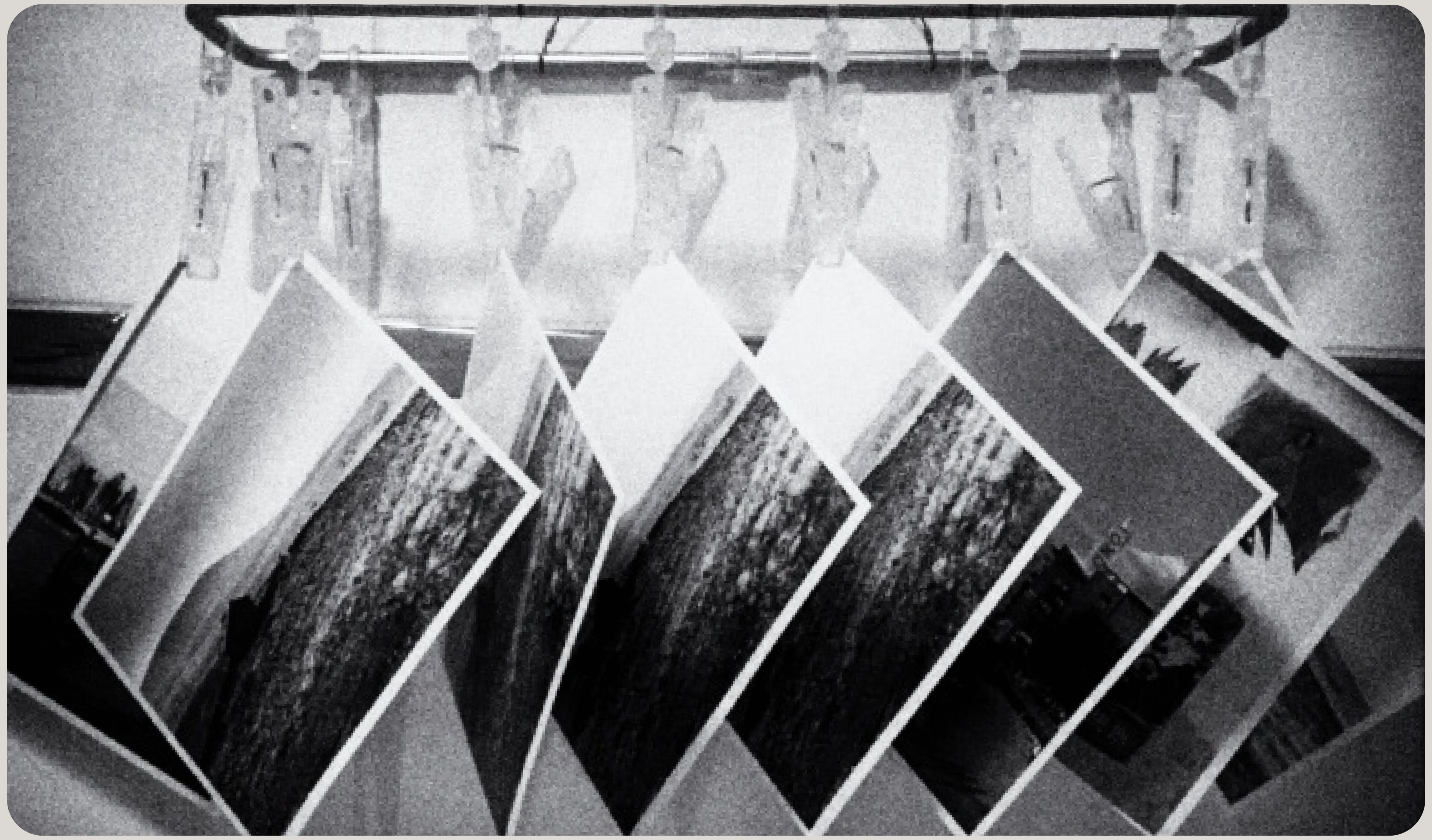


Photo of B&W photography prints (Prior, Rory, 2019)

This printing process of black and white photos starts in a dark room where the main tool needed is an enlarger that shines light through the film and light-sensitive paper. When the enlarger shines light through the film it casts shadows onto the light-sensitive paper, developing the picture. As the paper is sensitive to light it will turn black in the places the light shines, a bit like a burn. However, under the shadow, the paper is protected and will stay white or a shade of grey. Then the photo paper is washed in chemicals to ensure the light-reactive aspect of the paper is no longer active. The yeastograms have the same properties, the yeast grows under the shadow that protects them from the UV light that kills the yeast developing a picture.

1.1|What is the Module?

This module will explain how to make yeastograms and give all the information and tools needed to do so whether it be in a bio-lab, biology class, or in a Fab Lab.

There are a lot of aspects to making yeastograms. This module is designed to give you all tools to teach you how to make a yeastogram. This module is broken down into 9 chapters.

1.2|What is the Organism

For the yeastogram project, the organism being used is yeast. Yeast is a single-celled fungus. Yeast feeds on sugars and produces ethanol and CO_2 as a by-product. That is why yeast is used in brewing and baking. In brewing the end goal is ethanol and in bread making the end goal is the CO_2 which makes the bread rise. (Yeast | Definition & Uses | Britannica, n.d.)

Photo of Yeast ("All About Yeast," n.d.)

1.3|Yeastogram process

Similar to developing a black-and-white photograph a yeastogram uses light and shadow to develop an image using organisms sensitive to UV light. The stencils are like the film, the UV lightbox setup is the enlarger, and the yeast and growth medium is the light-sensitive photo paper. Just like with film development, the growth is dependent on where the stencils block the light to cast shadows. When the yeast is exposed to UV light over a 24-hour period of time the yeast exposed to light will die off, while the yeast protected by the shadow will grow and turn light. Therefore the colour of the stencil needs to be inverted; blacking out spaces where the yeast should grow.

SCOBY mothers kept in a small glass

SCOBY mothers kept in a small glass

HEALTH AND SAFETY

BSL-1

For work involving BSL-1 organisms, such as non-harmful bacteria, a sterile lab is not strictly necessary, but a clean and controlled workspace is essential. You can conduct these activities in a well-maintained studio or similar environment outside of a traditional laboratory, provided the space is organised and protocols are in place to minimise contamination and ensure safety. Ensure that surfaces are disinfected before and after work, and avoid areas where food is prepared or consumed. Additionally, restrict access to the workspace during experiments to avoid unintentional exposure or contamination of materials.

SPACE

•Lab environment
(bioFABLAB, biology classrooom or a very clean kitchen canbe use

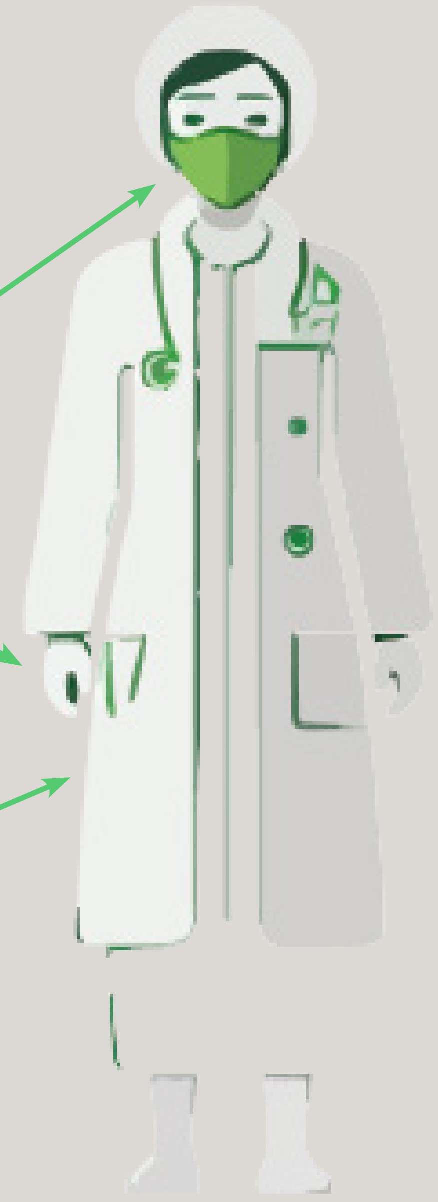
•Access restrictions
(guests can bring new contaminants)

STYLE

•Glove up
(witch clean hand)

•Mask up
(nose and mouth)

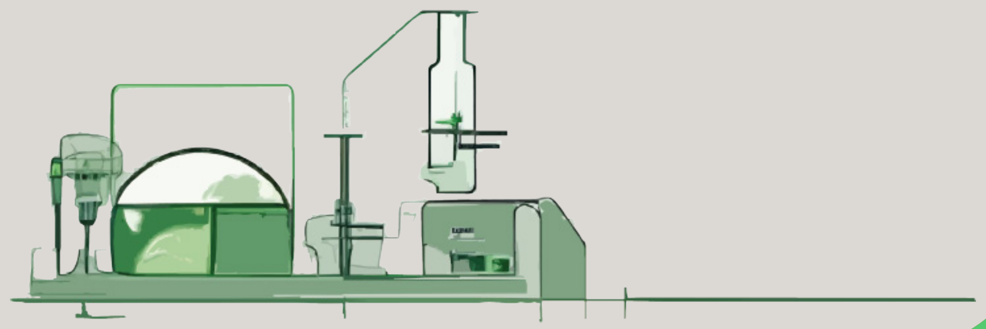
•Dress up
(like a pro)



STERILISE

•Ingredients
(keep ingredients in closed containers)

•Tools
(clean all tools)



•Tables
(clean all surfaces and workbenches)

2|SOURCING

This chapter of the module is to help you prepare for the experiments. Sourcing the ingredients is quite straightforward as most can be bought at a normal grocery store.

2.1|Sourcing Living Organism

The easiest living organism to source is baker yeast. This can be found at most grocery stores.

2.2|Sourcing Ingredients

Most growth medium ingredients can also be bought at a grocery store. Sometimes finding Agar Agar can be difficult. It is easiest to find it online, however vegan and health stores are the most likely to carry it. Isopropyl alcohol can be found in most pharmacies or bulk industrial cleaning stores. Below is a list of the needed ingredients.

Growth Medium Ingredients

- [ ] Distilled Water
- [ ] Sugar
- [ ] Malt extract
- [ ] Agar agar
- [ ] Activated Coal - Activated Charcoal
- [ ] Food colouring
- [ ] Bakers Yeast Distilled Water
- [ ] Sugar
- [ ] Agar agar
- [ ] Activated Coal - Activated Charcoal
- [ ] Food colouring
- [ ] Bakers Yeast
- [ ] Isopropyl alcohol

Recipe

- [ ] 250 ml distilled water
- [ ] 5 - 25 g sugar
- [ ] 5 g malt extract
- [ ] 3,75 g agar agar
- [ ] 6-8 drops of food colouring

2.3|Tools and Equipment

Much of the equipment can be found or modified from normal kitchenware. In the lab equipment section, we have outlined equipment but also have suggestions for similar equipment that may be easier to find.

General

- [ ] Laboratory book
- [ ] Kitchen towels
- [ ] Microwave oven
- [ ] Hotplates or stove
- [ ] Pot
- [ ] Precision or kitchen scales
- [ ] Spoons
- [ ] Clear plastic paper (Optional)
- [ ] Permanent marker

Equipment

- [ ] Camping stove
- [ ] Laminar flow hood (Optional)
- [ ] Pressure cooker (or Autoclave)
- [ ] Beakers
- [ ] Laboratory bottles (pickling jars)
- [ ] Drigalski-Spatula (or spoon)
- [ ] Centrifuge Tube
  (or small ~100 ml sealed glass jar container)
- [ ] Pipette

Health and Safety

- [ ] Laboratory gloves
- [ ] Safety Glasses
- [ ] Lab Coat
- [ ] Fine Particulate Dust Mask (Optional)

2.4|Spatial Requirements and equipment

A clean lab environment is ideal such as a biology classroom. A kitchen can also work as you will have access to a stove, a sink and running water. Good ventilation is also important.

Sterile Zones

First, it is important to cover sterile zones. This is an important aspect when working with biological subjects. At some points of making yeastograms, it is important to make a sterile zone. This is to ensure that no outside contamination occurs. There are two main ways to ensure that the workspace is sterile. The first is to use a laminar flow BIO hood and the second is to use an open flame.

Most designers don't have access to a laminar flow hood and will need to use the open flame method, using a Bunsen burner or camping stove.

Before Checklist

- [ ] Have a fire extinguisher or blanket nearby.
- [ ] Make sure the room is ventilated.
- [ ] Make sure there is nothing flammable in the area.

Create a Sterile Zone

1. Clean all glassware with 70% or more isopropyl alcohol solution and let dry.
2. Clean the surface with 70% or more isopropyl alcohol solution and let dry.
3. Place a camping stove or bunsen burner in the area where a sterile zone is needed.
4. Light the flame.

This method will create a sterile zone in a radius of approximately 50 cm to work by (Seyfried & Czjzek, 2013). More information on preparing a sterile environment can also be found in this teaching material (O'Connor, 2018).

2.5|Moulds and Containment - Requirements & Why "parameters"

This section will discuss a basic lightbox. The development of the yeastogram relies upon controlling its exposure to light. The lightbox creates the environment for the image to develop in the petri dish.

Lightbox

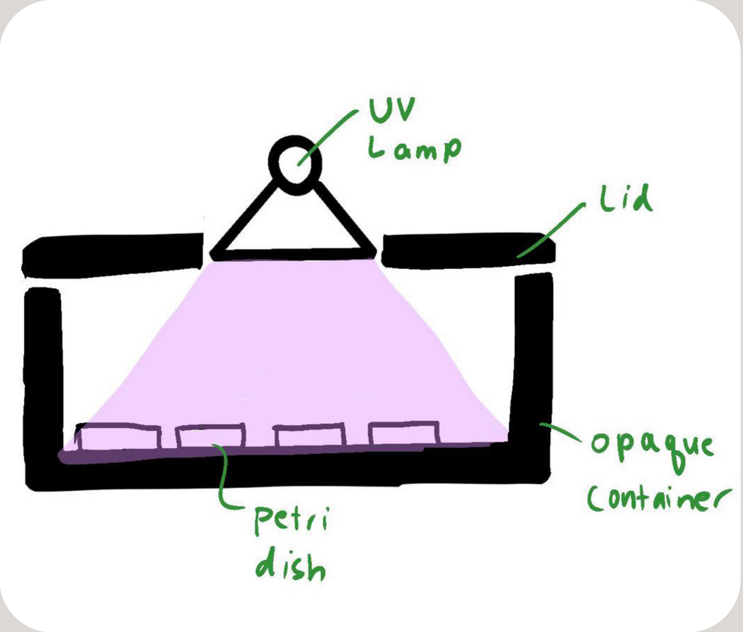
Ideally, the yeast-covered Petri dishes will only be exposed to UV light and no other light sources during development. There are of course many ways to build a lightbox setup, but a simple method is to place the petri dishes and UV lamp in an opaque box.

Instructions on making a from-scratch lightbox will be included in the Fab Techniques section.

Lightbox Equipment

Box
- Opaque
- 4 petri dishes = 15 cm^3
- Plastic, Cardboard, ect.
- IKEA - SOCKERBIT

LED
- 390-410 nm
- Minimum power 3 W



Recommended Setup

TIP!

•Exposure to sunlight and certain angles might ruin the experiment.

3|PREP (DAY 1)

3.1|Prep Stencils

The stencil is an important part of the yeastogram as that makes the picture. Anything that can cause a shadow on the petri dish will produce some image after exposure to UV light. Many different types of stencils can be used to make yeastograms. In the Fab Techniques chapter making a stencil out of stick-on vinyl.

If you don't have access to vinyl, draw on the lid or the clear plastic paper with a black permanent marker.

Ingredients

Petri dish lid or plastic paper
Permanent marker

Instructions

Draw an image by hand on the sterilised lid or the clear plastic paper. If using the paper then cut the image to shape. Store Petri dish lids or stencils in a clean area to avoid contamination.

Photo of different stencil types

TIP!

•Black vinyl stickers work well and create a high contrast images as the light can't pass through the sticker
•Exposure to sunlight and certain angles might ruin the experiment.

Note!
Exposure to sunlight and certain angles might ruin the experiment.

Example of hand drawn stencil (Miyazaki)

Close up of vinyl cut stencil

3.3|Prep Growth Medium

Tools

- [ ] Metal whisk
- [ ] Medium pot with a lid.
- [ ] Isopropyl spray.
- [ ] 4-6 Petri dishes sterilised
- [ ] Bunsen Burner (or Camping Stove)

Ingredients (FabLab_RUC, 2018)

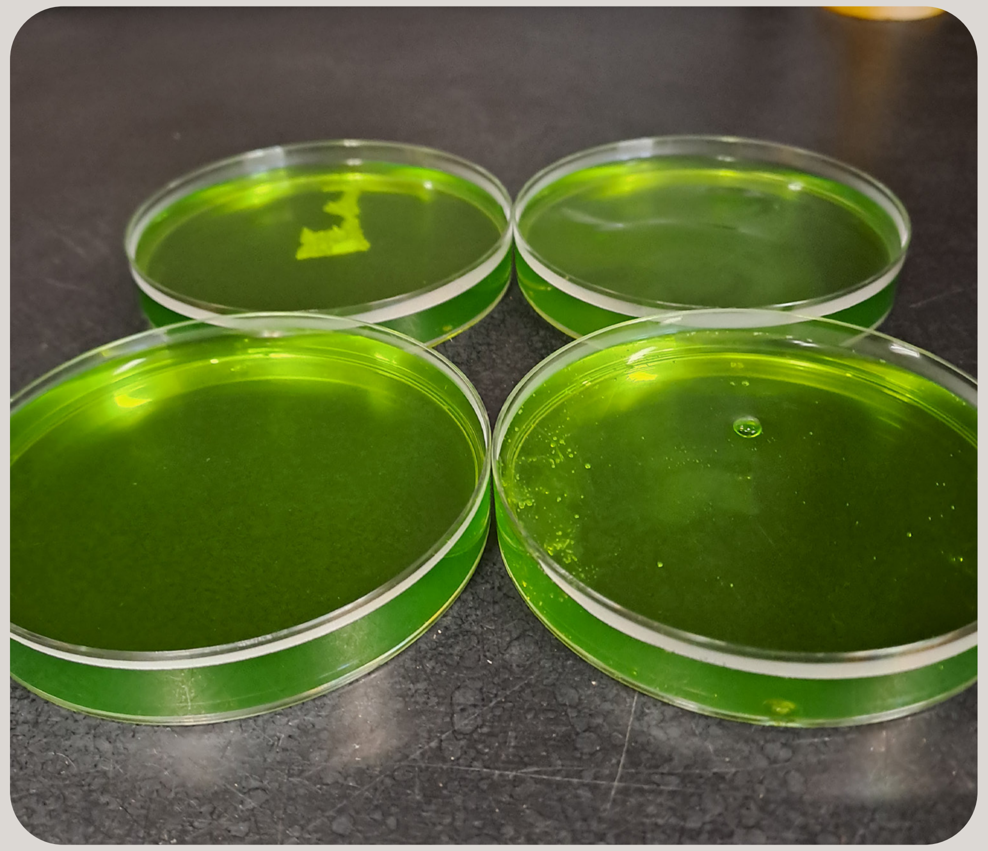
- [ ] 250 ml distilled water
- [ ] 5 - 25 g sugar
- [ ] 5 g malt extract
- [ ] 3,75 g agar agar
- [ ] 6-8 drops of food colouring

TIP!

• In this recipe, we are using the stovetop method for sterilisation. If you do have an Autoclave us a method you like for growth mediums.

TIP!

• This will make a growth medium for 4 petri dishes. Make a bigger batch if you want to prepare more petri dishes.



Petri dishes with growth medium

Instructions

Mix and sterilise growth media

1. Measure and pour 250 ml water into the pot
2. Bring water to a low boil
3. Add all other ingredients to the boiling water
4. Whisk until the material is dissolved
5. Let the solution boil for 5 minutes under a closed lid

Caution: When using fire for a sterile zone have a fire extinguisher or blanket nearby. Make sure the room is ventilated and there is nothing flammable in the area.

Transtion and Cooling

1. Create a sterile zone
   a. Clean all petri dishes with 70% or more isopropyl alcohol solution and let dry
   b. Clean the surface with 70% or more isopropyl alcohol solution and let dry
   c. Place a camping stove or bunsen burner in the area where a sterile zone is needed
   d. Light the flame
2. Place the closed pot in a sterile zone and let cool
3. Wait until the pot is cool enough to touch

Pour into Perti dishes

1. Place Petri dishes and growth medium in the sterile area.
2. Pour growth medium into the Petri dishes until they are at least half full.
3. Place the lid on the Petri dishes

Storage

1. Place the dishes in the fridge to solidify
2. Remove condensation from the lids once or twice a day with a clean paper towel.
3. Use within 1 to 2 days after going in the fridge

When the growth medium is firm like jelly then it is in a usable state.

4|MAKE AND GROW (DAY 2)

In this chapter you will finish making the yeastogram and place it into the UV lightbox.

4.1|Make the yeastogram

Tools

- [ ] Pot
- [ ] 200 ml glass jar centrifuge tube (or small glass jar)

Premade Ingredients

- [ ] Petri dishes with solidified growth medium

Ingredients (FabLab_RUC, 2018)

- [ ] 45 ml of Sterilised Water
- [ ] 0,23 g of baker's yeast
- [ ] 0,5 g sugar - optional

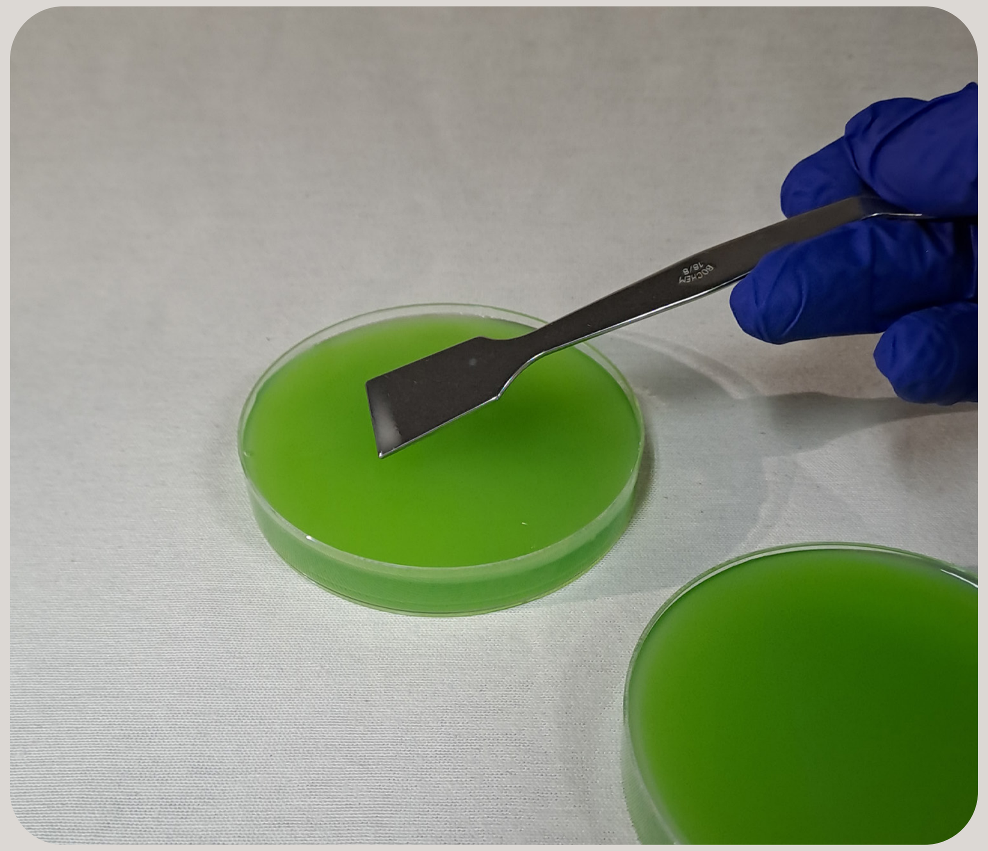


Photo of yeast solution on growth medium

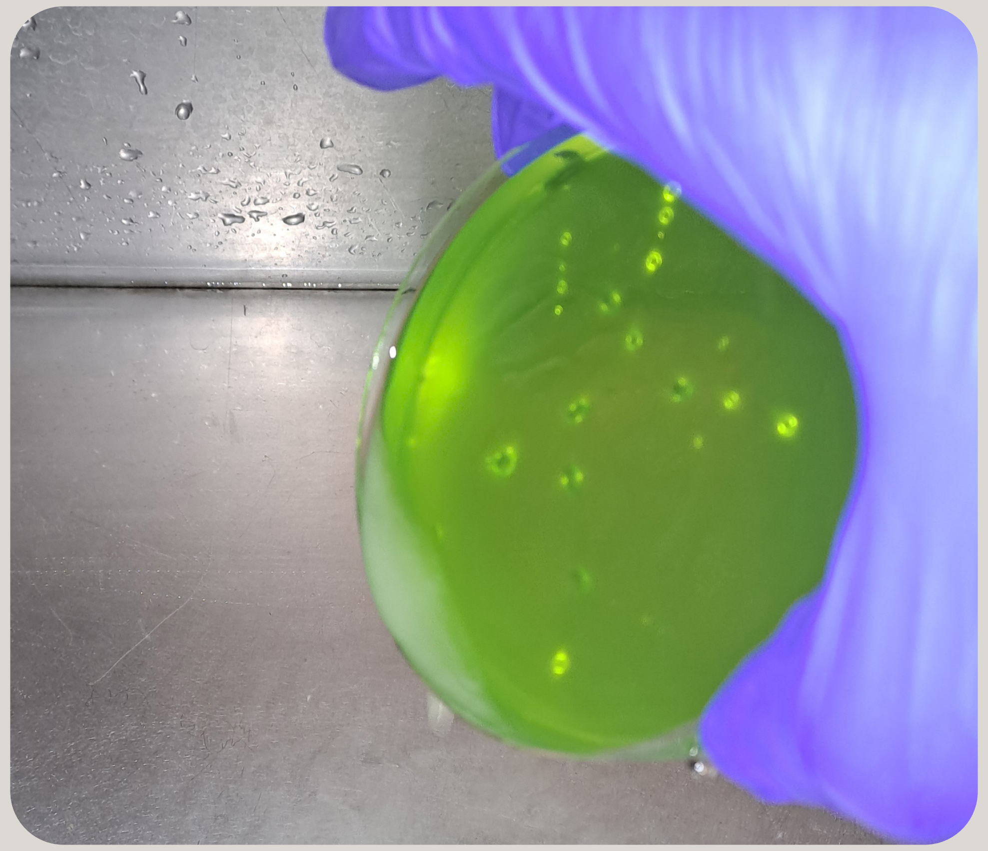


Photo of step 5 in Introduce the yeast to the medium

TIP!

•This formula fits into a 50 ml centrifuge tube and should make enough yeast solution for 2-4 petri dishes.

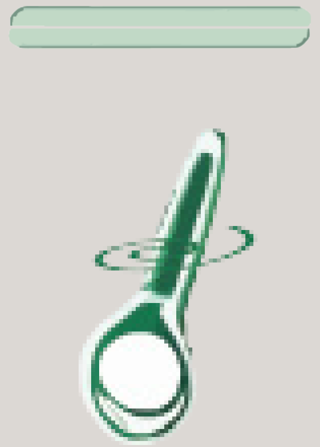
Instructions

Sterilising water

1. Measure 45 ml of water in a centrifuge tube
2. Place the centrifuge tube in a pot and add water Pour the water into a centrifugal tube to a level that covers half the centrifuge tube
3. Bring water to a boil and boil for at least 5 minutes
4. Let cool for at least 5 minutes

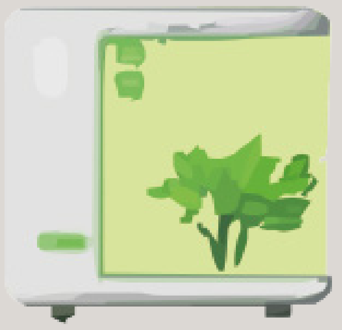
Dissolve yeast

1. Check if the centrifuge tube is cool enough to touch
2. Measure 0,23 g yeast
3. Open the centrifuge tube and pour the yeast into the water
4. Close the tube and shake the tube until the yeast is fully dissolved



Introduce the yeast to the medium

1. Bring the growth medium and yeast solution from the refrigerator to a sterile zone
2. Remove the lid from the petri dish
3. Pour yeast solution into the petri dish
4. Use a spatula or spoon to massage the yeast into the growth medium
   - Make sure that to damage the growth medium
5. Then pour the yeast medium until the last drop



Storage

1. Place the lid with the stencil onto the petri dish
2. Place the petri dish into the UV lightbox
3. Make sure the light fully covers the petri dish
4. Let the light expose the yeastogram for 24 - 48 hours

4.2|Growth Conditions

Optimum temperature range
The optimal tempature is 25 degrees C. The minimum tempature is 15 degree C.

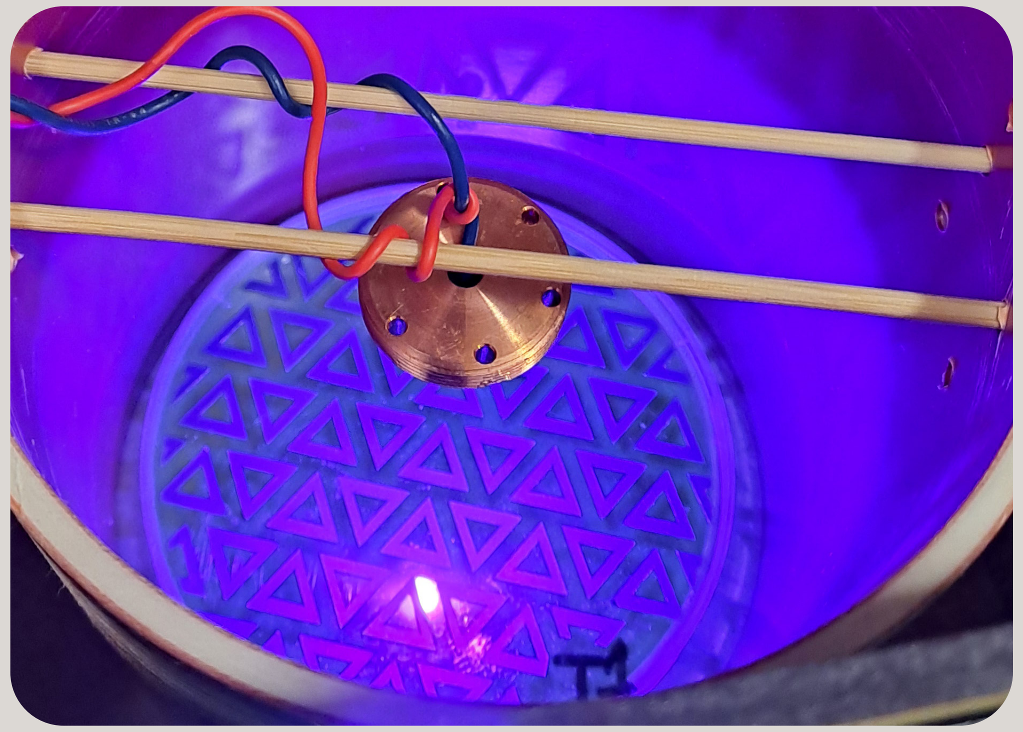
pH
In the growth medium recipe you can check the pH after boiling it. The pH should be 5,5.

Sunlight
Make sure to grow the yeastogram out of direct sunlight. Any exposer to the sun may effect the result of the final yeastogram.

Sunlight
Make sure to grow the yeastogram out of direct sunlight. Any exposer to the sun may effect the result of the final yeastogram.

Tip!
24 hours is sufficient, however, overexposure will not hurt the result.

Photo of yeastogran



How the Petri dish looks in the lightbox

Photo of Yeastogram tube

Photo of lightbox used in this module

5|HARVESTING (DAY 3)

After 24 hours under the UV light, your yeastogram is complete. You should see the yeast right away. The yeast will continue to grow after being taken out of the lightbox. Sometimes the yeastogram is faint at first and becomes more noticeable after a few days.

Photo of two different yeastograms
Note: Left - vinyl, Right - permanente marker

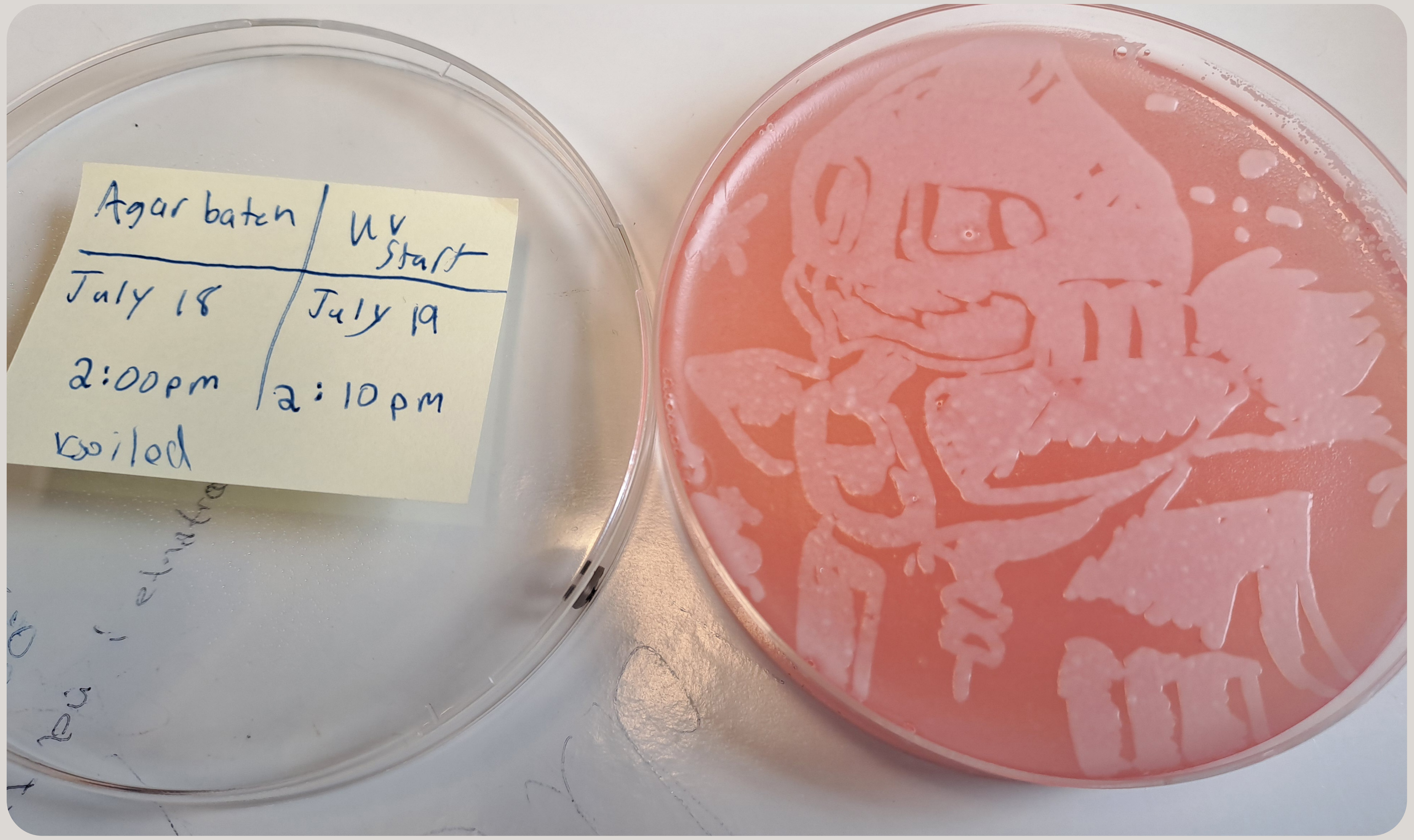


Photo of yeastogram (Miyazaki)

Photo of yeastogram made with vinyl

TIP!

•At this step it is possible to switch back to a clear lid for easier monitoring in storage. Sanitise the stencil lid will isopropyl alcohol and use later.

6|STORAGE AND DISPOSAL

6.1|Storage

To store them it is recommended that a new lid is placed on them and they are placed in a cool dry place. It might make sense to get some kind of storage container. Make sure that there is no mould growth on the yeastogram. Mould can cause respiratory issues for people exposed.

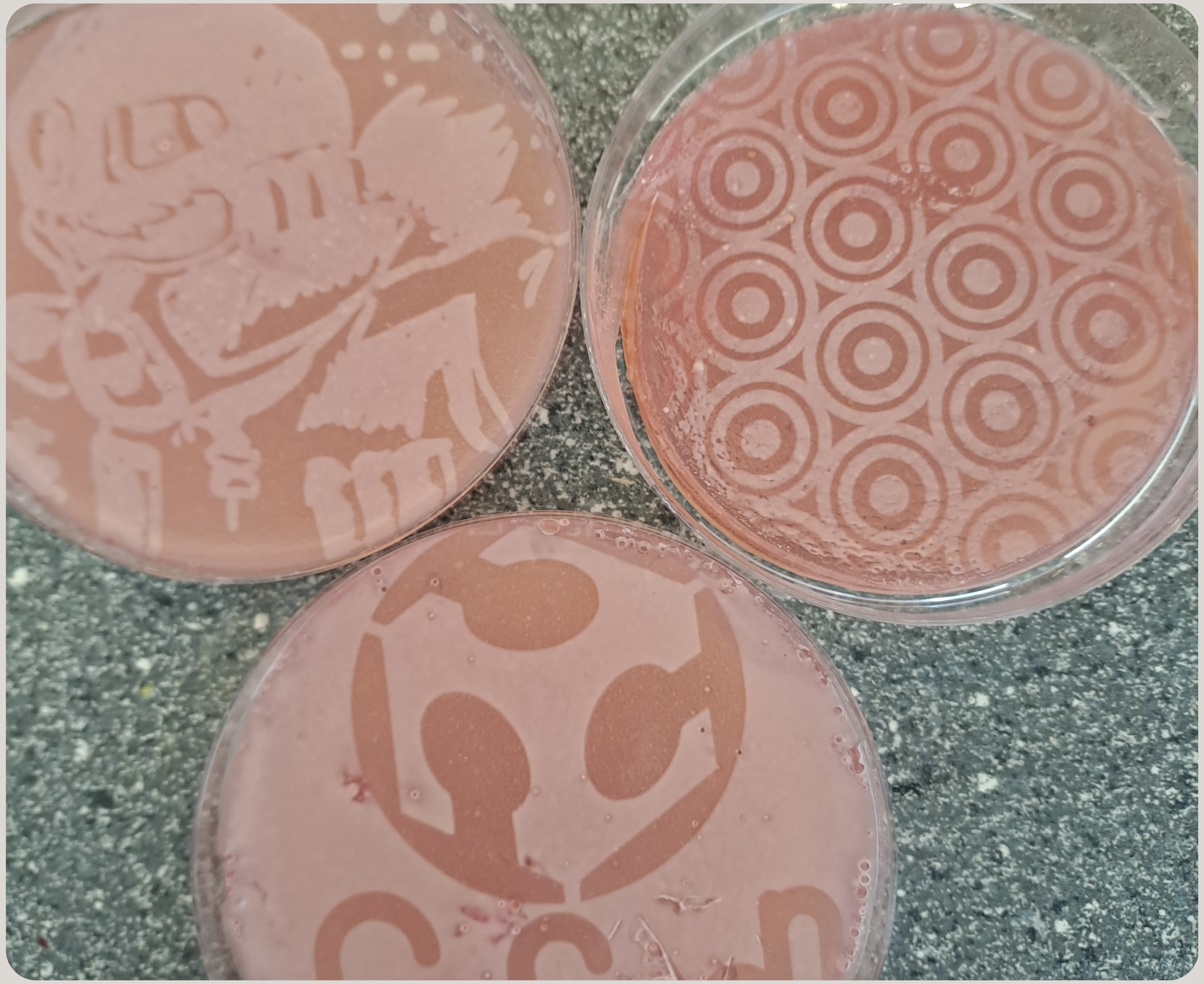


Photo of yeastogram stored for 1 month+

6.2|Disposal

Once you have decided that the yeastogram is ready for disposal here are some general instructions.

If mouldy then it is important that you do not open the lid of the petri dish. Wrap the petri dish in a plastic bag and dispose of the dish in the general waste.

If the yeastogram is not moulded then it is possible to remove the yeastogram from the dish and dispose of it in the bio-food waste. Generally, it is not a good idea to reuse petri dishes for new yeastograms. But, it is possible to save the dish and sanitise it for a project that does not require very sterilised Petri dishes.

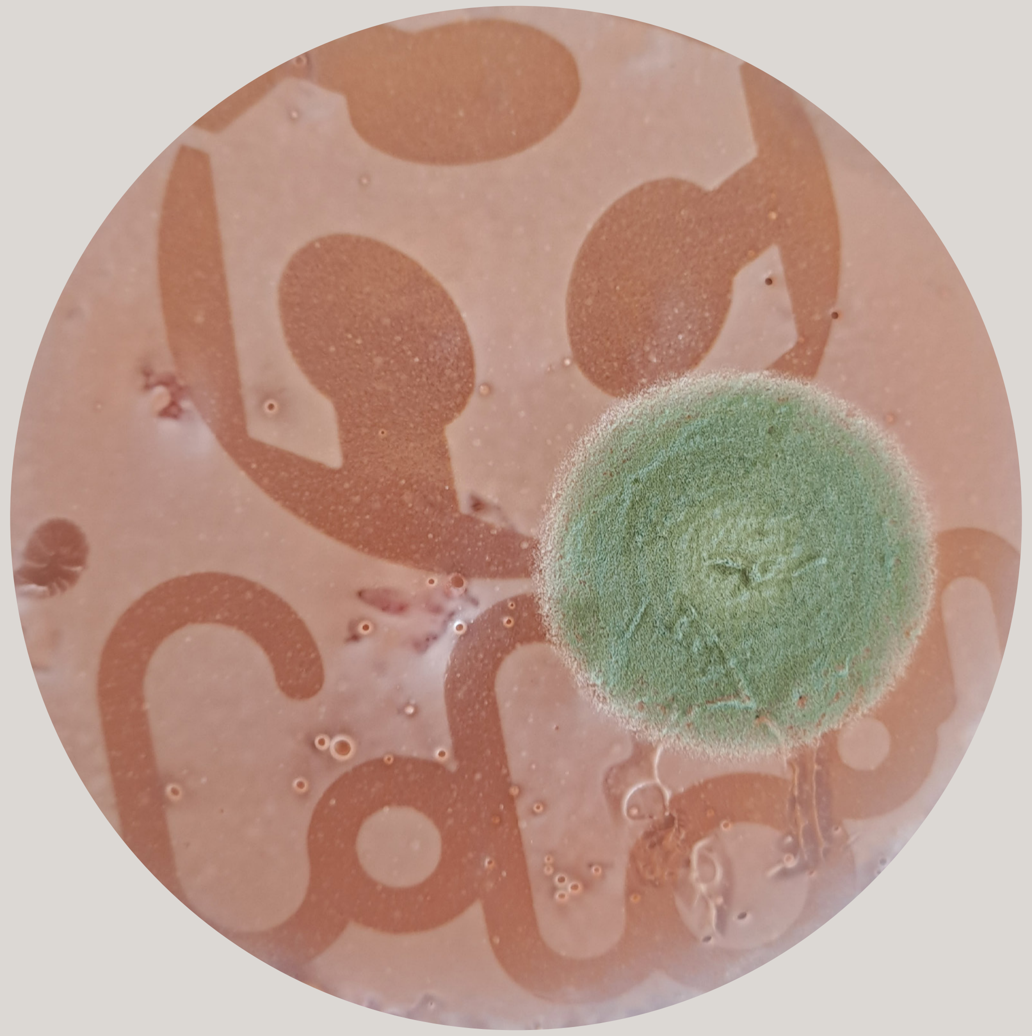


Photo of yesatogram with mould

TIP!

•At this step it is possible to switch back to a clear lid for easier monitoring in storage. Sanitise the stencil lid will isopropyl alcohol and use later.

7|REPLICATION

To continue this project we have provided an additional formula in Appendix D. Pavillon_35 Recipe. This formula can use the instructions from above. The only difference is the ingredients. Also, don't be afraid to try different methods for the making of the yeastogram.

Please feel free to contact the CoCoon group if you have any questions about this project. There are also other great bio-design resources available in the CoCoon modules.

The yeastogram project does not stop here. The CoCoon team will be making supplemental information based on the work done to make this module including workshop instructions for the Yeastograms.

Finally, the work continues with you. The CoCoon project's goal is to make bio-design more accessible for people in the world. Please share your work and tag us @cocoon.bio on Instagram.

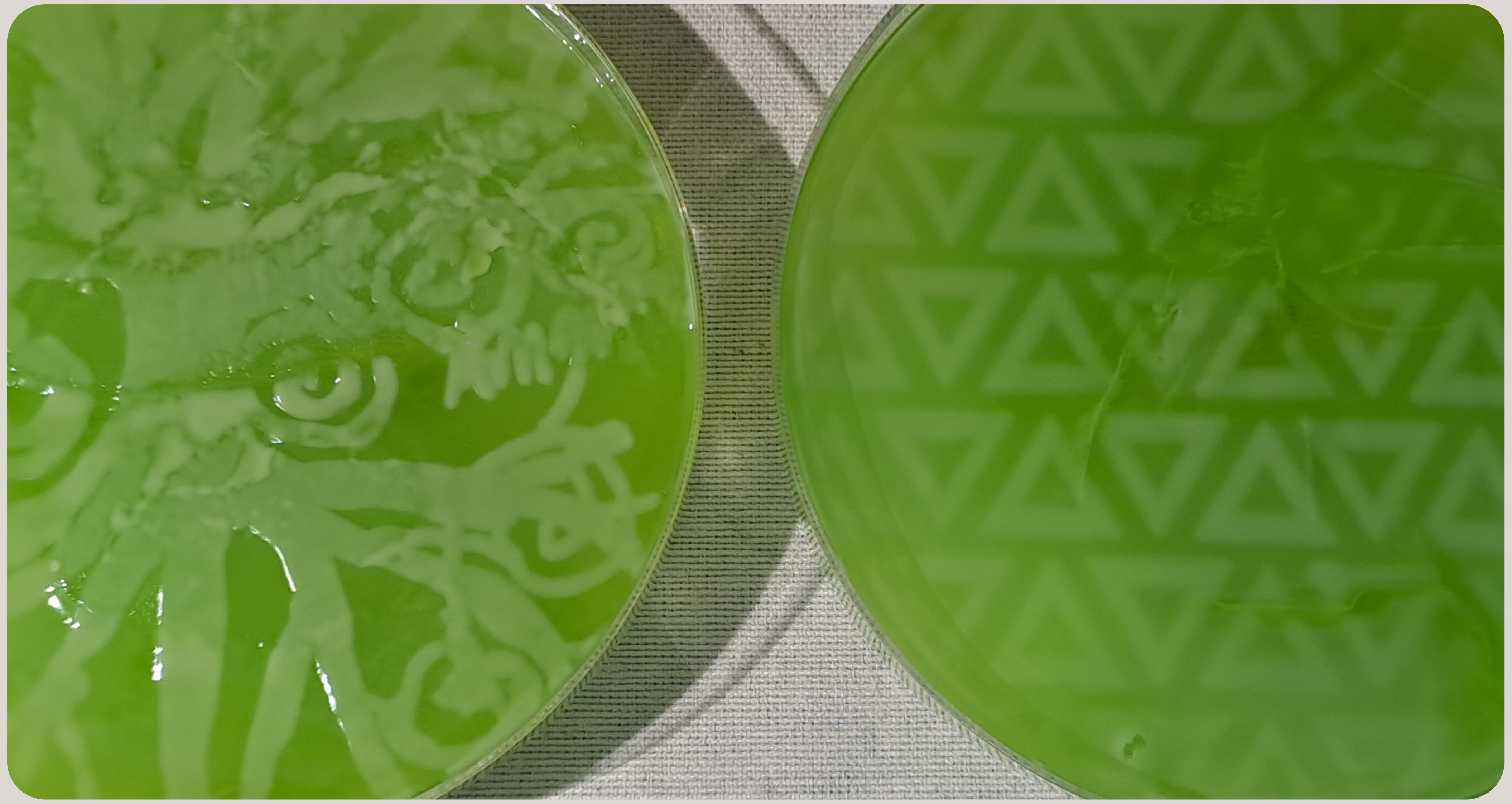


Photo of two yeastograms
Note: Left - hand drawn, right - vinyl

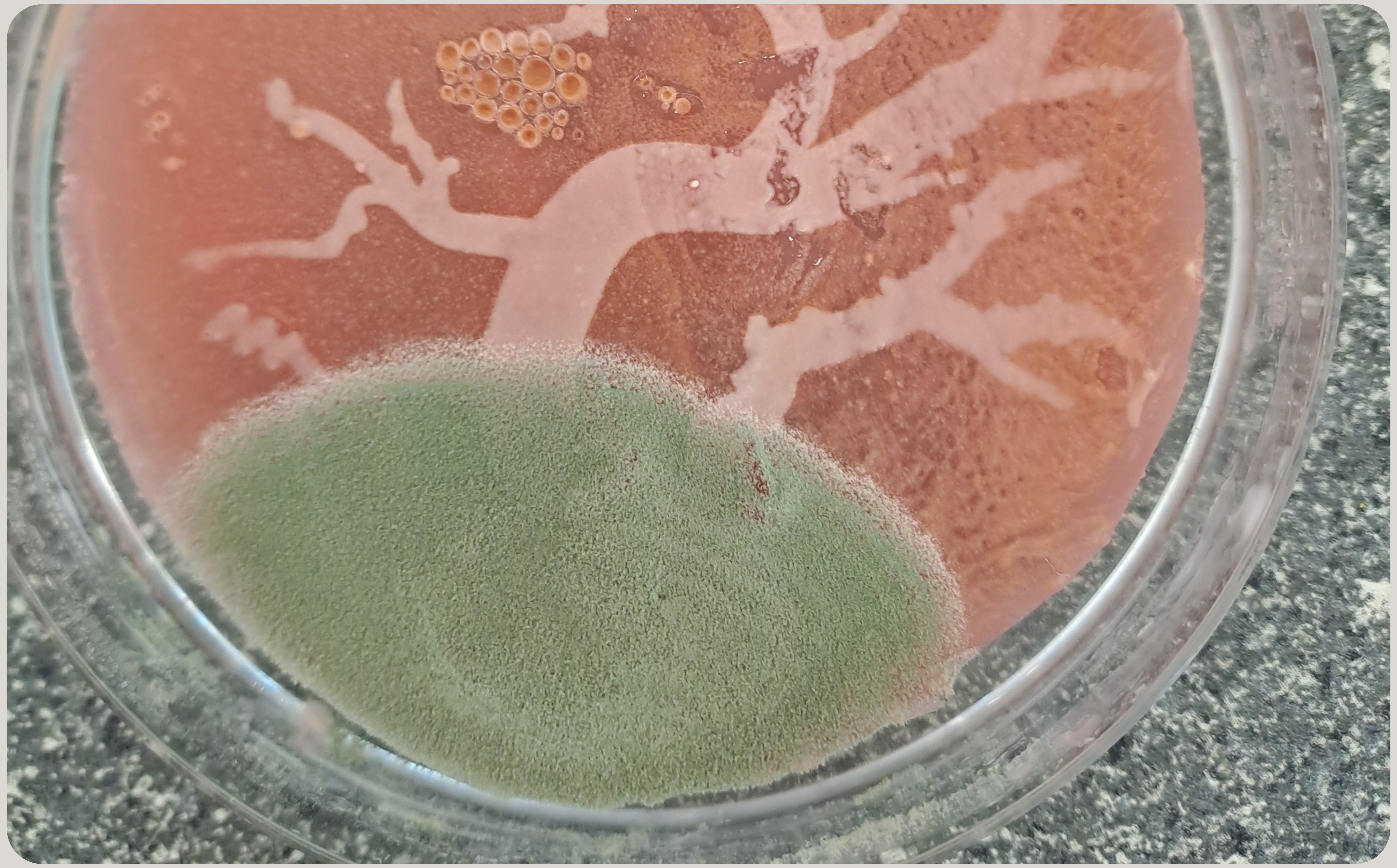


Photo of mould on yeastogram

Close up photo of yeastogram

TIP!

•At this step it is possible to switch back to a clear lid for easier monitoring in storage. Sanitise the stencil lid will isopropyl alcohol and use later.

8|FAB TECHNIQUES

So for the yeastogram project, there are a lot of things in this module that can be improved using a Fab Lab and fabrication techniques

8.1|Lightbox

The lightbox that is discarded in the containment is the basic possible setup to get started with the yeastogram. However, it is not designed with the yeastogram specifically in mind. Below are examples of different light boxes and also the specific specifications of the key parts.

In general, when designing box material for the lightbox some criteria will need to be considered: size, number of dishes, coverage from external light, and accessibility of items. This can be played around with, but here we will detail some methods.

The light box used for the making of this module used PVC tubing for the internal supports. This is because it was cheap and easily modified. It was important to have flexibility on the height at which the LED was away from the petri dish. So, holes were drilled at different heights on the pipe to allow for adjustment.

Photo of the lightbox made in the Fab Lab

Components

Lightbox Electronics

In Fab Lab Reykjavík the team used 390 nm 3 W LEDs. However, the Fab Lab RUC (2018) team used 410 nm LEDs and 350 mA approx 500 mW which was more closely in line with the original pavillon_35 work.

In the appendix, there will be information on where to buy these LEDs, but ultimately it is a personal preference. However, it is recommended that the LED is at least 3 watts to ensure that it is bright enough to cover the petri dish. One 3 W LED should cover at least 4 petri dishes.

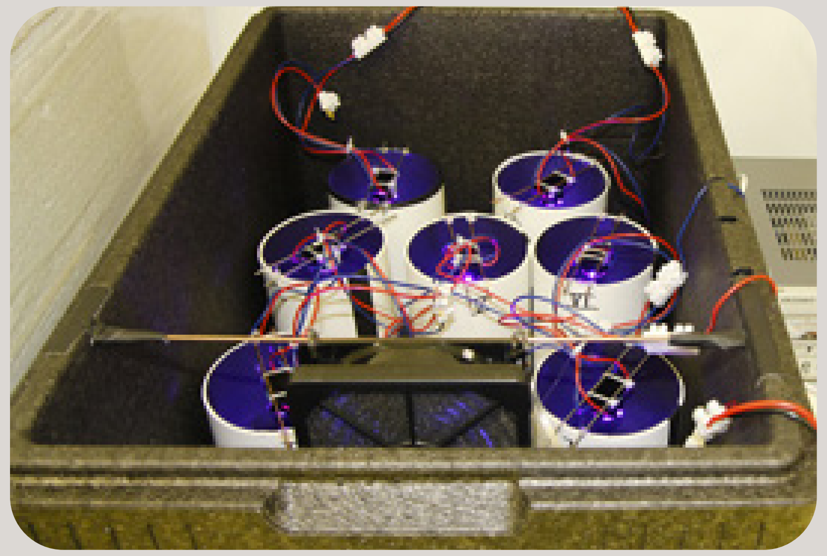
LED Safety

It is recommended that caution be used when handling these LEDs. The UVA spectrum is likely not going to cause any health effects to your skin. However, when working with 3-watt LEDs it is important not to shine these directly into your or someone else’s eyes.

Electrical Safety

It is important to discuss the amount of LEDs you would like in your setup and get some guidance from a professional on how to set up the box. The Fab Lab Reykjavík used a 5,5-volt source supplied by an Arduino board and 47 ohm resistors with the two (3W 395 nm) LEDs wired in parallel.

Example of Yeastogram Setup (Yeastograms, 2019)



Example of Yeastogram Setup (Seyfried & Czjzek, 2013)

8.2|Stencils

As discussed in the preparation stage it is possible to make more complicated stencils. The tested methods in the making of this module were inkjet printing and black vinyl. Black vinyl works the best and gives the crispest images. Instructions on inkjet printing a stencil will be provided in the supplemental material.

For vinyl cutting, it is recommended that you go to your local Fab Lab with the size of petri dishes you need a stencil for. Here is an instruction book that includes instructions on making a vinyl stencil on flr.is or this citation (flr, n.d.).

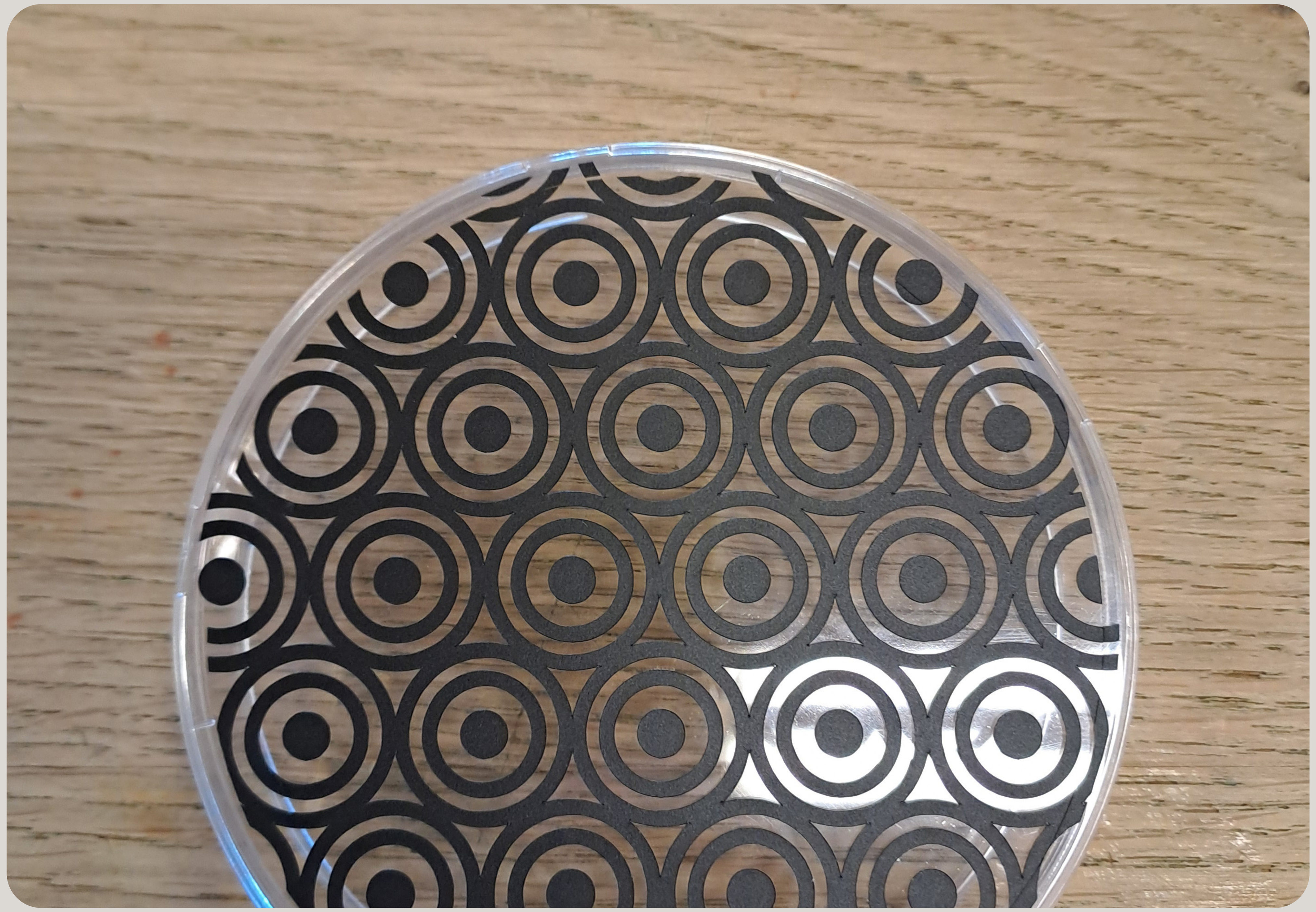
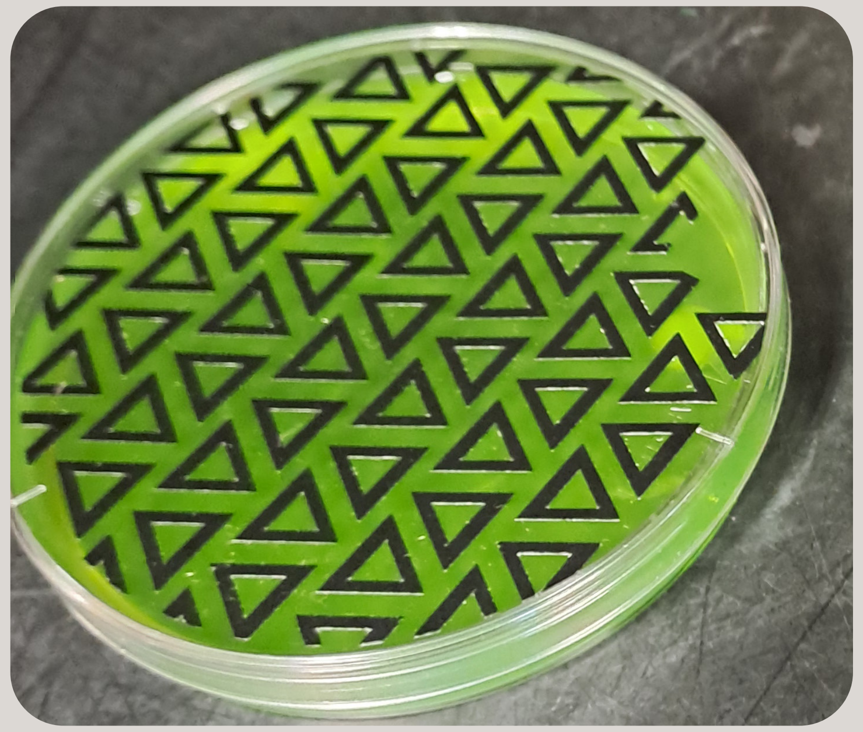


Photo of vinyl stencil



Example of vinyl stencels

Example of vinyl stencels

Photo of the process of moving the vinyl stencel to the Perti Dish

10|GET INSPIRED

10.1. What has been done?

Yeastograms have been around since about 2013 so for over ten years to grow. Pavillon_35 provided a recipe that has been used as a basis for yeastograms since it became public via their website (Seyfried & Czjzek, 2013).

#Yeastograms

The account Yeastogram on Instagram made by Johanna Rotko started on March 22, 2016. Around 3 years after pavillon_35 created receipt #1. Now the Yeastogram account has 3.900 plus followers and posts 4-6 times a month. There are a lot of interesting artworks on this page.

It is also interesting that physical art is of course the yeastogram itself. The photograph of the yeastogram is also art. The photograph fixes the yeastogram at the time the photo was taken but the yeastogram is always changing over time as it is a living thing.

Fine Art

The artist's name is Johanna Rotko and she is a Finnish bio artist who originally took a yeastogram workshop from pavillon_35. She is currently working with yeastogram and also doing artistic research that explores the relationship with microbes (Rotko, n.d.). She has had gallery exhibitions.

Petri Dish Size

This module is designed for standard-size Petri dishes, however, there is no limit on the shape and size of the yeastogram. The only limiter is the UV light box. If you make the UV light box bigger a different sized petri dish could be used.

Types of Yeast

In this module, only baker's yeast was used to make yeastograms, but there are many different types of yeast. The artist from #yeastogram is using different types of, but also using wild yeast. This could also be why other organisms are more prevalent in their work.

Photo of gallery (Rotko, 2022)

Photo of gallery (Aalto_Media, 2014)

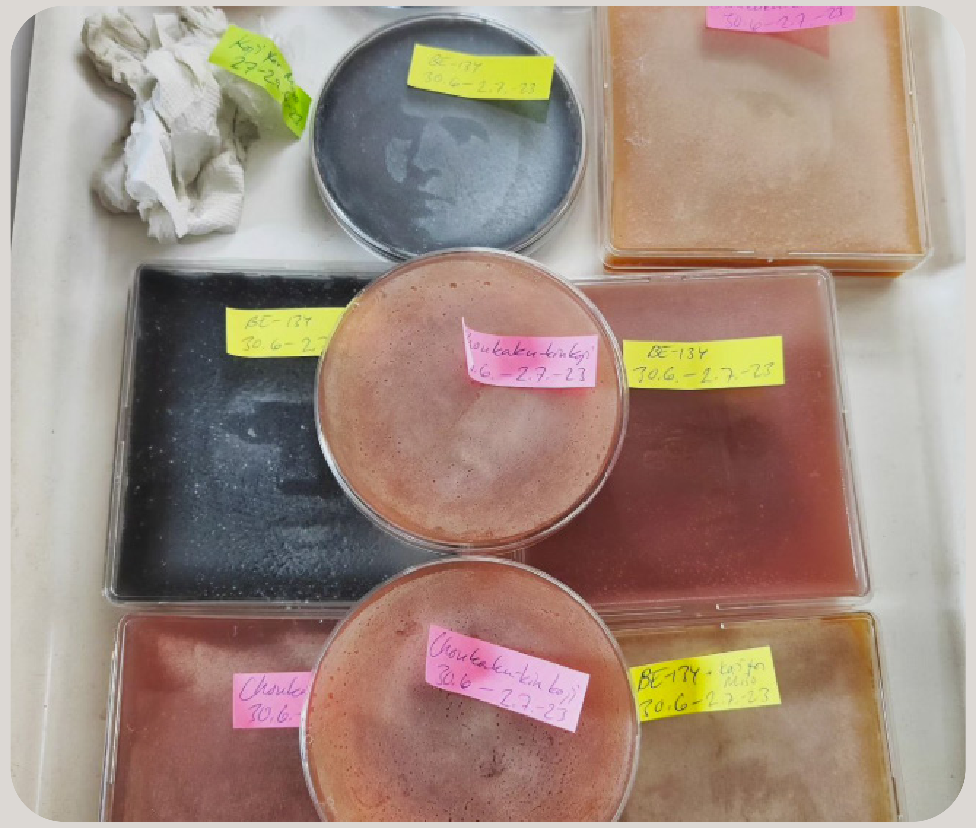


Photo of different yeastograms (Yeastograms on Instagram, 2023)

Image of different yeast types (yeastograms, 2018)

10.2. What can be done?

The yeastogram has been around for a while, but there are still many different things that can be done. Here are some ideas on methods that can be used in future yeastograms. Of course, these are not all of the possible changes to the method, but some ideas to get you started.

Different Organisms

This project specifically worked with yeast and UV. However, the process of making a picture out of an organism could be transferred to different types of organisms. Originally the Yeastogram team at pavillon_35 was inspired by Colloids (Coliroid - Parts.Igem.Org, n.d.) and an artist making pictures out of E Coli (O'Neill, 2012).

"Fixing" the Yeastogram

In black-and-white photography, there is a process called "fixing". This is a process where the photosensitive paper is washed in chemicals to ensure that the image will not change when exposed to more light. In this module, it was discussed that taking a photo of the yeastogram was light fixing it. However, it might be possible to "fix" the actual yeastogram. The idea is that you would encase the yeastogram in an acrylic or casting resin. Casting resin has been used to cast many things: food, drinks, and more.

Using Film

Yeastogram is very similar to black and white photography. This has been mentioned many times in this module. But here is a way to connect B&W film photography and yeastograms even more.

The idea is to use developed film from B&W photography to make a stencil. In order to do this you would just need to ensure the image has a high contrast and that the height of the film is significantly away from the petri dish. Instead of the film laying directly on the petri dish like the other stencil the film would be near the LED. The LED would act as an enlarger.

Photo of yeastograms

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